DETERMINATION OF WHITE BLOOD CELLS USING FOLDSCOPE WITH SMARTPHONE

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ABSTRACT

We have traditionally used Microscope in a clinical laboratory for the determination of white blood cells of human blood smear. Now, in this study we were used Foldscope with Smartphone in the place of Microscope and examine many samples of human blood smear which was collected from local diagnostic centers. We were very quickly quantity & morphology analysis of all types of WBC cells such as Neutrophils, Lymphocytes, Monocytes, Eosinophils, Basophils in blood smear with the help of Foldscope & image taken by Smartphone. The main objective of this study is to use Foldscopefor quantity & morphology analysis of human WBCs at field level especially poor resource area where healthcare services or centers is not available & where carry of microscope is not possible.

Keywords: Foldscope; White blood cells; Diagnostic; Healthcare

INTRODUCTION

The Microscope is used in a clinical laboratory for determination & morphology analysis of white blood cells of human blood smear, but due to its high cost, heavyweight & portability issue, it is not available everywhere such as rural areas, flooded area. Handling & using of microscope also required well trained &skilled microscopist. Here we implemented a novel origami-based cheap and portable microscope "Foldscope" [1] for determination of white blood cells of human blood smear.This foldscope is origami-based printed and folds paper microscope, which can magnify up to 2000 X, would be sufficient to identify harmful microorganisms like E. coli and Giardia[2].The counting and analysis of blood cells allow the evaluation and diagnosis of a vast number of diseases.

The generic term leukocytes refer to a set of cells quite different each other. The leukocyte cells containing granules are called granulocytes and include neutrophils, basophils, and eosinophils. The cells without granules are called agranulocytes and include the lymphocytes and monocytes. Thus we can distinguish between them, not only according to the shape or size but also thanks to the presence of granules in the cytoplasm and even by the number of lobes in the nucleus. The lobes are the most substantial part of the nucleus and are connected by thin filaments.Neutrophils are mainly present in human blood with percentage ranging between 50 and 70%, have sizes around10-12 microns and are distinguishable due to the number of lobes present in the nucleus, which can be up to a maximum of 5. Basophils instead represent only 0-1% of lymphocytes in human blood, have a diameter of about 10 microns and, generally, a nucleus with two lobes. Eosinophils are present for the 1-5% in human blood, have predominantly rounded shape with dimensions around 10-12 microns, and have a nucleus with more lobes, but not greater than 2. They differ from other white blood cells for the presence of granules, which include paracrystalline structures in the form of "coffee bean".

In human blood is ubiquitous the presence of lymphocytes, with a percentage of 20-45% and a size of 7-15 microns, characterized by a rounded nucleus and a cytoplasm inferior. Monocytes are the most voluminous white blood cells, with a diameter of 12-18 microns and representing 3-9% of circulating leukocytes[3].

MATERIAL AND METHODOLOGY

Samples: We collected a total of 25Leishman stained human blood film smear slides were used as sample to determination of white blood cells using Foldscope with Smartphone. These blood slides were collected from Maa Tara Pathology Mathahi, Madhepura, MaaKoshi Laboratory Madhepura, Yaduvansi Laboratory Madhepura& New Micro Lab Madhepura, Bihar, India.

Materials: One commercial handheld, portable optical origami types paper microscope, named "Foldscope" was used the conduct this study. This Foldscope was bought from Foldscope Instruments, Inc. (San Francisco, CA).

Mobile-phone (Samsung Galaxy A6+, Samsung, Korea) was coupled with the Foldscope by using tape and magnetic coupler for taking an image of the blood samples. The Foldscope was manually panned and focused according to the guideline of the manufacturer. LED magnifier was used as a light source.

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Methodology: Raw Foldscope paper was open and assembled in order to conduct this study. After assembly, stained blood film slides were being imaged through Foldscope and mobile phone.

Image Processing: All images were saved in JPEG format.

Fig 1: Foldscope

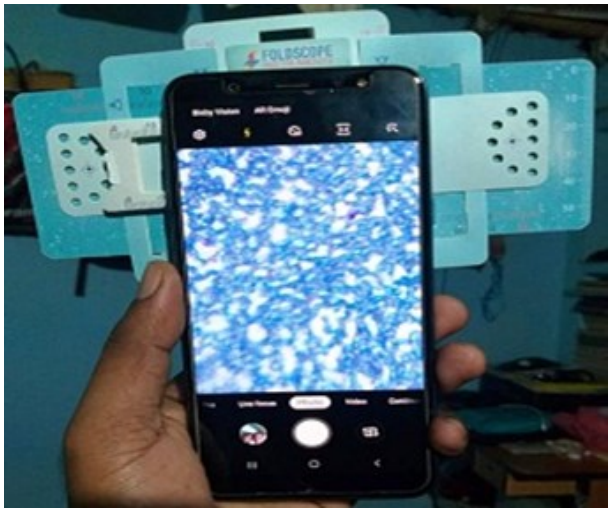

Fig 2: Foldscope fixed with smartphone

RESULTS

The study was conducted total 25 Leishman stained human blood film slides were collected from local diagnostic centers of Madhepura, Bihar, India. All human blood film slides were adjusted on Foldscope one by one, and images ware taken with an adjusted smartphone. During image taking LED magnifier was used as a light source. The Smartphone captured images of the blood smear are illustrated in figure 3 to 6. We apply the zoom option of the Smartphone camera 8X in image taken. Morphologically WBCs cells were found very clearly in figure 3 to 6 respectively.

We also count the percentage of WBCs of all 25 blood film slides one by one using first Microscope & then Foldscope with Smartphone by moving blood film slidefrom one field to the next systematically 100 cells of each slide & recorded the types of WBCs seen in each field. We ware found the following results.

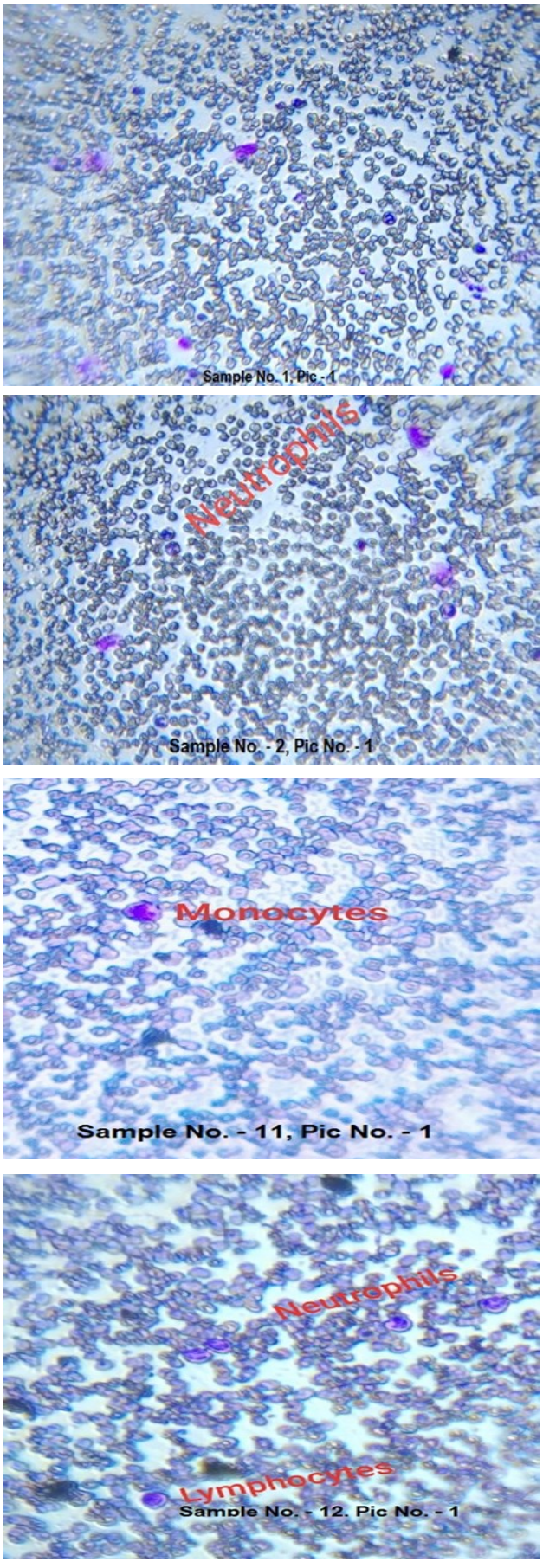

Fig 3: Foldscope captured an image of Human blood cells (8X zoom in phone camera)

Table 1: Performance of quantitative test

Slide No.	Neutrophils		Lymphocytes		Monocytes		Eosionophils		Basophils		Total
	M	F	M	F	M	F	M	F	M	F	
1.	57	56	38	38	1	1	4	5	0	0	100
2.	62	60	28	32	2	1	8	7	0	0	100
3.	71	73	23	21	1	2	5	4	0	0	100
4.	60	55	35	40	1	0	4	5	0	0	100
5.	56	58	40	38	0	1	4	3	0	0	100
6.	55	53	39	42	1	1	5	4	0	0	100
7.	62	65	32	30	1	1	5	4	0	0	100
8.	60	59	29	30	2	1	9	10	0	0	100
9.	65	67	25	24	1	1	9	8	0	0	100
10.	42	40	49	51	1	2	8	7	0	0	100
11.	58	60	36	34	1	2	5	4	0	0	100
12.	71	72	23	22	1	2	5	4	0	0	100
13.	58	61	30	28	1	1	11	10	0	0	100
14.	55	57	39	40	1	0	5	3	0	0	100
15.	52	50	43	45	0	1	5	4	0	0	100
16.	64	66	32	30	1	0	3	4	0	0	100
17.	75	74	21	22	1	1	3	3	0	0	100
18.	60	62	33	31	1	0	6	7	0	0	100
19.	62	58	32	36	1	2	5	4	0	0	100
20.	72	74	22	20	1	1	5	5	0	0	100
21.	55	57	32	33	2	1	11	9	0	0	100
22.	71	72	20	19	1	2	8	7	0	0	100
23.	60	56	30	36	1	1	9	7	0	0	100
24.	60	63	35	32	0	0	5	5	0	0	100
25.	62	59	32	35	1	1	5	5	0	0	100

*M = Microscopic observation, *F = Foldscopic observation. In quantitative test results were slide no. 3, 17, 20 & 22 show abnormalities of Neutrophils, Slide no. 10 show abnormalities of Lymphocytes, & slide no. 2, 8, 9, 10,18, 20,21, 22, 23 show abnormalities of Eosinophils.

DISCUSSION

Here we use an origami-based paper microscope, which is known as "Foldscope" for determination of human blood WBCs cells morphology & quantity analysis at the place of microscope. The magnification capacity of Foldscope is 140X & resolution 2µm. All blood film slides are observed under both types of equipment – Microscope & Foldscope & seen very few differences ± 4. In the study white LED light source use for observation of WBC cells in Foldscope.

Our current findings in Foldscope are a little bit blurry as compared to light microscopic images, but still clear to read each cell separately. The possible reason behind this blurriness is uneven light distribution in the Foldscope and non-rigidity of the paper-based device. For this reason, the device was not 100% flat, and even to capture the image through mobile phone and the room's ambient light couldn't illuminate the sample evenly.

In the future, it is suggested to use external white LED illumination with the Foldscope as it has this versatility to use, and if so, maybe it is possible to use the device by putting in a stand and thus way one can get a better image.

It the future, it is also suggested to develop and apply better blood cell counting and shape analysis through automated algorithms [4] and mobile phone-based apps [5], which could help to easier diagnosis in the low resource healthcare setting areas & pathological laboratory.

CONCLUSION

In this work, "Foldscope" is easy to use for the determination of WBCs of human blood & they give good results. The method we applied & describe here is novel, cheap, quite convenient, & suitable for human blood haematology mainly morphological analysis &quantity investigation like cell counting. This method is beneficial to Pathological laboratory, especially where a lack of resources. The image of WBCs cells of human blood is viewing very clear & identical. This novel paper microscope "Foldscope" could lead a better healthcare improvement in poor resource area where healthcare services or centres is not available & where carry of microscope is not possible.

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