PRACTICE POINTER

Medical photography using mobile devices

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What you need to know

- Covid-19 has accelerated the use of medical photography, with many specialist services requesting it as part of the referral process
- Poor quality images may lead to misinterpretation and a delay in diagnosis or treatment, but training in medical photography for clinicians and patients is limited
- Ways to improve the quality of images captured with mobile devices include taking both overview and close-up images, increasing light, and holding devices at an appropriate distance from the subject.

Despite widespread use of mobile devices for medical photography,[1-3] there is a distinct lack of published resources offering technical and practical advice to help clinicians and patients take images of a suitable quality for clinical use. Since covid-19, however, specialties such as dermatology and wound care now consider photographs a mandatory part of the referral pathway, and a basic understanding of medical photography principles has quickly become a requirement for many clinicians. Similarly, many patients now send images to their healthcare provider as part of a "virtual consultation." Clinicians need to understand not only how to take good medical photographs in the consulting room, but also how to support their patients to do this remotely.

Accuracy in capture

The limitations of image quality in mobile device technology raise the question whether smart phones are suitable for medical photography. The answer is it depends. There are many factors to consider, in particular the purpose of capture and whether a standardised or non-standardised approach is required. A correlation study comparing on-site wound evaluation versus remotely viewed digital images in plastic and reconstructive emergency surgery concluded that efficiency in clinical decision making is less based upon the quality of imaging but on the timing and method of delivery.[4] On the other hand, a case-control study evaluating the importance of standardisation in preoperative and postoperative photographs concluded that poor photographic technique can result in potentially significant error and misrepresent surgical outcomes.[5] Low quality images may therefore still result in high accuracy and concordance rates where standardisation is not a prerequisite for assessment, but may be misleading in instances where standardisation is paramount, such as demonstrating preoperative and post-surgical facial aesthetic surgery.

There are also medicolegal considerations; poorly taken medical photographs have been found to provide no evidential value in family law cases[6] and, worse still, been described as misrepresenting fact.[7] The question then becomes whether a mobile device makes poorer photographic technique more likely. A cross-sectional survey evaluating the accuracy of dermatological diagnoses based on photographs taken with a mobile device demonstrated multiple false positives and a drop in diagnostic specificity to 50% when compared with face-to-face diagnosis.[8]

It is difficult to draw any conclusions about the efficacy of medical photography using mobile devices as there are such varying degrees of user proficiency. Diagnostic specificity may be improved by training general practitioners to acquire greater diagnostic knowledge through medical photographs.

What is a good medical photograph?

The intrinsic nature of a good medical photograph is judged not by its level of artistry but on its ability to accurately document a clinical condition while preserving patient confidentiality and privacy (see box 1). A good medical photograph should convey information on lesion location, size, colour, texture, and depth. For example, a photograph of a rash should provide an idea of distribution, colour, and whether it is raised or flat on the skin. This is also the case for a burn assessment, where a photograph demonstrating depth can determine the potential for wound healing and will subsequently guide the initial treatment.

Box 1: Legal and ethical considerations of medical photography

Consent

Before photography takes place, consent should be gained. Consent must be specific in nature and cover the purpose, procedure, and processing of such data. It is good practice to get the patients written consent; if this is not practical, the patient's oral consent should be obtained and documented on file.

Further information on consent can be found in the GMC's *Making and using visual recording of patients (summary)* (https://www.gmc-uk.org/ethical-guidance/ethical-guidance-for-doctors/making-and-using-visual-and-audio-recordings-of-patients).

Data protection

Taking photographs of an individual on a mobile device, subject to exceptions, is classified as processing personal data and therefore must comply with the Data Protection Act 2018 and the General Data Processing Regulations EU. Both provide strict regulation for the safe processing of personal data. The mobile device should be protected using a strong passcode, and any cloud-based backup systems disabled before use. The use of a dedicated healthcare mobile device capture application that provides secure encryption is recommended.

When undertaking medical photography, users must therefore consider what information is required in the photograph and how best to capture it. While different medical specialties will have their own preference as to what constitutes a good image, applying the basic principles of medical photography should enable a clinician or patient to take better quality photographs and reduce the risk of medical error from inaccurate interpretation.

Key principles of medical photography

Consider these five key principles when undertaking medical photography with a smartphone (see also fig 1):

Fig 1 | Quick reference guide to the key principles of medical photography, for both patients and clinicians

- Lighting
- Focus
- Location and severity
- Colour
- Perspective

Lighting

To achieve correct exposure, a photographer must balance three key settings; aperture, shutter speed, and ISO (box 2). These variables may have a negative impact on the resulting image; an image shot with a slow shutter speed may cause motion blur, an image shot with a high ISO may cause "grain", and an image captured with a large aperture will have a shallow depth of field (area in focus). These settings are selected automatically on most mobile devices, so how can users maximise image clarity without the ability to change them? The answer lies in increasing the quantity of light. By simply adding more light to the room, photographing the lesion closer to a light source, or using flash, the camera will be able to use a faster shutter speed and a lower ISO. Users must also be aware that the angle of light can affect accuracy (fig 2). Some smartphone manufacturers offer the ability to manually adjust exposure settings, but the benefits of image capture in full manual mode may not outweigh the complexity of adjusting the settings. Most mobile device cameras have a fixed aperture lens, so the adjustment of aperture and subsequent effects on the image are not discussed.

Box 2: Common terms in mobile device photography

- *Aperture*—The hole within a lens through which light travels to the camera sensor. The larger the aperture the more light that enters the camera. The smaller the aperture the larger the depth of field will be (amount of the image in focus). The aperture is often fixed in mobile device cameras.
- *Shutter speed*—The length of time a camera shutter is open to expose light to the sensor. A slow shutter speed allows more light to enter the camera. Any movement during the period the shutter is open will result in motion blur.
- *ISO*—The camera sensor's sensitivity to light. A high ISO setting requires less light to expose the image, but results in more "noise" or "grain" in the image.
- *White balance*—This is the process of removing unwanted colour casts by balancing the colour temperature of a light source to ensure that what the eye sees as white is rendered white in the photograph. Most devices default to an automatic white balance setting. To aid the device in calculating the correct colour temperature of a scene, use a plain white or neutral background, use flash or daylight, and remove clothing.

- *Flash*—In medical photography, the more light the better. If photograph is being taken in a room with little or no daylight, ensure the flash is set to on.
- *High dynamic range (HDR)*—This merges multiple shots into a single image to expose both light and dark areas. This should be set to off as it can lead to inaccurate colour rendition and exposure.
- *Scene optimiser*—This uses artificial intelligence to recognise the environment and apply automatic colour and contrast adjustments. This should be set to off as it can result in over-saturated colours and increasing or decreasing contrast.
- *Live photo*—This shoots multiple frames to produce a short video. This should be set to off as it results in larger file sizes, which slow upload speeds and double the data collected.

Fig 2 | Lighting postoperative photographs of a patient's ear after tumour removal, taken to aid discussion with secondary care over the assessment of granulation tissue. *Left.* Image was taken with a low degree of ambient light and no flash, leading to the camera setting a slow shutter speed resulting in motion blur. *Middle.* The introduction of daylight reduces in motion blur, but the angle of the light combined with the shape of the ear creates multiple shadows. This makes it difficult to identify the presence of healthy granulation tissue and absence of desiccation necrosis. *Right.* Turning on the flash to increase the quantity of light allows the mobile device to use a faster shutter speed and lower ISO while also providing more effective cavity illumination due to the close proximity of the flash to the camera lens.

Focusing

Most out of focus images can be attributed to the user breaching the camera lens minimum focus distance. This is the shortest distance at which the lens can focus and is measured from the device lens to the subject (see fig 3). The minimum focus distance varies between devices, with some having better macro (close-up) capability than others. It is good practice to avoid moving the device closer than a hand's width to the subject (about 10 cm). While this may seem to limit a device's ability to provide close-up detail, the high resolution of camera phones allows sufficient detail to be retained for clinical evaluation. Some devices have two or more lenses including a telephoto lens. The zoom function on the device should be used cautiously as it may result in digital zoom by cropping into the image as opposed to optical zoom, which retains image quality by using the telephoto lens.

Fig 3 | The minimum focus distance at which a mobile device camera can focus is usually around 8-12 cm. When photographing small lesions, it is tempting to breach this distance to show the lesion close up. This results in focus past the area of interest (left image). With the increase in resolution of modern devices, photographing the lesion further away and then zooming in retains sharpness and clarity (right image zoomed to 100%)

Location and severity

In most situations, consider taking an overview or "wide" photograph as well as a close-up. This can help to provide additional clinical context: to help determine the urgency of a referral or include an anatomical landmark to help identify a biopsy site and reduce the risk of wrong site surgery.[9] For a patient with a widespread rash, an overview picture front and back with sensitive body areas covered (if not involved) can be useful in monitoring the response to treatment. Combine the overview photograph with close-up images in case the resolution of the overview photograph is insufficient when zooming in.

Colour

Achieving colour accuracy is often imperative in medical photography. In telepathology or teledermatology, colour can provide valuable information leading to a quick diagnosis. To achieve accurate colour reproduction, a white balance must be set which takes into account the colour temperature of the light source and eliminates any unwanted colour casts. Most mobile devices default to an auto white balance setting, which sets a colour temperature by using a combination of artificial intelligence and machine learning. This has the potential to be problematic for medical photography as mobile device cameras have been shown to produce substantial colour errors.[10] Accurate analysis of skin tones has also been found to be difficult, with the Gender Shade study in 2018 showing that artificial intelligence and machine learning technology produces unfair bias against people with darker skin tones.[11] Automated facial analysis algorithms and datasets were found to have substantial disparities in gender classification, with classifiers performing best for lighter skin tones.[11] While this is based on facial analysis, the same types of bias may persist in other computer vision tasks such as automatic white balancing. Manufacturers are introducing development tools such as the Monk Skin Tone (MST) Scale,[12] which should assist devices in more accurately documenting diversity in skin tones. However, there are ways for users to directly improve the devices' auto white balancing:

- Use a plain white background (avoid a coloured background and remove any brightly coloured clothing in the frame)
- Use a single light source such as flash or daylight and avoid a combination of varying colour temperatures (such as daylight plus tungsten light).

These actions will help a device's auto white balance to set a more accurate colour temperature and reduce unwanted colour casts (see fig 4). We also suggest increasing the light levels using daylight or flash: flash is preferable but may not always be practical (such as when taking an overview picture with a mobile device at a distance from the subject).

Fig 4 | Using a brightly coloured background can deceive the camera's auto white balance (AWB) setting into determining the scene may be "warmer" or "cooler" than it is in reality. This leads to inaccurate colour reproduction (left images). To assist the device's AWB system, use a plain white or colourless background, use flash or daylight, and ensure there are no mixed light sources (right images).

Ultimately, the information the user wants to convey in the image determines the emphasis placed on achieving accurate colour reproduction. For example, a quantitative study on diagnostic accuracy for common skin lesions based on colour versus grey-scale dermoscopic images found that morphologic characteristics, and not colour, were the primary diagnostic clue.[13] Colour accuracy may therefore be secondary to the accurate documentation of morphology.

Achieving correct perspective

An incorrect perspective can lead to misinterpretation of size and location. Accepted practice is that photographs are taken with the patient in an anatomical position.[14] Some lesions or conditions may require various angles of capture to document the full extent of the condition. For analysis of scale, a measurement scale/ruler should be placed adjacent to the lesion. The appearance of a lesion can also be distorted by the "camera to subject" distance and/or angle. The patient (or mobile device) should be moved to ensure that the camera is perpendicular to the subject, ensuring that the area of interest falls within the centre of the frame and that the edges of the lesions are clearly defined. To assist in demonstrating depth or protrusion, consider taking additional images from varying angles.

Additional considerations: file formats

Many mobile devices have cameras that allow images to be saved in different file formats. Choosing the correct file format has an impact on memory storage and image quality. The main file types a mobile device can capture are HEIF and JPEG, with some devices allowing capture of RAW. A description of the file types is provided below:

- *RAW*—This is an uncompressed file format. The full range of image data are retained, which allows multiple changes to be made in post-production to variables such as exposure, colour, and contrast without a loss of image quality. RAW files result in an increased file size and a requirement to convert the image for use.
- *JPEG*—A JPEG is a processed version of the image with adjustments already applied. While small changes to a JPEG can be made, it cannot be modified extensively as this results in artefacts and a possible reduction in image quality. We suggest the device is set to record JPEG at the highest resolution possible and that no post-production changes are applied.
- *HEIF (high efficiency image format)*—This is a relatively new compressed image file format that is similar to JPEG but takes

up less space. HEIF is not as widely supported by computer software and online platforms, and it therefore often requires conversion to a JPEG. As a result, JPEG remains the most universally accepted file format.

Education into practice

- How do you support patients to take photographs for virtual consultations currently?
- How can you share learnt medical photography techniques with colleagues?
- What changes will you make when taking medical photographs as a result of reading this article?

How patients were involved in the creation of this article

A patient co-author (MT) provided insight on concerns and perceptions having previously had medical photographs taken. He was able to provide substantial contributions to the patient photography resources created for clinicians to share with patients.

How this article was created

We obtained information relating to prevalence, patient perception, consent, and information governance by means of topic searches in PubMed and Medline. We used the basic principles of medical photography published in the Institute of Medical Illustrators (IMI) national guidelines,[15] applying them to mobile device photography. We also undertook internet searches to gather practice points for general mobile device photography in order to incorporate suitable techniques within the area of medicine. The quality of clinical images received within existing telemedicine programmes were evaluated, and several improvement methods were identified.

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