**Open-source Smartphone Adapter in Digital Photomicrography**

Himel Mondal, Shaikat Mondal

Department of Physiology, Fakir Mohan Medical College and Hospital, Balasore, Odisha, 1Department of Physiology, Raiganj Government Medical College and Hospital, Raiganj, West Bengal, India

**Abstract**

**Background and Aim:** Smartphones can be used to capture images from the microscope. There are commercial and homemade adapters that can be used to overcome the difficulty of focusing on a smartphone camera. We conducted this study to test if the usage of a homemade adapter reduces the time and effort of the operator in comparison to the free-hand technique in smartphone photomicrography. **Materials and Methods:** We made a simple smartphone adapter for digital photomicrography. Thirty-two operators first captured the image on the smartphone with the free-hand technique and then with the adapter thrice from a microscope. The time for focusing was compared statistically by paired t-test. A survey was conducted to know operators’ opinions on adapter-assisted photomicrography. **Result:** All the participants were able to capture images from the microscopes. The average time for focusing with adapter was (11.89 ± 4.19 seconds) significantly ($P=0.0001$) lower than the free-hand technique (25.56±11.81 seconds). However, the images yielded from both techniques were of equal quality. The majority of the participant found the method to be easy and reduce their effort in focusing and capturing an image. **Conclusion:** Low-cost homemade smartphone adapter helps in reducing the time required for capturing an image from the microscope. It decreases the effort of the operator in comparison to the free-hand technique. Hence, it may be a good choice for those who need to capture images from the microscopes frequently for either telemedicine or research purpose in resource-limited settings.

**Keywords:** Photomicrography; smartphone; microscopy; telemedicine

**INTRODUCTION**

Many of the resource-limited settings still do not have photomicroscopy enabled microscopes. For those settings, smartphone photomicroscopy would help in capturing images from the microscope for distant diagnosis.

Two techniques of smartphone photomicrography are prevalent-freehand and adapter-assisted. In the freehand technique, the operator positions the camera lens on the eyepiece to capture the image. In the adapter-assisted technique, the operator uses an adapter with the smartphone. An example is shown in Figure 1. There are various types of adapters that may help in smartphone photomicrography [Table 1].[1-4]

Does usage of the adapter reduce the time and effort of focusing? The question is still unanswered in the literature.

**AIM**

This study aimed to find out if the usage of a smartphone adapter reduces the time and perceived effort of the operators.

**METHODS**

This cross-sectional observational study was conducted after obtaining approval from Institutional Ethics Committee (Reference number: IEC/09/FAC/2019, dated 14 August 2019). All the research participants were recruited after obtaining written informed consent. All of them were above 18 years of age. We further declare that we conducted the study in accordance with the Declaration of Helsinki by the World Medical Association.

As the proprietary adapters are not procurable from all corners of the world, we used an open-source model for the test – simple smartphone adapter for digital photomicrography (sSADP).[1] We conducted the study with 32 operators who captured the image of a focused object thrice from microscope eyepiece.
with the freehand technique first, then assisted with the adapter as shown in Figure 1. The time from starting the camera program to capture an image was stored for analysis. The participants were also asked to share their experience of focusing and capturing the image and their perception on the adapter in reducing their effort on a 5-point Likert-type scale. Data were expressed in mean and standard deviation and tested statistically by paired $t$-test (for comparing the time of two techniques), one-way analysis of variance (for comparing episode-wise time in each technique), and Chi-square test (for the survey response) with $\alpha = 0.05$ in GraphPad Prism software version 6.01 (GraphPad Software, CA, USA).

### Table 1: Design of different types of smartphone adapter for digital photomicrography

| Design                                      | Category | How it works                                                                                     | Example               |
|---------------------------------------------|----------|--------------------------------------------------------------------------------------------------|-----------------------|
| Adjustable eyepiece casing; moveable stage for smartphone$^{(1)}$ | Proprietary | With adjustable screw, adapter is fixed with the eyepiece of the microscope; the smartphone is fixed on the attached stage | Magnifi, Skylight, Snapzoom |
| Eyepiece is built-in; smartphone case$^{(2)}$ | Proprietary | iPhone is attached on the case; ordinary eyepiece from microscope is removed; smartphone case-attached eyepiece is introduced | LabCam                |
| Adjustable eyepiece casing; attachment on the back of the smartphone$^{(3)}$ | Proprietary | A small adhesive part is attached to smartphone and adjustable eyepiece casing is fixed on that part | SmartphoneAdMi        |
| Fixed eyepiece casing attached on a board$^{(4,6)}$ | Open     | Smartphone is held or fixed with the adapter with camera aligned with eyepiece casing; Smartphone moved along Z-axis to focus the image [Figure 1] | Paper-roll and back cover, paper-wrapped and hardboard, sSADP |

### Table 2: Comparison of time (seconds) required to capture image from a microscope by the freehand and the adapter-assisted technique ($n=32$)

| Episodes  | Mean±SD Free-hand | Mean±SD Adapter-assisted | $P^*$  |
|-----------|-------------------|--------------------------|--------|
| 1st episode | 27.81±11.76       | 12.81±4.01               | <0.0001|
| 2nd episode | 25.78±13.69       | 11.91±4.60               | <0.0001|
| 3rd episode | 23.09±11.43       | 10.94±4.77               | <0.0001|
| Average   | 25.56±11.81       | 11.89±4.19               | <0.0001|

*Two tail $P$ value of paired $t$-test. SD: Standard deviation

### Results

There was noticeable less time required to capture the image by smartphone aided with the adapter when compared to the freehand technique [Table 2].

Three images captured with a smartphone by the freehand technique are shown in Figure 2a, and the same field captured with the help of the adapter is shown in Figure 2b. Both had a similar quality.

There was a reduction in time in both freehand and adapter-assisted technique with repeated measurement [Figure 3]. The majority of the participants found the focusing to be very easy with the sSADP and thinks that it reduced their effort in photomicrography [Table 3].

### Discussion

We found that the smartphone adapter helps in reducing the time for focusing through the microscope eyepiece in comparison to the freehand technique. Hence, researchers, academicians, and laboratory personnel from any resource-limited settings can use this type of homemade device for capturing images from the microscope with less time and effort. However, in both the techniques, focused images would be of equal quality.
The reason for the reduction in time may be attributed to the reduction of the number of axis for focusing. In the freehand technique, an operator needs to move her/his smartphone camera in X, Y, and Z-axis. If the operators use an adapter, movement in the X and Y axis is not required, and the only movement in the Z-axis is required.

**Conclusion**

Smartphone adapter-assisted photomicrography requires less time and effort than the freehand technique. However, both the methods yield similar image quality. Homemade and low-cost adapters may be built and used in resource-limited settings for academic and diagnostic purposes.

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**Conflicts of interest**

There are no conflicts of interest.

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