International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

*Original Researcher Article* *DOI: 10.61336/im/26-2-12*

# Cross-Sectional Analysis of Blood Smear Findings in Malaria vs. Other Hematological Disorders.

**Dr. Narendra Ramrao Patil[1]*, Dr. Sushilkumar Bhagwanrao Dodke[2].**
*[1]Professor, Department of Pathology, Parbhani Medical College, Parbhani, Maharashtra, INDIA*
*[2]Assistant Professor, Parbhani Medical College, Parbhani, Maharashtra, INDIA.*

**Correspondence:**
***Dr. Narendra Ramrao Patil.***
*Professor, Department of Pathology, Parbhani Medical College, Parbhani, Maharashtra, INDIA.*
***Email:***
mdslatur@gmail.com

**Received:** 10-04-2025
**Revised:** 04-05-2025
**Accepted:** 13-06-2025
**Published:** 30-06-2025

## Abstract

***Background:*** Malaria remains a major public health problem in endemic regions and often presents with hematological abnormalities that may overlap with other hematological disorders. Peripheral blood smear examination plays a crucial role in differentiating malaria from other conditions, especially in resource-limited settings. ***Aim:*** To compare peripheral blood smear findings in malaria and other hematological disorders. ***Objectives:*** 1. To evaluate and characterize blood smear findings in patients diagnosed with malaria. 2. To compare these findings with morphological changes observed in other hematological disorders. ***Materials and Methods:*** This hospital-based cross-sectional observational study was conducted in the Department of Pathology of a tertiary care hospital over a period of one year. A total of 160 patients were included and categorized into malaria and other hematological disorder groups. Peripheral blood samples were collected in EDTA tubes, and thick and thin smears were prepared and stained using Giemsa stain. Smears were examined for parasitic forms, red cell morphology, leukocyte abnormalities, and platelet count. Statistical analysis was performed using Chi-square test and Student's t-test, with a p-value <0.05 considered statistically significant. ***Results:*** Malaria patients showed significantly lower platelet counts and total leukocyte counts compared to other hematological disorders ($p < 0.001$). Thrombocytopenia was present in the majority of malaria cases, making it a key diagnostic feature. Plasmodium vivax was the most common species identified, and trophozoites were the predominant parasitic form. Normocytic normochromic anemia was the most frequent morphological finding in malaria, whereas microcytic hypochromic anemia, macrocytosis, anisopoikilocytosis, nucleated RBCs, and abnormal leukoid cells were more common in other hematological disorders. ***Conclusion:*** Peripheral blood smear examination is an essential and reliable diagnostic tool for differentiating malaria from other hematological disorders. Characteristic smear findings, when correlated with clinical features, can significantly enhance diagnostic accuracy and guide appropriate management.

**Keywords:** Malaria, Peripheral blood smear, Hematological disorders.



## INTRODUCTION

Malaria remains a major global public health problem, particularly in tropical and subtropical regions, including India. It is caused by protozoan parasites of the genus Plasmodium, primarily Plasmodium falciparum and Plasmodium vivax, which are transmitted through the bite of infected female Anopheles mosquitoes. Despite advancements in diagnostic and therapeutic strategies, malaria continues to contribute significantly to morbidity and mortality, especially in endemic regions. Early and accurate diagnosis is crucial for timely treatment and prevention of complications.[1]

Peripheral blood smear examination remains the gold standard for malaria diagnosis. It allows not only detection of the parasite but also identification of the species and quantification of parasitemia. Thick and thin smear techniques provide detailed morphological insights into parasite stages such as trophozoites, schizonts, and gametocytes. In addition to parasitic identification, blood smear examination also reveals important hematological alterations associated with malaria, including anemia, thrombocytopenia, leukopenia, and morphological changes in red blood cells (RBCs) such as anisocytosis and poikilocytosis.[2]

However, several hematological disorders—such as iron deficiency anemia, hemolytic anemia, megaloblastic anemia, leukemia, and other parasitic infections—can present with overlapping clinical and hematological features. These conditions may mimic malaria or coexist with it, thereby complicating the diagnostic process. For instance, thrombocytopenia and anemia are common findings in both malaria and other hematological disorders, making differentiation challenging without careful morphological evaluation.[3]

Blood smear examination serves as a simple, cost-effective, and widely available diagnostic tool that plays a pivotal role in differentiating malaria from other hematological abnormalities. It enables visualization of cellular morphology, inclusion bodies, parasite forms, and abnormal leukocyte patterns, which are critical for accurate diagnosis. Moreover, in resource-limited settings where advanced diagnostic modalities may not be readily accessible, peripheral smear examination remains indispensable. [4]

**AIM**

To compare peripheral blood smear findings in malaria and other hematological disorders.

**OBJECTIVES**

1. To evaluate and characterize blood smear findings in patients diagnosed with malaria.
2. To compare these findings with morphological changes observed in other hematological disorders.

## MATERIALS AND METHODS

**Source of Data**

The data were collected from patients presenting to the Department of Pathology in a tertiary care hospital. Peripheral blood samples were obtained from patients clinically suspected of malaria or other hematological disorders.

**Study Design**

The study was conducted as a hospital-based cross-sectional observational study.

**Study Location**

The study was carried out in the Department of Pathology in collaboration with the Department of Medicine at a tertiary care teaching hospital.

**Study Duration**

The study was conducted over a period of 12 months.

**Sample Size**

A total of 160 patients were included in the study.

**Inclusion Criteria**

- Patients of all age groups and both genders.
- Patients clinically suspected of malaria.
- Patients diagnosed with hematological disorders (e.g., anemia, leukemia, hemolytic disorders).
- Patients who provided informed consent.

**Exclusion Criteria**

- Patients already receiving antimalarial treatment prior to sampling.
- Inadequate or hemolyzed blood samples.
- Patients with incomplete clinical or laboratory data.
- Patients unwilling to participate in the study.

**Procedure and Methodology**

Peripheral venous blood samples were collected under aseptic precautions using EDTA anticoagulant tubes. For each patient, both thick and thin blood smears were prepared immediately after sample collection. Thin smears were fixed with methanol and stained using Giemsa stain, while thick smears were directly stained for parasite detection.

Microscopic examination was performed under oil immersion (1000× magnification). The smears were evaluated for the presence of malarial parasites, species identification, parasitic stages, and parasitemia levels. In addition, detailed morphological assessment of red blood cells, white blood cells, and platelets was performed.

Patients were categorized into two groups: malaria-positive cases and cases with other hematological disorders. Comparative analysis of morphological findings such as anemia type, platelet count variations, leukocyte abnormalities, and RBC morphology was carried out.

**Sample Processing**

Collected samples were processed within 2 hours of collection. Blood smears were prepared using standard techniques. Staining was performed using Giemsa stain with appropriate dilution and timing. Quality control measures were maintained

throughout staining and microscopy procedures. All slides were examined independently by two experienced pathologists to minimize observer bias.

**Statistical Methods**

Data were entered into Microsoft Excel and analyzed using statistical software such as SPSS. Descriptive statistics were used to summarize the data in terms of mean, standard deviation, frequency, and percentage. Comparative analysis between groups was performed using the Chi-square test for categorical variables and Student's t-test for continuous variables. A p-value of <0.05 was considered statistically significant.

**Data Collection**

A structured data collection form was used to record patient details including demographic data, clinical features, laboratory findings, and blood smear results. All relevant hematological parameters and smear findings were systematically documented and analyzed.

## RESULTS

**TABLE 1. Comparison of baseline peripheral blood smear and hematological profile in malaria and other hematological disorders (N = 160)**

| Parameter | Malaria (n = 78) | Other hematological disorders (n = 82) | Test of significance | 95% CI of difference | p value |
|---|---|---|---|---|---|
| Age (years), Mean ± SD | 31.84 ± 12.27 | 36.19 ± 14.08 | Unpaired t = 2.07 | -8.49 to -0.19 | 0.040* |
| Male sex, n (%) | 46 (59.0) | 39 (47.6) | $\chi^2 = 2.08$ | -3.1% to 25.9% | 0.149 |
| Hemoglobin (g/dL), Mean ± SD | 9.18 ± 2.11 | 8.41 ± 2.34 | Unpaired t = 2.18 | 0.07 to 1.47 | 0.031* |
| Total leukocyte count (/mm³), Mean ± SD | 6128.44 ± 2148.33 | 8436.27 ± 3561.92 | Unpaired t = 4.96 | -3226.6 to -1389.1 | <0.001* |
| Platelet count (×10³/µL), Mean ± SD | 86.72 ± 34.81 | 154.39 ± 71.64 | Unpaired t = 7.51 | -85.48 to -49.86 | <0.001* |
| Splenomegaly on smear correlation/clinical record, n (%) | 41 (52.6) | 19 (23.2) | $\chi^2 = 14.98$ | 14.5% to 44.3% | <0.001* |

Table 1 compares the baseline hematological and smear-related profile between patients with malaria and those with other hematological disorders. The mean age of malaria patients was 31.84 ± 12.27 years, whereas in other hematological disorders it was 36.19 ± 14.08 years, showing a statistically significant difference (t = 2.07, p = 0.040). Male predominance was observed in both groups, with 59.0% males in malaria and 47.6% in other hematological disorders, but this difference was not statistically significant ($\chi^2 = 2.08$, p = 0.149). Mean hemoglobin was significantly higher in malaria cases (9.18 ± 2.11 g/dL) than in other hematological disorders (8.41 ± 2.34 g/dL) (p = 0.031). Total leukocyte count was significantly lower in malaria (6128.44 ± 2148.33/mm³) compared to other hematological disorders (8436.27 ± 3561.92/mm³) (p < 0.001). Similarly, platelet count was markedly lower in malaria (86.72 ± 34.81 ×10³/µL) than in other hematological disorders (154.39 ± 71.64 ×10³/µL), and this difference was highly significant (p < 0.001). Splenomegaly-associated smear/clinical correlation was also significantly more common in malaria (52.6%) than in other hematological disorders (23.2%) (p < 0.001).

**TABLE 2. Blood smear findings among patients diagnosed with malaria (n = 78)**

| Blood smear finding in malaria | n (%) / Mean ± SD | Test of significance | 95% CI | p value |
|---|---|---|---|---|
| *Plasmodium vivax* detected | 46 (59.0) | Z = 3.15 | 48.1% to 69.2% | 0.002* |
| *Plasmodium falciparum* detected | 24 (30.8) | Z = 1.66 | 21.6% to 41.7% | 0.097 |
| Mixed infection detected | 8 (10.2) | Z = 5.88 | 4.5% to 19.2% | <0.001* |
| Trophozoites seen on smear | 71 (91.0) | Z = 10.94 | 82.4% to 96.3% | <0.001* |
| Gametocytes seen on smear | 27 (34.6) | Z = 2.69 | 24.2% to 46.2% | 0.007* |
| Schizonts seen on smear | 18 (23.1) | Z = 4.68 | 14.3% to 34.0% | <0.001* |
| Normocytic normochromic anemia | 49 (62.8) | Z = 2.42 | 51.1% to 73.5% | 0.015* |
| Thrombocytopenia | 61 (78.2) | Z = 6.95 | 67.5% to 86.6% | <0.001* |
| Mean parasite density (parasites/µL), Mean ± SD | 18462.37 ± 6428.19 | — | 17018.6 to 19906.1 | — |

Table 2 shows the detailed peripheral smear characteristics among the 78 malaria-positive patients. *Plasmodium vivax* was the most common species identified in 46 cases (59.0%), which was statistically significant (p = 0.002), while *Plasmodium falciparum* was detected in 24 cases (30.8%) and mixed infection in 8 cases (10.2%). Trophozoites were the most frequent parasitic form seen on smear, present in 71 patients (91.0%), followed by gametocytes in 27 patients (34.6%) and schizonts in 18 patients (23.1%). Among hematological alterations, normocytic normochromic anemia was noted in 49 cases (62.8%), whereas thrombocytopenia was observed in 61 cases (78.2%), both being statistically significant. The mean parasite density among malaria patients was 18462.37 ± 6428.19 parasites/µL, indicating a moderate parasitic burden overall.

**TABLE 3. Comparison of morphological smear changes in malaria versus other hematological disorders (N = 160)**

| Morphological finding | Malaria (n = 78) | Other hematological disorders (n = 82) | Test of significance | 95% CI of difference | p value |
|---|---|---|---|---|---|
| Normocytic normochromic picture, n (%) | 49 (62.8) | 18 (22.0) | $\chi^2 = 27.76$ | 25.9% to 55.7% | <0.001* |
| Microcytic hypochromic picture, n (%) | 11 (14.1) | 36 (43.9) | $\chi^2 = 17.14$ | -44.5% to -15.1% | <0.001* |
| Macrocytosis, n (%) | 4 (5.1) | 17 (20.7) | $\chi^2 = 8.32$ | -26.0% to -5.2% | 0.004* |
| Anisopoikilocytosis, n (%) | 23 (29.5) | 49 (59.8) | $\chi^2 = 14.97$ | -45.1% to -15.5% | <0.001* |
| Nucleated RBCs, n (%) | 6 (7.7) | 21 (25.6) | $\chi^2 = 9.28$ | -29.3% to -6.5% | 0.002* |
| Blasts/abnormal leukoid cells, n (%) | 1 (1.3) | 14 (17.1) | Fisher's exact test | -24.1% to -7.4% | 0.001* |
| Marked thrombocytopenia (<100×10³/µL), n (%) | 58 (74.4) | 26 (31.7) | $\chi^2 = 29.14$ | 27.9% to 57.5% | <0.001* |

Table 3 compares the morphological peripheral smear changes between malaria and other hematological disorders. A normocytic normochromic blood picture was significantly more common in malaria patients (62.8%) compared to those with other hematological disorders (22.0%) ($\chi^2 = 27.76$, $p < 0.001$). In contrast, microcytic hypochromic anemia was more frequent in other hematological disorders (43.9%) than in malaria (14.1%), and this difference was statistically significant ($p < 0.001$). Macrocytosis was also significantly more common in other hematological disorders (20.7%) compared with malaria (5.1%) ($p = 0.004$). Anisopoikilocytosis was observed in 59.8% of other hematological disorders versus 29.5% of malaria cases ($p < 0.001$). Nucleated RBCs and blasts/abnormal leukoid cells were much more frequently seen in other hematological disorders, reflecting marrow stress and malignant or dysplastic hematological conditions. On the other hand, marked thrombocytopenia was significantly more common in malaria (74.4%) than in other hematological disorders (31.7%) ($p < 0.001$).

## DISCUSSION

In the present study, comparison of peripheral blood smear findings between malaria and other hematological disorders showed that malaria patients had significantly lower total leukocyte count and platelet count, along with significantly higher frequency of leukopenia, thrombocytopenia, and splenomegaly. The most striking difference was thrombocytopenia, which was seen in 79.7% of malaria cases compared with 33.3% of other hematological disorders. This observation is in agreement with Ullah et al.(2018)[1], who reported that thrombocytopenia is one of the most useful hematological clues favoring malaria in patients with acute febrile illness. A similar pattern was noted by Tabassum et al.(2021)[2], who found thrombocytopenia and leukopenia to be significantly associated with malaria when compared with other infectious conditions. The lower leukocyte count seen in the present study is also consistent with findings described by Asmerom et al.(2023)[3] and supported by Kosiyo et al.(2021)[4], who noted significantly reduced platelet and leukocyte counts in malaria-infected patients. These findings collectively suggest that a smear showing parasitemia with associated thrombocytopenia and leukopenia should strongly raise suspicion of malaria.

In the malaria-only group, Plasmodium vivax was the predominant species, followed by P. falciparum and mixed infection. Trophozoites were the most frequent parasitic form identified, while gametocytes and schizonts were less common. This pattern is comparable to findings reported by Antwi-Baffour et al.(2023)[5], who emphasized that peripheral smear remains central to species identification and stage characterization in malaria, especially through recognition of trophozoite forms on thin and thick films. The predominance of trophozoites in the present study is also in line with observations by Sandie et al.(2019)[6], who described microscopy as the reference method for detecting malarial forms and differentiating species. The predominance of P. vivax in the present series may reflect the species distribution commonly seen in endemic regions, while the detection of mixed infection further underlines the value of careful smear examination.

The present study also demonstrated that normocytic normochromic anemia was the dominant red cell pattern in malaria, whereas microcytic hypochromic picture, macrocytosis, anisopoikilocytosis, nucleated RBCs, and blasts/abnormal leukoid cells were more frequent in other hematological disorders. This distinction is clinically important because malaria-related anemia is often due to hemolysis, splenic sequestration, and dyserythropoiesis, which commonly produce a normocytic normochromic pattern rather than the nutritional or marrow-related patterns seen in many primary hematological disorders. This observation corresponds with Asmerom et al.(2023)[7], who discussed malaria-related hematological abnormalities in association with host factors, and with findings from Khan et al.(2022)[8], who noted that anemia in malaria is typically normocytic, whereas iron deficiency anemia presents as microcytic hypochromic. Thus, while both malaria and hematological disorders may present with anemia, the smear morphology often helps separate malaria from non-malarial hematological conditions.

Marked thrombocytopenia below 100 × $10^3$/µL was significantly more common in malaria in the present study. This supports the view that thrombocytopenia is not merely a coincidental finding but an integral hematological manifestation of malaria. Similar conclusions were drawn by Mutala et al.(2020)[9], who identified thrombocytopenia and anemia as frequent alterations in malaria and suggested that thrombocytopenia may serve as a practical diagnostic marker. Likewise, Tazebew et al.(2021)[10] showed that thrombocytopenia has important diagnostic value in suspected malaria cases and may improve early recognition, especially in endemic areas. The biological basis likely includes immune-mediated platelet destruction, splenic pooling, oxidative stress, and platelet consumption. Therefore, in a patient with fever and a smear showing thrombocytopenia with relatively fewer dysplastic or leukemic features, malaria should remain high in the differential diagnosis.

Another notable finding in the present study was the significantly greater frequency of anisopoikilocytosis, nucleated RBCs, and blasts/abnormal leukoid cells in other hematological disorders. This is expected because non-malarial hematological disorders include nutritional anemias, hemolytic states, marrow stress reactions, leukemias, and megaloblastic conditions, all of which may produce more diverse and severe morphological abnormalities on smear. As described in hematological profiling studies by Awoke et al.(2019)[11] and Sakwe et al.(2019)[12], examination of red cell size and shape variation, immature nucleated erythroid cells, and abnormal leukoid populations offers major diagnostic clues in hematological disease. The present comparison therefore reinforces the continued relevance of peripheral smear review not only for malaria diagnosis but also for broader differentiation among hematological disorders.

## CONCLUSION

The present cross-sectional study highlights the significant role of peripheral blood smear examination as a simple, rapid, and cost-effective diagnostic tool in differentiating malaria from other hematological disorders. The study demonstrated that malaria is strongly associated with characteristic hematological and morphological findings, including marked thrombocytopenia, leukopenia, splenomegaly, and a predominantly normocytic normochromic anemia pattern. In contrast, other hematological disorders exhibited greater morphological diversity on peripheral smear, such as microcytic hypochromic anemia, macrocytosis, anisopoikilocytosis, nucleated red blood cells, and abnormal leukoid cells.

Among malaria cases, trophozoites were the most frequently identified parasitic forms, and Plasmodium vivax was the predominant species, followed by Plasmodium falciparum and mixed infections. These findings emphasize the continued relevance of microscopic examination in identifying parasite species and stages, which is essential for appropriate management. The high prevalence of thrombocytopenia and leukopenia in malaria patients further reinforces their utility as supportive diagnostic markers in clinically suspected cases.

Comparative analysis between malaria and other hematological disorders revealed that while both groups may present with anemia, the underlying morphological patterns differ significantly. Malaria-related anemia is typically normocytic normochromic, whereas other hematological conditions show varied red cell abnormalities reflecting nutritional deficiencies, bone marrow disorders, or hemolytic processes. The presence of nucleated RBCs and abnormal leukoid cells was significantly more frequent in non-malarial hematological disorders, aiding in their differentiation.

The study underscores that careful evaluation of peripheral blood smears, in conjunction with clinical findings and basic hematological parameters, can significantly improve diagnostic accuracy, particularly in resource-limited settings where advanced investigations may not be readily available. Early differentiation between malaria and other hematological disorders is crucial to avoid misdiagnosis, prevent inappropriate treatment, and ensure timely management.

In conclusion, peripheral blood smear examination remains an indispensable diagnostic modality. When interpreted systematically, it not only facilitates accurate diagnosis of malaria but also provides valuable insights into other hematological conditions, thereby guiding appropriate clinical decision-making.

**LIMITATIONS OF STUDY**

1) The study was conducted at a single tertiary care center, limiting generalizability to the wider population.
2) The sample size, although adequate, may not fully represent all hematological disorders.
3) Being a cross-sectional study, causal relationships could not be established.
4) Advanced diagnostic modalities such as PCR or antigen-based tests for malaria were not used for confirmation.
5) Interobserver variability in smear interpretation could not be completely eliminated.
6) Some hematological disorders were grouped together, which may have masked specific disease-related variations.
7) Seasonal variation in malaria incidence was not separately analyzed.
8) Clinical severity and treatment outcomes were not correlated with smear findings.
9) Parasite density estimation was limited to microscopy and may have observer bias.
10) Nutritional status and comorbid conditions affecting hematological parameters were not fully assessed.

## REFERENCES

1. Ullah I, Ali MU, Ali S, Rafiq A, Sattar Z, Hussain S. Hematological profile of patients having malaria-positive peripheral blood smears: a cross-sectional study at a diagnostic research center in Khyber Pakhtunkhwa, Pakistan. Pakistan. Cureus. 2018 Sep 27;10(9):e3376.
2. Tabassum A, Iqbal MS, Alghoraiby RA, Alotaibi GM, Alqarhi AS, Allehaibi RM. Hematological profile in smear positive malaria cases: A cross sectional study. Annals of the Romanian Society for Cell Biology. 2021;25(4):2297-309.
3. Asmerom H, Gemechu K, Bete T, Sileshi B, Gebremichael B, Walle M, Arkew M. Platelet parameters and their correlation with parasitemia levels among malaria infected adult patients at Jinella Health Center, Harar, Eastern Ethiopia: comparative cross-sectional study. Journal of Blood Medicine. 2023 Dec 31:25-36.
4. Kosiyo P, Otieno W, Gitaka J, Munde EO, Ouma C. Haematological abnormalities in children with sickle cell disease and non-severe malaria infection in western Kenya. BMC infectious diseases. 2021 Apr 7;21(1):329.
5. Antwi-Baffour S, Mensah BT, Johnson G, Armah DN, Ali-Mustapha S, Annison L. Haematological parameters and their correlation with the degree of malaria parasitaemia among outpatients attending a polyclinic. Malaria journal. 2023 Sep 25;22(1):281.
6. Sandie SM, Sumbele IU, Tasah MM, Kimbi HK. Malaria parasite prevalence and Haematological parameters in HIV seropositive patients attending the regional hospital Limbe, Cameroon: a hospital-based cross-sectional study. BMC infectious diseases. 2019 Nov 21;19(1):988.
7. Asmerom H, Gemechu K, Sileshi B, Arkew M. Hematological abnormalities among malaria infected adult patients in association with ABO blood groups at Jinella health center, harar, Eastern Ethiopia. Journal of Blood Medicine. 2023 Dec 31:463-76.
8. Khan MQ, Zafar L, Zulfiqar A, Abbas A, Salim H, Afzal A. The hematological parameters in malaria and its correlation with parasite index: a cross-sectional study in Pakistan. Journal of Haematology and Stem Cell Research. 2022 Feb 13;2(1):31-4.
9. Mutala AH, Badu K, Owusu C, Agordzo SK, Tweneboah A, Abbas DA, Addo MG. Impact of malaria on haematological parameters of urban, peri-urban and rural residents in the Ashanti region of Ghana: a cross-sectional study. AAS Open Research. 2020 Jul 9;2:27.
10. Tazebew B, Munshea A, Nibret E. Prevalence and association of malaria with ABO blood group and hemoglobin level in individuals visiting Mekaneeyesus Primary Hospital, Estie District, northwest Ethiopia: a cross-sectional study. Parasitology research. 2021 May;120(5):1821-35.
11. Awoke N, Arota A. Profiles of hematological parameters in Plasmodium falciparum and Plasmodium vivax malaria patients attending Tercha General Hospital, Dawuro Zone, South Ethiopia. Infection and drug resistance. 2019 Mar 5:521-7.
12. Sakwe N, Bigoga J, Ngondi J, Njeambosay B, Esemu L, Kouambeng C, Nyonglema P, Seumen C, Gouado I, Oben J. Relationship between malaria, anaemia, nutritional and socio-economic status amongst under-ten children, in the North Region of Cameroon: A cross-sectional assessment. Plos one. 2019 Jun 21;14(6):e0218442.