International Journal of Medical and Pharmaceutical Research

Online ISSN-2958-3683 | Print ISSN-2958-3675
Frequency: Bi-Monthly
Website: https://ijmpr.in/

Research Article

Comparative Evaluation of Hematological Parameters in Sickle Cell Trait and Sickle Cell Disease

Dr. Sanket Khimabhai Der

Senior Resident, Pathology Department, GMERS Rajpipla

OPEN ACCESS

Corresponding Author:

Dr. Sanket Khimabhai Der
Senior Resident, Pathology Department, GMERS Rajpipla.

Received: 06-02-2026
Accepted: 05-03-2026
Published: 14-03-2026

ABSTRACT

Introduction: Sickle cell disease (SCD) is a hereditary hemoglobinopathy caused by a mutation in the β-globin gene that results in the formation of hemoglobin S (HbS). Under hypoxic conditions, HbS polymerizes and causes red blood cells to assume a sickle shape, leading to hemolysis and vaso-occlusive complications. Individuals with sickle cell trait (SCT) are usually asymptomatic but may show mild hematological variations. Sickle cell disorders are highly prevalent in several regions of India, particularly among tribal populations.

Methods: A cross-sectional comparative study was conducted in a tertiary care hospital. Patients diagnosed with sickle cell hemoglobinopathies using high-performance liquid chromatography (HPLC) were included. Hematological parameters, including hemoglobin, RBC count, MCV, MCH, MCHC, and RDW, were recorded and compared between sickle cell trait and sickle cell disease groups. Statistical analysis was performed using SPSS version 26.

Results: A total of **120 patients** were included in the study. Among them, **70 (58.3%) had sickle cell trait and 50 (41.7%) had sickle cell disease**. The majority of participants belonged to the **18–30 years age group (41.7%)**, and males constituted **55%** of the study population. Patients with sickle cell disease showed significantly lower hemoglobin levels (**8.9 ± 1.8 g/dL**) compared with trait carriers (**11.8 ± 1.5 g/dL**, $p<0.001$). RBC count and red cell indices were also lower in the disease group, whereas RDW values were higher. HPLC analysis revealed significantly higher HbS levels in sickle cell disease patients.

Conclusion: Significant differences were observed in hematological parameters and hemoglobin fractions between sickle cell trait and sickle cell disease patients. Combined evaluation using hematological indices and HPLC plays an important role in diagnosis and differentiation of sickle cell disorders.

Keywords*: Sickle cell disease, sickle cell trait, hematological parameters, hemoglobin S, HPLC.*

INTRODUCTION

Sickle cell disease is a genetic hemoglobinopathy caused by a point mutation in the β-globin gene that leads to the formation of hemoglobin S (HbS). Under hypoxic conditions, HbS polymerizes and causes deformation of red blood cells into sickle-shaped forms. These abnormal cells exhibit decreased deformability and increased fragility, resulting in hemolysis and recurrent vaso-occlusive events [1].

Sickle cell disease contributes significantly to global morbidity and mortality, particularly in regions where malaria has historically been endemic. In India, sickle cell disorders are predominantly observed among tribal populations in central and western states such as Gujarat, Maharashtra, Madhya Pradesh, and Chhattisgarh [2].

Epidemiological studies have reported varying prevalence rates of sickle cell disorders across India. Balgir reported that the prevalence of sickle cell trait in tribal populations ranges between **5% and 15%**, while the prevalence of sickle cell disease is generally **below 2%** [3]. A community-based study by Purohit et al. documented prevalence rates of **9.87% for sickle cell trait and 0.32% for sickle cell disease** among tribal groups in Rajasthan [4]. Similarly, **Kamble and Chaturvedi** reported that the prevalence of sickle cell disease was **5.7%** among patients attending a rural hospital in central India, highlighting the significant burden of the disease in this region [5].

Hematological abnormalities are commonly observed in patients with sickle cell disease due to chronic hemolysis and increased erythropoietic activity. These patients typically present with anemia, reduced RBC counts, and altered red cell indices compared with individuals carrying the sickle cell trait [6]. Therefore, comparative evaluation of hematological parameters between sickle cell trait and sickle cell disease patients may provide useful information for diagnosis and clinical management.

Aim: To compare hematological parameters between patients with sickle cell trait and sickle cell disease.

OBJECTIVES

1. To evaluate hematological parameters in patients with sickle cell trait.
2. To evaluate hematological parameters in patients with sickle cell disease.
3. To compare red cell indices and hemoglobin fractions between the two groups.

METHODOLOGY

The present study was designed as a cross-sectional comparative study conducted in the Department of Pathology at a tertiary care hospital. The study population consisted of patients diagnosed with sickle cell hemoglobinopathies, including sickle cell trait and sickle cell disease, confirmed through high-performance liquid chromatography (HPLC) analysis. Patients attending the hospital during the study period and meeting the inclusion criteria were enrolled for evaluation of hematological parameters and comparative analysis between the two groups.

Sample Size: The sample size for the study was determined based on the reported prevalence of sickle cell disease of **5.7%** from a previous epidemiological study conducted in central India by **Kamble and Chaturvedi** [5]. Accordingly, the minimum required sample size was estimated, and **120 participants were included in the study** to ensure adequate representation and improve the reliability of the findings.

Inclusion Criteria

- Patients diagnosed with sickle cell trait or sickle cell disease by HPLC
- Patients of both genders and all age groups

Exclusion Criteria

- Patients with other hemoglobinopathies
- Patients who had received blood transfusion within the last three months
- Incomplete laboratory data

Data Collection and Statistical Analysis

Blood samples were collected from the study participants and analyzed using automated hematology analyzers. The hematological parameters recorded included hemoglobin concentration, red blood cell (RBC) count, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), and red cell distribution width (RDW). In addition, peripheral smear examination was performed to evaluate red blood cell morphology, and high-performance liquid chromatography (HPLC) was used to confirm and classify the type of hemoglobinopathy.

The collected data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) software version 26.0. Continuous variables were expressed as mean ± standard deviation, and comparisons between the sickle cell trait and sickle cell disease groups were performed using Student's t-test. A p-value of less than 0.05 was considered statistically significant.

RESULTS

A total of **120 patients diagnosed with sickle cell hemoglobinopathies** were included in the study. The age distribution showed that the **majority of participants belonged to the 18–30 years age group (41.7%)**, followed by **31–45 years (33.3%)**, while **16.7% were younger than 18 years** and **8.3% were above 45 years of age**. These findings indicate that sickle cell disorders were more commonly detected among young adults in the present study.

Regarding gender distribution, **males constituted 55% of the study population**, while **females accounted for 45%**, indicating a slight male predominance. However, sickle cell disorders were observed in both genders.

Table 1: Distribution of Sickle Cell Disorders

Diagnosis	Frequency	Percentage
Sickle Cell Trait	70	58.3%
Sickle Cell Disease	50	41.7%

Sickle cell trait was more common than sickle cell disease in the present study, with **70 individuals identified as carriers** and **50 individuals diagnosed with sickle cell disease**.

Patients with sickle cell disease showed **significantly lower hemoglobin levels and RBC counts** compared with individuals with sickle cell trait. Red cell indices such as **MCV and MCH were also lower in the disease group**, indicating increased hemolysis and ineffective erythropoiesis. In contrast, **RDW values were significantly higher in sickle cell disease**, reflecting greater variability in red blood cell size.

Table 2: Comparison of Hematological Parameters

Parameter	SCT (Mean ± SD)	SCD (Mean ± SD)	p-value
Hemoglobin	11.8 ± 1.5	8.9 ± 1.8	<0.001
RBC Count	4.5 ± 0.6	3.2 ± 0.7	<0.001
MCV	84 ± 6	76 ± 7	0.002
MCH	27 ± 3	23 ± 3	0.004
MCHC	33 ± 2	30 ± 3	0.006
RDW	14 ± 2	18 ± 3	<0.001

Hemoglobin fraction analysis revealed significant differences between the two groups. **HbA levels were significantly higher in sickle cell trait**, whereas **HbS levels were markedly higher in sickle cell disease patients**. HbF levels were also elevated in the disease group, possibly representing a compensatory response. A slight increase in HbA_2 was also observed in sickle cell disease patients.

Table 3: Comparison of Hemoglobin Fractions (HPLC)

Fraction	SCT (%)	SCD (%)	p-value
HbA	58.6 ± 5.2	3.4 ± 2.1	<0.001
HbS	38.9 ± 4.8	88.5 ± 6.2	<0.001
HbF	1.8 ± 0.9	6.4 ± 2.5	<0.001
HbA_2	2.7 ± 0.6	3.1 ± 0.7	0.03

DISCUSSION

The present study demonstrated that **sickle cell trait was more prevalent than sickle cell disease**, with 58.3% of cases identified as trait carriers. Similar observations were reported by **Purohit et al. [4]**, who documented a higher prevalence of sickle cell trait (9.87%) compared with sickle cell disease (0.32%) in tribal populations.

In the present study, the **mean hemoglobin level was significantly lower in sickle cell disease patients (8.9 g/dL) compared with sickle cell trait individuals (11.8 g/dL)**. Comparable findings were reported by **Patel et al. [6]**, who studied 61 patients and reported significant hematological differences between sickle cell disease (47 cases) and sickle cell trait (14 cases), indicating more severe hematological alterations in disease patients.

Similarly, the **RBC count was lower in sickle cell disease patients (3.2 million/µL)** compared with **sickle cell trait individuals (4.5 million/µL)** in the present study. **Modi et al. [7]** also reported reduced hemoglobin levels and altered red cell indices in sickle cell disease patients due to increased hemolysis and ineffective erythropoiesis.

The **RDW value was significantly higher in sickle cell disease patients (18%) compared with sickle cell trait individuals (14%)**, indicating increased anisocytosis. Studies evaluating red cell indices such as **Shamsuddin et al. [8]** have highlighted the importance of these parameters in assessing erythropoietic activity and differentiating hematological disorders.

In addition, **HPLC analysis in the present study demonstrated markedly higher HbS levels in sickle cell disease patients (88.5%) compared with sickle cell trait individuals (38.9%)**, indicating the predominance of abnormal hemoglobin in disease cases. These findings support the role of hemoglobin fraction analysis in distinguishing sickle cell disease from sickle cell trait.

CONCLUSION

The study demonstrated significant differences in hematological parameters between sickle cell trait and sickle cell disease patients. Individuals with sickle cell disease showed lower hemoglobin levels, reduced RBC counts, and higher RDW values compared with trait carriers. HPLC analysis also revealed distinct hemoglobin fraction patterns, highlighting its importance in accurate diagnosis and differentiation of sickle cell disorders.

RECOMMENDATIONS

1. Larger **multicenter studies** should be conducted to better understand regional variations in sickle cell disorders.
2. **Screening programs and genetic counseling** should be strengthened in high-risk populations.
3. Early diagnosis using **HPLC and hematological analysis** can help improve patient management and reduce complications.

REFERENCES

1. Rees DC, Williams TN, Gladwin MT. Sickle-cell disease. Lancet. 2010;376:2018-31.
2. Weatherall DJ, Clegg JB. Inherited haemoglobin disorders: an increasing global health problem. Bull World Health Organ. 2001;79:704-12.
3. Balgir RS. The burden of haemoglobinopathies in India and the challenges ahead. Curr Sci. 2000;79:1536-47.
4. Purohit P, Patel S, Patel D. Prevalence of sickle cell disorders among tribal populations in Rajasthan: a community-based study. Indian J Med Res. 2014;139:812-7.
5. Kamble M, Chaturvedi P. Epidemiology of sickle cell disease in a rural hospital of central India. *Indian Pediatr.* 2000 Apr;37(4):391-6. PMID: 10781232.
6. Patel KG, Chaudhari C, Sharma D. A study of clinical and hematological profile of children with sickle cell disease in a tertiary care hospital, Valsad, India. *Int J Contemp Pediatr*. 2017;4(4):1317-1321.
7. Modi SD, Agrawal VR, Bhake AS, Agrawal A. Study of hematological profile in sickle cell patient. *IOSR J Dent Med Sci*. 2018;17(2):73-76. doi:10.9790/0853-1702097376.
8. Shamsuddin S, Upadhyaya K, Sudhakar S, Ahamed ZA. Evaluation of red cell indices and manual reticulocyte parameters in iron deficiency, vitamin B12 deficiency and beta thalassemia minor patients in a tertiary care hospital. *Int J Res Med Sci*. 2023;11.