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Study of Peripheral Smear Findings in Patients with Chronic Kidney Disease in a Tertiary Care Centre

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HIGHLIGHTS

- CKD shows major hematological alterations.
- Normocytic normochromic anemia predominates.
- Thrombocytopenia and leukocyte changes observed.
- Elevated urea, creatinine, proteinuria significant.
- Peripheral smear aids CKD management.

Key Words:
Chronic Kidney Disease
Peripheral Smear
Anaemia
Haematological Abnormalities

ABSTRACT

Introduction: Chronic kidney disease (CKD) is a progressive disorder associated with significant hematological and biochemical alterations, particularly anemia, thrombocytopenia, and proteinuria. Peripheral smear examination, though simple and cost-effective, provides valuable insights into morphological spectrum of anemia and other blood abnormalities in CKD patients. This study aimed to evaluated the peripheral smear findings and correlate them with clinical and biochemical parameters in patients with CKD. **Material & Methods:** A cross-sectional study was conducted on 98 patients diagnosed with CKD at tertiary care centre. Detailed demographic, clinical, biochemical data were collected. Peripheral smear analysis was performed to assess red blood cell (RBC) morphology, leukocyte variations, platelet abnormalities. Serum urea, creatinine, and urine albumin were also evaluated to correlate hematological findings with renal function status. **Results:** The study population had a male predominance (60.20%) and most patients were aged 51–75 years (68.37%). Hypertension (39.80%) and diabetes mellitus (36.73%) were the leading comorbidities. Normocytic normochromic anemia was the most common finding (69.39%), followed by microcytic hypochromic anemia (7.14%). Thrombocytopenia was present in 35.71% of cases. Leukocyte abnormalities included neutrophilia (14.29%) and toxic granulations (8.16%). Biochemically, 94.90% of patients had elevated urea levels (>40 mg/dL), and 86.73% had creatinine levels between 1.2–8 mg/dL; 13.27% exceeded 8 mg/dL. Albuminuria was present in over 90% of patients, with 44.90% having 2+ proteinuria. **Conclusion:** The predominance of normocytic normochromic anemia and significant platelet and leukocyte abnormalities highlight the hematological burden of CKD. Elevated urea, creatinine, proteinuria confirmed advanced renal dysfunction. Peripheral smear remains an inexpensive yet powerful diagnostic tool, offering critical insights into disease severity and aiding timely interventions. Integrating smear analysis with standard renal function tests can improve CKD management, particularly in resource-limited settings.

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INTRODUCTION

Chronic kidney disease (CKD) is a major global health concern, affecting millions worldwide. It is characterized by a progressive and irreversible decline in kidney function, ultimately leading to end-stage renal disease (ESRD), which often requires dialysis or kidney transplantation. CKD, also referred to as chronic renal failure, is defined by the National Kidney Foundation's Kidney Disease Outcomes Quality Initiative as kidney damage or a glomerular filtration rate (GFR) of less than 60 ml/min/1.73 m² for a period of three months or more. Anaemia, a common complication of CKD, is defined by the World Health Organization (WHO) as a condition characterized by a deficiency in the number of red blood cells (RBCs) or hemoglobin in the blood, with cut-off values adjusted for age, gender, physiological status, smoking habits, and altitude. Specifically, hemoglobin concentrations below 11 g/dL in children under five and pregnant women, below 12 g/dL in non-pregnant women, and below 13 g/dL in men are considered indicative of anaemia [104]. Anaemia is further classified by severity: mild anaemia (men 10.1–13 g/dL, women 10.1–12 g/dL), moderate anaemia (7.1–10 g/dL), and severe anaemia (<7 g/dL) [104]. Kidney function can be estimated using the Cockcroft-Gault formula: (140 − age) × body weight (kg) / (72 × serum creatinine), multiplied by 0.85 for females [1,2].

CKD is categorized into five stages based on estimated GFR (eGFR), which helps guide management strategies. Stage 1 involves kidney damage with normal or elevated GFR (≥90 ml/min/1.73 m²), often asymptomatic, with proteinuria, haematuria, or structural abnormalities detectable on imaging [3]. Early intervention through lifestyle modifications can slow disease progression. Stage 2 shows mild GFR reduction (60–89 ml/min/1.73 m²) with kidney damage, where subtle changes in blood pressure and electrolyte balance may appear, highlighting the importance of managing underlying conditions such as diabetes and hypertension. Stage 3 is defined by moderate GFR reduction (30–59 ml/min/1.73 m²), accompanied by fatigue, fluid retention, and changes in urine output, with anaemia, bone mineral disorders, and cardiovascular complications becoming more prevalent, necessitating pharmacological and dietary interventions [4,5]. Stage 4 involves severe reduction in GFR (15–29 ml/min/1.73 m²), with metabolic complications, electrolyte imbalances, and worsening anaemia, often requiring erythropoiesis-stimulating agents (ESAs) and phosphate binders, while preparing for renal replacement therapy [6]. Stage 5, or ESRD, is defined by GFR below 15 ml/min/1.73 m², requiring dialysis or transplantation, with prominent uraemia, severe anaemia, metabolic acidosis, and cardiovascular complications [7].

Anaemia is a frequent haematological complication in CKD, arising due to inadequate erythropoietin production, chronic inflammation, iron deficiency, and reduced RBC survival, while leukopenia and thrombocytopenia are comparatively rare [8]. Altered haematological parameters, including haemoglobin, haematocrit, RBC count, total leukocyte count, and platelet count, are often observed, partly due to marrow suppression by retained uremic toxins and aluminium exposure during haemodialysis [9]. Renal involvement is also reported in 15–18% of sickle cell disease patients, affecting multiple kidney structures. Peripheral blood smear examination provides a simple and cost-effective tool to assess RBC morphology, helping to determine anaemia type and severity in CKD patients. The most common pattern observed is normocytic normochromic anaemia, although other morphological abnormalities such as microcytosis, hypochromia, spherocytes, and schistocytes may also be present depending on disease severity and underlying causes [10].

Several studies have highlighted the prevalence and morphological patterns of anaemia in CKD. Mohammed MR & Mahmood B. 2022**,** reported that 94% of 300 CKD patients exhibited normocytic normochromic anaemia, with 21% showing features suggestive of hemolysis [11]. Other studies have documented fragmented RBCs, burr cells, hypochromic microcytic cells, spherocytes, and schistocytes, reflecting ongoing haemolysis or iron deficiency anaemia. Studying peripheral smear findings in CKD is crucial for detecting coexisting haematological disorders, guiding targeted management, and improving patient outcomes [12].

The aimed of the study was to evaluated peripheral smear findings in patients with chronic kidney disease, with a primary objective of assessing the overall peripheral smear patterns and an additional objective of examining the types of anemia observed on the peripheral smear in these patients.

MATERIAL & METHODS

This prospective observational study was conducted at the Department of General Medicine, at tertiary care centre from June 2023 – May 2025. Ethical approval has been obtained from the Ethical Approval Committee of tertiary care centre.

Study Population

The study population comprised 98 patients who provided written informed consent, were aged above 18 years, and diagnosed with chronic kidney disease (Stage I–V). Patients were excluded if they had systemic illnesses unrelated to renal failure, pregnancy, aplastic anemia, hematological malignancies leading to secondary renal failure, or a history of blood transfusion within the past three months. Thus, the sample represented individuals with CKD while minimizing potential confounding conditions.

Data Analysis

All participants were briefed about the study design and purpose, and written informed consent was obtained. Detailed medical

and treatment history was elicited, complete physical examinations were conducted, and patients were categorized by creatinine clearance using the Cockcroft-Gault equation. Peripheral blood smears were examined for RBC morphology and anemia typing, classified per WHO criteria. Blood and urine samples with relevant investigations were analyzed, and data processed using SPSS with appropriate statistical tests, considering $p<0.05$ significant.

RESULTS

In this study of 98 chronic kidney disease patients, the majority (68.37%) were aged 51–75 years, followed by 18.37% in the 25–50 years group, 11.22% in the 76–100 years group, and only 2.04% below 25 years. A male predominance was observed, with 60.20% males compared to 39.80% females. These findings suggest that CKD is most common in middle-aged and elderly populations, with a higher burden among men than women.

Among 98 chronic kidney disease patients, about 46% had comorbidities (including 1% with ADPKD, along with hypertension and diabetes), while 54% reported none.

Among the 98 patients with chronic kidney disease, nearly half (48.98%) exhibited moderate anemia with haemoglobin levels between 7.1 and 9 g/dL, while 34.70% had mild anemia with levels of 9.1 to 12 g/dL. Severe anemia (4.1–7 g/dL) was seen in 14.29% of patients, and very severe anemia (<4 g/dL) and normal haemoglobin levels (>12 g/dL) were each observed in 1.02% of patients. Regarding comorbidities, 39.80% of patients had hypertension, 36.73% had diabetes mellitus, and 13.27% had both conditions.

Ischemic heart disease was present in 13.27% of patients, while the majority did not have these comorbidities. Among 98 chronic kidney disease patients, 69.39% had normocytic normochromic peripheral smears, 5.10% showed mild anisocytosis with microcytes and mild hypochromia, and 4.08% each exhibited normocytic hypochromia or mild anisocytosis with tear drop cells, microcytes, target cells, pencil cells, and mild hypochromia.

Among 98 chronic kidney disease patients, 74.49% had normal WBC counts, 14.29% showed neutrophilia, 8.16% had toxic granules in polymorphs, and 3.06% exhibited hyper segmented polymorphs.

Among 98 chronic kidney disease patients, 52.04% had normocytic normochromic anemia, 7.14% showed microcytic hypochromic anemia, and 5.10% had mild microcytic hypochromic anemia, with the remainder displaying various other hematologic abnormalities.

Among 98 chronic kidney disease patients, 64.29% had platelet counts within the normal range, while 35.71% showed thrombocytopenia, and none had thrombocytosis.

Among 98 chronic kidney disease patients, 44.9% had 2+ albuminuria, 24.49% had 1+ albumin, 13.27% showed trace amounts, and smaller proportions exhibited higher levels, with only 2.04% having no albumin in urine.

Among 98 chronic kidney disease patients, 94.9% had urea levels above 40 mg/dl, while 5.1% had normal levels between 20 and 40 mg/dl.

Among 98 chronic kidney disease patients, 86.73% had creatinine levels between 1.2 and 8 mg/dL, while 13.27% had levels above 8 mg/dL, with none in the normal range.

Table 1: Comorbid conditions of patients with chronic kidney disease

Comorbid condition	Count (%)
Yes	44(44.90%)
ADPKD	1(1.02%)
No	53(54.08%)
Total	98(100.00%)

Table 2: Peripheral smear (RBC) of patients with chronic kidney disease

Peripheralsmear(RBC)	Count (%)
Anisocytosis, Microcyte, Hypochromia	3 (3.06%)
Anisopoikilocytosis, Microcyte++, Tear Drop Cells+, Hypochromia	2 (2.04%)
Microcytic Hypochromic	2 (2.04%)
Mild Anisocytosis Macrocytes with Normochromia	3 (3.06%)
Mild Anisocytosis Microcytes Mild Hypocromia	5 (5.10%)
Mild Anisocytosis Microcytes, Tear Drop Cells Pensil Cells Target Cells Mold Hypochromia	2 (2.04%)
Mild Anisocytosis, Tear Drop Cells +, Microcytes +, Target Cells +, Pencil Cells, Mild Hypochomia	4 (4.08%)
Moderate Unisocytosis Microcytosis Poikilocytosis, Mild Hypochromia Anisochromia	2 (2.04%)
Normocytic Hypoochromic	4 (4.08%)
Normocytic Normochromic	68 (69.39%)
Predominantly Microcytic, Few Microcytes Mild Hypochromia	2 (2.04%)
Total	98 (100.00%)

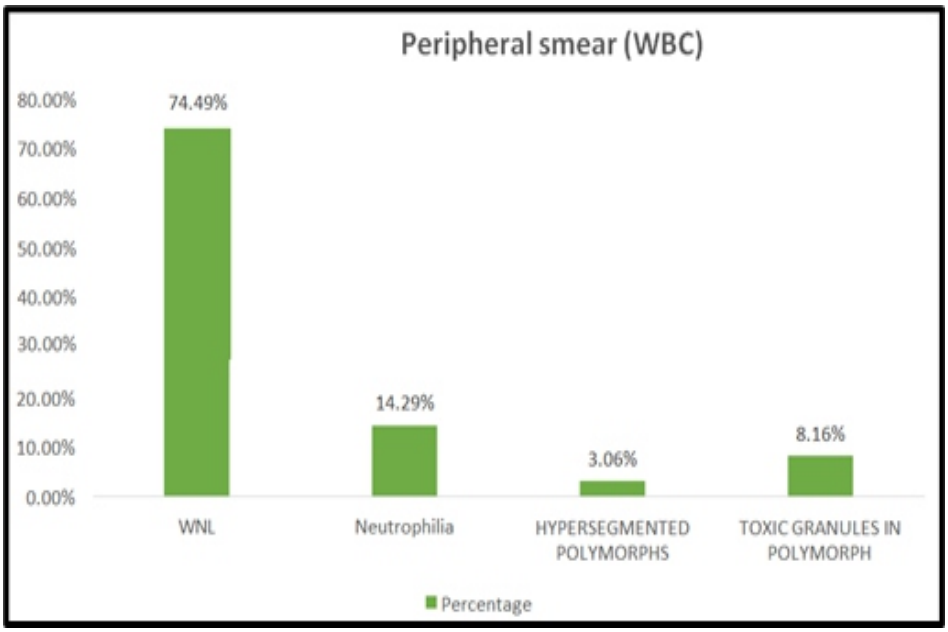

Figure 1: Peripheral smear (WBC) of patients with chronic kidney disease

Table 3: PS-Impression of patients with chronic kidney disease

PS-Impression	Count (%)
Leucocytosis with Thrombocytopenia	6 (6.12%)
Leukocytosis	2 (2.04%)
Microcytic Hypochromic Anaemia	7 (7.14%)
Microcytic Hypochromic Anaemia with Thrombocytopenia	2 (2.04%)
Mild Hypochromic Normocytic Anemia	2 (2.04%)
Mild Megaloblastic Anemia	3 (3.06%)
Mild Microcytic Hypochromic Anaemia	5 (5.10%)
Mild Normocytic Hypoochromic Anaemia	4 (4.08%)
Mild Normocytic Normochromic Anaemia with Thrombocytopenia	8 (8.16%)
Mild Normocytic Normochromic Anaemia with Thrombocytopenia with Polymorpholeukocytosis	4 (4.08%)
Normocytic Normochromic Anaemia	51 (52.04%)
Polymorpholeucocytosis	4 (4.08%)
Total	98 (100.00%)

Table 4: PS-Platelet of patients with chronic kidney disease

PS-Platelet	Count (%)
Within normal range (1 lakh to 4.5 lakh)	63 (64.29%)
Thrombocytopenia(less than 1.5 lakh)	35 (35.71%)
Thrombocytosis (Morethan 4.5 lakh)	0 (0.00%)
Total	98 (100.00%)

Table 5: URINE R/M of patients with chronic kidney disease

URINE R/M	Count (%)
Albumin+	6 (6.12%)
Albumin1+	24 (24.49%)
Albumin2+	44 (44.90%)
Albumin3+	5 (5.10%)
Albumin4+	4 (4.08%)
AlbuminTrace	13 (13.27%)
AlbuminNil	2 (2.04%)
Total	98 (100.00%)

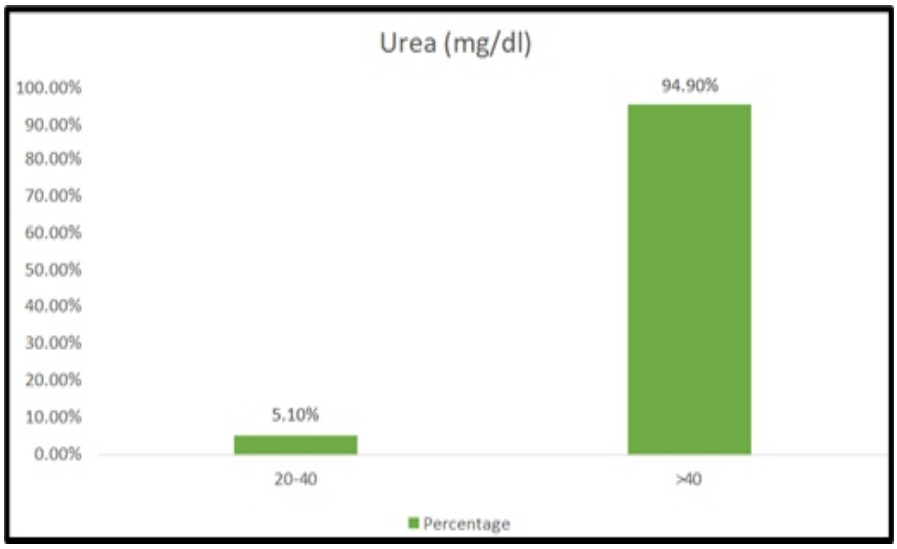

Figure 2: Sr. Urea level of patients with chronic kidney disease

Table 6: Sr. Creatinine level of patients with chronic kidney disease

Sr. Creatinine	Count (%)
0.6 to 1.2 mg/dl (Normal)	0(0.00%)
1.2-8 mg/dl	85 (86.73%)
>8 mg/dl	13 (13.27%)
Total	98 (100.00%)

DISCUSSION

Chronic kidney disease (CKD) is a progressive and irreversible condition characterized by gradual loss of renal function, often leading to multiple systemic complications including anaemia, electrolyte imbalances, cardiovascular disease, and immune dysfunction. Among these, haematological abnormalities, particularly anaemia and platelet dysfunction, significantly affect patient morbidity and quality of life. Peripheral smear examination serves as a simple, cost-effective, and informative tool for morphological assessment of red blood cells (RBCs), leukocytes, and platelets, allowing clinicians to classify anaemia and detect subtle hematologic changes in CKD patients. This study assessed peripheral smear findings in 98 CKD patients admitted to a tertiary care centre, with a focus on RBC morphology, leukocyte and platelet abnormalities, and their correlation with clinical and biochemical parameters. The demographic analysis revealed a male predominance (60.20%), with the majority of patients aged 51–75 years (68.37%). This suggested that CKD is more prevalent in older adults, likely due to the cumulative impact of long-standing comorbidities such as hypertension (39.80%) and diabetes mellitus (36.73%) [13,14].

Among the 98 patients, 44.90% had at least one comorbid condition, highlighting the close association between CKD and systemic diseases. Hypertension was the most common comorbidity, observed in 39.80% of patients, consistent with its dual role as both a cause and consequence of CKD, mediated through glomerular hyperfiltration, interstitial fibrosis, and activation of the renin-angiotensin-aldosterone system (RAAS) [15]. Diabetes mellitus was present in 36.73% of patients, reflecting its global and Indian contribution to CKD via chronic hyperglycemia, oxidative stress, and glomerular injury. Interestingly, 13.27% of patients had both hypertension and diabetes, which accelerates progression to end-stage renal disease (ESRD) through cumulative endothelial and microvascular damage [16]. Additionally, 13.27% of patients had ischemic heart disease (IHD), underscoring the high cardiovascular burden in CKD, while 1.02% were diagnosed with Autosomal Dominant Polycystic Kidney Disease (ADPKD), consistent with global prevalence estimates. These findings emphasize the importance of early screening and management of comorbidities to slow CKD progression and reduce complications [17].

Anaemia is among the most frequent and clinically significant complications of CKD, resulting from erythropoietin deficiency, iron deficiency, reduced RBC lifespan, and chronic inflammation. In this study, 48.98% of patients had moderate anaemia (Hb 7.1–9 g/dL), 34.70% had mild anaemia (Hb 9.1–12 g/dL), 14.29% had severe anaemia (Hb 4.1–7 g/dL), and 1.02% had life-threatening anaemia (<4 g/dL), while only 1.02% had normal hemoglobin levels. Peripheral smear evaluation revealed

that 69.39% had normocytic normochromic anaemia, characteristic of anaemia of chronic disease, whereas 7.14% had microcytic hypochromic anaemia, and 5.10% exhibited mild microcytic hypochromic features. Other morphological abnormalities observed included anisocytosis, poikilocytosis, tear drop cells, target cells, and pencil cells, reflecting nutritional deficiencies and marrow suppression due to uremic toxins. Gafter-Gvili A, et. al; 2019; highlight the need for early erythropoiesis-stimulating agent (ESA) therapy and iron repletion to improve quality of life and reduce transfusion requirements [18].

White blood cell (WBC) and platelet abnormalities were also notable. In this cohort, 74.49% had normal WBC counts, 14.29% showed neutrophilia, 8.16% exhibited toxic granulations, and 3.06% had hypersegmented polymorphs, indicating susceptibility to infection, inflammation, or nutritional deficiencies. Platelet counts were normal in 64.29% of patients, while 35.71% had thrombocytopenia, reflecting uremic platelet dysfunction, bone marrow suppression, and dialysis-related effects. These abnormalities underscore the importance of regular hematological monitoring to identify early infection risk, bleeding tendencies, or nutritional deficiencies [19,20].

Biochemical assessment showed that 94.90% of patients had blood urea >40 mg/dL and 86.73% had serum creatinine between 1.2–8 mg/dL, indicating moderate to severe renal dysfunction, while 13.27% had creatinine >8 mg/dL [21]. Urine albumin analysis revealed 44.90% with 2+ albuminuria, 24.49% with 1+, 13.27% with trace amounts, 5.10% with 3+, and 4.08% with 4+ albumin, highlighting widespread glomerular injury and its prognostic significance [22].

Comparisons with previous studies indicate consistency in demographic distribution, haematological patterns, comorbidities, and proteinuria prevalence. Overall, the findings reaffirm that normocytic normochromic anaemia is the predominant haematological abnormality in CKD, with thrombocytopenia and leukocyte changes further complicating disease management. Early detection of haematological and biochemical derangements, including peripheral smear evaluation, is crucial for timely intervention, delaying CKD progression, and reducing morbidity and mortality, especially in tertiary care settings where advanced diagnostics and therapeutic interventions are accessible [23,24].

CONCLUSION

This study highlights the strong association of CKD with diabetes (36%) and hypertension (39%), with a predominance among adult and elderly males, consistent with earlier Indian studies. Though rare, ADPKD remained the most common inherited cause. Normocytic normochromic anemia predominated, alongside thrombocytopenia, neutrophilia, and toxic granulations, reflecting marrow dysfunction, uremic toxicity, and infection risk. Elevated urea, creatinine, and proteinuria signaled advanced disease. Peripheral smear proved a simple, cost-effective tool for detecting hematological abnormalities, underscoring its clinical value in early diagnosis, management, and improved outcomes. among adult and elderly males, consistent with earlier Indian studies. Though rare, ADPKD remained the most common inherited cause. Normocytic normochromic anemia predominated, alongside thrombocytopenia, neutrophilia, and toxic granulations, reflecting marrow dysfunction, uremic toxicity, and infection risk. Elevated urea, creatinine, and proteinuria signaled advanced disease. Peripheral smear proved a simple, cost-effective tool for detecting hematological abnormalities, underscoring its clinical value in early diagnosis, management, and improved outcomes.

ABBREVIATIONS

CKD: Chronic Kidney Disease
RBC: Red Blood Cell
Hb: Hemoglobin
DM: Diabetes Mellitus
HTN: Hypertension

LIMITATIONS & FUTURE PERSPECTIVES

The study was limited by its single-centre design, relatively small sample size, and short duration, which may restrict generalizability. Future research could focus on multicenter studies with larger cohorts to validate findings, evaluate long-term outcomes, and explore innovative diagnostic and management strategies for appendicular perforation, improving patient prognosis and reducing complications.

CLINICAL SIGNIFICANCE

Timely detection and management of acute appendicitis are crucial to prevent perforation, reducing morbidity and mortality. The study identifies high-risk groups, such as males and individuals at age extremes, highlighting the need for targeted preventive strategies and clinical vigilance. Delayed presentation significantly increases perforation risk, underscoring the importance of early healthcare access and dawareness campaigns. Postoperative complications, including surgical site infections and prolonged ileus, emphasize the need for thorough preoperative risk assessment and tailored postoperative care. Recognizing the distal third of the appendix as the most common perforation site aids surgeons in effective intraoperative planning and management.

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AUTHOR CONTRIBUTIONS

All authors significantly contributed to the study conception and design, data acquisition, or data analysis and interpretation. They participated in drafting the manuscript or critically revising it for important intellectual content, consented to its submission to the current journal, provided final approval for the version to be published, and accepted responsibility for all aspects of the work. Additionally, all authors meet the authorship criteria outlined by the International Committee of Medical Journal Editors (ICMJE) guidelines.

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CONFLICT OF INTEREST

Authors declared that there is no conflict of interest.

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None

ETHICAL APPROVAL & CONSENT TO PARTICIPATE

All necessary consent & approval was obtained by authors.

CONSENT FOR PUBLICATION

All necessary consent for publication was obtained by authors.

DATA AVAILABILITY

All data generated and analyzed are included within this research article. The datasets utilized and/or analyzed in this study can be obtained from the corresponding author upon a reasonable request.

USE OF ARTIFICIAL INTELLIGENCE (AI) & LARGE LANGUAGE MODEL (LLM)

The authors confirm that no AI & LLM tools were used in the writing or editing of the manuscript, and no images were altered or manipulated using AI & LLM.

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