



DIAGNOSTIC UTILITY OF MENTZER INDEX AS A SCREENING TOOL IN DIFFERENTIATING IRON DEFICIENCY ANEMIA AND THALASSEMIA TRAIT IN PEDIATRIC POPULATION: A CROSS-SECTIONAL STUDY IN A TERTIARY CARE CENTRE

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ABSTRACT

Background: Microcytic hypochromic anemia is frequently encountered in pediatric practice. Iron deficiency anemia and thalassemia trait are among the common causes, but their management is different. Iron deficiency anemia requires iron replacement and dietary correction, whereas thalassemia trait requires confirmation, avoidance of unnecessary iron therapy, family screening and genetic counselling. The Mentzer index is a simple, inexpensive screening parameter derived from routine complete blood count values. **Aim:** To evaluate the diagnostic utility of Mentzer index in differentiating iron deficiency anemia and thalassemia trait among pediatric patients with microcytic anemia. **Materials and Methods:** This hospital-based cross-sectional study was conducted in a tertiary care centre among 100 pediatric patients aged 6 months to 18 years with microcytic anemia. Complete blood count parameters, serum ferritin and hemoglobin electrophoresis/HbA2 findings were evaluated. Mentzer index was calculated as mean corpuscular volume divided by red blood cell count. A value >13 was considered suggestive of iron deficiency anemia, while a value <13 was considered suggestive of thalassemia trait. **Results:** Out of 100 pediatric patients, 96 were diagnosed as iron deficiency anemia and 4 as thalassemia trait. Among iron deficiency anemia cases, 90 showed Mentzer index >13 and 6 showed Mentzer index <13 . Among thalassemia trait cases, 3 showed Mentzer index <13 and 1 showed Mentzer index >13 . For diagnosis of iron deficiency anemia, Mentzer index showed sensitivity of 93.8%, specificity of 75.0%, positive predictive value of 98.9%, negative predictive value of 33.3% and diagnostic accuracy of 93.0%. The association between Mentzer index category and final diagnosis was statistically significant. **Conclusion:** Mentzer index is a rapid, cost-effective and useful screening tool for differentiating iron deficiency anemia from thalassemia trait in children with microcytic anemia. However, it should not be used as a single confirmatory test. Serum ferritin and hemoglobin electrophoresis/HbA2 estimation remain essential for final diagnosis.

KEYWORDS : Mentzer Index, Iron Deficiency Anemia, Thalassemia Trait, Microcytic Anemia, Pediatric Anemia, Ferritin

INTRODUCTION

Anemia is one of the most common hematological problems in children and continues to be an important public health concern. In childhood, untreated anemia can affect growth, development, immunity, school performance and overall quality of life.[2,3] Among the morphological patterns of anemia, microcytic hypochromic anemia is encountered very often in pediatric practice.

The two clinically important causes of microcytic anemia in children are iron deficiency anemia and thalassemia trait. Although both conditions may present with low hemoglobin and reduced mean corpuscular volume, their pathogenesis, treatment and long-term implications are different. Iron deficiency anemia commonly occurs because of inadequate iron stores, poor dietary intake, increased requirement during growth, poor absorption or chronic blood loss. It is usually associated with low hemoglobin, low MCV, low MCH, raised red cell distribution width and reduced serum ferritin.[2,3]

Thalassemia trait is an inherited hemoglobin disorder characterized by reduced synthesis of globin chains. In these patients, microcytosis may be out of proportion to the degree of anemia, and the red blood cell count is often normal or relatively high. Correct identification is important because these children generally do not need iron therapy unless iron deficiency coexists. A missed diagnosis may lead to unnecessary iron supplementation and delayed genetic counselling.[4]

Iron studies and hemoglobin electrophoresis or HPLC are important for differentiating iron deficiency anemia from

thalassemia trait. However, these tests may not be available at every peripheral or resource-limited centre. For this reason, red cell indices derived from routine complete blood count have been used as simple screening tools.[5-8]

Mentzer index is one of the commonly used screening indices. It is calculated by dividing mean corpuscular volume by red blood cell count. A value >13 favours iron deficiency anemia, whereas a value <13 favours thalassemia trait.[1] Previous studies have reported variable diagnostic performance of Mentzer index in different populations, which may be due to differences in age group, nutritional status, prevalence of thalassemia trait and laboratory methods.[5-10]

The present study was undertaken to assess the diagnostic utility of Mentzer index in differentiating iron deficiency anemia and thalassemia trait among pediatric patients with microcytic anemia in a tertiary care centre.

AIM

To evaluate the diagnostic utility of Mentzer index in differentiating iron deficiency anemia and thalassemia trait among pediatric patients with microcytic anemia.

MATERIALS AND METHODS

This hospital-based cross-sectional observational study was conducted in the Department of Pathology, Chhattisgarh Institute of Medical Sciences (CIMS), Bilaspur, Chhattisgarh, India. The study included pediatric patients aged 6 months to 18 years who presented with microcytic anemia and had complete blood count parameters available for evaluation. A total of 100 cases were included. Hemoglobin, red blood cell

count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, red cell distribution width, serum ferritin and hemoglobin electrophoresis/HbA2 findings were recorded where available. The Mentzer index was calculated by dividing MCV by RBC count. Cases were categorized as iron deficiency anemia or thalassemia trait after correlation of red cell indices with serum ferritin and hemoglobin electrophoresis/HbA2 findings.

The study included pediatric patients aged 6 months to 18 years who presented with microcytic anemia and had complete blood count parameters available for evaluation, including hemoglobin, mean corpuscular volume and red blood cell count. Patients who were further evaluated with serum ferritin and/or hemoglobin electrophoresis/HbA2 estimation for establishing the final diagnosis were included in the study.

Patients with incomplete hematological data were excluded from the study. Cases with a recent history of blood transfusion, known chronic systemic illness, aplastic anemia, non-thalassemic hemolytic anemia, mixed hematological disorders or coexisting conditions that could significantly alter ferritin interpretation were also excluded.

The parameters studied included age, sex, hemoglobin concentration, red blood cell count, mean corpuscular volume, mean corpuscular hemoglobin, mean corpuscular hemoglobin concentration, red cell distribution width, serum ferritin, hemoglobin electrophoresis/HbA2 findings, calculated Mentzer index and the final diagnosis.

RESULTS

A total of 100 pediatric patients with microcytic anemia were included. Iron deficiency anemia was diagnosed in 96 cases and thalassemia trait in 4 cases. Thus, iron deficiency anemia was the predominant cause of microcytic anemia in the present study population, while thalassemia trait constituted a small proportion of cases.

Table 1: Age Distribution of Study Population

Age group	Number of cases	Percentage
6 months-5 years	28	28%
6-10 years	38	38%
11-18 years	34	34%
Total	100	100%

Table 2: Sex Distribution of Study Population

Sex	Number of cases	Percentage
Male	58	58%
Female	42	42%
Total	100	100%

Table 3: Distribution of Cases According to Final Diagnosis

Final diagnosis	Number of cases	Percentage
Iron deficiency anemia	96	96%
Thalassemia trait	4	4%
Total	100	100%

Table 4: Hematological and Biochemical Profile of Cases

Parameter	Iron deficiency anemia (n=96)	Thalassemia trait (n=4)
Hemoglobin (g/dL), mean +/- SD	8.7 +/- 1.3	9.3 +/- 1.1
RBC count (million/cumm), mean +/- SD	3.8 +/- 0.5	5.6 +/- 0.6
MCV (fL), mean +/- SD	67.2 +/- 7.1	62.4 +/- 5.8
MCH (pg), mean +/- SD	21.4 +/- 3.2	19.8 +/- 2.9
RDW (%), mean +/- SD	18.2 +/- 2.8	14.5 +/- 1.9
Serum ferritin (ng/mL), mean +/- SD	10.8 +/- 5.6	65.3 +/- 24.8
HbA2 (%), mean +/- SD	2.5 +/- 0.4	5.4 +/- 0.8
Mentzer index, mean +/- SD	17.7 +/- 3.4	11.2 +/- 1.8

Children with iron deficiency anemia showed lower serum ferritin and higher RDW, while children with thalassemia trait showed relatively higher RBC count and increased HbA2. The Mentzer index was higher in iron deficiency anemia and lower in thalassemia trait.

Table 5: Distribution of Cases According to Mentzer Index and Final Diagnosis

Final diagnosis	Mentzer index >13	Mentzer index <13	Total
Iron deficiency anemia	90	6	96
Thalassemia trait	1	3	4
Total	91	9	100

Among 96 cases of iron deficiency anemia, 90 cases showed Mentzer index >13 and 6 cases showed Mentzer index <13. Among 4 cases of thalassemia trait, 3 cases showed Mentzer index <13 and 1 case showed Mentzer index >13. Therefore, Mentzer index correctly classified the majority of iron deficiency anemia cases and most thalassemia trait cases, although the small number of thalassemia trait cases limits interpretation of predictive values for this group.

Table 6: Diagnostic Performance of Mentzer Index for Iron Deficiency Anemia

Diagnostic parameter	Value
Sensitivity	93.8%
Specificity	75.0%
Positive predictive value	98.9%
Negative predictive value	33.3%
Diagnostic accuracy	93.0%

Table 7: Diagnostic Performance of Mentzer Index for Thalassemia Trait

Diagnostic parameter	Value
Sensitivity	75.0%
Specificity	93.8%
Positive predictive value	33.3%
Negative predictive value	98.9%
Diagnostic accuracy	93.0%

The association between Mentzer index classification and final diagnosis was statistically significant (chi-square value = 22.16, $p < 0.001$).

Table 8: Summary of Major Findings

Parameter	Finding
Total cases	100
Iron deficiency anemia	96 cases
Thalassemia trait	4 cases
Most common diagnosis	Iron deficiency anemia
Correctly classified iron deficiency anemia cases	90/96
Correctly classified thalassemia trait cases	3/4
Overall diagnostic accuracy	93.0%
p-value	<0.001

DISCUSSION

Microcytic anemia is a common finding in pediatric practice. The main clinical challenge is to separate iron deficiency anemia from thalassemia trait because both conditions may look similar on routine blood counts, but they require different clinical approaches. Iron deficiency anemia needs iron therapy and correction of nutritional factors, while thalassemia trait needs confirmation, counselling and family screening rather than empirical iron therapy.[2-4]

In the present study, iron deficiency anemia accounted for 96% of cases and thalassemia trait accounted for 4% of cases. This pattern is clinically expected because nutritional iron deficiency remains a frequent cause of anemia in children. At the same time, thalassemia trait should not be missed, particularly in children with persistent microcytosis and

relatively high red blood cell count.[4]

Mentzer index is attractive for routine use because it requires only MCV and RBC count, both of which are available in a standard complete blood count. In the present study, Mentzer index showed an overall diagnostic accuracy of 93%. For iron deficiency anemia, the sensitivity and specificity were 93.8% and 75.0%, respectively. For thalassemia trait, the sensitivity and specificity were 75.0% and 93.8%, respectively.

AlQarni et al. reported 74% sensitivity and 63% specificity of the Mentzer index for -thalassemia trait among Saudi children with microcytosis. In comparison, the present study demonstrated a comparable sensitivity of 75.0%, but considerably higher specificity of 93.8% for thalassemia trait. The similarity in sensitivity suggests that the Mentzer index performed consistently in identifying children with thalassemia across the two study populations, whereas the higher specificity observed in the present study indicates better discrimination of thalassemia from iron deficiency anemia. This difference may be attributable to variations in sample size, geographical and population characteristics, disease prevalence, inclusion criteria, and the proportion of children with concomitant or borderline iron deficiency. The present findings therefore support the usefulness of the Mentzer index as a simple and low-cost screening parameter, while definitive diagnosis should still be confirmed by appropriate iron studies and hemoglobin analysis/ electrophoresis or HPLC.

Sherali et al. reported 80.7% sensitivity and 77.7% specificity of the Mentzer index for detecting iron deficiency anemia among 347 children, using serum ferritin as the reference standard. In the present study, the Mentzer index demonstrated a sensitivity of 75.0% and specificity of 93.8% for thalassemia trait. Although the sensitivity observed in the present study was slightly lower, the specificity was substantially higher. This difference should be interpreted cautiously because Sherali et al. primarily evaluated the ability of the Mentzer index to identify IDA, whereas the present study evaluated its discriminatory ability between IDA and thalassemia using confirmatory investigations for both conditions. Differences in age distribution, sample composition, disease prevalence and reference standards may also explain the variation in diagnostic performance.

“Vehapoglu et al. reported a sensitivity of 98.7% and specificity of 82.3% for the Mentzer index in differentiating -thalassemia trait from iron deficiency anemia. In comparison, the present study demonstrated a lower sensitivity of 75.0% but a higher specificity of 93.8%. Thus, while the Mentzer index showed greater ability to identify thalassemia cases in the study by Vehapoglu et al., the present study demonstrated better ability to correctly exclude non-thalassemia cases. This variation may be related to differences in study population, sample composition, prevalence of thalassemia and iron deficiency, and diagnostic criteria.”

Published studies have reported substantial variation in the diagnostic performance of the Mentzer index. A direct comparison of the present findings with previous studies is summarised in Table 9. Differences in age group, disease prevalence, sample size, reference standards and cut-off values likely account for much of this variability. Overall, the evidence supports the Mentzer index as a practical screening parameter, while confirmatory testing remains necessary. Other red-cell indices based on MCV, RBC count and RDW have shown similar screening utility, but none consistently replaces serum ferritin and haemoglobin analysis.[8]

Table 9: Comparison of the Present Study with Previous Studies Evaluating the Mentzer Index

Author and year	Study details and comparison
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Present study, 2026	Population: 100 paediatric patients with microcytic anaemia: 96 IDA and 4 thalassemia trait cases. Reference standard: Serum ferritin and haemoglobin electrophoresis/HbA2 findings. Findings: For IDA: sensitivity 93.8%, specificity 75%, PPV 98.9%, NPV 33.3% and accuracy 93%. For thalassemia trait: sensitivity 75%, specificity 93.8%, PPV 33.3%, NPV 98.9% and accuracy 93%. Comparison: Mentzer index showed good overall screening performance, especially for identifying IDA. Interpretation of thalassemia-specific estimates is limited by the small number of thalassemia trait cases.
AlQarni et al., 2024 [5]	Population: 434 Saudi children with microcytosis; some had overlapping iron deficiency and thalassemia findings. Reference standard: Ferritin and haemoglobin electrophoresis findings. Findings: For beta-thalassemia trait, sensitivity was 74% and specificity 63%. For IDA, sensitivity was 61% and specificity approximately 36%. Performance was inadequate for standalone diagnosis. Comparison: The present study showed similar sensitivity for thalassemia trait (75%) but considerably higher specificity (93.8%). Both sensitivity and specificity for IDA were also higher in the present study.
Alkamali et al., 2024 [16]	Population: Infants attending primary healthcare centres in Dubai. Reference standard: Laboratory diagnosis of IDA and beta-thalassemia was compared with Mentzer index classification. Findings: Mentzer index demonstrated very high sensitivity of approximately 99% but relatively low specificity of 54.5%. It was useful for screening but limited for confirmation. Comparison: The present study had slightly lower sensitivity for IDA but substantially higher specificity. Both studies support its use as an initial screening test rather than a definitive diagnostic method.
Wu et al., 2024 [17]	Population: Children evaluated for thalassemia minor using genetic testing and haematological parameters. Reference standard: Genetic testing/Sanger sequencing was used for diagnostic confirmation. Findings: The optimal Mentzer index cut-off was 16.833, with sensitivity of 100% and specificity of 27.8%. This differed from the conventional cut-off of 13. Comparison: The present study used the conventional cut-off of 13 and achieved more balanced diagnostic performance, indicating that the optimal cut-off may vary according to population and reference standard.
Sherali et al., 2023 [9]	Population: 347 children with hypochromic microcytic anaemia. Reference standard: Serum ferritin was used as the reference standard for IDA. Findings: For detecting IDA, sensitivity was 80.7%, specificity 77.7%, PPV 56.8%, NPV 91.6% and diagnostic accuracy 78.4%. Comparison: The present study showed higher sensitivity (93.8%), PPV (98.9%) and accuracy (93%) for IDA, with slightly lower specificity (75%). The higher PPV may be related to the very high prevalence of IDA in the present sample.

Tabassum et al., 2022 [15]	Population: 100 antenatal women with microcytic hypochromic anaemia. Reference standard: Serum ferritin for IDA and haemoglobin electrophoresis for beta-thalassemia trait. Findings: For IDA, sensitivity was 91% and specificity 83%. For beta-thalassemia trait, sensitivity was 83% and specificity 91%. Mentzer index was considered a useful and cost-effective screening test. Comparison: Results were broadly comparable. The present study showed slightly higher sensitivity for IDA (93.8%) and specificity for thalassemia trait (93.8%), but lower thalassemia sensitivity (75%).
Vehapoglu et al., 2014 [11]	Population: 290 children with microcytic anaemia. Reference standard: Confirmed beta-thalassemia trait versus IDA. Findings: Mentzer index correctly classified approximately 91% of children. For detecting beta-thalassemia trait, sensitivity was 98.7%, specificity 82.3% and Youden index 81%. It was reported as one of the most reliable indices evaluated. Comparison: The present study showed lower sensitivity for thalassemia trait (75%) but higher specificity (93.8%). The lower sensitivity may be explained by inclusion of only four thalassemia trait cases.
Sirdah et al., 2008 [7]	Population: 2,196 confirmed cases: 1,272 beta-thalassemia minor and 924 IDA cases. Reference standard: CBC-derived indices were compared with the confirmed final diagnosis. Findings: Mentzer index showed approximately 82.9% sensitivity and 83.6% specificity for differentiation of IDA from beta-thalassemia minor. Red-cell indices were useful for screening but could not replace confirmatory testing. Comparison: The present study showed higher sensitivity for IDA (93.8%) and higher specificity for thalassemia trait (93.8%). Differences may reflect population characteristics and the small number of thalassemia cases in the present study.
Demir et al., 2002 [6]	Population: 63 patients: 26 with iron deficiency anaemia (IDA) and 37 with beta-thalassemia trait (BTT). Reference standard: Confirmed IDA versus BTT; eight haematological discrimination indices were evaluated. Findings: Mentzer index was useful for differentiating IDA from BTT, although it was not superior for every diagnostic parameter. The authors assessed performance using sensitivity, specificity and Youden index. Comparison: The present study also supports Mentzer index as a preliminary screening tool. However, the present sample had a marked predominance of IDA and showed an overall diagnostic accuracy of 93%.

Abbreviations: IDA, iron deficiency anaemia; BTT, beta-thalassemia trait; CBC, complete blood count; PPV, positive predictive value; NPV, negative predictive value; HbA2, haemoglobin A2.

In the present study, the high positive predictive value for iron deficiency anemia indicates that children with Mentzer index > 13 are more likely to have iron deficiency anemia. Similarly,

α Mentzer index < 13 should raise suspicion of thalassemia trait, especially when the RBC count is relatively high despite microcytosis. Similar observations have been reported in studies evaluating erythrocyte indices as screening tools in microcytic anemia.[8-10]

The practical value of Mentzer index lies in its simplicity. It can guide clinicians in resource-limited settings and help decide which patients need iron studies, hemoglobin electrophoresis or further hematological evaluation. However, overlap can occur, especially in mild iron deficiency, combined iron deficiency with thalassemia trait, recent transfusion and inflammatory states affecting ferritin. Therefore, clinical judgment and confirmatory tests remain essential.

Limitations

The present study had a few limitations. First, the sample size was limited to 100 cases. Second, this was a single-centre study, so the findings may not represent the wider pediatric population. Third, the number of thalassemia trait cases was small, which may affect the stability of specificity, negative predictive value and thalassemia-specific diagnostic estimates. Fourth, cases with coexisting iron deficiency anemia and thalassemia trait may affect the performance of Mentzer index if not identified separately. Larger multicentre studies with complete iron profile and molecular confirmation, where available, may provide stronger evidence.

CONCLUSION

The present study showed that iron deficiency anemia was the most common cause of microcytic anemia among pediatric patients, while thalassemia trait constituted a small proportion of cases. Mentzer index showed good diagnostic utility in differentiating iron deficiency anemia from thalassemia trait, with an overall diagnostic accuracy of 93%.

In PHC, CHC and resource limited settings Mentzer index is simple, rapid, inexpensive and easily available from routine complete blood count parameters. It may be used as an initial screening parameter in children with microcytic anemia and identify those who require further confirmatory evaluation and referral to higher centers for definitive diagnosis and appropriate management. However, it should not be used as a standalone confirmatory test. Serum ferritin and hemoglobin electrophoresis/HbA2 estimation remain important for final diagnosis and appropriate clinical management.

Conflict of Interest

The author declares no conflict of interest.

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