






2021 international consensus statement on optical coherence tomography for basal cell carcinoma: image characteristics, terminology and educational needs

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Abstract

Background Despite the widespread use of optical coherence tomography (OCT) for imaging of keratinocyte carcinoma, we lack an expert consensus on the characteristic OCT features of basal cell carcinoma (BCC), an internationally vetted set of OCT terms to describe various BCC subtypes, and an educational needs assessment.

Objectives To identify relevant BCC features in OCT images, propose terminology based on inputs from an expert panel and identify content for a BCC-specific curriculum for OCT trainees.

Methods Over three rounds, we conducted a Delphi consensus study on BCC features and terminology between March and September 2020. In the first round, experts were asked to propose BCC subtypes discriminable by OCT, provide OCT image features for each proposed BCC subtypes and suggest content for a BCC-specific OCT training curriculum. If agreement on a BCC-OCT feature exceeded 67%, the feature was accepted and included in a final review. In the second round, experts had to re-evaluate features with less than 67% agreement and rank the ten most relevant BCC OCT image features for superficial BCC, nodular BCC and infiltrative and morpheiform BCC subtypes. In the final round, experts received the OCT-BCC consensus list for a final review, comments and confirmation.

Results The Delphi included six key opinion leaders and 22 experts. Consensus was found on terminology for three OCT BCC image features: (i) hyporeflexive areas, (ii) hyperreflexive areas and (iii) ovoid structures. Further, the participants ranked the ten most relevant image features for nodular, superficial, infiltrative and morpheiform BCC. The target group and the key components for a curriculum for OCT imaging of BCC have been defined.

Conclusion We have established a set of OCT image features for BCC and preferred terminology. A comprehensive curriculum based on the expert suggestions will help implement OCT imaging of BCC in clinical and research settings.

Conflict of Interest

VL Johnsson received research grants from AMEE and the Danish Ministry of Higher Education and Science. J Welzel received honoraria for webinar and establishment of OCT training platform. CSK Fuchs, VK Ortner, MG Tolsgaard, M Haedersdal, M Mogensen, P Guitera, LJ Nayahangan, G Pellacani, A Rossi and K Mosterd have nothing to disclose.

[†] OCT-BCC expert panel (collaborative co-authors) shown in Acknowledgement section.

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Introduction

Keratinocyte carcinoma is the most common type of cancer worldwide. Basal cell carcinomas (BCC) account for up to 80% of all KC lesions.¹ BCCs are most commonly found on sun-exposed skin such as the face and neck. Since the most significant aetiological factor appears to be ultraviolet radiation, many patients develop multiple lesions reflecting a generalized actinic degeneration of the skin. Other risk factors include genetic predisposition, increasing age, male sex, fair skin type and immunosuppression. As BCCs grow slowly and metastasize rarely, their mortality rate is <0.1%.² However, the public health burden of BCC is considerable due to the high morbidity caused by cosmetic and functional impairment.³

Optical coherence tomography (OCT) is a non-invasive imaging technology widely applied in investigating inflammatory and neoplastic skin lesions to explore the cutaneous micromorphology in vivo; it enables real-time, high-resolution, cross-sectional imaging by measuring light scattering in tissue.^{4,5} Conventional OCT is an interferometry-based imaging method, providing real-time images to a depth of 1500 μm with a resolution of <3–7.5 μm . Moreover, the quantitation of speckle variance permits an angio-tomographic view of the cutaneous microvasculature, commonly referred to as dynamic OCT.⁶

The diagnostic sensitivity and specificity of OCT for BCC are 95% (91–97%) and 77% (69–83%), respectively, with lobular pattern and hyperreflective peritumoral stroma reported to be the most prevalent morphological features.⁴ Several morphological OCT characteristics of BCC have been identified and evaluated for the characterization of BCC subtypes.⁷

While there is a maturing body of literature reflecting the clinical interest in OCT characteristics of BCCs, recommendations for OCT-based BCC diagnosis and subtyping, such as the German national guidelines for BCC, have yet to be developed on an international level.^{7–21} The Delphi method is a commonly used technique to generate expert opinion-based evidence and build consensus concerning topics that lack, or are not suitable for, empirical or experimental research.²² It uses iterative rounds of surveys followed by a final review phase to collect feedback on the preliminary consensus. The Delphi process has many advantages including participant anonymity, which reduces potential bias of dominant individuals, and the entirely virtual set-up permitting the inclusion of a large number of participants without geographic restrictions.²³ As both empirical evidence on OCT-BCC characteristics and terminology and international guidelines on the use of OCT for BCC imaging are lacking, this study aimed to

establish an expert consensus on key OCT image features characterizing BCCs, the appropriate terminology for each image feature and finally the necessary content for a curriculum OCT imaging of BCC. By establishing a terminology for OCT-BCC imaging, this study can provide a platform for future investigations on the clinical relevance for each feature.

Materials and Methods

Study design

Between March 2020 and September 2020, an iterative three-round Delphi process was carried out to establish international consensus on (i) the key image features of basal cell carcinoma in OCT images, (ii) the terminology for the OCT BCC image features and (iii) to identify content that should be included in a curriculum for new OCT BCC trainees. All information was collected through online iterative survey questionnaires. The principle of two-third qualified majority was employed as consensus agreement in the first two rounds, eliminating BCC features that failed to reach 67% consensus.^{22,24–26} The surveys were distributed via SurveyMonkey (San Mateo, CA, USA). All data were anonymized. The Danish legislation exempts this type of study from ethical approval.

Delphi steering group

The steering group consisted of medical doctors with experience in OCT scanning in dermatology (CSKF and VKO), a professor in dermatology (MH) and two medical education scientists (LJN and MGT). The group managed all aspects of the study, including identification of participants, creation of survey questionnaires, piloting and analysis of the data.

Study population

The steering group invited a group of key opinion leaders (KOLs) to help reaching out to a broad and representative number of OCT experts. The identification of KOLs was based on the following criteria: board certified dermatologists with attachment to an academic institution, a minimum of five years of experience in imaging of BCC using OCT and published research on OCT of BCC (see Table 1 for demographic information). We approached seven possible KOLs, six of which replied and were included in the study. The KOLs were tasked to (1) participate in the Delphi rounds and (2) invite at least two participants with a minimum of two years of experience in OCT imaging of BCC. KOLs and invited participants will be referred to as 'experts' in the following.

Table 1 Delphi participants demographic characteristics

Demographics	Number, %
Gender, %	
Female	18 (64)%
Age group, %	
20-29	3 (11)%
30-39	14 (50)%
40-49	6 (21)%
50-59	4 (14)%
60-69	1 (4)%
Country, %	
Australia	3 (11)%
Italy	8 (29)%
Denmark	3 (11)%
United States	5 (18)%
The Netherlands	4 (14)%
Germany	3 (11)%
Chile	1 (4)%
Brazil	1 (4)%
Experience in dermatology (years, %)	
2-4	7 (25)%
5-9	8 (29)%
10-15	6 (21)%
16-20	1 (4)%
More than 20	6 (21)%
Board-certified dermatologists	18 (64.3%)
Medical doctors	27 (93.1%)
Conventional OCT	31 (88.6%)
Commercially available OCT (Vivosight)	22 (78.6%)
Experience in teaching OCT	19 (67.9%)
Average students supervised per teaching expert	8.5 (SD 7.7)
Average number of students undergoing training/year	4.2 (SD 4.53)
Number of scans per department/week	12.3 (SD 9.8)
Number of scans per participant/week	5.6 (SD 7)

Data collection

Round 1 - Demographics and brainstorming During the first Delphi round, demographic information including local practices and experience in OCT of BCC was collected (see Table 1). Experts were then asked which BCC subtypes they consider distinguishable in OCT scans and to list all image features relevant for each proposed OCT BCC subtype.

After completing the first round, the results were objectively explored, and the image features listed by the experts were summarized by the steering group. After elimination of duplicates, OCT image features were collected into OCT BCC subtype groups and screened for synonymous terms that require additional review in round two.

Round 2- Elimination and prioritization In the second round, experts were asked to choose the terms they found the most

accurate for each specific image feature identified in round 1. Afterwards, experts were asked to list up to ten BCC subtype image characteristics and rank them in order of diagnostic importance, awarding the highest-ranked feature 10 points and the lowest 1 point. Total points for each feature were calculated and ranked. Experts were encouraged to comment on all questions to address and resolve potential conflicts.

Round 3 – final review In the third and final Delphi round, the experts were requested to conduct a final review of the results and add comments if necessary.

Development of an OCT BCC curriculum In Delphi round 1, experts were asked to identify training needs and suggest a suitable curriculum for trainees learning OCT of BCCs.

Data analysis

Descriptive and relative frequencies were used to describe the survey respondents and the results of the consensus. Data were recorded and organized in Microsoft® Excel® for Microsoft 365 MSO.

Results

Seven KOLs were invited to take part in the Delphi process, six of which responded and agreed to participate. The KOLs recruited a total of 22 experts. Demographic description of Delphi participants is shown in Table 1.

First Delphi round

The response rate was 100% in round 1 ($n = 28$ experts). In total, 17 BCC subtypes were suggested by the experts to be discriminable in OCT scans. The proposed BCC subtypes are listed in the supplementary Table S2. After an initial qualitative review by the steering group, consultation of the current literature and exclusion of subtypes not suggested by at least four experts, the included subtypes comprised *nodular BCC*, *superficial BCC* and less common variants (encompassing *infiltrative and morpheiform BCCs*).^{27–29} The number of proposed image features for each specific BCC subtype varied from 0 to 40. The terminology for seven image features (25 words in total) was synonyms. The seven image features and each of their synonyms were grouped and included in Round 2.

Second Delphi round

In round 2, 93% ($n = 26$) answered the survey. Experts evaluated the terminology of the seven image features that had not reached consensus in Round 1. Table 2 presents the proposed terminologies and consensus levels.

Ranking of image features for each OCT identifiable BCC subtypes was performed in round 2. The complete lists of the 10 most important image features according to the

Table 2 Proposed terminology for specific OCT image characteristics identified in Delphi round 2

	Number of experts	%
Which of the following terms do you find most accurate for describing a dark grey/black area in a scan?		
Hyporeflective area	19	73.1
Dark area	5	19.2
Hypoechoic area	2	7.7
Which of the following terms do you find most accurate when describing a white/light grey area?		
Hyperreflective area	19	73.1
Bright	7	26.9
Which of the following terms do you find most accurate for describing tumour nodules in a scan?		
Hyporeflective ovoid structure	20	76.9
Hyporeflective round area	4	15.4
Hyporeflective ovoid area	2	8.0
Which of the following terms do you find most accurate when describing a tumor nest in a scan?		
Hyporeflective nest	14	53.8
Ovoid nest	9	34.6
Tumour nest	3	11.5
Which of the following terms do you find most accurate when describing the epidermal layer bulging into dermis in a scan?		
Hyporeflective bulging into dermis	13	50
Chain-like protrusions with hyporeflective rim	8	30.8
Chain of multiple epidermal bulges	4	15.4
String of pearls	1	3.8
Which of the following terms do you find most accurate when describing tumour islands in an infiltrative BCC?		
Grape-like appearance	12	46.2
Shoal of fish	7	26.9
Shoal-like appearance	4	15.4
Star-like appearance	3	11.5
Which of the following terms do you find most accurate describing dark areas under tumour islands in a scan?		
Hyporeflective clefting	14	53.8
Hyporeflective rim	6	23.1
Hyporeflective borders	6	23.1

Delphi expert panel are presented in supplementary Tables S3–S5. The top three morphologic image characteristics for nodular, superficial and infiltrative BCC subtype are described below.

For *Nodular BCCs*, the top three OCT features were (1) hyporeflective ovoid structure in dermis, (2) hyporeflective clefting and (3) hyporeflective border. The three most important features for *superficial BCCs* were (1) hyporeflective nests or ovoid structures protruding from epidermis, (2) hyporeflective bulging into dermis and (3) epidermal bound nests. For the group of *infiltrative and morpheiform BCCs* the top three characteristics were the following: (1) grape-like appearance, (2) multiple nodules separated from epidermis and 3) smaller and more aggregated nests.

Final Delphi round

The response rate of round 3 was 86% ($n = 24$ experts). Experts were presented with the final list of BCC subtypes and ranked image features and were given the possibility to comment if they disagreed or had other inputs to the final lists. A complete list of all comments/objections to BCC features and terminology can be found in supplementary Table S6.

OCT training and curriculum

There was consensus among experts that dermatologists should be in charge of both acquiring (93%) and interpreting (100%) OCT images, and a detailed summary can be found in supplementary material, Table S7. Experts proposed that an average of >125 scans (minimum–maximum range 10–500 scans) is needed to perform OCT scans of BCCs independently. While 40% of respondents suggested up to 50 supervised scans to be sufficient, the majority considered a higher number (20%: 50–100 scans, 20%: 100–200 scans; 20%: >200 scans) to be needed to gain proficiency. Further, there were suggestions to reach a benchmark percentage for accuracy in diagnosis and to have a specific training period (weeks to months) and that dermatopathologists and Mohs surgeons might need less training. Components of a comprehensive OCT BCC curriculum were proposed by the experts, with 85% suggesting theoretical lectures encompassing general knowledge about OCT imaging and 33% hands-on practice for experiential learning. With regard to continuous self-study and (re-)certification in OCT scanning, 37% proposed the development of an OCT BCC examination. Detailed results are presented in supplementary material Table S8.

Discussion

Herein we report a Delphi consensus on a condensed set of OCT terms to describe BCC characteristics (Table S4, S5, S6). We reasoned that a more unified terminology would improve reporting standards, allowing for an even broader adoption of OCT for BCC by physicians. We believe that our proposed OCT-BCC consensus provides a robust academic scaffold to healthcare practitioners and associated professions for the training of staff, standardized reporting of findings and clinical implementation of OCT in dermatology.

The implementation of accurate and consistent OCT terminology in clinical dermatology is essentially twofold. First, communication on OCT lesion characteristics can be critical in clinical settings where patients receive medical care from different practitioners, e.g. for referral of complex lesions to specialized Mohs surgery centers. OCT imaging, therefore, requires concise and standardized reporting to convey all the pertinent details to the treating clinician. Second, the dissemination and adoption of reproducible terminology for reporting on descriptive OCT-BCC morphology could help streamline medical coding, improve the accuracy of insurance billing codes and expedite the reimbursement process of OCT examinations.³⁰

A reproducibly applied OCT terminology would benefit BCC research. In epidemiologic studies, consistent labelling of BCC features in OCT scans would facilitate the pooling of data from multiple sources. This advantage is particularly relevant in OCT research given the currently limited number of experts skilled in identifying and subtyping BCC lesions using OCT and will contribute to ongoing efforts of introducing AI algorithms.^{31,32} These aggregated metadata sets can provide helpful tools for the diagnostic and prognostic decision-making process and eventually evolve into bed-side treatment triage systems. Involvement of experts in medical education may be needed to ensure that the training curricula are designed based on the latest evidence on visual-cognitive learning in medical imaging. Evidence on the learning curve of OCT-BCC diagnosis is sparse but suggests adequate diagnostic accuracy after 183–311 OCT scans.²⁰ While all experts suggested hands-on scanning as part of the OCT training curriculum, their opinions on training volume differed substantially. Numerous studies have shown that case volume is a poor indicator of competency. Consequently, a pre-defined number of scans may fail to ensure proficiency for some learners, while imparting an unnecessary training burden on others.^{33–35} Compared to experts, trainees search images for distinctive features less efficiently,^{36–38} exhibit overall longer viewing times³⁹ and formulate fewer diagnostic hypotheses.³³ By aggregating features of a particular skin disease into larger chunks of information, experienced OCT users likely rely on pattern recognition for visual diagnosis, which is faster than analytical reasoning.⁴⁰ Evidence suggests that both types of reasoning processes, the intuitive and rapid processing versus the effortful and analytical processing, should be employed since the sole use of analytical reasoning is insufficient to develop visual expertise^{29,36,41} but pivotal in reducing cognitive bias during clinical decision making.⁴² Consequently, a comprehensive OCT training curriculum should strive to equip novices with a sound theoretical understanding for the analytical aspects of BCC imaging, as well as set the appropriate framework to develop the fine motor muscle memory to consequently reduce the cognitive load associated with the technical aspects of image acquisition.⁴³

By bundling the expertise of medical education scientists and OCT skin cancer imaging professionals, our study was designed to produce robust low bias results in an emerging field that still lacks high-level evidence. The terminology presented in this consensus statement was vetted by a group of KOLs and experts in which >75% have more than five years of experience of imaging and assessing BCCs. Participants also practice in different parts of the world, adding representation and generalizability to our terminology scheme. Given the relative novelty of OCT in dermatology, its cost of acquisition and the lack of formal OCT imaging curricula/fellowships, OCT-BCC imaging represents a niche with a consequently lower number of experts able to participate. The terminology should be endorsed, validated in large prospective trials and refined by the rapidly growing

community of OCT imaging experts. While our surveys and proposed terms were entirely in English, translation of the suggested terminology into other languages is essential for its clinical implementation to accurately report OCT findings of BCC features in medical records. Additionally, we did not address device-specific parameters or proprietary software such as dynamic OCT features. As changes in vascularization are prominent features of BCC lesions in clinical-dermoscopic evaluation, wider adoption of OCT-angiography will likely influence the way we currently assess BCCs in OCT. Technical advances in the field, such as multimodal RCM-OCT devices, line-field confocal OCT, and OCT contrast agents may also impact the relevance of certain features included in this OCT-BCC consensus.^{44–46} Future consensus should specifically address subtyping, angiographic/dynamic OCT features, complimentary use of OCT with other optical imaging techniques and treatment-specific changes in BCC appearance to facilitate monitoring. The current OCT-BCC 2021 consensus is based on almost unanimous agreement on BCC features and can be seen as a best-practice guideline. However, comments and objections have been raised (supplementary Table S1) such as the synonymous terminology of the highest-ranked image characteristics as well as personal preferences for describing infiltrative BCCs using analogical expressions, e.g. grape-like. These disagreements may be due to differences in technical equipment, lexical variation, and experience in related fields such as ultrasound and dermatopathology and need to be addressed in future consensus statements.

As the first of its kind, this international OCT-BCC consensus will inevitably need to be reviewed and expanded to incorporate the growing scientific evidence, address technological advances in OCT imaging and remain relevant in the rapidly changing landscape of dermatological education. Expert consensus studies on other types of skin cancer and BCC-mimickers are needed to design clinical guidelines and comprehensive curricula for OCT-trainees.

Conclusion

This Delphi study has provided the 2021 OCT imaging consensus statement on BCC characteristics and terminology as well as suggestions to establish a comprehensive OCT-BCC imaging curriculum to facilitate the implementation of this technique in clinical practice and research settings.

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Consent for publication

The authors consent to the publication of this submission (manuscript and figures)

Author Contributions

Study conception and design: CSKF, LJJ, VLJ, MGT, MH. Acquisition of data: CSKF, MM, AMR, GP, JW, KM, PG. Analysis and interpretation of data: CSKF, VKO, MGT, MH. Drafting of manuscript: CSKF, VKO, LJJ, MGT, MH. Critical revision: MM, AMR, GP, JW, KM, PG, LJJ, VLJ.

Data availability statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions

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Supplementary Material I. Development of content for an OCT-BCC imaging curriculum.

Table S2. Proposed BCC subtypes and number of proposed image characteristics.

Table S3. Nodular BCC image features.

Table S4. Superficial BCC image features.

Table S5. Infiltrative and morpheaphorm BCC image features.

Table S6. Overview of comments and objections to the consensus statement.

Table S7. Responsibilities for OCT imaging.