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Parent-provided photographs as an outcome measure for childhood chalazia

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Abstract

Purpose—To determine whether smartphone photographs of children's eyelids are reliable for diagnosing the presence of chalazia.

Methods—In this prospective cross-sectional study, 60 participants, 7 months to 16.5 years of age, at four sites were enrolled; all participants had a chalazion measuring at least 2 mm on at least one eyelid based on an in-person clinical examination by a pediatric eye care professional. Smartphone photographs taken by the parent during the office visit were uploaded to the study website. A masked reader assessed each photograph for the presence or absence of chalazia; results were compared with the gold standard clinical examination results. Sensitivity and specificity for the presence of chalazion by eyelid were calculated.

Results—Photographs were available for 240 eyelids; 85 had at least one chalazion and 155 were without a chalazion based on clinical examination. The masked reader correctly classified 68 of 85

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Disclosures: Dr. Arnold is President of Glacier Medical Software, which makes cloud-based ROP Check software; he is also President of PDI Check, which makes a vision screening game for autostereoscopic Nintendo 3DS. Dr. Arnold coordinates the Alaska Blind Child Discovery, which has received discounted vision screening technology from several vendors.

*See eSupplement 1, available at jaapos.org.

eyelids with at least one chalazion and 151 of 155 eyelids without chalazia for a sensitivity of 80% (95% CI, 72%–86%) and a specificity of 97% (95% CI, 94%–99%). Sensitivity improved to 89% for chalazia 5 mm or larger and 94% when superficially located within the eyelid.

Conclusions—Parental smartphone photographs appear to be useful in assessing chalazia in children as an alternative to in-office follow-up examinations. These photographs may be a valuable outcome measure in future clinical trials of chalazia treatment, especially when assessing larger lesions.

Chalazia are chronic, localized swellings or cysts of lipogranulomatous inflammation in the eyelid caused by meibomian gland obstruction. These common acquired, inflammatory eyelid lesions[1] have been reported to represent 3.6% of childhood eye disorders presenting to an ophthalmology referral center.[2] Although a chalazion is not an infection, the eyelid can become significantly inflamed and swollen, or secondarily infected, causing preseptal cellulitis in some cases.[3] Multiple lesions and recurrences are common. If upper eyelid chalazia are sufficiently large, they can induce astigmatism by pressing on the cornea[4,5] or even cause amblyopia if the visual axis is obscured in early childhood.[6]

Management of chalazia often requires multiple visits, which can be costly and burdensome to the family. Visual inspection is the primary means for monitoring a chalazion's response to treatment. Given that the majority of the Western world has Internet access, and at least 81% of Americans have a smartphone,[7] mobile devices are promising for telemedicine purposes. If review of smartphone photographs by an eye care professional has acceptable sensitivity and specificity for chalazia detection, mobile technology could be used for follow-up visits in clinical practice and also in clinical trials of treatments for chalazia.

To our knowledge, the accuracy of using photographs to assess the presence or absence of childhood chalazia has not been evaluated. The objective of this study was to determine the sensitivity and specificity of detecting chalazia by evaluating smartphone photographs of children's eyelids taken by their parents compared with the gold standard in-person clinical examination.

Methods

This study was conducted in accordance with the tenets of the Declaration of Helsinki by the Pediatric Eye Disease Investigator Group (PEDIG) at one academic and three private practice clinical sites. The protocol and US Health Insurance Portability and Accountability Act–compliant informed consent and assent forms were approved by institutional review boards, and written consent and assent were obtained from a parent or guardian (hereafter referred to as "parent") of each participant and from the participant (if applicable). The protocol is available on the PEDIG website (www.pedig.net).

Children eligible for this prospective study were 6 months to 17 years of age, diagnosed with at least one new or recurrent chalazion measuring 2 mm in diameter or larger during a standard-of-care office visit with a parent present with a smartphone.

Four eye care professionals (three pediatric ophthalmologists and one pediatric optometrist) performed in-person clinical examinations. By inspection and palpation, they determined the number of chalazia and identified the largest per eyelid (referred to as “worst” chalazion [eSupplement 2, available at jaapos.org]). The largest chalazion was characterized by eyelid affected, depth (superficial or deep), size in mm, proximity to lid margin (involves, approaches, remote), and appearance (ie, color, amount of swelling [none, mild, moderate, severe], visible head). Presence of blepharitis, plugged meibomian glands, or inflamed eyelid margins were noted. The in-person clinical examination served as the gold standard assessment.

While at the doctor’s office, parents followed written instructions (eSupplement 3, available at jaapos.org) for taking direct (not selfie) digital photographs and uploading them to the study’s secure website. Parents took three required photographs showing both eyes simultaneously with: (1) eyelids closed, (2) eyelids open and looking straight ahead, and (3) eyelids open and looking up. A fourth photograph was requested with eyes open and both lower eyelids pulled down exposing the palpebral conjunctiva. Examples of these four requested photographs (eSupplement 4, available at jaapos.org) were provided on the instruction sheet and served as the frame of reference (ie, facial orientation and image size) for the photographs. Room lighting, camera flash and focus, smartphone model, and test distance were not specified. The written instructions noted that “additional optional photographs” could be taken if parents felt it helpful; these were also uploaded.

The eye care professional reviewed the four requested photographs for clarity and correct frame of reference, not to determine chalazion visibility. If the clarity or frame of reference was deemed unacceptable, the parent was asked to retake the photograph. The parent then uploaded the final photographs. The proportion of participants for whom the four requested photographs were successfully uploaded and for whom the masked reader was able to grade all four eyelids for the presence of chalazia was determined.

A masked pediatric ophthalmologist remotely and independently reviewed the uploaded photographs on a high-resolution MacBook Pro 13-inch screen (Apple, Cupertino CA). The four requested photographs were initially reviewed for photographic clarity using a scale of excellent, good, or poor. Photographs with good or excellent clarity were deemed sufficient and those with poor clarity as insufficient.

The masked reader then reviewed the eyelids in the four photographs for chalazia. When identified, the number of chalazia per eyelid was documented and only the largest chalazion on each eyelid was characterized using the same criteria used for the in-office assessment (eSupplement 2). For estimation of chalazion size, the scale of the photograph was normalized using the horizontal corneal white-to-white measurement, assuming a median normal white-to-white corneal diameter of 11.60 mm.[8] Characteristics that could not be determined from the requested photographs were identified as “not able.” After the initially requested photographs were evaluated, any additional optional photographs were reviewed. Post hoc, the masked reader assessed whether the initially requested photographs complied with the described frame of reference provided to the parents (eSupplement 4).

Statistical Methods

The planned convenience sample size was 60 participants. In cases of multiple chalazia present on a single eyelid, only the largest chalazion was characterized and used for analyses; thus, chalazia descriptions only pertain to the largest chalazion on a particular eyelid.

The masked reader's assessments of the parent-provided photographs were compared with the gold standard clinical examination assessments. Sensitivity was calculated by dividing the number of eyelids in which the masked reader correctly determined a chalazion present (numerator) by the total number of eyelids with a clinical diagnosis of a chalazion (denominator). Specificity was defined as the proportion of eyelids in which the masked reader correctly determined a chalazion was absent out of the total number of eyelids with a clinical diagnosis of no chalazion. All sensitivity and specificity measures were calculated separately for masked reader assessments based on (1) the four initially requested photographs alone and (2) all gradable photographs, including any additional optional photograph(s). The associated 95% confidence intervals were calculated for the sensitivity and specificity estimates using logistic regression with generalized estimating equations (GEE).

In an exploratory analysis, sensitivity and specificity were calculated in subgroups determined by child's age (<5 years / ≥5 years), masked reader's assessment of photographic clarity (all four requested photographs graded as sufficient clarity / one or more graded as insufficient clarity), photographs taken with requested frame of reference (yes/no), and eyelid affected (upper/lower). In addition, sensitivity was calculated in subgroups determined by chalazion size (<5 mm / ≥5 mm), depth (superficial/deep), vertical position (involving, approaching, or remote to the eyelid margin), and horizontal position (nasal, central, or temporal). The sensitivity and specificity and associated 95% confidence intervals in subgroups were calculated by including each factor separately in the logistic regression model with GEE.

For eyelids where both the clinical assessment and the masked reader agreed on the identification of a single chalazion, further agreement identifying the chalazion's depth (deep or superficial), vertical position (involving, approaching, or remote from eyelid margin), and horizontal position (nasal, central, or temporal) between the clinical examination and remote photographic assessment were evaluated using Cohen's kappa coefficient.

The assessments of different eyelids from the same child were assumed to be independent from each other for calculation of agreement (sensitivity, specificity, and Cohen's kappa coefficient). All analyses were conducted using SAS version 9.4 (SAS Institute Inc, Cary, NC).

Results

Table 1 summarizes baseline characteristics for the 60 participants. The average age was 6.0 years (range, 7 months to 16.5 years); 37 (62%) were female. Based on clinical

examinations of the 60 participants (240 eyelids), 85 (35%) had at least one chalazion: 39 (65%) on 1 eyelid, 17 (28%) on 2 eyelids, 4 (7%) on 3 eyelids; none had chalazia on all 4 eyelids. Of the 85 chalazia, clinical examiners characterized 49 (58%) as deep, 43 (51%) centrally positioned in the eyelid, and 51 (60%) approaching the eyelid margin. Additional features are summarized in Table 2.

Fifty-eight (97%) of the 60 parents acquired all four requested photographs. Two parents were unable to photograph their child's lower eyelids pulled down; thus, 238 of the requested 240 photographs were uploaded. Of these 238, the treating eye care professional deemed clarity and frame of reference as adequate on the initial attempt for 192 (81%); 46 (19%) required one or more retakes prior to uploading. The masked examiner only reviewed the uploaded photographs. Of the 238 submitted, the masked examiner determined that 82% (194) were of sufficient (excellent or good) clarity (eSupplement 5, available at jaapos.org). Post hoc, the masked examiner determined that 31 (52%) participants were photographed within the correct frame of reference (eSupplement 4). Twenty-four of the 60 (40%) parents submitted additional optional photograph(s).

Sensitivity and Specificity for Presence or Absence of Chalazi

The masked reader assessed each participant's eyelid in the requested photographs regardless of clarity or frame of reference. Using these photographs, the masked reader correctly classified 68 of the 85 eyelids that had at least one chalazion based on clinical diagnosis, resulting in a sensitivity of 80% (95% CI, 72%–86%). Sensitivity increased to 84% (71 of 85 eyelids correctly classified; 95% CI, 74%–90%) when the additional optional photographs were included in the assessment. The masked reader correctly classified 151 of the 155 eyelids without a chalazion, resulting in a specificity of 97% (95% CI, 94%–99%). Specificity was unchanged at 97% (150 of 155 eyelids correctly classified; 95% CI, 93%–99%) when the additional optional photographs were included.

Sensitivity and specificity for chalazion characteristics were calculated in exploratory analyses (eSupplement 6, available at jaapos.org). Chalazia 5 mm or larger in size were correctly identified in 49 of 55 eyelids, resulting in a sensitivity of 89% (95% CI, 79%–95%). In contrast, only 19 of 30 chalazia <5 mm in size were identified by the masked reader, resulting in a sensitivity of 63% (95% CI, 46%–78%), for a difference of 26% (95% CI, 8%–44%). The masked reader correctly identified 34 of the 36 eyelids with a chalazion that was superficially located in the eyelid, resulting in a sensitivity of 94% (95% CI, 80%–99%), whereas the sensitivity for chalazia located deep in the eyelid (34 of 49) was only 69% (95% CI, 58%–79%) for a sensitivity difference of 25% (95% CI, 12%–38%). The masked reader demonstrated better sensitivity in correctly identifying chalazia that approached (84%; 95% CI, 73%–91%) or involved (89%; 95% CI, 66%–97%) the eyelid margin versus those remote from the eyelid margin (56%; 95% CI, 34%–76%), with a difference in sensitivity of 28% (95% CI, 4% to 52%) and 33% (95% CI, 6% to 59%), respectively. Both sensitivity and specificity were similar between subgroups based on age, eyelid affected, photograph clarity, and frame of reference (eSupplement 6).

Additional Measures of Agreement

Sixty-three eyelids were determined to have one chalazion by both the clinical and masked reader's assessment. Amongst these eyelids, the masked reader's assessment agreed with the clinical assessment with respect to depth, horizontal position, and vertical position for 54 (86%), 50 (79%), and 38 (60%) of these 63 eyelids, respectively, with kappa coefficients (95% CI) of 0.72 (0.55–0.88), 0.65 (0.49–0.82), and 0.19 (−0.03 to 0.42), respectively. The masked reader's assessment of chalazion width was on average 0.9 ± 3.0 mm (standard deviation) smaller than the width determined on clinical examination for 61 of these 63 eyelids (masked reader was unable to assess chalazion width for 2 eyelids).

Discussion

Using parent-submitted smartphone photographs of children's eyelids, a pediatric eye care professional correctly identified the presence of chalazia in 80% of cases, and in 84% of cases when additional optional photographs were included. Specificity was 97% whether additional optional photographs were included or not. To the best of our knowledge, this is the first study to evaluate pediatric chalazia by a remote assessment of parent-provided digital photographs.

Several clinical characteristics were evaluated in exploratory analyses to determine their impact on the masked reader's ability to identify chalazia in photographs. Chalazia larger in size, shallower in depth, and approaching or involving the eyelid margin improved the concordance between the in-person diagnosis and parent-taken photographic evaluation.

Studies evaluating the use of remote photographic images for pediatric medical diagnoses have been conducted. For example, a pediatric dermatology trial compared parent-submitted photographs of the child's skin condition with in-person diagnosis by a dermatologist. The researchers reported a sensitivity of 83% for the accurate diagnosis of pediatric skin conditions, and concluded parental photographs were of sufficient quality to assess pediatric skin conditions in most cases.[9] In our study, parental photographs were analyzed only for the presence or absence of chalazia, not to distinguish chalazia from other eyelid lesions.

Most ophthalmic professionals have not yet embraced remote evaluation of patient-obtained photographs of the eye or eyelid,[10] but tele-ophthalmic care for conditions like chalazia could have benefits, including improved access to care in underserved areas and reduced patient wait times for clinical visits. Clinical application of smartphone photographs may become more widely used as demand for tele-ophthalmic care increases.[11] The present study demonstrated that smartphone photographs alone were sufficient to identify the presence of chalazia in 84% of cases, lending itself readily as a tool for future clinical studies and potentially decreasing the burden of follow-up visits in clinical practice. Including the child's clinical history (which was withheld from the masked reader) would likely increase the sensitivity found from photographic evaluation alone.

To our knowledge, the current study provides the largest prospectively collected data characterizing clinical features of pediatric chalazia. Nearly two-thirds of the children presented with a single lesion; one-third, with two or more. Chalazia were mostly located in

the central upper eyelid and approached or involved the eyelid margin. Swelling or injection were seen much less commonly. One-third showed lid margin inflammation, blepharitis, or meibomian gland plugging. In a recent retrospective study of 11,270 patients with chalazia, 79% of chalazia were unilateral, 39% in the upper eyelid, and 6% lateral in position at presentation.[12] However, only 24% of this cohort were children, data specific to the pediatric participants were not provided, and many clinical descriptors were not available for comparison with our prospective study.

Our study is not without limitations. The sample size of 60 children was modest and our participants' chalazia may not represent all pediatric chalazia. Small and chronic chalazia may be underrepresented because parents may not have sought medical care. We did not assess skin pigmentation or eyelid anatomy, which could affect photo interpretation. We also did not track the smartphone models used and thus there was likely variability in camera quality. No clinical history was shared with the masked examiner, which would be expected to improve chalazion identification.

Although parents were provided written instructions, the masked examiner found that clarity and correct frame of reference of the photographs were achieved in only 82% and 52%, respectively. It is possible that parents may not have been diligent in following the study-provided instructions knowing the clinical examination had been completed and photographic quality would not affect their child's treatment. Parents taking photographs at home for a tele-ophthalmic visit might be more careful when their child's care depends solely on submitted photographs. Although less than half the parents submitted additional photographs, sensitivity increased from 80% to 84% when these photographs were included; thus, having additional photographs for all participants may have improved sensitivity. Finally, the present study only evaluated children with a diagnosed chalazion. Clinically, a complete differential diagnosis is considered when a child presents with any type of lid swelling. The present study did not assess the ability of the examiner to distinguish chalazia from other eyelid lesions.

In conclusion, smartphone photographs of children's eyelids taken by their parents can be used by eye care professionals to identify the presence of clinically diagnosed chalazia with a sensitivity of at least 80% and a specificity of 97%. Thus, parent-submitted photographs could be useful when monitoring pediatric chalazia for resolution in clinical practice and in future clinical trials evaluating treatments for chalazia.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Table 1.

Baseline characteristics of participants and eyelids

Total number of participants	**N = 60**
Sex, no. (%)	
Female	37 (62)
Male	23 (38)
Age, years, no. (%)	
<5	30 (50)
5 to <10	19 (32)
10 to <15	7 (12)
15 to <18	4 (7)
Mean ± SD	6.0 ± 4.2
Race and ethnicity, no. (%)	
White (Not Hispanic or Latino)	35 (58)
Hispanic or Latino	10 (17)
Black/African American	6 (10)
American Indian/Alaskan Native	1 (2)
Asian	1 (2)
Native Hawaiian / other Pacific Islander	1 (2)
More than one race	3 (5)
Unknown/not reported	3 (5)
Number eyelids with chalazia, no. (%) [N = 240]	
1	39 (65)
2	17 (28)
3	4 (7)
4	0 (0)
Number of chalazia in one eyelid, no. (%)	
0	155 (65)
1	78 (32)
2	7 (3)
Width of largest chalazion on the eyelid, no. (%)	
N/A (no chalazia present)	155 (65)
<5 mm	30 (13)
5 to <10 mm	37 (15)
10 to <15 mm	15 (6)
15 to <20 mm	3 (1)
Mean ± SD	6.4 ± 3.5

SD, standard deviation.

Table 2.

Characteristics of the chalazia identified by clinical examination[a]

Total number of eyelids with chalazia	85 (100)
Depth	
Superficial	36 (42)
Deep	49 (58)
Vertical position	
Involving eyelid margin	18 (21)
Approaching eyelid margin	51 (60)
Remote from eyelid margin	16 (19)
Horizontal position	
Nasal	18 (21)
Central	43 (51)
Temporal	24 (28)
Affected eyelid	
Lower	33 (39)
Upper	52 (61)
Presence of erythema	
None	34 (40)
Mild/moderate	44 (52)
Severe	7 (8)
Presence of eyelid swelling	
None	26 (31)
Mild/moderate	57 (67)
Severe (full eyelid)	2 (2)
Presence of pyogenic granuloma	
Yes	7 (8)
No	78 (92)
Bulbar conjunctival injection	
Yes	10 (12)
No	75 (88)
Meibomian gland plugging	
Yes	27 (32)
No	58 (68)
Inflamed eyelid margins	
Yes	26 (31)
No	59 (69)
Blepharitis present	
Yes	21 (25)
No	64 (75)

[a]Characteristics are for largest chalazion when more than one chalazion present on a single eyelid.