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Towards three-dimensional temporal monitoring of naevi: a comparison of methodologies for assessing longitudinal changes in skin surface area around naevi

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DEAR EDITOR

Although change in a skin lesion is a sensitive clue to the diagnosis of melanoma, all skin lesions grow at some point during their lifespan. Few studies have assessed how skin lesions change in size relative to the body. Rhodes et al estimated the relative growth of congenital naevi in infants by comparing naevus surface area (heretofore we refer to surface area simply as area) changes to regional body area changes calculated using height and weight data and adjusted for age and found disproportionate growth in the first six months followed by proportionate growth thereafter.¹ As body sites change at different rates and are influenced by age, sex, and environmental factors, it is unclear if this approach is uniformly valid or if other methodologies might be more applicable.^{1,2} Until recently, measuring change in skin area has not been readily feasible (i.e., paper cast or palm techniques³) but the advent of three-dimensional (3D) stereophotogrammetry-based imaging in dermatology clinics⁴ now offers an opportunity for precise studying of perilesional area changes. Here we compared 3D-imaging observed area changes to those calculated from two-dimensional (2D) imaging or inferred from height and weight data as part of the Study of Nevi in Children (SONIC), which to our knowledge is first to longitudinally follow naevi using 3D imaging.

SONIC was approved by the Harvard University Institutional Review Board and adhered to the guidelines of the Helsinki Declaration. Participant accrual and data collection have been

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previously reported.^{5–8} Relevant to this study, participants had 180° anterior and posterior 3D body images and 2D overview images of the back and legs captured at baseline (~age 14) and three-years later using standardised poses, along with height and weight measurements. 3D images were obtained using a customised Vectra Body System (Canfield Scientific, Inc., Fairfield, NJ), which had a stereo-capture array of twelve 21-megapixel digital single-lens reflex cameras configured to meet study capture field and photographic texture resolution requirements. The calibrated dimensional imaging system collected each image under 4-milliseconds to produce a 3D model. Vectra systems have been validated for accuracy and are in clinical use.^{4,9–13} Digital 2D images were obtained using a Phase One P25 Camera Back, Hasselblad 503w Camera System, 2kWatt Studio Flash System (Canfield Scientific, Inc.).

Area around naevi (or “perilesional area”) was measured on 3D and 2D images using four neighbouring landmark naevi (“anchors”) that surrounded the naevus. These “anchors” had to be clearly visible at both time points (Figure 1). When four neighbouring landmark naevi could not be identified, the index naevus was used as the fourth landmark. In a pilot experiment using 3D images of a single participant taken 15 minutes apart, we explored the precision and repeatability of the 3D VECTRA body system and use of perilesional area measurements for 10 back naevi. We found a mean coefficient of variability of 1.04%, supporting the reproducibility of this approach.

To further explore area change measurements, we calculated 3D and 2D regional area, defined as the area of the upper back, lower back, or lower leg (Figure 2), and total body surface area (TBSA) ($TBSA = xH^yM^z$; x, y, and z are constants equalling 0.02667, 0.38217, and 0.53937, respectively, H is height, and M is mass).^{14,15} A convenience sample of 93 naevi from 65 participants (33 males) was chosen from the upper back (n=29), lower back (n=21), upper leg (n=22), and lower leg (n=21). Feasibility of naevus perilesional area measurements was required for inclusion and we over-selected naevi on the lower back and legs to include similar proportions by anatomical site (see online supplement).

The mean 3D perilesional area increased after three-years by 16.1 % (95% CI, 13.0%–19.3%). There was nearly perfect inter- and intra-observer reliability (intraclass correlation coefficient of 0.99 for both measures). To assess the accuracy of the 3D imaging system and measurement tool, coloured adhesive dots that were originally placed adjacent to naevi during photography sessions for tracking purposes were randomly selected from 10 participants and their diameters were measured at both time points. The mean (SD) diameter was 12.83mm (0.13mm) and comparable to the manufacturer’s reported specification of 12.70mm.

Non-visible landmark naevi located on curved surfaces precluded 2D perilesional area measurements in 29 (31.2%) cases. For the 64 naevi with both 2D and 3D perilesional area measurements, 3D perilesional area measurements were consistently greater than 2D (baseline: 69.0cm² v. 59.4cm²; follow-up: 87.5cm² v. 72.6cm², p-values<0.001), but there was no difference in the mean change between 3D and 2D perilesional area (17.0% vs. 17.6%, p=0.8).

Change in regional area differed from change in 3D perilesional area but did not reach statistical significance in this small sample (3D perilesional area v. 3D regional area was 17.9% v. 20.5%, $p=0.07$; 3D perilesional area v. 2D regional area was 17.9% v. 13.6%, $p=0.05$). However, we did identify a significant difference in the change between 3D perilesional area and TBSA (16.1% v. 13.3%, $p=0.02$).

This study is first to compare methodologies for calculation of area changes around naevi using a reference standard of 3D stereophotogrammetry-based imaging. We found a significant difference in the mean percent area change between calculated TBSA and direct perilesional area measurements. This difference can be attributed to disproportionate growth of anatomical sites. Consistent with this interpretation, we found regional area change to be a closer approximation to perilesional area change than TBSA. Although 2D perilesional area appears to be a similarly valid and reliable method for monitoring change in area over time compared to 3D perilesional area, it is not always feasible for lesions bordering sharply-curved anatomical sites when landmark lesions cannot be visualized.

A limitation of this study is that perilesional area may notably not be applicable to individuals with few skin lesions. Further study is needed to examine whether the differences in methodologies identified in this study are clinically important. Knowledge of changes in the size of skin lesions relative to their surroundings may someday aid automated melanoma detection efforts as well as provide insight into naevus growth dynamics.

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Figure 1.

Perilesional area measurements on 3D and 2D images. (A) 3D back image. The perilesional area measurement of the naevus with adjacent teal coloured sticker is shown with blue shading and delineated by four neighbouring or “landmark” naevi. (B) Rotated image of part (A) that visually depicts how 3D area measurements account for surface topography. (C) Identical perilesional area measurement performed on 2D back image.

Figure 2.

Regional area measurements on 3D and 2D images. (A) 3D back image. The regional area measurement of the upper back is shown with blue shading and delineated by the nape of the neck to the bilateral acromion processes to the level of the lower tips of the scapulae. (B) Rotated image of part (A) that visually depicts how 3D area measurements account for surface topography. (C) Identical regional area measurement performed on 2D back image.