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Performance evaluation of digital morphology analyzer CellaVision DM1200

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Abstract

Introduction: For white blood cell (WBC) differentials, manual counting is the standard method, but blood smears can now be automatically analyzed thanks to advancements in digital imaging technologies. In this study, we aimed to evaluate the performance of CellaVision DM1200 on white blood cell differentials and erythrocyte abnormalities, using blood smears from normal and abnormal samples. The pre-classification and reclassification of WBCs by CellaVision were compared to the reference manual count.

Methods: Our evaluation for CELLAVISION DM1200 took several steps initiating by precision which includes repeatability and reproducibility. The accuracy was determined by comparison of results between the optical microscope and CELLAVISION DM1200, using Passing Bablok regression analysis. We also studied the ability of the CellaVision DM1200 system to identify clinically important abnormalities compared with manual microscopic differential counting by calculating sensitivity and specificity. Red blood cells were also evaluated by studying sensitivity and specificity.

Results: Repeatability and reproducibility showed acceptable results. Regarding the comparability between the optical microscope and CELLAVISION DM1200, post-classification showed good results compared to pre-classification. Evaluation of color, size, and morphology abnormalities of RBCs showed good results.

Conclusion: After verification, the CELLAVISION DM1200's performance for WBC differential and detection of abnormalities of RBCs appears to be satisfactory, even in abnormal samples. However, CELLAVISION DM1200 cannot fully replace manual WBC differential counting, reclassification and slide review are still required in abnormal samples.

Keywords: CELLAVISION DM1200; Manual counting; White blood cells; Red blood cells; Platelets; Pre-classification; Post-classification

1. Introduction

For white blood cell (WBC) differentials, manual counting is the standard method where two hematology experts count 200 cells to get a total of 400 cell [1]. But it is a hard and subjective process that varies from observer to observer [2]. The morphology of peripheral blood smears can now be automatically analyzed thanks to advancements in digital imaging technologies.

In order to standardize and reduce time and labor in the laboratory workflow, digital morphology analyzers need to use high optical magnification (×100). The International Council for Standardization in Hematology (ICSH) recently reviewed digital morphology analyzers and made suggestions that outline their possible advantages and limitations. It was underlined that reclassification is still required, particularly in patients suspected of having abnormal blood cells, even if digital morphology analyzers make up a portion of the laboratory workflow [3].

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Since the 1970s, a number of digital morphology analyzers have been created [4]. When a digital morphology analyzer is recently installed, all performance characteristics must be fully evaluated, in accordance with ICSH guidelines [5]. Previous studies have evaluated the CellaVision DM96 (DM96, CellaVision AB, Lund, Sweden) and the Sysmex DI-60 (DI-60, Sysmex, Kobe, Japan) [6,2,3,4]. According to a survey by the Institute for Quality Management in Healthcare (IQMH), CellaVision was utilized by the majority of laboratories (91%) that used digital morphology analyzers, with the DI-60 being used by the remaining 9% [7].

In this study, we aimed to evaluate the performance of CellaVision DM1200 on white blood cell differentials and erythrocyte abnormalities, using blood smears from normal and abnormal samples. The pre-classification and reclassification of WBCs by CellaVision were compared to the reference manual count.

2. Material and methods

2.1. Blood samples

This study was conducted in the hematology laboratory of University Hospital Mohammed VI, MARRAKESH.

Blood samples was obtained by venipuncture in EDTA K3 Carestainer tube with 4ml. Blood smears were prepared and stained using an automated slide-maker stainer (Sysmex XN50), respecting the time between sampling and preparation of the smear.

2.2. Steps of evaluation

Our evaluation for CELLAVISION DM1200 took several steps into account. Regarding the study of precision; 10 samples were selected with varying white blood cell counts, normal and abnormal samples were included, with each sample repeated 5 times a day to establish repeatability and for 5 days to determine reproducibility. Next, the mean, standard deviation, and coefficient of variation were calculated using the SPSS program. The CV percentages were interpreted as follows: %CV =< 10% excellent, %CV 10% -20% good, %CV 20% -30% acceptable, %CV >30% poor. The accuracy was determined by comparison of results between the optical microscope and CELLAVISION DM1200, it was carried out using Passing Bablok regression analysis, with 50 samples selected, including both normal and abnormal samples. Pearson correlation coefficients (r) with a 95% confidence interval (CI) were obtained and interpreted as follows: <0.30 negligible; 0.30 to 0.50 weak; 0.50 to 0.70 moderate; 0.70 to 0.90 high; 0.90 to 1.00 very high. We also studied the ability of the CellaVision DM1200 system to identify clinically important abnormalities compared with manual microscopic differential counting by calculating sensitivity and specificity, using the following calculations: Sensitivity = (True positive / True positive +False negative) x100 , Specificity = (True negative / True negative +False positive) x100. the data was saved using Microsoft Excel, statistical analysis was performed with the aid of the Statistical Package for Social Sciences (SPSS) IBM version 22.

2.3. Analysis with CellaVision DM1200

The DM1200 consists of a slide scanning unit and a computer. The scanning unit consists of a microscope (·10, ·50, and ·100 objective), a CCD digital camera, an automatic immersion oil unit, a slide feeding unit with a barcode reader, a rack feeding unit, and a control unit that manages the motors, sensors, oil application, and lighting. The slides are loaded into the system and processed immediately and continuously. The instrument scans the slides, takes digital photos, and uses software based on an artificial neural network to analyze the cells. The digital images of the pre-classified cells are presented to the operator on a computer screen. The operator can enlarge individual cells for a more detailed view, accept the pre-classification and leave the cells in the suggested category, or move individual cells to another category, reclassifying them by clicking on the cell and using the drag-and-drop function. Non-identified cells as blasts and atypical cells can also be classified by operator. For the evaluation of red blood cells and platelets, the images can be highlighted by clicking on the screen to enlarge the cells. Red blood cell abnormalities are classified as: polychromia, hypochromia, microcytosis, macrocytosis, anisocytosis, and poikilocytosis, and are reported on a scale of 0 to 3.

3. Results

3.1. Repeatability

For the repeatability of normal smears, the percentage of the coefficient of variation (CV) was excellent for mature neutrophils and lymphocytes, poor for precursor neutrophils, monocytes, basophils, and eosinophils. For the

repeatability of pathological smears, the percentage of the coefficient of variation (CV) was good for lymphocytes, acceptable for blasts and mature neutrophils (Table 1,2).

Table 1 Repeatability of normal smears: n=25

Cell class	Standard deviation	Coefficient of variation
MATURE NEUTROPHIL	1.60 (0.54 – 2.86)	2.35 % (0.87 – 4.16)
NEUTROPHIL PRECURSOR	0.62 (0.44 – 0.89)	86.28 % (34.25 – 223.5)
LYMPHOCYTE	1.37 (0.44 – 2.07)	8.44 % (2.14 – 21.12)
MONOCYTE	1.51 (0.44 – 2.60)	39.83 % (6.57 – 108.60)
EOSINOPHIL	0.74 (0.44 – 1.58)	61.42 % (12.45 – 223.5)
BASOPHIL	0.55 (0.44 – 0.89)	135.03 % (37.25 – 223.5)
UNIDENTIFIED	0.59 (0.44 – 0.70)	62.17 % (15.96 – 91.33)
ARTIFACT	0.64 (0.44 – 1.14)	103.63 % (43.84 – 223.5)
GIANT PLATELET	0.85 (0.44 – 1.51)	54.83 % (2.23 – 37.25)
PLATELET AGGREGATION	0.44	223.5 %

Table 2 Repeatability of pathological smears: n=25

Cell class	Standard deviation	Coefficient of variation
BLAST	5.73 (2.88 – 10.61)	28.59 % (6.18 – 65.49)
PROMYELOCYTE	1.62 (1.3 – 2.07)	41.36 % (36.96 – 46.42)
MYELOCYTE	1.65 (0.83 – 3.16)	44.47 % (17.55 – 71.25)
METAMYELOCYTE	0.49 (0.44 – 0.54)	52.85 % (15.71 – 90)
NEUTROPHIL PRECURSOR	1.19 (0.44 – 2.07)	42.19 % (18.15 – 69.61)
MATURE NEUTROPHIL	2.48 (1.51 – 3.8)	28.44 % (11.10 – 55.83)
LYMPHOCYTE	3.29 (1.64 – 6.1)	15.78 % (7.94 – 30.27)
MONOCYTE	1.52 (0.44 – 2.34)	38.41 % (1.89 – 71.25)
BASOPHIL	1.45 (0.54 – 2.7)	106.47 % (23.27– 148.33)
UNIDENTIFIED	2.55 (1.51 – 3.57)	30.13 % (27.08 – 37.97)
NRBC	0.63 (0.44 – 0.83)	46.95 % (37.72 – 55)
ARTIFACT	0.68 (0.54 – 0.83)	96.87 % (90 – 103.75)
GIANT PLATELET	0.8 (0.44 – 1.78)	122.72 % (55 – 220)
PLATELET AGGREGATION	0.44	220 %

3.2. Reproducibility

For reproducibility, the results of normal smears were excellent for neutrophils, good for lymphocytes. The results of pathological smears were good for lymphocytes, acceptable for blasts and mature neutrophils (Table 3,4).

Table 3 Reproducibility of normal smears: n=125

Cell class	Standard deviation	Coefficient of variation
MATURE NEUTROPHIL	2.62 (1.75 – 3.44)	3.87 % (2.16 – 5.02)
NEUTROPHIL PRECURSOR	0.86 (0.59 – 1.2)	65.76 % (43.65 – 96.77)
LYMPHOCYTE	2.28 (1.46 – 2.82)	12.25 % (7.45 – 17.75)
MONOCYTE	1.51 (1.03 – 2.10)	40.77 % (16.21 – 80.90)
EOSINOPHIL	0.86 (0.58 – 1.14)	84.13 % (22.66 – 204)
BASOPHIL	0.61 (0.27 – 0.98)	155.63 % (47.75 – 346.25)
UNIDENTIFIED	0.88 (0.27 – 1.28)	130.14 % (55.25 – 346.25)
ARTIFACT	0.67 (0.27 – 1.08)	135.40 % (43.75 – 346.25)
GIANT PLATELET	1.39 (0.77 – 1.91)	54.83 % (25.40 – 86.5)
PLATELET AGGREGATION	0.38 (0.2 – 0.62)	305.96 % (181.66 – 500)

Table 4 Reproducibility of pathological smears: n=125

Cell class	Standard deviation	Coefficient of variation
BLAST	5.73 (2.88 – 10.61)	28.64 % (6.18 – 65.53)
PROMYELOCYTE	1.62 (1.3 – 2.07)	41.46 % (37.03 – 46.57)
MYELOCYTE	1.65 (0.83 – 3.16)	44.55 % (17.56 – 71.25)
METAMYELOCYTE	0.49 (0.44 – 0.54)	53.64 % (15.96 – 91.33)
NEUTROPHIL PRECURSOR	1.19 (0.44 – 2.07)	42.19 % (18.19 – 69.88)
MATURE NEUTROPHIL	2.48 (1.51 – 3.8)	28.51 % (11.15 – 55.89)
LYMPHOCYTE	3.29 (1.64 – 6.1)	15.80 % (7.97 – 30.28)
MONOCYTE	1.52 (0.44 – 2.34)	38.48 % (1.92 – 71.25)
BASOPHIL	1.45 (0.54 – 2.7)	107.19 % (23.29 – 149)
UNIDENTIFIED	2.55 (1.51 – 3.57)	30.18 % (24.02 – 38.06)
NRBC	0.63 (0.44 – 0.83)	46.95 % (38.04 – 55.87)
ARTIFACT	0.68 (0.54 – 0.83)	97.97 % (91.33 – 104.62)
GIANT PLATELET	0.8 (0.44 – 1.78)	124.42 % (55.87 – 223.5)
PLATELET AGGREGATION	0.44	223.5 %

3.3. Accuracy

The DM1200 monitor displays the pre-classified leukocytes according to cell type. The operator must examine each cell and can move a cell to a different cell class (reclassify the cell) or leave the cell in the category suggested by the instrument. Non-identified cells must also be classified by the operator.

The evaluation of the accuracy of the results was performed by determining the correlation coefficient (r) between the average of the manual differential of two laboratory operators and the pre- and reclassified CELLAVISION results for all cell classes.

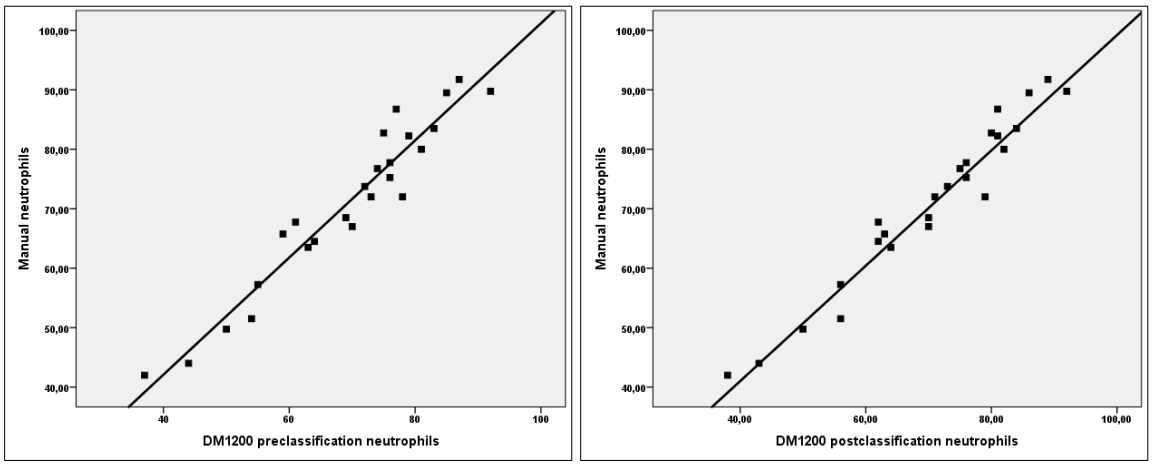
Within the comparability of normal smears, pre-classification and manual counting showed very high correlations for mature PNN, lymphocytes and eosinophils, high correlations for basophils and giant platelets, moderate correlations for monocytes and band neutrophils, weak correlation for NRBC. Post-classification and manual counting showed improved correlations (Table 5), (Figure 1).

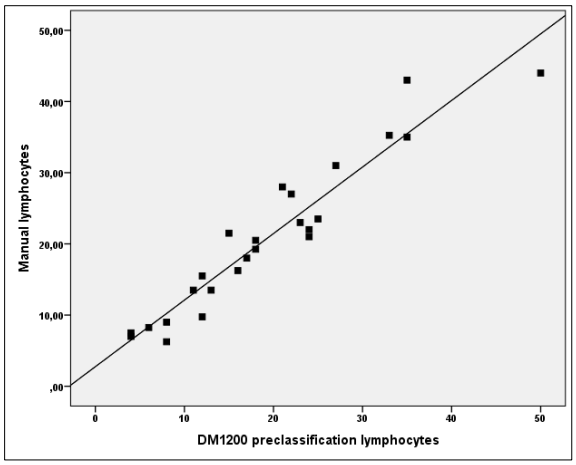
As for the comparability of pathological smears, pre-classification and manual counting showed very high correlations for mature PNN and NRBC, high correlations for monocytes, band neutrophils, metamyelocytes and myelocytes, moderate correlation for promyelocytes, weak correlations for blasts, lymphocytes and giant platelets, very weak correlations for basophils and eosinophils (Table 6), (Figure 2).

In brief, post-classification and manual counting showed very high correlations for all cell classes except eosinophils, giant platelets and platelet aggregates.

Table 5 Correlation of manual counting with pre-classification and post-classification in normal smears

cell Class	Correlation coefficient before classification	Correlation coefficient after classification	Slope(a)	Slope(a) after classification	Intercept(b)	Intercept(b) after classification
Mature PNN	0.96	0.97	0.98	0.97	2.69	2.21
Lymphocyte	0.95	0.96	0.93	0.92	2.75	2.70
Monocyte	0.66	0.73	0.57	0.61	2.18	1.88
Basophil	0.74	0.76	0.65	0.76	0.20	0.24
Eosinophil	0.94	0.95	0.82	0.78	0.25	0.28
PNN immature	0.54	0.73	0.09	0.38	-0.03	0.01
NRBC	0.46	0.47	0.31	0.31	0.02	0.02
Giant platelet	0.77	0.98	0.12	0.74	0.43	0.02
Platelet aggregation	-0.06	0.21	-0.26	0.95	1.77	1.56
Artifact	0.06	0.21	0.02	0.07	0.07	0.04

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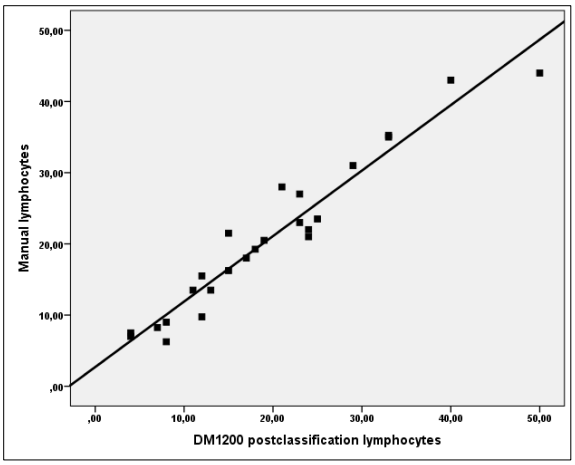
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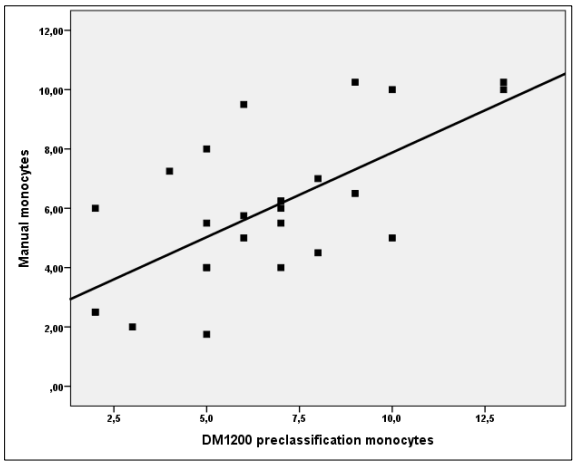
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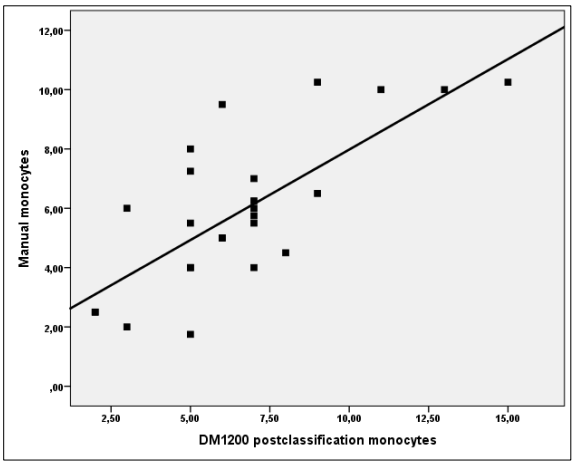
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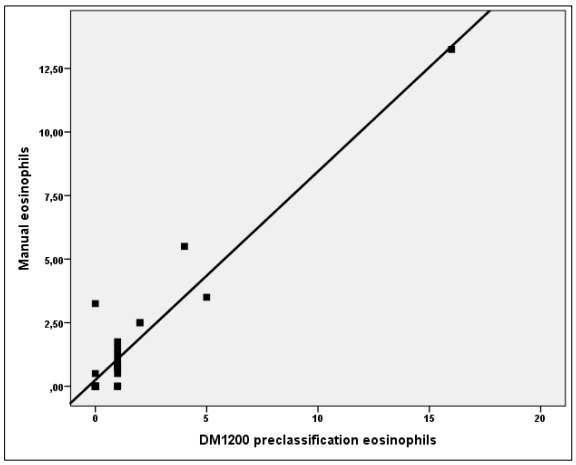
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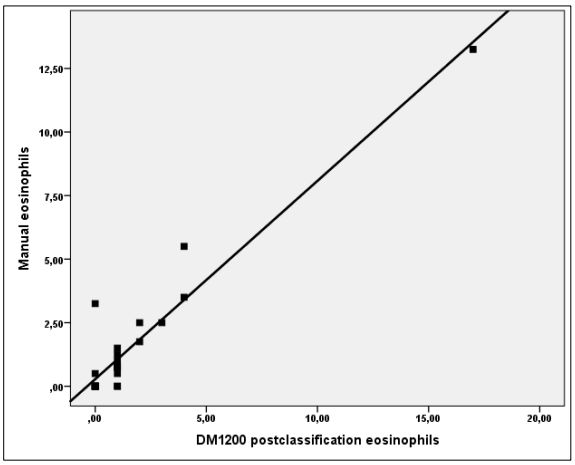
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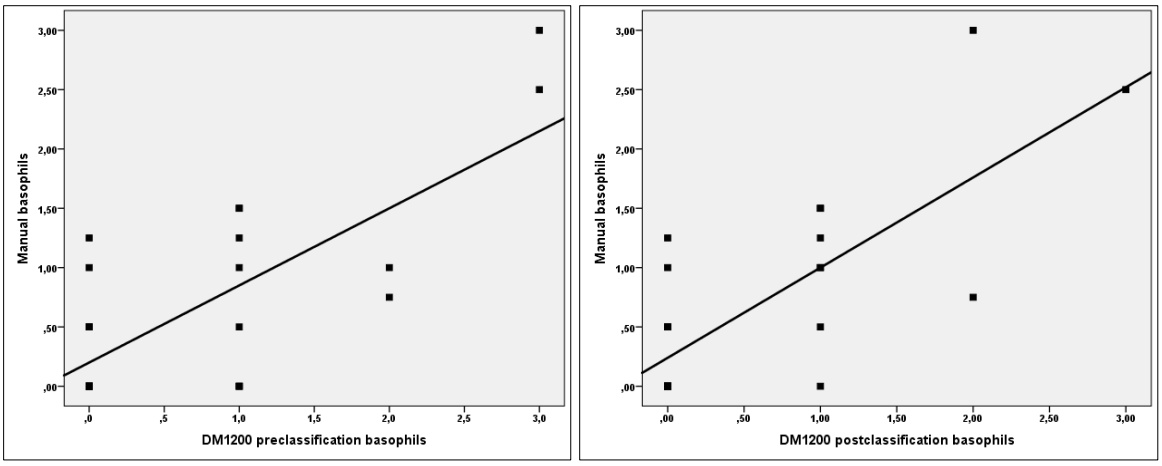
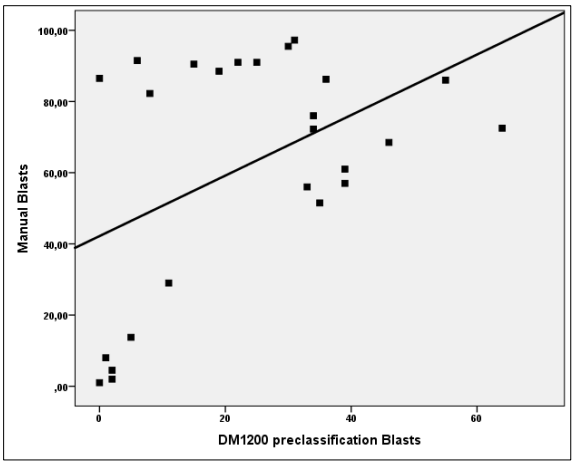


Figure 1 Comparison of WBC differentials between CellaVision DM1200 and manual count in normal smears: (A): pre-classification neutrophils. (B): post-classification neutrophils. (C): pre-classification lymphocytes. (D): post-classification lymphocytes. (E): pre-classification monocytes. (F): post-classification monocytes. (G): pre-classification eosinophils. (H): post-classification eosinophils. (I): pre-classification basophils. (J): post-classification basophils

Table 6 Correlation of manual counting with pre-classification and post-classification in pathological smears

Cell class	Correlation Coefficient before classification	Corrélation Coefficient after classification	Slope(a)	Slope(a) after classification	Intercept (b)	Intercept(b) after classification
Blast	0.47	0.97	0.85	1.06	42.20	0.72
Promyelocyte	0.52	0.97	0.11	0.78	-0.10	-0.09
Myelocyte	0.84	0.99	1.43	0.89	-0.33	0.02
Metamyelocyte	0.76	0.92	2.49	1.02	0.06	0.30
PNN immature	0.78	0.90	0.44	1.73	-0.24	0.03
PNN mature	0.96	0.97	1.13	1.03	0.19	-0.43
Lymphocyte	0.37	0.96	0.27	0.99	4.64	-0.79
Monocyte	0.83	0.93	0.90	1.02	-0.50	-0.22
Basophil	0.04	0.96	0.01	0.88	0.35	-0.01
Eosinophil	0.08	0.39	0.10	0.45	0.36	0.25
NRBC	0.99	0.99	2.35	1.74	-0.54	-0.57
Giant platelet	0.43	0.56	0.16	0.25	-5.55	1.38
platelet aggregates	0.27	0.69	0.10	0.95	0.04	0.04
Artifact	0.60	0.11	0.39	0.11	-0.17	0.15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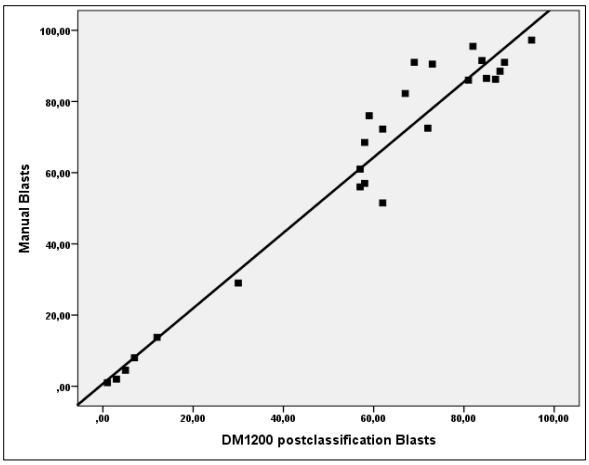
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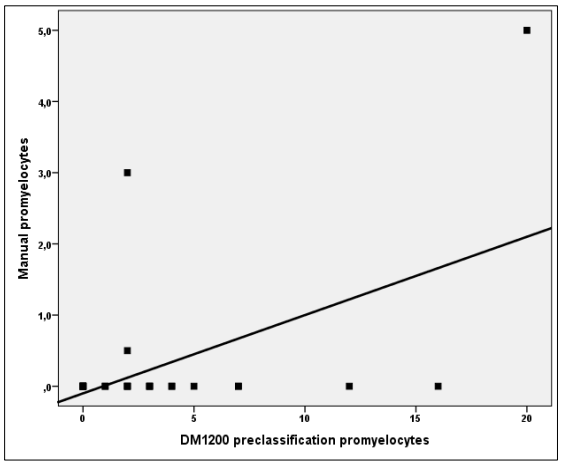
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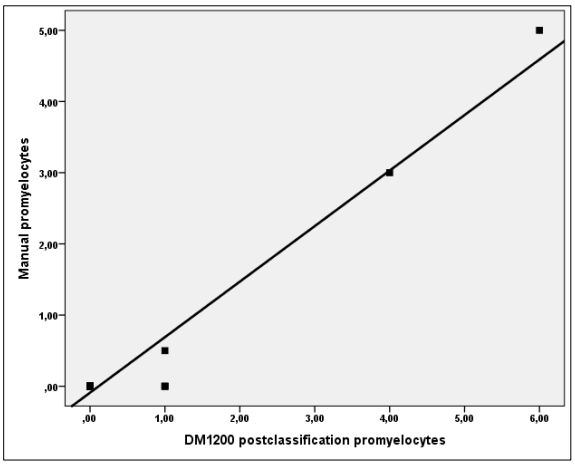
DM1200 preclassification promyelocytes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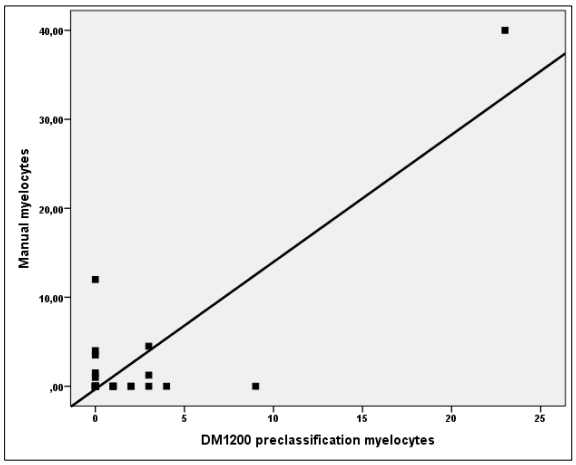
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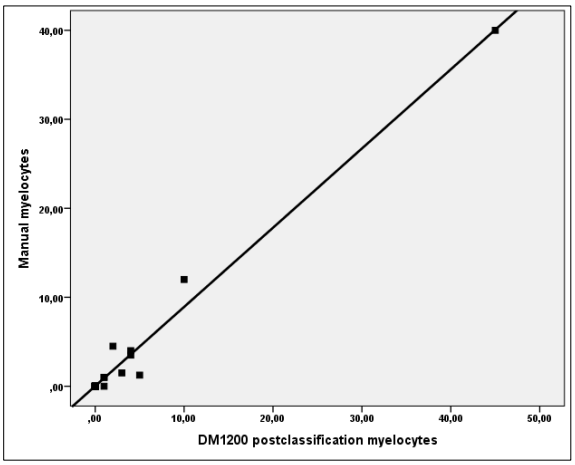
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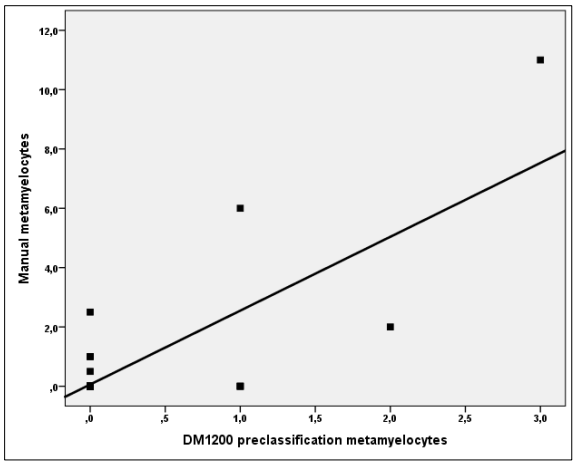
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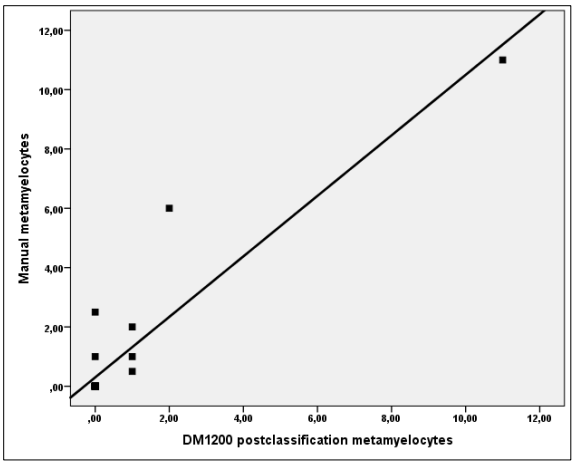
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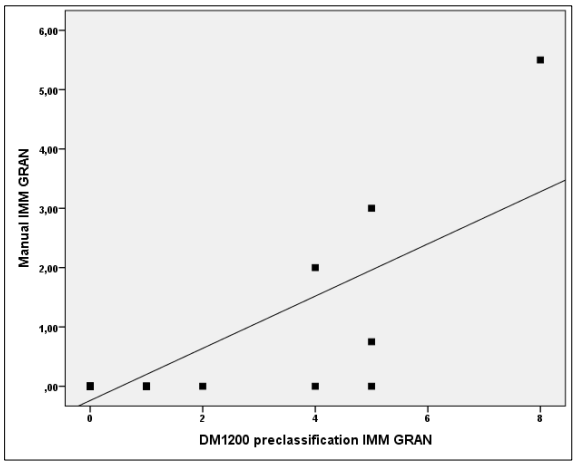
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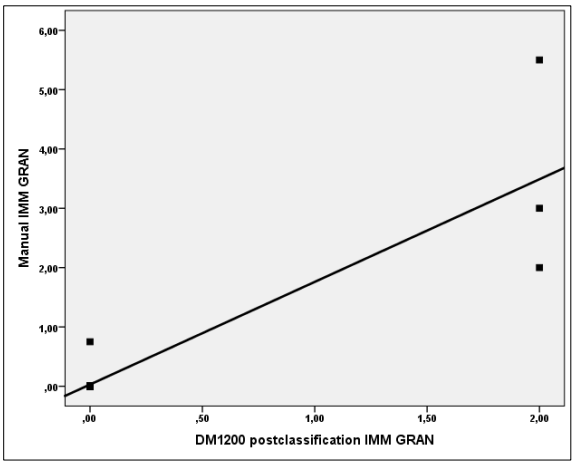
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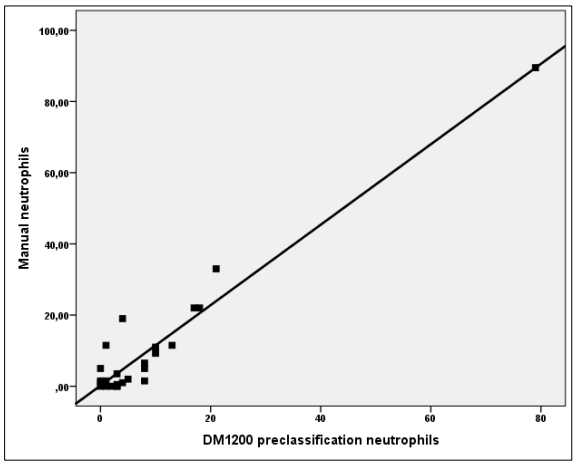
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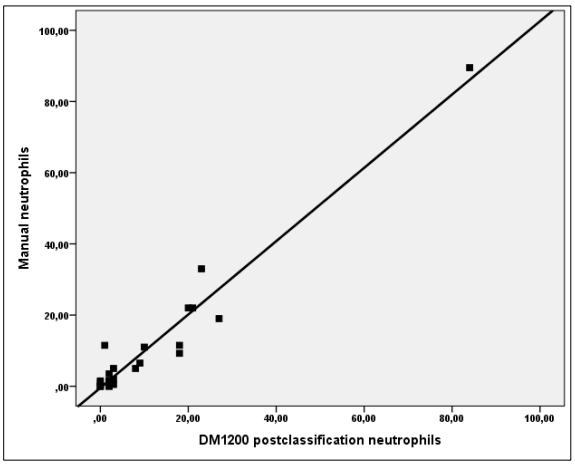
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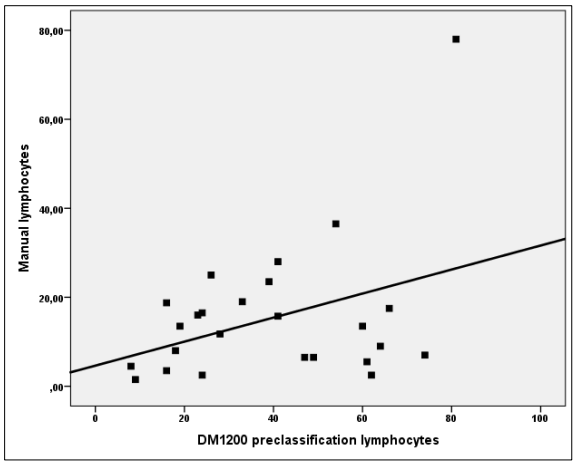
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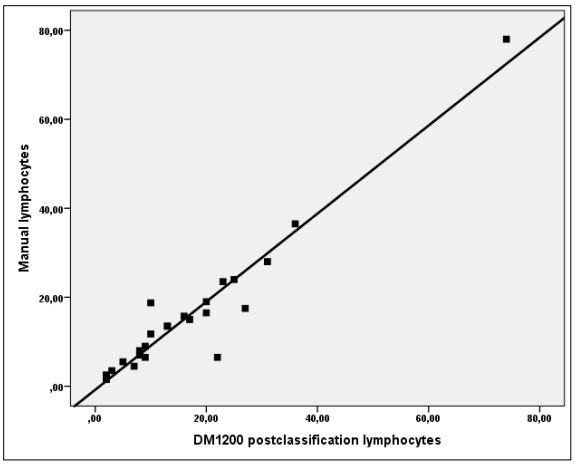
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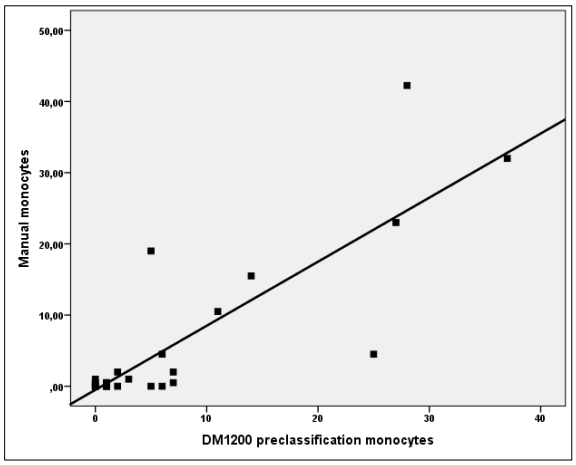
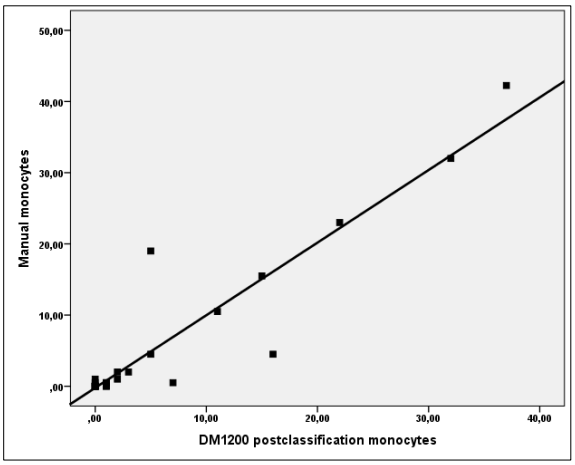
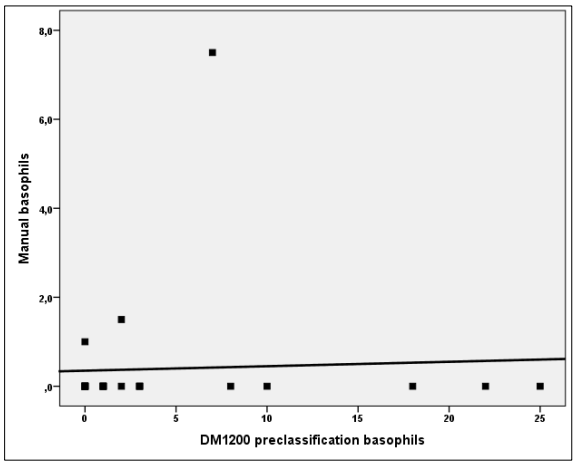
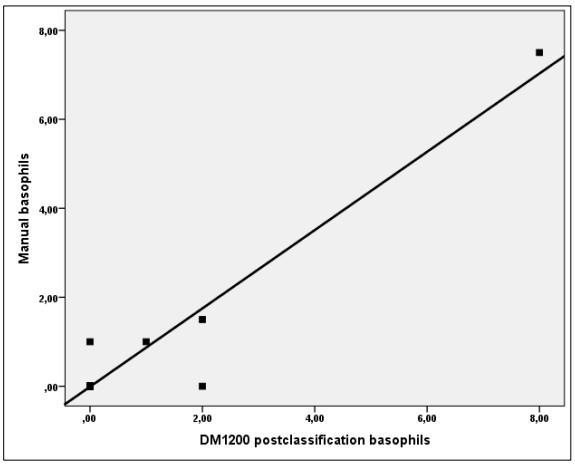

Manual monocytes
DM1200 preclassification monocytes


Manual monocytes
DM1200 postclassification monocytes


Manual basophils
DM1200 preclassification basophils


Manual basophils
DM1200 postclassification basophils

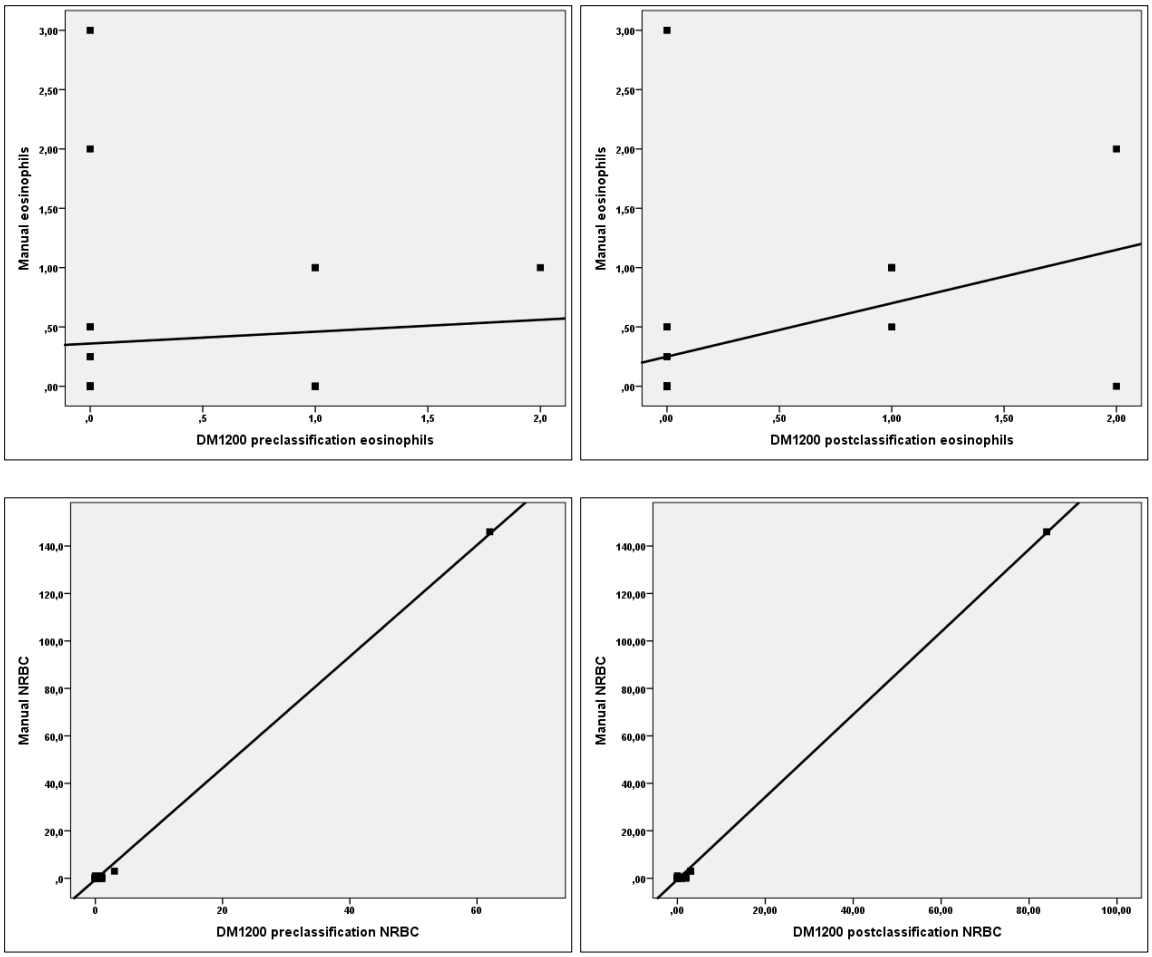


Figure 2 Comparison of WBC differentials between CellaVision DM1200 and manual count in pathological smears: A: pre-classification blasts. B: post-classification blasts. C : pre-classification promyelocytes. D: post-classification promyelocytes. E: pre-classification myelocytes. F: post-classification myelocytes. G: pre-classification metamyelocytes. H: post-classification metamyelocytes. I: pre-classification immature granulocytes. J: post-classification immature granulocytes

Ability of the CellaVision DM1200 system to identify clinically important abnormalities compared with manual microscopic differential counting:

The sensitivity of pre-classification was high for immature granulocytes, promyelocytes, and giant platelets (98%, 88%, and 98% respectively), while the sensitivity of reclassification increased for all cell classes except for platelet aggregates (50%). The sensitivity of the blasts increased from 38% to 91%. The specificity of the pre-classification was high for blasts, metamyelocytes, NRBC, and plasma cells (100%, 90%, 88%, 88% respectively). The specificity of the reclassification increased for all cell classes except for blasts and myelocytes (61%, 74%) (Table 7).

Table 7 Sensitivity and specificity of abnormal cells

CELL CLASS	SENSITIVITY	SENSITIVITY AFTER CORRECTION	SPECIFICITY	SPECIFICITY AFTER CORRECTION	EFFICIENCY	EFFICIENCY AFTER CORRECTION
PLATELET AGGREGATES	40%	50%	79%	100%	72%	90%
GIANT THROMBOCYTES	98%	100%	12%	95%	27%	96%
NRBC	61%	84%	88%	89%	69%	85%
BLASTS	38%	91%	100%	61%	39%	90%
PROMYELOCYTES	88%	100%	24%	88%	29%	90%
MYELOCYTES	42%	92%	51%	74%	46%	84%
METAMYELOCYTES	24%	62%	90%	98%	65%	84%
IMMATURE GRANULOCYTES	98%	100%	23%	92%	34%	93%
PLASMOCYTES	-	-	88%	96%	-	-

3.4. RBC analysis

The ability of Cellavision DM1200 to detect various erythrocyte abnormalities was evaluated by studying sensitivity and specificity, referring to the results of optical microscopy. The categories of erythrocyte abnormalities evaluated are: polychromia, hypochromia, microcytosis, macrocytosis, anisocytosis, and poikilocytosis. During the pre-classification, the sensitivity was > 90% for all abnormalities except hypochromia, while the specificity was > 97% for all abnormalities. During post-classification, the results reached 100% for all erythrocyte abnormalities (Table 8).

Table 8 Evaluation of color, size, and morphology abnormalities of RBCs

Red blood cell anomaly	Sensitivity Pre-classification	Post-classification Sensitivity	Specificity Pre-classification	Post-classification Specificity
Polychromia	100%	100%	97%	100%
Hypochromia	50%	100%	100%	100%
Anisocytosis	96%	100%	100%	100%
Microcytosis	93%	100%	97%	100%
Macrocytosis	90%	100%	100%	100%
Poikilocytosis	95%	100%	100%	100%

4. Discussion

In this study, we thoroughly evaluated the performance of Cellavision DM1200, including precision (repeatability, reproducibility), comparability of pre-classification and post-classification with manual counting, sensitivity and specificity in detecting abnormal cells, as well as the assessment of color, size, and morphological abnormalities of red blood cells. The percentage of the coefficient of variation (CV) for normal smears was excellent for mature neutrophils, good for lymphocytes, poor for the rest of the cells, which is explained by the low number of these cells in these samples. For the pathological smears, the CV was good for lymphocytes, acceptable for blasts and mature PNNs, and still poor for the rest of the cells. In previous studies including the analysis of pathological samples, the precision tended to increase with higher percentages of cells, but they also show that differences in CV even for samples with a similar average of cells. For example, a study analyzed samples with an almost identical mean relative number of monocytes (7.3 ± 7.65%), producing CVs ranging from 3.88% to 12.42%. This shows that not only the relative number of cells, but also many other characteristics have a significant influence on the precision obtained [8].

Reproducibility was evaluated from a sample prepared in 10 blood smears, the results were excellent for neutrophils,

acceptable for lymphocytes. In a previous study, good reproducibility was observed in each cell category except for band neutrophils, eosinophils, and basophils, which were in low numbers in all three cases tested on the DI-60 automated analyzer [6].

For comparability, we compared the data obtained from DM1200 with the manual count, which is the gold standard for WBC differentials. We evaluated not only normal samples but also abnormal samples, following the recommendations of the ICSH [5]. The pre-classification compared to manual counting in normal samples showed a high to very high correlation for normal cell classes except for monocytes, whose correlation was moderate. This is close to the result of a study that showed a weaker correlation at 0.11 for monocytes [2]. On the other hand, our results differ from those of other studies that showed weaker correlations in basophils, with the reported correlation coefficients being as follows: 0.56 for DI-60, 0.36 for vision Pro, 0.76 for DM96 [6,9,10]. In our study, banded neutrophils showed a moderate correlation, which aligns with the results of other studies [10,11]. The pre-classification compared to manual counting in pathological samples showed a high to very high correlation for the majority of cells, a moderate correlation for promyelocytes, and weak correlations for blasts and lymphocytes. This may be due to misclassification of the cells, as there are blasts that were counted as lymphocytes. This is demonstrated by the good correlation (> 0.90) between the reference method and the DM1200 post-classification. The very weak correlation for basophils may be due to the small number of cells counted.

A very high accuracy is required for blast detection to correctly diagnose patients with malignancies; manual microscopic revision is, therefore, mandatory for all smears with blast detection on DM1200. This microscopic revision is also important for patients with abnormal lymphocytes to precisely determine cases with mononucleosis syndrome.

The correlation for eosinophils is not as effective as the manual method; this could be a staining issue that could be avoided, as eosinophils appear more pink on the DM1200 screen than under the microscope [2].

For NRBC, in normal smears, a weak correlation is observed between DM1200 and manual counting, as for pathological smears, the comparability showed a very high correlation. This is explained by the low number of NRBCs in normal smears and their presence in pathological smears.

Our study shows a high overall efficiency in post-classification compared to pre-classification for all classes of abnormal cells, this is consistent with the results of previous studies evaluating DM96 and DI60 [2, 12]. Low sensitivity was found for blasts, myelocytes and metamyelocytes in pre-classification, these results show that these cells may be underestimated by DM1200. These results are similar to what was reported in a study that evaluated Vision Pro [9], and differ from the results of other studies that evaluated DM96 they showed a high sensitivity of blast detection 74%, 98%, 91% [13,10,14]. In our data, the specificity in pre-classification was high at 100% for blasts, this result is similar to what was reported by a previous study: 99.8% [11].

Regarding the assessment of erythrocyte abnormalities, our data showed high sensitivity for all abnormalities except hypochromia (50%), and high specificity for all abnormalities, which is consistent with the results of the sensitivity of hypochromia from a study evaluating DI-60. This previous study showed high specificity and low sensitivity for hypochromia and microcytosis, and low specificity with high sensitivity for macrocytosis and anisocytosis [12]. Our specificity results are similar to those of Egelé et al who reported a specificity >90% for all erythrocyte abnormalities [15]. In the cases with suspicion of hemoglobinopathies, manual revision is also required.

Regarding the platelets, studies have reported a failure of the CellaVision to detect platelet aggregates [3], due to the presence of platelet aggregates outside the area screened by the CellaVision, for example, in the feather and lateral edges of the smear.

Finally, ICSH recommendations clarified the situations in which CellaVision has limitations and for which a manual microscopic review should be considered. These situations are cited as follows: All samples from newborns and from patients with leukemia, suspicion of the presence of pathological cell types, including blasts, plasma cells, and immature granulocytes, suspected dysplastic cells, suspected schistocytes, screening for intracellular parasites (Malaria, Babesia, other parasites), RBC agglutinates, Platelet aggregates [3]. Our study also supports their opinions, seen that we have limitations for blasts, various immature cells, platelet aggregates, then for basophils and eosinophils.

5. Conclusion

After verification, the CELLAVISION DM1200's performance for WBC differential and detection of abnormalities of RBCs appears to be satisfactory, even in abnormal samples.

However, CELLAVISION DM1200 cannot fully replace manual WBC differential counting, reclassification and slide review are still required in abnormal samples.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

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