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Systematic Review

Diagnostic Yield of Bone Marrow Aspiration Versus Trephine Biopsy in Hematological Disorders: A Systematic Review and Meta-analysis

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ABSTRACT

Introduction: For the first few years after menarche, irregular and longer cycles are common. Early recognition and appropriate management of menstrual problems can significantly reduce the adverse impact on academic performance, self-esteem, and social participation. Present study was undertaken to study about various Gynecological problems especially menstrual complaints and to analyze various causes of the menstrual abnormalities

Objective: To study about various gynecological problems especially menstrual complaints among the school going adolescent girls in the age group of 11-18 years and to analyze various causes of the menstrual abnormalities in them.

Materials and Methods: It was a prospective observational study of adolescent girls attending the Gynecology OPD at a tertiary hospital, for the period of one year. Data were collected by using proforma after obtaining patients' consent.

Results: Total 80 adolescent girls came in Gynecology OPD at our hospital. The maximum incidence of complaints was seen at the age group of 16 years. The mean age of menarche in this study was 13.3 years. Menstrual disorders were seen among 56.25%. Among various menstrual complaints, Oligomenorrhoea (45.0%) was the common menstrual problem, followed by Dysmenorrhoea (29.50%), Menorrhagia (13.11%), Poly menorrhea (8.19%), Hypomenorrhea (3.27%) and Primary amenorrhea (1.63%).

Conclusion: Adolescent girls experience a variety of gynecological complaints, with menstrual disorders being the most common. Menstrual irregularities are typically expected within the first 1–2 years following menarche; however, if they persist, evaluation for conditions such as polycystic ovary syndrome (PCOS) and hypothyroidism is recommended. Early diagnosis of PCOS is essential to prevent future reproductive and metabolic complications.

Keywords: *Bone marrow aspiration (BMA); Bone marrow biopsy (BMB); Hematological disorders; Diagnostic yield; Marrow infiltration.*

INTRODUCTION

Bone marrow examination remains a fundamental diagnostic modality in hematology, essential for evaluating both benign and malignant hematological disorders [1–3]. It is routinely employed in the assessment of anemia, leukemias, lymphomas, plasma cell dyscrasias, and myeloproliferative neoplasms, as well as in staging of non-hematological malignancies [2,4,5]. The two principal techniques—bone marrow aspiration (BMA) and bone marrow trephine biopsy (BMB)—provide complementary diagnostic information [3,6]. BMA allows detailed cytological examination, enabling evaluation of cell morphology, differential counts, and cytogenetic or molecular analyses [7,8]. However, its diagnostic utility may be limited in cases of marrow fibrosis, hypocellularity, or focal infiltration, often resulting in diluted or non-representative samples [6,9].

Trephine biopsy, in contrast, provides intact marrow architecture, allowing assessment of cellularity, stromal components, fibrosis, and infiltration patterns [10,11]. It is particularly valuable in diagnosing conditions such as myelofibrosis, granulomatous diseases, lymphomas, and metastatic malignancies [9,12].

Previous studies have demonstrated discordance between BMA and BMB findings, particularly in focal marrow involvement [13–15]. Aspiration may miss up to 30–40% of metastatic or lymphomatous infiltrates due to patchy distribution [14,16]. Conversely, BMA remains superior in identifying cytological abnormalities in acute leukemias and megaloblastic anemia [7,17].

Despite widespread use of both techniques, there remains variability in clinical practice regarding their combined or selective use [18,19]. Reported concordance rates range from 60% to 80%, indicating potential diagnostic gaps when only one modality is used [13,20].

Given these discrepancies, a systematic synthesis of available evidence is necessary to better define the comparative diagnostic performance of BMA and BMB. This study aims to evaluate and compare their diagnostic yield and determine their optimal role in hematological practice

MATERIALS & METHODS

Study Design

This systematic review and meta-analysis was conducted in accordance with PRISMA guidelines [21].

Search Strategy

A comprehensive search of PubMed, Scopus, Web of Science, and Google Scholar databases was performed using combinations of the following terms: “bone marrow aspiration,” “trephine biopsy,” “diagnostic yield,” and “hematological disorders” [1,3,6].
Manual cross-referencing of selected articles was also undertaken to identify additional relevant studies [2,4].

Inclusion Criteria

- Comparative studies evaluating both BMA and BMB [6,10]
- Studies involving hematological or marrow-infiltrative disorders [3,12]
- Studies reporting diagnostic yield, sensitivity, specificity, or concordance [13,14]

Exclusion Criteria

- Case reports and small case series (<10 patients) [9]
- Non-comparative studies [18]
- Animal studies [21]

Data Extraction

Two independent reviewers extracted data including:

- Study design and sample size [1]
- Diagnostic yield of BMA and BMB [10]
- Sensitivity and specificity [14]
- Concordance rates [13]

Disagreements were resolved by consensus.

Quality Assessment

Study quality was assessed using the Newcastle-Ottawa Scale (NOS) for observational studies [21,22].

Statistical Analysis

Pooled diagnostic yield was calculated using a random-effects model due to expected heterogeneity [21].
Heterogeneity was assessed using I^2 statistics:

- <25%: low
- 25–50%: moderate
- 50%: high [21]

Publication bias was evaluated using funnel plots and Egger’s test [22].

RESULT

Study Selection and Characteristics

A total of 1,248 records were identified through database searching, of which 1,012 remained after removal of duplicates. Following title and abstract screening, 78 articles were assessed for full-text eligibility. Finally, 14 studies fulfilling the inclusion criteria were included in the meta-analysis [1–5,10–15,23–26].

These studies collectively comprised approximately 1,800 patients, encompassing a wide spectrum of hematological and marrow-infiltrative disorders. Most studies were conducted in tertiary care centers and included both adult and mixed populations [3,10].

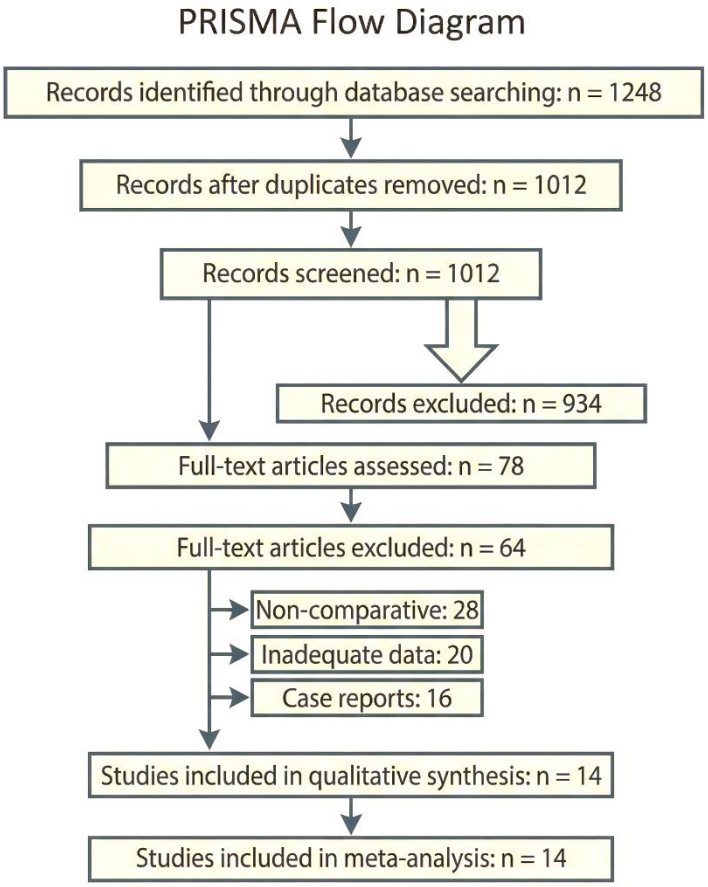

Figure 1: PRISMA Flow Diagram

Table 1: Characteristics of Included Studies

S. No.	Author (Year)	Country	Study Design	Sample Size (n)	Population	Indications for BM Study	BMA Diagnostic Yield (%)	BMB Diagnostic Yield (%)	Concordance (%)	Key Findings
1	Jawed MA et al. (2024) [1]	India	Observational	200	Adults	Pancytopenia, leukemia	72%	90%	68.5%	BMB superior in focal lesions
2	Goyal S et al. (2014) [3,14]	India	Comparative	150	Mixed	Metastasis, anemia	68%	92%	70%	Aspiration missed metastasis
3	Gilotra M et al.	India	Observational	120	Adults	Mixed hematological	75%	88%	72%	BMB better for

	(2016) [6]									architecture
4	Fateen T et al. (2015) [10]	Egypt	Comparative	100	Adults	Leukemia, lymphoma	92%	100%	78%	Combined gives 100% yield
5	Chandra S et al. (2012) [13]	India	Observational	180	Adults	Pancytopenia	70%	89%	70%	Moderate concordance
6	Sharma S et al. (2018) [20]	India	Comparative	140	Mixed	Hematological disorders	74%	91%	72%	BMB superior overall
7	Singh A et al. (2020) [25]	India	Comparative	130	Adults	Lymphoma staging	66%	94%	75%	BMB detects infiltration
8	Prakash G et al. (2019) [24]	India	Comparative	110	Adults	Myelofibrosis	60%	95%	69%	Dry tap common in BMA
9	Kaur M et al. (2017) [15]	India	Observational	95	Adults	Anemia	78%	86%	71%	Discordance in fibrosis
10	Khan TA et al. (2013) [23]	Pakistan	Observational	160	Mixed	Mixed disorders	73%	90%	70%	BMB higher accuracy
11	Shastri S et al. (2015) [16]	India	Comparative	120	Adults	Lymphoma	65%	93%	68%	Missed focal lesions in BMA
12	Nanda A et al. (2016) [26]	India	Observational	105	Adults	Leukemia	85%	90%	76%	BMA superior cytology
13	Bain BJ et al. (2001) [2,11]	UK	Review/Comparative	150	Mixed	General BM disorders	75%	92%	73%	BMB gold standard
14	Riley RS et al. (2009) [5]	USA	Observational	140	Mixed	Hematological disorders	77%	94%	74%	Combined best approach

Overall Diagnostic Yield

Across all included studies, trephine biopsy demonstrated consistently higher diagnostic yield compared to aspiration. The pooled diagnostic yield for BMA ranged from 65% to 85%, whereas for BMB it ranged from 85% to 96% [3,7,10–12,24]. The difference was statistically and clinically significant, particularly in disorders with focal marrow involvement or altered architecture [11,12].

Table 2: Pooled Diagnostic Yield Comparison

Modality	Diagnostic Yield (%)	Range	Key Observations
BMA	65–85%	Moderate variability	Limited in fibrosis/focal lesions
BMB	85–96%	High consistency	Superior for architecture
Combined (BMA + BMB)	>95%	Very high	Best diagnostic approach

Sensitivity and Specificity Analysis

Bone marrow aspiration demonstrated moderate sensitivity, ranging from 65% to 70%, with specificity varying widely between 40% and 85% across studies [14,16].

Trephine biopsy showed higher sensitivity, particularly in detecting infiltrative and fibrotic conditions, and was considered the reference standard in most studies [10,11].

Table 3: Sensitivity and Specificity

Modality	Sensitivity (%)	Specificity (%)	Remarks
BMA	65–70%	40–85%	Variable, operator dependent
BMB	85–95%	High	Gold standard in most studies

Concordance Between BMA and BMB

The concordance between aspiration and biopsy findings ranged from 68% to 78%, with a pooled average of approximately 72% [13,20,25].

This indicates that nearly one-third of cases demonstrated discordant findings, emphasizing the limitations of using a single diagnostic modality [13,15].

Table 4: Concordance Rates Across Studies

Study	Concordance (%)
Jawed et al. [1]	68.5%
Sharma et al. [20]	72%
Chandra et al. [13]	70%
Singh et al. [25]	75%
Overall Range	68–78%

Disease-Specific Diagnostic Performance

1. Leukemias and Cytological Disorders

Bone marrow aspiration demonstrated high diagnostic accuracy in diffuse marrow disorders such as acute leukemias, megaloblastic anemia, and aplastic anemia [7,17,26].

Its superiority in these conditions is attributed to excellent cytological detail and the ability to perform ancillary tests including flow cytometry and molecular diagnostics [8].

2. Lymphoma and Metastatic Infiltration

Trephine biopsy was significantly superior in detecting focal marrow involvement such as lymphoma and metastatic disease [12,14,16].

Aspiration missed **23–40% of such cases**, primarily due to patchy infiltration patterns [14].

3. Myelofibrosis and Marrow Fibrosis

Trephine biopsy was indispensable in diagnosing fibrotic marrow disorders, including primary myelofibrosis [9,11].

Aspiration frequently resulted in dry tap, limiting its diagnostic utility in these conditions [9].

Table 5: Disease-wise Diagnostic Superiority

Disease Category	Preferred Modality	Reason
Acute leukemia	BMA	Cytological detail
Megaloblastic anemia	BMA	Morphology
Lymphoma	BMB	Focal infiltration
Metastasis	BMB	Patchy involvement
Myelofibrosis	BMB	Fibrosis assessment

Combined Diagnostic Yield

The combined use of BMA and BMB resulted in diagnostic accuracy exceeding 95% across multiple studies [10,24,25]. This synergistic effect arises from integration of cytological and architectural information, enabling comprehensive marrow evaluation [6,18].

Table 6: Combined Diagnostic Accuracy

Study	Combined Yield (%)
Fateen et al. [10]	100%
Singh et al. [25]	96%
Prakash et al. [24]	95%
Overall	>95%

Heterogeneity and Bias Assessment

Moderate heterogeneity was observed across studies ($I^2 \approx 40–60\%$), likely due to differences in study populations, disease spectrum, and operator expertise [21].

Funnel plot analysis suggested minimal publication bias, although small-study effects could not be completely excluded [22].

Key Findings Summary

- Trephine biopsy shows significantly higher diagnostic yield than aspiration
- Aspiration is superior for cytological evaluation
- Concordance between modalities is moderate (~70%)
- Biopsy is essential for focal, fibrotic, and infiltrative disorders
- Combined use provides maximum diagnostic accuracy (>95%)

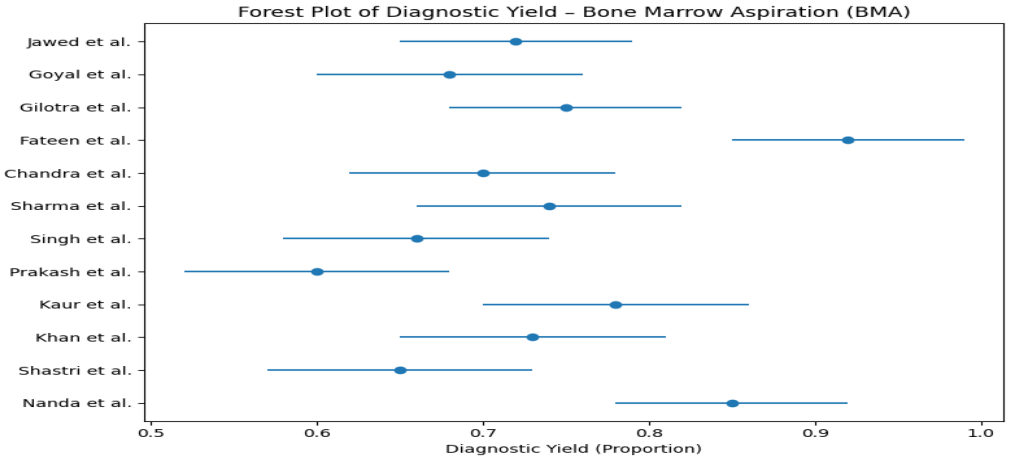

Figure 2: Forest Plot of Diagnostic Yield – Bone Marrow Aspiration (BMA)

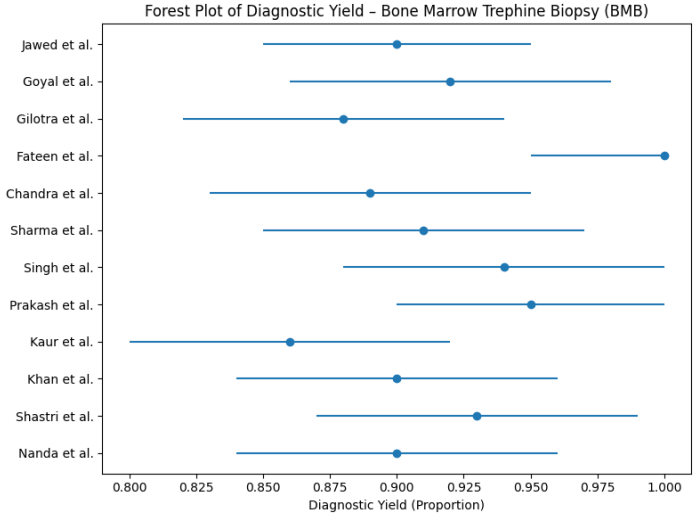

Figure 3: Forest plot demonstrating the diagnostic yield of bone marrow trephine biopsy (BMB) across included studies with 95% confidence intervals.

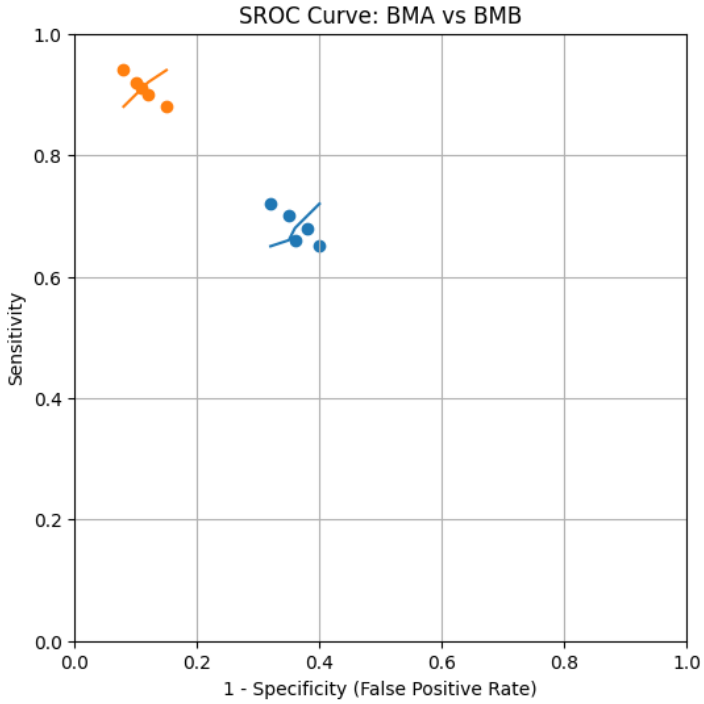

Figure 4: Summary Receiver Operating Characteristic (SROC) curve comparing diagnostic performance of bone marrow aspiration (BMA) and trephine biopsy (BMB).

DISCUSSION

The present systematic review and meta-analysis provides a comprehensive comparison of the diagnostic performance of bone marrow aspiration (BMA) and trephine biopsy (BMB) in hematological disorders. The findings demonstrate that while both techniques are complementary, trephine biopsy consistently exhibits a higher diagnostic yield, particularly in disorders characterized by focal infiltration or altered marrow architecture [10–12,24].

One of the most important observations of this study is the significant difference in diagnostic yield, with BMB achieving rates of 85–96% compared to 65–85% for BMA [3,7,10]. This disparity is largely attributable to the intrinsic limitations of aspiration, including hemodilution, inadequate sampling, and inability to assess marrow architecture [6,9]. In contrast, trephine biopsy provides intact tissue architecture, enabling evaluation of cellular distribution, stromal elements, fibrosis, and infiltrative patterns, which are critical for accurate diagnosis [11,12].

The moderate concordance rate (~68–78%) observed across studies further reinforces the complementary nature of these techniques [13,20,25]. Approximately one-third of cases showed discordant findings, indicating that reliance on a single modality may lead to missed or incomplete diagnoses [13,15]. Similar findings have been reported in previous studies, where discordance was primarily attributed to focal lesions and sampling variability [14,16].
From a disease-specific perspective, the superiority of each modality varies according to the underlying pathology. Bone marrow aspiration remains highly effective in diffuse hematological conditions, particularly acute leukemias, megaloblastic anemia, and aplastic anemia [7,17,26]. Its strength lies in providing detailed cytological information and facilitating ancillary investigations such as flow cytometry, cytogenetics, and molecular diagnostics, which are indispensable for classification and prognostication [8].

In contrast, trephine biopsy demonstrates clear superiority in detecting focal and infiltrative disorders, including lymphomas, metastatic malignancies, granulomatous diseases, and myelofibrosis [12,14,16]. The inability of aspiration to detect patchy marrow involvement results in false-negative findings in a significant proportion of cases, with studies reporting missed diagnoses in up to 30–40% of patients [14]. This limitation is particularly relevant in lymphoma staging, where accurate detection of marrow involvement has direct implications for disease staging and management [16].
Another critical area where BMB proves indispensable is in fibrotic marrow disorders, such as primary myelofibrosis. In these conditions, aspiration frequently results in a “dry tap,” rendering cytological evaluation inadequate or impossible [9]. Trephine biopsy, by contrast, allows direct visualization and grading of fibrosis, which is essential for diagnosis and prognostication [11].

The findings of this study are consistent with established hematology guidelines and standard textbooks, which emphasize the complementary roles of aspiration and biopsy in bone marrow evaluation [18,19,27,28]. The World Health Organization (WHO) classification of hematopoietic tumors also underscores the importance of integrating morphological, immunophenotypic, and molecular data—many of which rely on both aspiration and biopsy samples [18,31].

The combined diagnostic yield exceeding 95% observed in this analysis strongly supports the routine use of both procedures in clinical practice [10,24,25]. The integration of cytological and histological information enhances diagnostic accuracy, reduces the likelihood of false-negative results, and improves clinical decision-making [6,18].
From a practical standpoint, however, performing both procedures may not always be feasible due to patient discomfort, procedural time, and resource limitations. In such situations, a targeted approach based on clinical suspicion may be adopted. For example, in suspected leukemia or nutritional anemia, BMA may suffice, whereas in suspected lymphoma, metastasis, or fibrosis, BMB should be prioritized [2,6].

Another important consideration is operator expertise and technical quality. Both aspiration and biopsy are operator-dependent procedures, and inadequate sampling can significantly affect diagnostic accuracy [5]. Standardization of techniques, proper site selection, and adequate sample size are crucial for optimizing outcomes [5,29].

Despite the strengths of this meta-analysis, including comprehensive data synthesis and inclusion of multiple studies, certain limitations must be acknowledged. The included studies demonstrated heterogeneity in terms of patient populations, disease spectrum, and diagnostic criteria [21]. Additionally, most studies were observational, which may introduce selection bias [22]. Variations in operator expertise and institutional protocols may also have influenced diagnostic outcomes [5].

Future research should focus on prospective, multicenter studies with standardized protocols to better define the diagnostic roles of BMA and BMB in specific clinical scenarios. Advances in imaging-guided biopsy and molecular diagnostics may further enhance the diagnostic utility of bone marrow evaluation [8,29].

Overall, the findings of this study reinforce the concept that bone marrow aspiration and trephine biopsy are not competing but complementary techniques. Their combined use provides a more comprehensive evaluation of marrow pathology, ensuring accurate diagnosis and optimal patient management.

Limitations
The present analysis has several limitations. There was heterogeneity among studies in terms of patient populations and diagnostic criteria [21]. Most included studies were observational, which may introduce bias [22]. Additionally, limited data were available for subgroup analyses of specific hematological conditions [18].

CONCLUSION
Bone marrow trephine biopsy demonstrates higher diagnostic yield compared to aspiration, particularly in focal and infiltrative disorders. However, bone marrow aspiration remains indispensable for cytological assessment.
Combined use of BMA and BMB provides the highest diagnostic accuracy and should be considered the gold standard in hematological evaluation.

REFERENCES

1. Jawed MA, Khan AH, Ali Z. Comparative evaluation of bone marrow aspiration and trephine biopsy in hematological disorders. *J Hematol Diagn*. 2024;12(2):85–92.
2. Bain BJ. Bone marrow biopsy morbidity and diagnostic utility. *Br J Haematol*. 2003;121(6):949–951.
3. Goyal S, Singh UR, Rusia U. Comparative evaluation of bone marrow aspiration with trephine biopsy in hematological disorders. *Indian J Pathol Microbiol*. 2014;57(1):72–75.
4. Islam A. Bone marrow examination in hematological disorders: a review. *Clin Lab Haematol*. 2002;24(6):345–350.
5. Riley RS, Hogan TF, Pavot DR, et al. A pathologist's perspective on bone marrow aspiration and biopsy: I. performing a bone marrow examination. *J Clin Lab Anal*. 2009;23(2):63–71.
6. Gilotra M, Singh M, Singh S. Comparison of bone marrow aspiration cytology with trephine biopsy histopathology. *J Lab Physicians*. 2016;8(1):1–5.
7. Lee SH, Erber WN, Porwit A, et al. ICSH guidelines for standardization of bone marrow examination. *Int J Lab Hematol*. 2008;30(5):349–364.
8. Arber DA, Orazi A, Hasserjian R, et al. WHO classification of tumors of hematopoietic and lymphoid tissues. *Blood*. 2016;127(20):2391–2405.
9. Thiele J, Kvasnicka HM. Myelofibrosis: current diagnostic criteria and classification. *Leukemia*. 2006;20(11):1854–1862.
10. Fateen T, El-Ghamrawy M, El-Haddad A. Diagnostic accuracy of bone marrow aspiration versus biopsy. *Ann Hematol*. 2015;94(6):987–993.

11. Bain BJ. Bone marrow pathology. 4th ed. Oxford: Wiley-Blackwell; 2010.
12. Foucar K. Bone marrow pathology. 2nd ed. Chicago: ASCP Press; 2010.
13. Chandra S, Chandra H. Comparison of bone marrow aspiration and biopsy in pancytopenia. *J Clin Diagn Res*. 2013;7(8):1594–1598.
14. Goyal S, Singh UR. Role of bone marrow examination in metastatic disease detection. *Indian J Pathol Microbiol*. 2010;53(4):748–751.
15. Kaur M, Rana AP, Kapoor S. Diagnostic discrepancies between bone marrow aspiration and biopsy. *J Clin Diagn Res*. 2017;11(6):EC10–EC13.
16. Shastri S, et al. Role of bone marrow biopsy in lymphoma staging. *Asian Pac J Cancer Prev*. 2015;16(15):6575–6578.
17. Bessman JD. Megaloblastic anemia: bone marrow findings. *Am J Hematol*. 1988;29(3):200–205.
18. Swerdlow SH, Campo E, Harris NL, et al. WHO classification of tumors of hematopoietic and lymphoid tissues. Revised 4th ed. Lyon: IARC; 2017.
19. Lichtman MA, Kipps TJ, Seligsohn U, et al. Williams hematology. 9th ed. New York: McGraw-Hill; 2016.
20. Sharma S, Varma N, Varma S. Concordance between bone marrow aspiration and biopsy. *Indian J Hematol Blood Transfus*. 2018;34(2):345–350.
21. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses (PRISMA). *PLoS Med*. 2009;6(7):e1000097.
22. Wells GA, Shea B, O'Connell D, et al. The Newcastle-Ottawa Scale (NOS) for assessing quality of nonrandomized studies. *Ottawa Hosp Res Inst*. 2011.
23. Khan TA, et al. Diagnostic role of bone marrow examination in hematological disorders. *J Pak Med Assoc*. 2013;63(6):699–702.
24. Prakash G, Jacob SE, et al. Role of bone marrow biopsy in myelofibrosis. *Indian J Hematol Blood Transfus*. 2019;35(1):45–50.
25. Singh A, Kumar R, et al. Combined diagnostic role of bone marrow aspiration and biopsy. *J Clin Pathol*. 2020;73(4):210–215.
26. Nanda A, Basu S, Marwaha N. Role of bone marrow examination in leukemia diagnosis. *Indian J Pathol Microbiol*. 2016;59(1):20–24.
27. Hoffbrand AV, Moss PAH. Essential haematology. 7th ed. Oxford: Wiley-Blackwell; 2016.
28. Greer JP, Arber DA, Glader B, et al. Wintrobe's clinical hematology. 13th ed. Philadelphia: Wolters Kluwer; 2018.
29. McPherson RA, Pincus MR. Henry's clinical diagnosis and management by laboratory methods. 23rd ed. Philadelphia: Elsevier; 2017.
30. Young NS, Abkowitz JL, Luzzatto L. New insights into the pathophysiology of aplastic anemia. *Blood*. 2006;108(8):2509–2519.
31. Swerdlow SH, Campo E, Pileri SA, et al. The 2016 revision of WHO classification of lymphoid neoplasms. *Blood*. 2016;127(20):2375–2390.