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Original Research Article

COMPARATIVE STUDY OF HAEMOGLOBIN RESPONSE AND ADVERSE EFFECTS FOLLOWING ORAL VERSUS INTRAVENOUS IRON THERAPY IN ADULTS WITH IRON DEFICIENCY ANAEMIA

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ABSTRACT

Background: Iron deficiency anaemia is a common haematological disorder associated with reduced functional capacity and impaired quality of life. Oral iron is widely prescribed, but gastrointestinal intolerance and variable absorption may limit its effectiveness. Intravenous iron offers an alternative for rapid iron replenishment and correction of anaemia. The aim is to compare haemoglobin response, improvement in iron stores, clinical outcomes, and adverse effects following oral versus intravenous iron therapy in adults with iron deficiency anaemia.

Materials and Methods: This hospital-based, prospective observational comparative study included 106 adult patients with iron deficiency anaemia at a tertiary care hospital. Patients were divided into two groups: oral iron therapy (n=53) and intravenous iron therapy (n=53). Haemoglobin levels were assessed at baseline, two, four, and eight weeks. Haematological indices, iron profiles, clinical responses, and adverse effects were evaluated. Statistical analysis was performed using SPSS version 28.0, with $p<0.05$ considered statistically significant.

Results: Baseline haemoglobin levels were comparable between groups (8.62 ± 1.05 vs. 8.48 ± 1.10 g/dL; p=0.504). At eight weeks, haemoglobin increased to 11.03 ± 1.12 g/dL following oral therapy and 11.92 ± 1.06 g/dL following intravenous therapy ($p<0.001$). Mean haemoglobin improvement was significantly greater with intravenous iron (3.44 ± 0.89 vs. 2.41 ± 0.83 g/dL; $p<0.001$). Serum ferritin was also higher following intravenous therapy (125.20 ± 48.10 vs. 32.50 ± 14.80 ng/mL; $p<0.001$). Haemoglobin normalization occurred in 39.62% versus 16.98% (p=0.017). Adverse effects were more frequent with oral iron (50.94% vs. 28.30%; p=0.028).

Conclusion: Intravenous iron therapy demonstrated greater haemoglobin improvement, superior iron-store replenishment, and fewer overall adverse effects compared with oral iron therapy. It may be particularly beneficial when rapid correction of iron deficiency anaemia is required.

Keywords: Iron deficiency anaemia, Oral iron therapy, Intravenous iron therapy, Haemoglobin response, Adverse effects.

INTRODUCTION

Iron deficiency anaemia (IDA) remains one of the most common nutritional and haematological disorders worldwide and represents a major public health concern, particularly in developing countries. It occurs when insufficient iron availability compromises haemoglobin synthesis and erythropoiesis, resulting in reduced oxygen-carrying capacity of the blood. The condition affects individuals across all age groups, with women of reproductive age, elderly individuals, and patients

with chronic medical disorders being particularly vulnerable. Common manifestations include fatigue, generalized weakness, dizziness, exertional dyspnoea, palpitations, and reduced physical performance. Untreated iron deficiency anaemia may adversely affect cognitive function, work productivity, cardiovascular health, and overall quality of life. Therefore, early diagnosis and appropriate treatment remain essential for reducing the associated clinical and socioeconomic burden.[1] Iron plays a fundamental role in haemoglobin formation, cellular metabolism, mitochondrial function, and oxygen transport. Normal iron homeostasis depends on an appropriate balance between dietary iron absorption, physiological utilization, recycling, and iron loss. Disturbances in this balance may lead to progressive depletion of iron stores, impaired erythropoiesis, and the development of microcytic hypochromic anaemia. The major causes of iron deficiency among adults include inadequate dietary intake, chronic gastrointestinal blood loss, excessive menstrual bleeding, malabsorption syndromes, and increased physiological requirements. Chronic inflammatory conditions may further interfere with iron metabolism through hepcidin-mediated restriction of intestinal iron absorption and iron mobilization. Understanding these mechanisms is essential for selecting appropriate iron replacement strategies and achieving satisfactory therapeutic outcomes.[2] The diagnosis of iron deficiency anaemia requires a comprehensive assessment incorporating clinical history, physical examination, and relevant laboratory investigations. Haemoglobin concentration, mean corpuscular volume, mean corpuscular haemoglobin, red cell distribution width, serum ferritin, serum iron, total iron-binding capacity, and transferrin saturation are important parameters for evaluating iron status. Serum ferritin is particularly useful for identifying depleted iron stores, although its interpretation may be complicated by inflammation, infection, and chronic diseases. In addition to confirming iron deficiency, identifying and treating the underlying cause of anaemia are necessary to prevent recurrence. Effective management should aim not only to normalize haemoglobin concentration but also to replenish iron stores, improve clinical symptoms, and restore functional well-being.[3] Oral iron supplementation is traditionally considered the first-line treatment for uncomplicated iron deficiency anaemia because of its availability, affordability, convenience, and effectiveness. Ferrous sulphate, ferrous fumarate, and ferrous gluconate are commonly prescribed preparations. However, the therapeutic response depends on intestinal absorption, dosage, treatment adherence, underlying gastrointestinal conditions, and the severity of iron deficiency. Oral iron therapy frequently produces gastrointestinal adverse effects, including nausea, vomiting, abdominal discomfort, constipation, diarrhoea, and metallic taste. These complications may reduce patient compliance and contribute to incomplete correction of anaemia. Furthermore, variations in dosing frequency and elemental iron concentration may influence absorption and tolerability, emphasizing the importance of individualized oral iron supplementation.[4] Intravenous iron therapy has emerged as an important alternative for patients requiring rapid iron replenishment or those demonstrating intolerance, inadequate response, or impaired absorption following oral supplementation. Modern intravenous preparations, including ferric carboxymaltose, iron sucrose, and ferric derisomaltose, allow controlled delivery of iron directly into the systemic circulation, bypassing gastrointestinal absorption. This approach is particularly relevant in patients with substantial iron deficits, ongoing blood loss, malabsorptive disorders, or circumstances requiring timely correction of anaemia. Intravenous iron may facilitate more predictable iron delivery and effective restoration of depleted iron stores. Nevertheless, treatment selection should consider clinical indications, formulation characteristics, monitoring requirements, patient preferences, and overall treatment costs.[5] Despite its therapeutic advantages, intravenous iron administration is associated with potential adverse reactions that require careful assessment. These include infusion-site discomfort, headache, dizziness, transient hypotension, hypersensitivity reactions, and infusion-related complications. Certain intravenous preparations, particularly ferric carboxymaltose, may also cause hypophosphataemia, making appropriate clinical monitoring important in susceptible individuals. Conversely, oral iron primarily produces gastrointestinal intolerance, which may interfere with adherence and treatment completion. Consequently, evaluating the safety profile of both treatment modalities is essential when determining the most suitable approach. The choice of iron therapy should therefore balance haemoglobin improvement, iron-store replenishment, adverse effects, convenience, and patient-specific clinical requirements.[6]

MATERIALS AND METHODS

The present study was designed as a hospital-based, prospective observational comparative study to evaluate and compare the haemoglobin response, improvement in haematological parameters, iron store replenishment, treatment tolerability, and adverse effects following oral versus intravenous iron therapy among adult patients diagnosed with iron deficiency anaemia (IDA). The study was conducted at a tertiary care hospital in collaboration with the Departments of General Medicine, Haematology, and Biochemistry. Adult patients attending the outpatient department or admitted to medical wards with clinically and laboratory-confirmed iron deficiency anaemia were screened for eligibility. All relevant clinical assessments, laboratory investigations,

treatment administration, and follow-up evaluations were performed according to standardized institutional protocols. A total of 106 adult patients with confirmed iron deficiency anaemia were included using a consecutive sampling technique. Patients were divided into two groups based on the iron replacement therapy prescribed by the treating physician. Group A comprised 53 patients receiving oral iron therapy, whereas Group B comprised 53 patients receiving intravenous iron therapy. Treatment allocation was based on clinical indications, baseline haemoglobin concentration, iron deficiency severity, gastrointestinal tolerability, and physician assessment. Both groups were evaluated using comparable clinical and laboratory parameters.

Inclusion Criteria

Adult patients aged 18 years and above, irrespective of gender, with laboratory-confirmed iron deficiency anaemia were included. Anaemia was defined as haemoglobin below 13 g/dL in males and below 12 g/dL in non-pregnant females, accompanied by biochemical evidence of iron deficiency, including serum ferritin below 30 ng/mL and/or transferrin saturation below 20%, interpreted in the clinical context. Patients who were haemodynamically stable, eligible for iron supplementation, and willing to provide informed consent and participate in follow-up assessments were considered eligible.

Exclusion Criteria

Patients with anaemia caused primarily by vitamin B12 deficiency, folate deficiency, haemolytic disorders, thalassaemia, aplastic anaemia, or other non-iron-deficiency conditions were excluded. Patients with severe anaemia requiring immediate blood transfusion, active major bleeding, advanced chronic kidney disease, active malignancy receiving chemotherapy, severe hepatic dysfunction, or uncontrolled systemic infection were excluded. Pregnant women, patients with a documented history of hypersensitivity to the prescribed iron preparation, and those receiving recent blood transfusions or parenteral iron therapy were also excluded.

Methodology

A structured case record form was used to collect demographic and clinical information, including age, gender, body mass index, dietary habits, socioeconomic status, menstrual and gastrointestinal history, underlying causes of iron deficiency, associated comorbidities, previous iron supplementation, and medication history. Clinical symptoms, including fatigue, generalized weakness, exertional dyspnoea, dizziness, palpitations, and reduced exercise tolerance, were documented. Baseline vital signs and relevant physical examination findings were recorded. Treatment adherence, tolerability, and clinical improvement were assessed during follow-up.

Laboratory Investigations

Baseline investigations included complete blood count, haemoglobin concentration, red blood cell count, haematocrit, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), red cell distribution width (RDW), and reticulocyte count. Iron profile assessment included serum ferritin, serum iron, total iron-binding capacity (TIBC), and transferrin saturation (TSAT). Additional investigations, including peripheral blood smear, serum vitamin B12, folate, C-reactive protein, renal function, and liver function tests, were performed when clinically indicated to establish the diagnosis and exclude alternative causes of anaemia.

Treatment Protocol

Patients in Group A received oral ferrous sulphate providing approximately 100 mg of elemental iron daily, with dosage adjustments based on gastrointestinal tolerability and clinical requirements. Patients in Group B received intravenous ferric carboxymaltose, with the total iron requirement calculated according to baseline haemoglobin concentration and body weight. The intravenous dose was administered according to institutional safety protocols, with appropriate monitoring during and after infusion. Both groups received dietary counselling and management of the underlying cause of iron deficiency whenever indicated.

Assessment of Haemoglobin Response and Treatment Outcomes

Haemoglobin concentration was assessed at baseline and during follow-up at the second, fourth, and eighth weeks. The primary outcome was the mean change in haemoglobin concentration from baseline to the fourth week. Secondary outcomes included haemoglobin improvement at the eighth week, proportion of patients achieving a haemoglobin increase of at least 2 g/dL, normalization of haemoglobin, changes in MCV, MCH, serum ferritin, and transferrin saturation, and improvement in anaemia-related symptoms. Treatment adherence and the requirement for additional iron supplementation were also evaluated.

Assessment of Adverse Effects

Adverse effects were systematically documented in both groups. Oral iron-related adverse effects included nausea, vomiting, abdominal discomfort, constipation, diarrhoea, and metallic taste. Intravenous iron-related adverse effects included infusion-site pain, phlebitis, headache, dizziness, hypotension, hypersensitivity reactions, and infusion-related reactions. Serum phosphate was assessed when clinically indicated for suspected hypophosphataemia. The frequency, severity, and management of adverse events, including treatment interruption or discontinuation, were recorded and compared between the groups.

Statistical Analysis

Data were entered into Microsoft Excel and analysed using IBM SPSS Statistics version 28.0. Continuous variables were expressed as mean ± standard deviation or median with interquartile range, whereas categorical variables were presented as frequencies and percentages. Independent-samples t-tests or Mann–Whitney U tests were applied for between-group comparisons. Paired t-tests or Wilcoxon

signed-rank tests assessed within-group changes. Repeated-measures analysis evaluated haemoglobin trends, while chi-square or Fisher's exact tests compared categorical outcomes and adverse effects. Multivariable regression was considered to adjust for baseline clinical differences. A two-tailed p-value below 0.05 was considered statistically significant, with 95% confidence intervals reported wherever appropriate.

RESULTS

[Table 1] Comparison of Baseline Demographic and Clinical Characteristics Between Oral and Intravenous Iron Therapy Groups (N=106)

A total of 106 patients with iron deficiency anaemia were included in the study, with 53 patients each receiving oral and intravenous iron therapy. The mean age was 37.84 ± 11.78 years in the oral iron group and 39.15 ± 12.06 years in the intravenous iron group, with no statistically significant difference (p=0.573). Females predominated in both groups, accounting for 67.92% and 66.04%, respectively (p=1.000). The mean BMI was comparable between the groups (23.61 ± 3.42 vs. 23.94 ± 3.57 kg/m²; p=0.628). Fatigue was the most common presenting symptom, reported in 90.57% of oral iron recipients and 92.45% of intravenous iron recipients. Menstrual blood loss was the leading cause of iron deficiency (45.28% vs. 41.51%), followed by nutritional deficiency (28.30% vs. 26.42%) and chronic gastrointestinal blood loss (15.09% vs. 18.87%). The distribution of underlying causes was comparable between the groups (p=0.936), indicating broadly similar baseline demographic and clinical characteristics.

[Table 2] Comparison of Haemoglobin Response at Baseline and During Follow-Up Between Oral and Intravenous Iron Therapy Groups (N=106)

The baseline mean haemoglobin concentration was comparable between the oral and intravenous iron groups (8.62 ± 1.05 vs. 8.48 ± 1.10 g/dL; p=0.504). At two weeks, the intravenous iron group demonstrated a significantly higher haemoglobin concentration than the oral iron group (9.62 ± 1.08 vs. 9.15 ± 1.04 g/dL; p=0.025). This difference became more pronounced at four weeks, with mean haemoglobin levels of 10.97 ± 1.05 g/dL in the intravenous group compared with 10.04 ± 1.07 g/dL in the oral group (p<0.001). At eight weeks, haemoglobin increased to 11.92 ± 1.06 g/dL following intravenous therapy and 11.03 ± 1.12 g/dL following oral therapy (p<0.001). The mean haemoglobin increase at four weeks was significantly greater with intravenous therapy (2.49 ± 0.74 vs. 1.42 ± 0.65 g/dL; p<0.001). Similarly, the eight-week haemoglobin increase was 3.44 ± 0.89 g/dL in the intravenous group compared with 2.41 ± 0.83 g/dL in the oral group (p<0.001), demonstrating a greater haematological response following intravenous iron administration.

[Table 3] Comparison of Haematological Parameters and Iron Profile Before and After Treatment in Oral and Intravenous Iron Therapy Groups (N=106)

The baseline haematological parameters and iron profiles were comparable between the two treatment groups, with no statistically significant differences observed (p>0.05). Following eight weeks of treatment, serum ferritin increased from 11.20 ± 5.60 to 32.50 ± 14.80 ng/mL in the oral iron group, whereas a substantially greater increase from 10.40 ± 5.40 to 125.20 ± 48.10 ng/mL was observed in the intravenous iron group (p<0.001). Serum iron increased to 62.40 ± 16.20 µg/dL following oral therapy compared with 94.30 ± 22.60 µg/dL following intravenous therapy (p<0.001). Transferrin saturation also improved significantly, reaching 20.40 ± 5.50% and 31.50 ± 7.10% in the respective groups (p<0.001). At eight weeks, mean corpuscular volume was significantly higher in the intravenous iron group than in the oral iron group (83.50 ± 5.90 vs. 77.90 ± 6.10 fL; p<0.001), while mean corpuscular haemoglobin was 27.20 ± 3.10 versus 25.40 ± 2.90 pg (p=0.003). Red cell distribution width decreased in both groups, although the between-group difference at eight weeks was not statistically significant (15.80 ± 1.60% vs. 16.30 ± 1.80%; p=0.134). These findings indicated greater improvement in iron stores and most erythrocyte indices following intravenous iron therapy.

[Table 4] Comparison of Clinical Response, Haemoglobin Improvement and Treatment Outcomes Between Oral and Intravenous Iron Therapy Groups (N=106)

A significantly greater proportion of patients receiving intravenous iron therapy achieved a haemoglobin increase of at least 2 g/dL at four weeks compared with those receiving oral iron therapy (73.58% vs. 16.98%; p<0.001). At eight weeks, this response was observed in 94.34% of intravenous iron recipients compared with 67.92% of oral iron recipients (p=0.001). Haemoglobin normalization was achieved in 39.62% of patients in the intravenous iron group compared with 16.98% in the oral iron group (p=0.017). Improvement in anaemia-related symptoms was also more frequent following intravenous therapy (86.79% vs. 67.92%; p=0.035). Treatment completion was higher in the intravenous group (96.23%) than in the oral group (83.02%), although this difference did not reach statistical significance (p=0.052). Furthermore, additional iron supplementation was required in significantly fewer patients receiving intravenous iron compared with oral iron (7.55% vs. 24.53%; p=0.032). These findings suggested that intravenous iron therapy was associated with a more rapid and effective clinical and haematological response.

[Table 5] Comparison of Adverse Effects, Treatment Tolerability and Discontinuation Between Oral and Intravenous Iron Therapy Groups (N=106)

Treatment-related adverse effects were significantly more frequent among patients receiving oral iron therapy than among those receiving intravenous iron therapy (50.94% vs. 28.30%; p=0.028). Gastrointestinal adverse effects were predominantly associated with oral iron administration, including nausea (20.75% vs. 5.66%; p=0.042), abdominal discomfort (18.87% vs. 3.77%; p=0.028), and constipation (28.30% vs. 1.89%; p<0.001). Metallic taste was reported in 11.32% of oral iron recipients but was absent in the intravenous group (p=0.027). Conversely, infusion-site pain or phlebitis occurred exclusively in the intravenous iron group (15.09%; p=0.006). Headache was reported in 5.66% and 7.55% of patients in the oral and intravenous groups, respectively, without a significant difference (p=1.000). Transient hypotension (3.77%) and mild hypersensitivity reactions (1.89%) were reported only in the intravenous group, although these differences were not statistically significant. Treatment discontinuation was more frequent with oral iron therapy (13.21% vs. 3.77%), but the difference was statistically insignificant (p=0.161).

Table 1: Comparison of Baseline Demographic and Clinical Characteristics Between Oral and Intravenous Iron Therapy Groups (N=106)

Parameter	Oral Iron (n=53)	Intravenous Iron (n=53)	p-value
Age (years), mean ± SD	37.84 ± 11.78	39.15 ± 12.06	0.573
Female sex	36 (67.92%)	35 (66.04%)	1.000
Male sex	17 (32.08%)	18 (33.96%)	—
BMI (kg/m²), mean ± SD	23.61 ± 3.42	23.94 ± 3.57	0.628
Fatigue at presentation	48 (90.57%)	49 (92.45%)	1.000
Associated comorbidities	16 (30.19%)	18 (33.96%)	0.835
Underlying cause of iron deficiency			0.936
Menstrual blood loss	24 (45.28%)	22 (41.51%)	—
Nutritional iron deficiency	15 (28.30%)	14 (26.42%)	—
Chronic gastrointestinal blood loss	8 (15.09%)	10 (18.87%)	—
Other causes	6 (11.32%)	7 (13.21%)	—

Table 2: Comparison of Haemoglobin Response at Baseline and During Follow-Up Between Oral and Intravenous Iron Therapy Groups (N=106)

Haemoglobin Parameter	Oral Iron (n=53)	Intravenous Iron (n=53)	p-value
Baseline haemoglobin (g/dL)	8.62 ± 1.05	8.48 ± 1.10	0.504
Haemoglobin at 2 weeks (g/dL)	9.15 ± 1.04	9.62 ± 1.08	0.025
Haemoglobin at 4 weeks (g/dL)	10.04 ± 1.07	10.97 ± 1.05	<0.001
Haemoglobin at 8 weeks (g/dL)	11.03 ± 1.12	11.92 ± 1.06	<0.001
Mean haemoglobin increase at 4 weeks (g/dL)	1.42 ± 0.65	2.49 ± 0.74	<0.001
Mean haemoglobin increase at 8 weeks (g/dL)	2.41 ± 0.83	3.44 ± 0.89	<0.001

Table 3: Comparison of Haematological Parameters and Iron Profile Before and After Treatment in Oral and Intravenous Iron Therapy Groups (N=106)

Parameter	Oral Iron (n=53) Baseline → 8 Weeks	Intravenous Iron (n=53) Baseline → 8 Weeks	Baseline p-value	8-Week p-value
Serum ferritin (ng/mL)	11.20 ± 5.60 → 32.50 ± 14.80	10.40 ± 5.40 → 125.20 ± 48.10	0.456	<0.001
Serum iron (µg/dL)	34.10 ± 10.60 → 62.40 ± 16.20	32.70 ± 11.00 → 94.30 ± 22.60	0.506	<0.001
Transferrin saturation (%)	10.50 ± 3.20 → 20.40 ± 5.50	10.10 ± 3.30 → 31.50 ± 7.10	0.528	<0.001
Mean corpuscular volume (fL)	70.80 ± 6.50 → 77.90 ± 6.10	70.10 ± 6.20 → 83.50 ± 5.90	0.572	<0.001
Mean corpuscular haemoglobin (pg)	22.10 ± 2.80 → 25.40 ± 2.90	21.80 ± 2.70 → 27.20 ± 3.10	0.576	0.003
Red cell distribution width (%)	18.40 ± 2.00 → 16.30 ± 1.80	18.70 ± 2.20 → 15.80 ± 1.60	0.464	0.134

Table 4: Comparison of Clinical Response, Haemoglobin Improvement and Treatment Outcomes Between Oral and Intravenous Iron Therapy Groups (N=106)

Treatment Outcome	Oral Iron (n=53)	Intravenous Iron (n=53)	p-value
Haemoglobin increase ≥2 g/dL at 4 weeks	9 (16.98%)	39 (73.58%)	<0.001
Haemoglobin increase ≥2 g/dL at 8 weeks	36 (67.92%)	50 (94.34%)	0.001
Haemoglobin normalization at 8 weeks	9 (16.98%)	21 (39.62%)	0.017
Improvement in anaemia-related symptoms	36 (67.92%)	46 (86.79%)	0.035
Completion of prescribed treatment regimen	44 (83.02%)	51 (96.23%)	0.052
Requirement for additional iron supplementation	13 (24.53%)	4 (7.55%)	0.032

Table 5: Comparison of Adverse Effects, Treatment Tolerability and Discontinuation Between Oral and Intravenous Iron Therapy Groups (N=106)

Adverse Effect / Parameter	Oral Iron (n=53)	Intravenous Iron (n=53)	p-value
Any treatment-related adverse effect	27 (50.94%)	15 (28.30%)	0.028
Nausea	11 (20.75%)	3 (5.66%)	0.042
Abdominal discomfort	10 (18.87%)	2 (3.77%)	0.028
Constipation	15 (28.30%)	1 (1.89%)	<0.001
Metallic taste	6 (11.32%)	0 (0.00%)	0.027
Infusion-site pain/phlebitis	0 (0.00%)	8 (15.09%)	0.006
Headache	3 (5.66%)	4 (7.55%)	1.000
Transient hypotension	0 (0.00%)	2 (3.77%)	0.495
Mild hypersensitivity reaction	0 (0.00%)	1 (1.89%)	1.000
Treatment discontinuation	7 (13.21%)	2 (3.77%)	0.161

DISCUSSION

The present study included 106 adult patients with iron deficiency anaemia, equally distributed between oral and intravenous iron therapy groups. The mean age was 37.84 ± 11.78 years in the oral iron group and 39.15 ± 12.06 years in the intravenous group (p=0.573), indicating comparable age distributions. Female patients predominated in both groups, accounting for 67.92% and 66.04%, respectively. Menstrual blood loss was the most common underlying cause of iron deficiency (45.28% vs. 41.51%), followed by nutritional deficiency (28.30% vs. 26.42%). Similar observations regarding the importance of menstrual blood loss were reported by Van Wyck et al. (2009), who conducted a randomized controlled trial involving 477 women with iron deficiency anaemia associated with heavy uterine bleeding. Their study demonstrated the clinical importance of menstrual blood loss as a cause of iron deficiency requiring replacement therapy, although all participants had uterine bleeding, unlike the mixed population in the present study. In their trial, haemoglobin increased by at least 2 g/dL in 82% of intravenous ferric carboxymaltose recipients compared with 62% of oral iron recipients (p<0.001).[7] The present study demonstrated a significantly greater and earlier haemoglobin response following intravenous iron therapy compared with oral iron supplementation. Baseline haemoglobin concentrations were comparable between the groups (8.62 ± 1.05 vs. 8.48 ± 1.10 g/dL; p=0.504). However, at two weeks, haemoglobin was significantly higher in the intravenous group (9.62 ± 1.08 vs. 9.15 ± 1.04 g/dL; p=0.025). At four weeks, the mean haemoglobin increase was 2.49 ± 0.74 g/dL following intravenous therapy compared with 1.42 ± 0.65 g/dL following oral therapy (p<0.001). Similarly, the eight-week haemoglobin increase was significantly greater in the intravenous group (3.44 ± 0.89 vs. 2.41 ± 0.83 g/dL; p<0.001). Comparable findings were reported by Onken et al. (2014) in a multicentre randomized controlled study involving 507 patients who had demonstrated an inadequate initial response to oral iron therapy. The investigators observed a significantly greater mean haemoglobin increase following intravenous ferric carboxymaltose than continued oral iron treatment (1.57 ± 1.19 vs. 0.80 ± 0.80 g/dL; p=0.001), assessed up to day 35.[8]

The present study also demonstrated significantly greater improvement in biochemical indicators of iron deficiency following intravenous iron therapy. At eight weeks, serum ferritin increased from 10.40 ± 5.40 to 125.20 ± 48.10 ng/mL in the intravenous group, whereas the oral iron group showed an increase from 11.20 ± 5.60 to 32.50 ± 14.80 ng/mL (p<0.001 for the between-group comparison at eight weeks). Serum iron concentrations also increased significantly, reaching 94.30 ± 22.60 µg/dL following intravenous therapy compared with 62.40 ± 16.20 µg/dL following oral therapy (p<0.001). These findings were consistent with the randomized controlled trial conducted by Kulnigg et al. (2008) among 200 patients with inflammatory bowel disease-associated iron deficiency anaemia. The investigators reported that median serum ferritin increased from 5.0 to 323.5 µg/L within two weeks following intravenous ferric carboxymaltose, subsequently decreasing to 43.5 µg/L by week 12. In comparison, oral ferrous sulphate produced a more gradual increase in ferritin from 6.5 to 28.5 µg/L over 12 weeks. Median haemoglobin improved from 8.7 to 12.3 g/dL in the intravenous group and from 9.1 to 12.1 g/dL in the oral group.[9] Improvement in erythrocyte indices and transferrin saturation was another important finding of the present study. At eight weeks, transferrin saturation increased to 31.50 ± 7.10% in the intravenous iron group compared with 20.40 ± 5.50% in the oral group (p<0.001). Mean corpuscular volume also improved more prominently following intravenous treatment, reaching 83.50 ± 5.90 fL compared with 77.90 ± 6.10 fL following oral therapy (p<0.001). Similarly, mean corpuscular haemoglobin was significantly higher in intravenous iron recipients (27.20 ± 3.10 vs. 25.40 ± 2.90 pg; p=0.003). However, the between-group difference in red cell distribution width at eight weeks was not statistically significant (p=0.134). These findings were supported by Ferrer-Barceló et al. (2019), who performed a randomized clinical trial involving 61 patients with anaemia following acute non-variceal gastrointestinal bleeding. At day 42, transferrin saturation normalization to at least 25% was achieved in 76.9% of patients receiving intravenous ferric carboxymaltose compared with only 24.1% receiving oral ferrous sulphate (p<0.001). Complete haemoglobin response was also achieved in 100% and 61.3% of patients, respectively (p<0.001).[10] The

proportion of patients achieving a clinically meaningful haemoglobin response was significantly higher following intravenous iron administration in the present study. At four weeks, 73.58% of patients receiving intravenous iron achieved a haemoglobin increase of at least 2 g/dL compared with 16.98% receiving oral iron (p<0.001). By eight weeks, this response was observed in 94.34% and 67.92% of patients, respectively (p=0.001). Furthermore, haemoglobin normalization was achieved in 39.62% of intravenous iron recipients compared with 16.98% of oral iron recipients (p=0.017). Similar findings were reported by Van Wyck et al. (2007) in a randomized controlled trial involving 352 women with postpartum anaemia, of whom 174 received intravenous ferric carboxymaltose and 178 received oral ferrous sulphate. The investigators reported that a haemoglobin increase of at least 2 g/dL was achieved earlier with intravenous therapy than oral therapy (median 7 vs. 14 days; p<0.001). Furthermore, 86.3% of intravenous iron recipients achieved a haemoglobin increase of at least 3 g/dL compared with 60.4% of oral iron recipients (p<0.001). Haemoglobin concentrations above 12 g/dL were attained in 90.5% and 68.6% of patients, respectively (p<0.001).[11] Clinical improvement and treatment completion were also more favourable in the intravenous iron group in the present study. Improvement in anaemia-related symptoms was reported in 86.79% of patients receiving intravenous iron compared with 67.92% receiving oral iron (p=0.035). Treatment completion was observed in 96.23% and 83.02% of patients, respectively, although the difference was not statistically significant (p=0.052). Additionally, the requirement for further iron supplementation was significantly lower in the intravenous group (7.55% vs. 24.53%; p=0.032). Comparable treatment-response findings were reported by Howaldt et al. (2022) in a randomized controlled trial involving 250 patients with inflammatory bowel disease-associated iron deficiency anaemia, comparing oral ferric maltol with intravenous ferric carboxymaltose. At 12 weeks, haemoglobin response, defined as an increase of at least 2 g/dL or normalization, was achieved in 84% of intravenous iron recipients compared with 67% receiving oral ferric maltol. The mean haemoglobin increase at 12 weeks was 3.0 g/dL following intravenous therapy and 2.5 g/dL following oral therapy. Treatment-emergent adverse events occurred in 36% and 59% of patients, respectively, while treatment discontinuation occurred in 3% and 10%.[12] The present study demonstrated a significantly higher frequency of treatment-related adverse effects among patients receiving oral iron therapy compared with intravenous iron therapy (50.94% vs. 28.30%; p=0.028). Gastrointestinal intolerance was particularly prominent among oral iron recipients, with constipation reported in 28.30%, nausea in 20.75%, abdominal discomfort in 18.87%, and metallic taste in 11.32%. These adverse effects were significantly less frequent or absent among intravenous iron recipients. Similar findings regarding the tolerability of oral iron were reported by Lindgren et al. (2009) in a randomized controlled trial involving 91 patients with inflammatory bowel disease-associated anaemia, comparing intravenous iron sucrose with oral iron sulphate. The investigators observed that only 48% of patients receiving oral iron tolerated the prescribed dosage, whereas 52% required dose reduction or treatment withdrawal because of poor tolerability. Study completion was achieved by 43 of 45 patients receiving intravenous iron compared with 35 of 46 patients receiving oral iron (p=0.0009). Furthermore, 41% of oral iron recipients remained anaemic at the end of treatment compared with 16% of intravenous iron recipients (p=0.007).[13]

Regarding treatment-related complications and discontinuation, the present study demonstrated that infusion-site pain or phlebitis occurred in 15.09% of intravenous iron recipients, whereas transient hypotension and mild hypersensitivity reactions were observed in 3.77% and 1.89%, respectively. Headache occurred in 7.55% of intravenous iron recipients compared with 5.66% of oral iron recipients, without a statistically significant difference (p=1.000). Despite these infusion-related adverse effects, treatment discontinuation was less frequent following intravenous therapy than oral therapy (3.77% vs. 13.21%), although the difference was statistically insignificant (p=0.161).

Similar findings concerning treatment discontinuation were reported by Schröder et al. (2005) in a randomized multicentre study involving 46 patients with inflammatory bowel disease-associated iron deficiency anaemia. The investigators observed that gastrointestinal adverse effects resulted in permanent treatment discontinuation in 20.8% of patients receiving oral iron sulphate, compared with only 4.5% of patients receiving intravenous iron sucrose.

Although short-term haemoglobin improvements were comparable between the treatment groups in their study, intravenous iron produced better replenishment of iron stores. These findings indicate that treatment selection should consider both haematological response and adverse-effect profiles.[14]

CONCLUSION

The present study demonstrated that intravenous iron therapy was associated with significantly greater and more rapid improvement in haemoglobin levels compared with oral iron therapy among adults with iron deficiency anaemia. Intravenous iron also showed superior replenishment of iron stores, improvement in haematological parameters, and higher rates of haemoglobin normalization. Oral iron therapy was associated with a significantly higher frequency of gastrointestinal adverse effects, whereas intravenous therapy demonstrated better overall

tolerability despite occasional infusion-related reactions. These findings suggest that intravenous iron may be a more effective treatment option for patients requiring rapid correction of anaemia or experiencing intolerance to oral supplementation.

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