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Research article

Dermoscopy can be safely and reliably used in ophthalmology

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ABSTRACT

Objective: To determine if dermoscopy, a technique widely utilized in dermatology for improved diagnosis of skin lesions, can be used comfortably for evaluating periorbital, eyelid, and conjunctival lesions.
Design: Proof-of-concept study in which a technique for performing dermoscopy near the eye was developed, related educational material was prepared, and a protocol for dermoscopic image capture was created.
Methods: Technicians used the developed materials to learn to take high-quality pictures with a 10x dermoscope attached to a standard cell phone camera. The images were assessed for diagnostic utility by an oculoplastic surgeon and two dermatologists.
Participants: 115 patients recruited from ophthalmology clinics from July 2021 to April 2023 were photographed, yielding 129 lesions with high-quality dermoscopic images as assessed by an oculoplastic surgeon and two dermatologists.
Results: Technicians reported a significant increase in confidence (measured on a 1–10 scale) with dermoscopy after training (pre-instruction mean = 1.72, median = 1, mode = 1, IQR = 1.25 vs mean = 7.69, median = 7.75, mode = 7 and 8, IQR = 1.5 post-instruction. Wilcoxon rank sum test with continuity correction, $W = 0$, $p < 0.001$, paired $t = 13.95$, $p < 0.0001$). Incorporating a contact plate with a 4 × 4mm reticule on the dermoscope aided in photographing ocular and periocular lesions.
Conclusion: Medical support staff in eye-care offices can be taught to use dermoscopes to capture high-quality images of periorbital, eyelid, and conjunctival lesions. Dermoscopy illuminates diagnostic features of lesions and thus offers a new avenue to improve decision-making in ophthalmology. Dermoscopy can be incorporated into telemedicine evaluations by ophthalmologists, oculoplastic surgeons, or affiliated dermatologists for triage of or rendering advice to patients and for planning of surgery if needed.

Dermoscopy is a non-invasive technique to improve diagnosis of skin lesions. Dermoscopy enhances visualization of pigmented, vascular, and other structures in skin, and has improved early detection and clinical monitoring of skin cancer [1]. The technique uses

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a dermoscope (also called dermatoscope), which is a handheld magnifying lens with polarized and non-polarized light settings. A dermoscope can easily be joined to a camera or smartphone attachment for acquisition and storage of high-resolution photos of the area under investigation. Dermoscopy is ideal for improving diagnosis and triage of skin lesions in telemedicine [2,3].

An increasing number of physicians inside and outside dermatology have implemented dermoscopy over the last decade [2]. Nevertheless, clinicians commonly shy away from using a dermoscope near the eye. In part, this may be because of fear of irritating, damaging, or inducing infection into the delicate structures of the eye. Additionally, the spherical contour of the orbit, eyelid, and globe makes it difficult to bring lesions into focus to obtain clear images.

Recently, a few studies have documented dermoscopic characteristics of periorbital, eyelid, and conjunctival lesions [4–9]. One study used dermoscopy to characterize several crucial diagnostic features of eyelid margin lesions such as pigmentation and vascular patterns [7]. These features not only aid in establishing the accurate diagnosis of specific lesions, but also enable differentiation among lesions that may appear clinically similar such as basal cell carcinomas and intradermal naevi [8]. As such, dermoscopy is a practical, cost-effective tool that can improve diagnostic accuracy and reduce unnecessary biopsies, ultimately leading to better patient outcomes.

Amidst increasing interest in employing dermoscopy in ophthalmology [2,4–6], our study aims to establish a standardized and user-friendly methodology for dermoscope usage in ophthalmology. Specifically, we seek to develop an efficient and cost-effective process for capturing images around the eye, ensuring safety and accuracy. To assess the feasibility of integrating dermoscopy into nationwide clinics, we've created educational materials for technicians and medical assistants to facilitate proficiency in image capture. Subsequently, we implemented this technique in a proof-of-concept study within ophthalmologic and oculoplastic clinics, focusing on patients with ophthalmic lesions.

1. Materials and methods

1.1. Technique development

Prior reports of ophthalmic dermoscopy were available to us [4–9]. From that starting point, we developed our technique and practiced on each other prior to examining patients. A method emerged for performing dermoscopy of periorbital skin, eyelid, and conjunctivae that is detailed below and in the Supplemental Figure and Video.

Important considerations emerged as we developed the technique. Dermoscopic examination of the brow, upper cheek, or outer eyelid surface can be performed in the same manner as any other skin. Dermoscopy of the eyelid margin, lashes, or conjunctiva, however, should be undertaken with caution, considering the sensitive tissues. Risk mitigation includes informing the patient to look away from the area of contact, providing a generous aliquot of ophthalmic gel for contact dermoscopy, and gentle application of pressure. Additionally, we used a dermoscope that attached to a contact plate with a 4 × 4mm hair-line reticule as opposed to the traditional, larger contact plate used in dermatology clinics that has a 10 mm reticule. The smaller contact plate is particularly helpful because it allows for better conformation to the skin with variable contours within periorbital regions.

1.2. Workflow of photograph acquisition

The dermoscope has 24 white LED lights (18 polarized and 6 non polarized). The maximum intensity of the light at the contact plate is 30 kLux (30 kilolumens). There are two settings: 1) polarized light and 2) non-polarized light, each of which only have one intensity that is not adjustable. Comprehensive assessment of a lesion involves non-contact polarized (polarized light is emitted and the dermoscope *does not* touch the lesion or skin surface), contact polarized (polarized light is emitted and the dermoscope *does* touch the lesion or skin surface with the contact plate), and contact non-polarized dermoscopy (non-polarized light is emitted and the dermoscope *does* touch the lesion or skin surface with the contact plate), although all three may not be required for every lesion. Polarized light dermoscopy preferentially highlights *subsurface* features with or without contact to the lesion [1,2,5]. Non-polarized dermoscopy reveals a detailed view of *surface* characteristics, especially when performed with contact.

To document the location and ordinary clinical appearance in a traditional manner, ordinary cameras or smartphones may be used. These can be connected easily and immediately via a magnetic clip to the dermoscope to document the dermoscopic findings as well.

Prior to examination, the dermoscope lens and contact plate should be cleaned with isopropyl alcohol (the manufacturer's recommendation for sterilization) or 0.5 % hydrogen peroxide and allowed to dry.

Non-contact dermoscopic photographs are obtained by positioning the dermoscope within a few centimetres of the area under investigation and adjusting the distance of the dermoscope from the patient as needed to capture a picture in focus. No additional materials are needed for capturing non-contact dermoscopic photographs.

For contact dermoscopy, the contact plate is snapped onto the front of the dermoscope**.** Cleaning of the contact plate before and after use is performed in the room with the patient to reinforce the steps being taken to mitigate chance of infection. Furthermore, our study team communicated to the patient that the cleaning of the dermoscope is being done to mitigate the risk of infection, and that the chance of infection, albeit low, is a risk. Then, a gel or liquid may be applied to the contact plate, and direct contact with the lesion is made.

For contact dermoscopy of the periorbital or eyelid skin, in which there is minimal risk of causing injury (such as infection, contusion or hematoma) due to the heavily keratinized nature of the skin surface, we used sterile 0.9 % sodium chloride solution; alternatively, due to the low-risk nature of the intervention, a non-sterile gel may be used or direct contact of the plate without an interface. On the eyelid margin or conjunctiva, we first anaesthetized the area with proparacaine hydrochloride (0.5 %) and we applied

lidocaine hydrochloride (3.5 %) sterile gel or unmedicated sterile ophthalmic gel to the contact plate. Others have obtained pre-dermoscopy anesthesia with tetracaine hydrochloride (1 %) [5,9].

1.3. Educational materials

We created both video and infographic training modules that show the steps and techniques for capturing quality dermoscopic photographs of lesions around the eye to teach dermoscopic techniques to the ophthalmic technicians and medical assistants who work in our oculoplastic clinic. To assess the efficacy of our training modules, we administered a pre- and post-survey to the ophthalmic technicians and medical assistants employing a Likert scale from 1 (not at all confident in obtaining dermoscopic images) to 10 (extremely confident). Additionally, we used a Likert scale from 1 (not at all useful) to 5 (extremely useful) to assess the utility of the two training module types (video and infographic).

1.4. Proof of concept

A proof-of-concept study was conducted to determine if dermoscopy could be implemented in ophthalmology clinics to safely capture quality diagnostic images. Approval was obtained from the University of Michigan Medical School Institutional Review Board (HUM00201391, approved for exemption on 6/15/2021), and patients provided written informed consent prior to participation. All research adhered to the tenets of the Declaration of Helsinki. Participants were enrolled prospectively from an oculoplastic surgery or a comprehensive ophthalmology clinic from July 2021 to April 2023. Medical students, ophthalmic technicians and medical assistants used a DermLite DL4 dermoscope (DermLite LLC, Aliso Viejo, CA 92656, USA) mounted to a cell phone for acquiring photographs. Photographs were given unique codes thereby removing any identifying information.

2. Results

2.1. Educational materials

There was a statistically significant improvement in technicians' and medical assistants' confidence in using the dermoscope to take quality pictures after the training modules and one 15-min session of in-person instruction. The confidence level (maximum 10) was low before training (mean = 1.72, median = 1, mode = 1, IQR = 1.25) and rose substantially in the post-training survey (mean = 7.69, median = 7.75, mode = 7 and 8, IQR = 1.5; Wilcoxon rank sum test with continuity correction, $W = 0$, $p < 0.001$, paired $t = 13.95$, $p < 0.0001$, Fig. 1).

Additionally, the ophthalmic technicians rated both the video and the infographic as very high in instructional effectiveness. Technicians' and medical assistants' rating (maximum 5) for the video had a median of 5, mode of 5, and an IQR of 1. Technicians' and medical assistants' rating (maximum 5) for the infographic had a median of 5, mode of 5 and an IQR of 1.

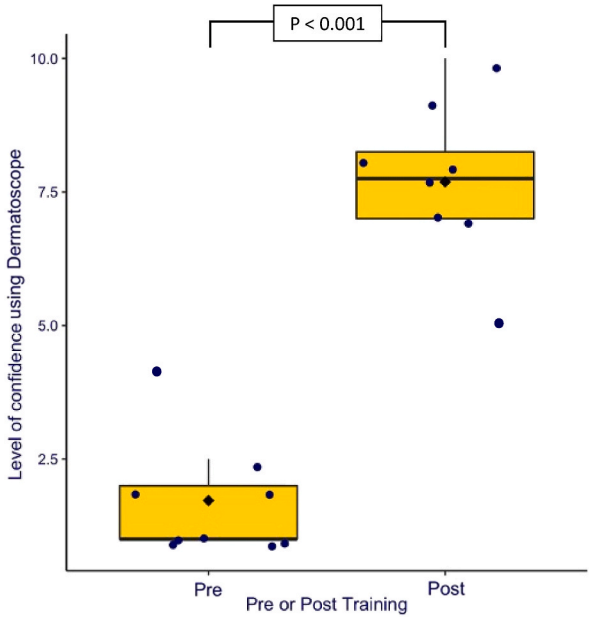


Fig. 1. Boxplot of confidence ratings on a 1–10 Likert scale before and after dermoscope training. Diamond indicates the mean; the horizontal line indicates the median. The size of the boxes represents the intra-quartile range with the whiskers representing the "minimum" (Q1 – 1.5*IQR) and "maximum" (Q3 + 1.5*IQR). Any outliers are marked outside of the whiskers.

2.2. Proof-of-concept study

115 patients were enrolled; their demographic characteristics are summarized in Table 1. The study involved patients ranging in age from 16 to 92 years, with a mean of 64 ± 15 SD years. A total of 129 lesions were captured from a variety of anatomical locations around the eye, including the conjunctiva, periorbital skin, eyelid, iris, medial canthus, and lateral canthus (Table 2). Most lesions were located on the eyelid (53 %), followed by lesions on the conjunctiva (19 %) and periorbital skin (17 %). Ninety percent of participants presented with only one lesion.

The quality of dermoscopic images were assessed by one oculoplastic surgeon and two dermatologists (see examples, Fig. 2A–D). Unsatisfactory pictures, mainly out of focus, occurred early in the study and became a lesser factor with experience on the part of the technical staff. It takes approximately 30 s to inspect and capture multiple images of a lesion. Only a portion of that time involves holding the dermoscope in place. Once appropriate images of the lesions are acquired, clinical evaluation of those images without the patient having to be present can take as much time as the physician needs. Typically, an experienced clinician can make an evaluation of the lesion in only a few minutes (from less than 1 to perhaps 3 min). There were no adverse safety events and no patient complained of discomfort or pain. Even with use of the small 4 × 4mm contact plate, we found it difficult to obtain proper focusing of the medial canthus area for contact dermoscopy because the contact plate has a broadly conical shape with a flat surface and is unable to fit correctly into the medial canthus; in those cases, however, we usually acquired a valuable non-contact dermoscopic image.

3. Discussion

Just as dermoscopy has enhanced clinical examination of skin lesions for dermatologists, it could improve diagnosis by ophthalmologists by identifying lesion features unseen by direct visualization. The use of dermoscopy in this setting is extremely advantageous. Periorbital dermoscopy adds diagnostic information to the current slit lamp exam with the addition of polarizing light, contact, and the comparison between polarizing and non-polarizing light. These elicit features in the dermis that would not otherwise be apparent with slit lamp exam alone. Making specific diagnoses (e.g., differentiating between benign and cancerous lesions) during the initial evaluation may save patients from having unnecessary biopsies or physician visits. In an evaluation of over 45,000 teledermatology cases, dermoscopy aided dermatologists in making a definitive benign diagnosis that approximately 70 % of anticipated in-person consultations were avoided (Tejasvi, T. Teledermatology at the Ann Arbor US Veterans Affairs Health System. Unpublished results).

In the cases where a specific diagnosis can be made via dermoscopy alone, the dermoscope may substitute as a non-invasive approach for a biopsy that might otherwise be taken, which may free up ophthalmologists and oculoplastic surgeons by reducing unnecessary biopsies. Our results show that medical support staff can be trained to acquire high-quality images via dermoscopy. They can capture images in satellite or distant locations that are uploaded to the electronic medical record or otherwise transmitted for later review by the physician. If used in such a store-and-forward telemedicine format, dermoscopy can serve to overcome barriers to care by improving access to ophthalmology, often reducing patient travel time and expense. For example, over 60 % of the 3142 counties in the United States do not have an ophthalmologist, let alone an oculoplastic surgeon [10], resulting in a troublesome lack of access to care for many individuals with lesions on the eye or surrounding tissues. Similar situations occur in Canada where ophthalmologists are concentrated in highly populated areas [11,12]. A pilot project allowing optometrists in Canada to e-consult ophthalmologists on glaucoma issues was later expanded to address other ophthalmologic issues including surgical inquiries; overall, 28 percent of planned in-person referrals were eliminated and, even considering the later introduction, 9 percent of all e-consults went to oculoplastic surgeons [12]. Thus, the use of dermoscopy in telemedicine could efficiently characterize and triage conjunctival or periorbital lesions in geographic areas where patients cannot easily access an ophthalmologist or oculoplastic surgeon. The use of dermoscopes by optometrists or their trained staff would therefore be extremely valuable in increasing diagnostic access for patients needing eye lesion triage and assessment.

The utility of optometrists as a support for specialty ophthalmic services has proved to be both feasible and effective in serving patients who otherwise would not have access to such specialty information and advice [12]. An additional approach could involve training a few technicians in hospitals or health centres in small communities to obtain ophthalmic dermoscopy at the request of

Table 1
Characteristics of 115 participants.

Baseline Characteristics	Patients (n = 115)
Age, years	
Mean (SD)	64.4 (15.4)
Median	66
Min, max	16, 92
Sex, n (%)	
Female	71 (61.7)
Male	44 (38.2)
Lesion count per patient, n [%]	
1 lesion	103 (89.6)
2 lesions	10 (8.7)
3 lesions	2 (1.7)

Table 2
Facial location of 129 lesions.

Lesions	Total (n = 129)
Lesion Type n, (%)	
Conjunctival	24 (18.6)
Iris	2 (1.6)
Lid	68 (52.7)
Medial Canthus	10 (7.8)
Lateral Canthus	3 (2.3)
Periorbital Skin	22 (17.1)

primary-care physicians. Regardless, the photographs can be transmitted to the appropriate specialist, whether that is an ophthalmologist, oculoplastic surgeon, or dermatologist. By way of example, a description of such a service and the potential compensation for the consultant as well as the requestor is available for Ontario (see https://econsultontario.ca). In turn, by replacing more invasive approaches, this intervention also reduces costs and morbidity associated with an invasive biopsy approach. Using dermoscopy to reduce unnecessary biopsies could lead to reduced patient morbidity, both from the medical and cosmetic aspects of the biopsy itself, as well as any travel or ancillary cost associated with making the trip to see an oculoplastic specialist (who are often not readily available). From a medical system perspective, using dermoscopy in this way may reduce costs associated with the biopsy and resulting pathology and therefore alleviate the financial burden of unnecessary procedures.

Another advantage of the dermoscope is the portability. There are indeed handheld slit lamps, however, the dermoscope is much more compact, portable, able to be used with only one hand, and easily attachable to any standard 35 mm camera, most mobile phones, or an iPad for quick access to imaging capabilities. The handheld slit lamps do not have camera attachment capabilities. In this way, the dermoscope combines the advantages of the non-portable slit lamp with camera with the portability of the hand-held slit lamp, in a smaller and easier to use device that also provides diagnostic clues via dermoscopy.

Limitations of our study include the difficulty in obtaining high-quality photos from the medial canthus. Furthermore, we did not enroll children under 18 years of age or patients with ocular inflammation, wounds and/or photophobia into our study and therefore we are unable to comment on dermoscopy use in these populations. However, there is no reason to believe that dermoscopy could not be conducted on patients with ocular inflammation, wounds, and some children. Patients with ocular inflammation may have difficulty with photophobia, but we suspect that patients may be able to tolerate dermoscopy light better than the light from a slit lamp examination because it takes a shorter amount of time to capture a photograph via dermoscope than it does to fully examine a periorbital lesion under the slit lamp.

Topical anesthesia might be necessary; however dermoscopy can still be performed on patients with wounds, as is done in dermatology. (Appropriate cleaning of the dermoscope contact plate would be required, or it would be preferable to use disposable contact plates if they become available.)

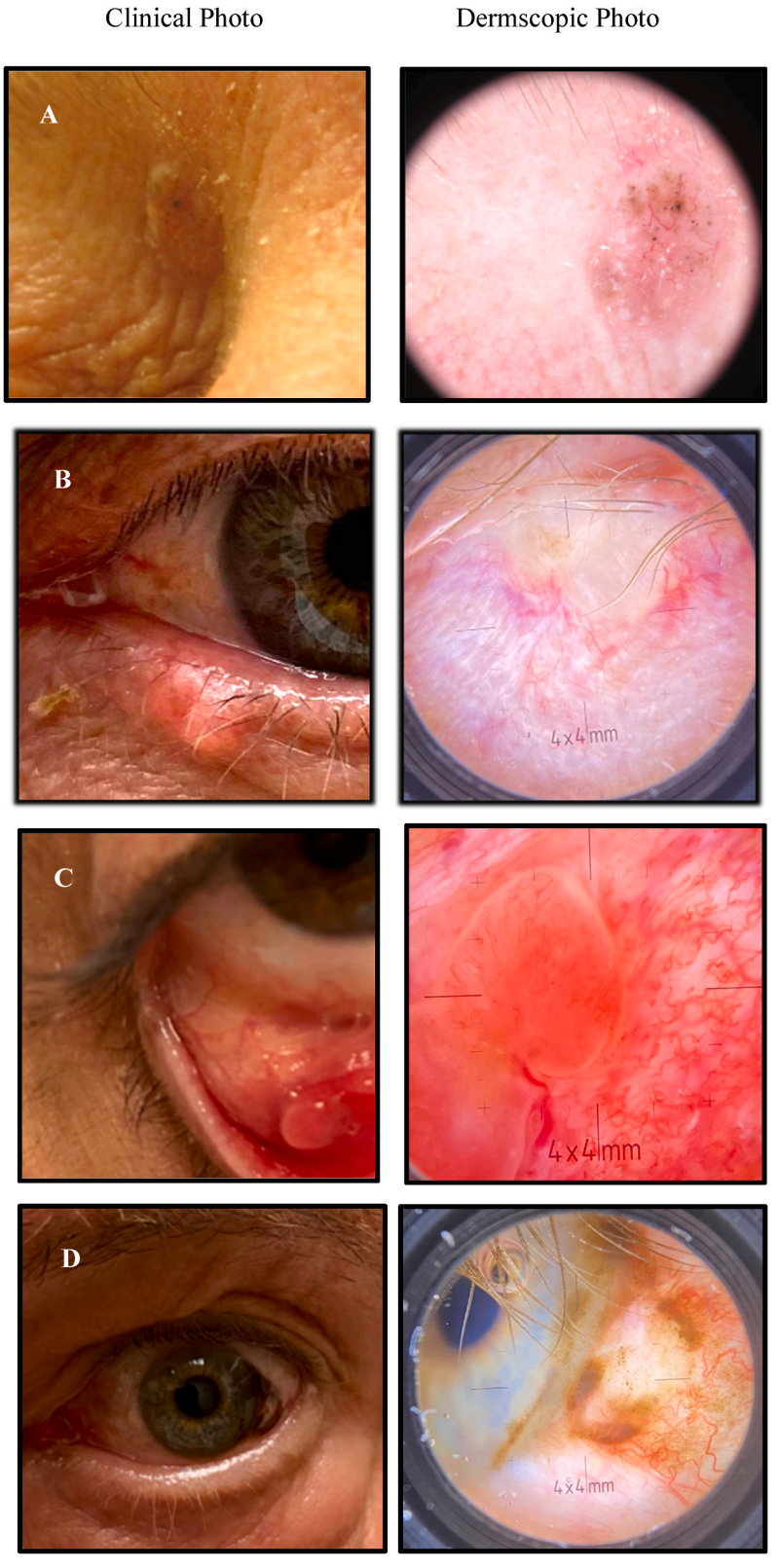
Although we did not enroll any children under 18 years of age, we foresee no increased risks in cooperative patients of any age. Young children, those who are developmentally delayed, or any other patient who is unable to comply will have difficulty with contact periorbital dermoscopy, just as they have trouble with the slit lamp biomicroscope. In these cases, standard of care for these types of patients who need eye examination is to perform eye exams under general anesthesia or sedation, and such exams could include dermoscopy. *Non-contact* dermoscopy should have similar challenges as portable slit lamp examination for children or any other vulnerable patient population.

An additional limitation of our study is the subjective nature of the technicians and medical assistant's individual assessments of their own proficiency. There were significant improvements in their confidence level using a dermoscope to obtain quality photographs of periorbital lesions, but the subjective nature of their own assessment does not indicate improvement in quality of the images themselves. The images that were captured in this study were reviewed by three independent physicians: one oculoplastic surgeon and two dermatologists and determined to improve over time. However, we do not have quantitative data from these physicians that "grades" the images, which remains a limitation of this study.

Lastly, the only superior conjunctival fornix lesion in our study was prolapsed enough to be examined and photographed with just a simple adjustment of the lid. Otherwise, there were no hidden superior fornix conjunctival lesions in our study. However, if the provider is able to evert the eyelid to expose the lesion (as would be done during the slit lamp examination of this type of lesion), we believe that any technician, optometrist or ophthalmologist should be able to obtain a high-quality dermoscopic image of a superior fornix conjunctival lesion.

4. Conclusions

We have developed a safe and convenient method for dermoscopy around and on the eye. We prepared teaching materials so that non-physicians could obtain dermoscopic pictures for teleophthalmology, which makes the model highly desirable for areas underserved for ophthalmology. Future work could include designing dermoscopes that are better suited for examination of the medial canthus and evaluating dermoscopy in the circumstances mentioned above and in other ophthalmologic situations.



(caption on next page)

Fig. 2. Clinical photographs shown in the left column with corresponding dermoscopic photographs to the right of each image. In row A, a lesion inferomedial to right orbital rim with indiscernible features. Corresponding non-contact polarizing dermoscopic photograph demonstrates in-focus branched vessels with white clods and dark brown to gray clods; this is diagnostic of basal cell carcinoma, which was confirmed by pathology. In row B, a partially biopsied lesion on the left lower lid margin with telangiectasias. Corresponding contact polarizing dermoscopic photograph demonstrates sharp, highly defined branched vessels and shiny white blotches and strands, diagnostic of basal cell carcinoma, which was confirmed on biopsy. Clinical photo in row C depicts a palpebral conjunctival lesion; polarized contact dermoscopy shows a circumscribed lesion with a reddish-orange background, with multiple fine looped and branched vessels, suggesting a benign vascular lesion. Biopsy of the lesion confirmed a benign vascular lesion (pyogenic granuloma). Row D depicts a pigmented conjunctival lesion that had undergone a biopsy. Dermoscopy demonstrates a dark-brown pigmented lesion with irregular and structureless brown pigment patterns around the biopsy site. Additionally, there are multiple brown clods and irregular, non-branching vessels. These are dermoscopic features concerning for malignant melanoma. Pathologic diagnosis of the portion taken for biopsy was primary acquired melanocytosis with severe atypia concerning for progression to malignant melanoma. In rows B, C and D, a small faceplate with a 4 × 4 mm scale inscription was used for contact dermoscopy images.

Data availability

The raw data from this study is not currently deposited in a public repository, but will be made available upon request.

CRediT authorship contribution statement

Kevin J. Schneider: Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kathryn G. Flaharty:** Writing – review & editing, Writing – original draft, Visualization, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Charles N. Ellis:** Writing – review & editing, Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Obaidah M. Bitar:** Writing – review & editing, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Hanna Barinova:** Writing – review & editing, Project administration, Methodology, Investigation, Data curation, Conceptualization. **Trilokraj Tejasvi:** Writing – review & editing, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Christine C. Nelson:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.heliyon.2024.e30293.

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