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Technique Standards for Skin Lesion Imaging
A Delphi Consensus Statement

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IMPORTANCE Variability in the metrics for image acquisition at the total body, regional, close-up, and dermoscopic levels impacts the quality and generalizability of skin images. Consensus guidelines are indicated to achieve universal imaging standards in dermatology.

OBJECTIVE To achieve consensus among members of the International Skin Imaging Collaboration (ISIC) on standards for image acquisition metrics using a hybrid Delphi method.

EVIDENCE REVIEW Delphi study with 5 rounds of ratings and revisions until relative consensus was achieved. The initial set of statements was developed by a core group (CG) on the basis of a literature review and clinical experience followed by 2 rounds of rating and revisions. The consensus process was validated by an extended group (EG) of ISIC members through 2 rounds of scoring and revisions. In all rounds, respondents rated the draft recommendations on a 1 (strongly agree) to 5 (strongly disagree) scale, explained ratings of less than 5, and optionally provided comments. At any stage, a recommendation was retained if both mean and median rating was 4 or higher.

RESULTS The initial set of 45 items (round 1) was expanded by the CG to 56 variants in round 2, subsequently reduced to 42 items scored by the EG in round 3, yielding an EG set of 33 recommendations (rounds 4 and 5): general recommendation (1 guideline), lighting (5), background color (3), field of view (3), image orientation (8), focus/depth of field (3), resolution (4), scale (3), color calibration (2), and image storage (1).

CONCLUSIONS AND RELEVANCE This iterative process of ratings and comments yielded a strong consensus on standards for skin imaging in dermatology practice. Adoption of these methods for image standardization is likely to improve clinical practice, information exchange, electronic health record documentation, harmonization of clinical studies and database development, and clinical decision support. Feasibility and validity testing under real-world clinical conditions is indicated.

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Supplemental content

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Acquisition of photographic images of skin lesions is a common procedure in dermatological practice. While an incalculable number of images are captured every day to document clinical findings, or for educational or research purposes, there is no current consensus on standards for image acquisition that are consistently being applied across the dermatological community.[1]

The value of photographic digital imaging has been evaluated more consistently in the setting of patients at high risk for melanoma using regional and/or total body, close-up, and dermoscopic imaging, as well as when following skin lesions using short-term monitoring.[2] However, the implementation of photographic imaging expands in daily practice to all aspects of dermatology, including biopsy site documentation, follow-up of inflammatory conditions and monitoring of therapeutic responses.[3,4]

Considering the rapid improvements in digital imaging technologies, and how ubiquitous digital imaging has become in our society, we are pressed to embrace a solution that will allow us to effectively standardize the use of digital imaging in dermatology. Whereas many other medical specialties have specific Digital Imaging and Communications in Medicine (DICOM) standards for digital communication across networks as well as associated metadata for description and cross-referencing, this is not yet the case for dermatology. The International Society for Digital Imaging of the Skin (ISDIS) believes this is related in part to the absence of a sizeable dermatologic imaging industry, the fact that much dermatological imaging

Table 1. Profile of Respondents and Participation in Delphi Rounds

Respondent	Expertise	Country	Round				
			R1	R2	R3	R4	R5
Core group							
C1	Dermatology	USA	Y	Y	N	Y	N
C2	Dermatology	Australia	Y	Y	N	Y	N
C3	Dermatology	USA	Y	Y	N	Y	N
C4	Dermatology	USA	Y	Y	N	Y	N
C5	Dermatology	Austria	Y	Y	N	Y	N
C6	Dermatology	Spain	N	N	N	Y	N
C7	Medical photography	USA	Y	N	N	Y	N
C8	Dermatology	Austria	N	N	N	Y	N
Expert group							
E1	Primary care	Australia	N	N	Y	N	Y
E2	Dermatology	USA	N	N	N	N	Y
E3	Dermatology	USA	N	N	N	N	Y
E4	Dermatology	Spain	N	N	Y	N	Y
E5	Dermatology	USA	N	N	N	N	Y
E6	Dermatology	Germany	N	N	N	N	Y
E7	Dermatology	Switzerland	N	N	Y	N	Y
E8	Dermatology	USA	N	N	N	N	Y
E9	Dermatology	Italy	N	N	Y	N	Y
E10	Dermatology	Italy	N	N	N	N	Y
E11	Dermatology	Israel	N	N	N	N	Y
E12	Medical informatics	Spain	N	N	N	N	Y
E13	Dermatology	Germany	N	N	N	N	Y
E14	Dermatology	Austria	N	N	Y	N	Y
E15	Dermatology	USA	N	N	N	N	Y
E16	Technology and dermatology	Australia	N	N	Y	N	Y

can be achieved with (adapted) consumer photographic equipment, and the growing use of mobile technologies in clinical practice.[5] To this end, ISDIS launched the International Skin Imaging Collaboration (ISIC): Melanoma Project to develop technology, technique, and terminology standards for skin lesion imaging.[5,6]

A recent review of technology and technique standards for routine camera-acquired skin-disease images concluded that dermatological imaging is evolving without defined standards. This is likely to affect image quality, impair exchangeability, and limit clinical benefit; thus calling for the development and adoption of universal technology and technique standards.[1] The absence of standards for digital photography in dermatology practice including the lack of DICOM standards is a major limitation for integration of dermatologic images across systems that support documentation, diagnosis, and clinical research.[6] The ISIC Technique Standards aim to reduce the current variation in skin lesion imaging by standardizing "methods for proper lesion identification, documentation of lesion attributes, and image acquisition parameters such as poses, lighting, magnification, and the use of size and color calibration markers."[7] We report herein a Delphi study conducted among members of ISIC to develop a Delphi consensus statement on imaging acquisition standards.

Methods

Design

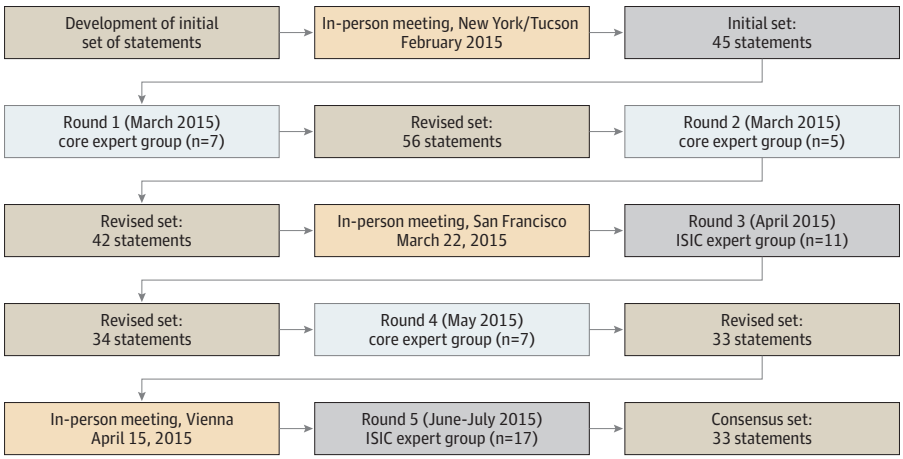
The consensus process used a Delphi method in which draft item statements were circulated to ISIC members for rating and comment. The Delphi method is an established method for consensus-building exercises among experts on issues where empirical evidence is limited or where the subject under consideration does not lend itself to empirical evaluation.[8-10] We used a hybrid design of alternating feedback rounds of a core group (CG) and an expert group (EG) until consensus was achieved (**Table 1**) (**Figure**). Statements were revised following each feedback round based on ratings and comments. The first 2 rounds (rounds 1 and 2) included the CG, which was followed by the first EG round (round 3), another CG round (round 4), and the second EG round (round 5).

Development and Revision of Statements

The initial set of 45 statements was developed by C.C. and H.P.S. with input from the ISIC core group (A.M., A.H., J.M., H.K., R.H., D.D.). The statements were grouped into 10 categories of standards: general, lighting, background color, field of view, image orientation, focus/depth of field, resolution, scale, color calibration, and image storage.

In each round, respondents were asked to rate items on a scale of 1 (strongly disagree) to 5 (strongly agree); to explain any rating less than 5; and to provide suggestions for substantive revisions or lesser changes in wording (Figure). Comments were optional for ratings of 5. The suggestions from CG respondents (rounds 1, 2, and 4) were used to make changes to the statements for the expert group rounds (rounds 3 and 5). In round 5, only suggestions for nonsubstantive changes to improve clarity were allowed since there had been thorough substantive changes in the earlier rounds, and the scores indicated an approximation to a consensus opinion.

Figure. International Skin Imaging Collaboration (ISIC) Consensus Study Flowchart



This chart reviews the process of how initially proposed statements were amended, deleted, or substituted, and additional statements were formulated, over the course of the evaluation cycles.

In round 2, in addition to being asked to rate and comment on a revised version of items, CG respondents were also requested to indicate whether they considered a given item to be an image acquisition standard (technical procedure to capture the images) or a metric standard (imaging features expected to be present in the acquired images). After round 2, the items with a 4 or 5 rating were retained for in-depth discussion at the March 22, 2015, meeting in San Francisco to finalize the items for the third round—which was the first survey to be sent to the larger ISIC EG. After round 4 (final round for the CG), the final set of items was finalized at the April 15, 2015, meeting in Vienna before the final survey was sent out to the larger ISIC EG for final ratings (round 5).

The San Francisco and Vienna meetings were critical in that they permitted in-depth discussion on those categories and items on which consensus was difficult to achieve in earlier cycles of the process. While such in-person working meetings may not be common in Delphi studies, they proved instrumental because they enabled discussion and revision in a broader group rather than the limited analyst group in a typical Delphi exercise.

Respondents

Respondents and the rounds in which they provided ratings and comments are summarized in Table 1. Rounds 4 and 5 had the highest participation among CG and EG members. Four of the 8 CG experts were US-based, 2 worked in Austria, and 1 each in Australia and Spain. With the exception of 1 CG member who was a medical photographer, all CG members were dermatologists with relevant clinical experience in dermatological imaging, including total body photography and dermoscopy. The CG experts shared a consistent use of imaging technology in their practice and contributions to the field of dermatological imaging through publications, research, and/or educational activities. They did not necessarily share a higher level of expertise than several participants in the EG. However, they committed to lead the different working groups within the ISIC initiative and had a vested effort in the project.

Of the 16 EG members who participated in rounds 3 and 5, five were US-based, 2 worked in Australia, and the remaining 9 were from various European countries. These EG members represented the various ISIC working groups providing expertise in key aspects of technology, privacy, terminology, technique, and medical photography. Fourteen were dermatologists. Two EG members were employed in industries with commercial interests in dermoscopy and thus dermatological imaging. Their responses were excluded from analysis owing to the possibility of actual or perceived conflict of interest. However, their substantive suggestions and contributions to the guidelines were fully considered in the drafting process.

Analysis

In each round, mean, median, and standard deviation were calculated for each statement (eFigure in the Supplement). Consensus was considered achieved for any statement with a median and mean score of 4 or more. All analyses for each of the 5 rounds were performed independently by 2 of the authors (C.K. and I.A.).

Results

The evolution of statements from the initial 45 to the final 33 is presented in the eFigure in the Supplement, including summary statistics, additions, deletions, and reformulations. Following the CG's feedback from round 1, the initial set of 45 statements was expanded to 56; which, based on subsequent CG feedback (round 2), was reduced to 42 statements. Following review by the EG (round 3) a revised set of 34 statements was submitted to the CG, which achieved consensus on a set of 33 statements (round 4). This set was submitted to the EG for final comment (round 5). Minor editorial revisions were made in follow-up. The ISDIS-Consensus Statement on Technique Standards for Skin Lesion Imaging is presented in **Table 2**.

Several developments are noteworthy. The categories "lighting," "background color," "field of view," "image orientation," "focus/depth of field," and "resolution" were the hardest to achieve consensus on and triggered major recommendations for revision in the first few rounds (eFigure in the Supplement). The first item "consistent imaging standards need to be implemented" received unanimous agreement among the CG and the larger EG throughout all 5 rounds.

In the category "lighting," agreement among the experts varied on several items, such as lighting source, angle of the lighting

Table 2. Consensus Statement

Consensus Item	Consensus Statement
Imaging standards	
1.1	Consistent imaging standards should be implemented for dermatological imaging, regardless of the purpose of capturing the images (eg, documentation, monitoring, seeking expert opinion).
Lighting	
2.1	Broad spectrum lighting is recommended to provide the most accurate representation of the skin type.
2.2	Irrespective of the light source, an even illumination across the area of interest should be achieved when capturing regional and close-up images for accurate assessment of skin type and surface texture without shadowing and hot spots.
2.3	Relative to the skin surface, and whenever possible, the lighting source should be on an angle or oblique to the skin being photographed.
2.4	Although obtaining both polarized and nonpolarized dermoscopic images of the lesion is ideal, it is up to the health care provider to decide if it is indicated.
2.5	If only 1 dermoscopic image is obtained it is preferable to obtain it with polarized light; however, it is up to the health care provider to ultimately decide whether to obtain the image in polarized or nonpolarized mode.
Background color	
3.1	When capturing images of the skin, a solid background color without patterns or disrupted surface is recommended.
3.2	When capturing images of the skin, a blue or black background is recommended to provide contrast to skin tones.
3.3	When capturing images of the skin, artifacts should be avoided in the background and on patient's skin (eg, jewelry) to avoid interference with the visualization of the patient's skin and corresponding skin lesions.
Field of view	
4.1	Optimally, when photographing a lesion (close-up or dermoscopy), the lesion should be balanced and centered in the field of view, while attempting to capture an equal area of healthy skin surrounding the lesion.
4.2	When photographing close-up images, there is no limit in the size of the lesion to be imaged.
4.3	When photographing lesions that are larger than the field of view provided by the dermoscopic lens, multiple images can be obtained to capture the largest proportion of the area of interest.
Image orientation	
5.1	Regional body images should be oriented with the superior aspect of the field of view facing toward the scalp (cephalic orientation).
5.2	Across regional and close-up images, the horizontal or vertical orientation should be consistent, when feasible.
5.3	When feasible, the orientation of close-up, and dermoscopic images should follow the same parameters used to obtain the relative regional image corresponding to the lesion of interest.
5.4	Dermoscopic images should be captured using the same orientation as the corresponding close-up image.
5.5	When capturing regional body, close-up, and dermoscopic images the camera should follow a similar orientation as the one obtained in previous imaging sessions.
5.6	Areas of the body that are challenging to photograph and require specific recommendations include the hands, feet, web spaces of fingers and toes, intergluteal cleft, genitalia, perineum, behind the ears, hair-bearing scalp, intertriginous skin, and superior frontal scalp.
5.7	For patients at the extremes of height and weight or those with physical impairments, general recommendations should be followed when possible, and otherwise treated on an individual basis. When required, additional regional images should be obtained to ensure that the complete cutaneous surface is visualized.
5.8	To ensure that the area of the body can be easily identified in regional images, sufficient visualization of the anatomical site (in many cases a joint) should be included in the field of view for proper localization of the lesion.
Focus/depth of field	
6.1	When photographing the skin, the focus point should target the center of the lesion of interest.
6.2	When photographing the skin, the maximum amount of the area of interest should be in focus.
6.3	When photographing the skin, the camera should be oriented perpendicular to the skin surface.
Resolution	
7.1	For regional images, a level of magnification should be used that sharply depicts the presence of hair follicles.
7.2	For close-up images, a level of magnification should be used that sharply depicts skin markings.
7.3	For dermoscopic imaging a level of magnification that allows clear visualization of dots is required (if present).
7.4	For dermoscopic imaging a level of magnification that allows clear visualization of regression structures is required (if present).
Scale	
8.1	For close-up imaging of lesions, a scale should be used and placed in the most appropriate axial plane according to the camera orientation (ie, vertical scale for vertical image frame) without obscuring or distracting from the area of interest.
8.2	For dermoscopic imaging of lesions, a method to define the size of the lesions should be included. Options to achieve this standard include, but are not limited to: inclusion of a scale in the contact dermoscopic lens and/or using a digital scale that can be retrieved as part of the image file.
8.3	When implementing a physical scale for dermoscopic images, the scale should be used and placed in the most appropriate axial plane according to the camera orientation (ie, vertical scale for vertical image frame) without obscuring or distracting from the area of interest.
Color calibration	
9.1	A white balance and color calibration procedure should be carried out according to the system manufacturer.
9.2	Imaging parameters should permit color comparisons between images and over time.
Image storage	
10.1	Images should be stored in formats that will not compromise the clinical quality of the images. Examples include, but are not limited to: JPG (minimally compressed), TIFF, PNG (lossless), and RAW.

source, and using polarized and nonpolarized light in dermoscopic images. These items required several revisions until consensus was achieved in rounds 4 and 5. In particular, the items on polarized vs nonpolarized dermoscopic images proved difficult and consensus was not achieved until round 4. In the category "background color," several respondents in rounds 1 through 2 suggested to add depth to the initial set of items. This led to additional items being generated for round 2, some of which were subsequently removed. Even though experts were in agreement that a distinct background color is needed for better visualization of skin, it took 2 rounds to achieve consensus on the actual shade of color. Initially, the option of a neutral gray background was included along with black or blue, but this background was not carried over to the final round because it failed to achieve consensus.

The category "field of view" consisted of 6 items in round 1, some of which were either revised into a new statement or summarized into 1 statement. Items such as whether the lesion should be positioned centrally in the field of view and using multiple images for lesions larger than the field of view achieved consensus in the first 2 rounds. It required 3 rounds and major revisions to achieve consensus on the size of lesion while photographing close-up images.

The category "image orientation" started off with 14 items in round 1. Five items that did not achieve the threshold of consensus endorsement in round 1 were not included in round 3. Items on the orientation of the camera in regional body, close-up, and dermoscopic images achieved consensus after 2 rounds; whereas the remaining items achieved full consensus from rounds 1 through 5.

Unlike some of the other categories, the category "focus/depth of field" was among the categories with greater ease to achieve full consensus. The items on the focus point and area in focus achieved full consensus in rounds 1 through 5. In addition, the item on orientation of the camera introduced in round 3 achieved full consensus from rounds 3 through 5.

For the category "resolution," most of the experts in round 2 made recommendations on reducing the text of the item on the level of magnification for regional images. Items which were repetitive in content and did not receive a mean of score of 4 or more were dropped in round 2. The remaining items in this category, such as level of magnification for close-up and dermoscopic images, received full consensus from rounds 1 through 5. The hair follicle resolution statement in the first 2 rounds was used in relation to both close-up and regional images. After round 2, the CG experts agreed for hair follicle resolution to be applied to regional images. For rounds 3 to 5, only the statement about the level of magnification in regional images depicting hair follicles was included. However, consistent through all 5 rounds and as initially proposed, the skin markings resolution was in relation to close-up images. Hair follicles and skin markings are structures that are always present for regional and close-up images, but dermoscopy structures are not always present. Hence, the experts elected either 1 or both of these criteria (dots and regression structures visualization) when present to be indicators of acceptable level of resolution for dermoscopic imaging (items 7.3, A and B).

The category "scale" started off with 1 item in round 1. Per respondents' feedback, 2 items on dermoscopic imaging of lesions were added, which received full consensus after 3 rounds.

Similarly, the category "color calibration," started off in round 1 with 1 item on interval white balance and color calibration. This item did not achieve consensus and was removed after round 3. The 2 items introduced in round 2 achieved full consensus in rounds 2 and 5. The final category "image storage" included a single item on the format of image storage. This item achieved full consensus throughout with minor wording changes in the first 3 rounds. We attempted to include more items for this category but, failing to achieve consensus, only a single item was retained.

Discussion

The rapid advances of digital imaging in dermatology are an urgent call for our medical specialty to standardize the methodologies of acquisition, storage, and viewing of skin images. Dermatological images are considered to be a medical record, and as such, it is critical that we implement best practices to safeguard the privacy and accuracy of the information that is being captured. It is also imperative that we evolve from our current inconsistent and individualized practices to a strategic, cohesive, and thoughtful protocol that will guarantee a successful approach to imaging implementation in daily dermatological practice. Several of the elements for practice implementation of medical imaging have been developed by other specialties, in particular radiology, and more recently by ophthalmology with well-established guidelines for best practice and quality assurance. The first step for our specialty is to determine the key aspects of dermatological imaging that we believe are critical for standardization, including imaging acquisition techniques, imaging metrics, and clinical flow requirements. Subsequently, automatization of the process is expected to evolve to achieve consistency over time and capability for optimization.

The effort carried out by the ISIC group through this consensus statement represents a step forward in leading our specialty toward clinical imaging standardization when photographing the human skin. Several aspects of the imaging process were classified and defined by categories and consensus. Equally important to the identification of those parameters that experts agree on is the identification of areas in need of additional discussion and consensus. While exercising the Delphi consensus methodology some areas of considerable controversy across imaging experts were identified.

One example included the type of light source to be used when acquiring dermoscopic images. While a significant proportion of the group favored a single image acquisition in polarized mode, specific arguments regarding the role of nonpolarized light in the assessment of certain lesions (eg, seborrheic keratosis) were made by several members. Therefore the consensus statement, attempting to address and simplify the acquisition of dermoscopic images delegated, at least for the time being, the decision on whether to capture the images with polarized or nonpolarized light to the user. One could predict that as the field continues to evolve with clinical images being acquired in a systematic and/or automated fashion that the selection of 1 light source for dermoscopic imaging will need to be addressed once again.[11]

Another statement that raised considerable controversy included the implementation of a physical scale for close-up and dermoscopic images (eFigure in the Supplement). The core and expert panels were divided between experts who preferred the visualization of the clinical image without the distraction of a physical scale and those who viewed the presence of a scale as critically

important in the standardization and evaluation process. Current imaging technologies do hold the capability of inputting the size of the lesion without the need for a physical scale. However, such methodology needs to be agreed on.

Early on in the consensus process consideration was given to implementing a minimal resolution standard, as has been recommended in the past.[12] However, representatives from the CG and EG indicated a preference for a resolution standard based on viewable features rather than a specific image size and pixels. Future projects looking at validation of the image acquisition parameters and barriers for implementation may need to consider other resolution parameters as imaging technology continues to evolve.

A few areas for future consideration have been suggested after the completion of the work reported herein. The use of a neutral gray background, in addition to the proposed blue or black color, which might enable better imaging of dark skinned patients, may need to be revisited. It may be necessary to standardize the sequence and protocol for linking multiple images from lesions larger than the field of view, especially if these images include captures of clinically suspicious areas—images that need to be correlated and reviewed with the corresponding dermoscopic images. It may also be helpful to consider procedures to assure that the camera is indeed perpendicular to the skin surface and to correct for potential image distortion secondary to camera orientation.

When comparing the imaging parameters proposed in the present study to the recently published American Telemedicine Association (ATA) guidelines, several differences and similarities are worth noting.[13] Both the ATA guidelines and the ISIC standards recommend using a solid, neutral color without patterns or disrupted surface. The ATA guidelines do indicate the need to avoid a reflectance surface and the ISIC standards specify the use of a black or blue background. Both entities also share similar recommendations in terms of image focus and the use of perpendicular orientation of the camera when capturing images. The ISIC standards include recommendations in terms of photographic scale for close-up and dermoscopic images, while ATA guidelines cover specific parameters such as image compression, use of flash, and resolution based on pixels. Overall, both documents validate several of the proposed imaging parameters while also being complementary.

A significant strength of the work herein is the wide representation of stakeholders, including academic and community dermatologists, medical photographers, industry representatives, and imaging experts from multiple fields. Another strength includes the adherence to a general consensus methodology, but also its adaptation to the challenges inherent to the consensus exercise. This enabled the development of a series of recommendations suitable for implementation in clinical practice. Some of the weaknesses include the inherent limitation of developing and assessing the proposed guidelines in a group of experts and the need for validation by the dermatology community at large. As a next step we will disseminate the proposed imaging standards to several research groups and clinical practices to evaluate the feasibility of the proposed recommendations.

Conclusions

The future of precision medicine in dermatology depends on our capability as a specialty to embrace the advances of imaging technology in a standardized, secured, and efficient manner. Given the complexity associated with reaching consensus across multiple parties including, but not limited, to community and academic dermatologists, teledermatology requirements, industry priorities, patient privacy, and technical demands, a concerted effort will need to be undertaken to create a common roadmap by which standardized imaging will be implemented in the dermatology field.

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