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DIAGNOSTIC UTILITY OF BONE MARROW TOUCH IMPRINT SMEARS AS AN ADJUNCT TO BONE MARROW ASPIRATION AND TREPHINE BIOPSY IN HEMATOLOGICAL DISORDERS: A RETROSPECTIVE STUDY

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ABSTRACT

Background: Bone marrow examination is the primary diagnostic method for the hematological disorders. Various methods of bone marrow assessment include the bone marrow aspiration (BMA), touch imprint cytology (BMI), and trephine biopsy (BMB). BMA provide the information about cell structure. However, results of BMA are unsatisfactory in case of hemodilution or a dry tap. In such cases, BMI can enhance diagnostic yield. This study aimed to assess the diagnostic efficacy of BMI as compared to the BMA and BMB.

Materials and Methods: This retrospective observational study was performed over two years at a tertiary care center. The study involves 102 patients who underwent BMA, BMI, and BMB. A pre structured proforma was used to capture the patients details. Results of BMB, BMA and BMI for all patients were obtained and compared.

Results: The mean age of the patients was 44.90 ± 20.82 years, and most of them were males (57.8%). Anemia (18.6%) was the most common indication, and pancytopenia (42.2%) was the most common finding on the peripheral smear. BMA gave a diagnosis in 70 cases (68.6%), but it was not clear in 22 cases (21.6%), mostly because of hemodilution and one dry tap. BMI and BMB, on the other hand, were able to find a diagnosis in all cases (100%). BMI showed 100% sensitivity, specificity, and overall diagnostic accuracy, which means that it agreed completely with the biopsy results. BMI was especially helpful when aspirates were not strong enough or were too weak.

Conclusion: Bone marrow touch imprint cytology is a useful addition to BMA that improves the accuracy of diagnoses, especially when aspirates are not good enough. It should be used regularly when examining bone marrow.

Keywords: Bone marrow aspiration; Touch imprint cytology; Trephine biopsy; Hematological disorders; Diagnostic accuracy.

INTRODUCTION

A bone marrow examination is a primary test that is used by clinicians to find out about hematological disorders non-hematological disorders.[1] It is helpful for diagnosing, classifying, and monitoring a range of clinical conditions such as anemias, leukemias, lymphoproliferative disorders, marrow infiltration by metastatic tumors, and other marrow pathologies.[2] A detailed examination of the bone marrow usually involves three different tests: bone marrow aspiration (BMA), bone marrow touch imprint cytology (BMI), and trephine biopsy (BMB).[3,4] Each of these methods gives different but useful information about the shape and structure of bone marrow.

BMA is a common way to examine the cytomorphological details of hematopoietic cells. It allow to examine shape of individual cells, count the different types of cells, and find cells that are abnormal or cancerous.[5] However, BMA may sometimes produce insufficient samples due to dilution with peripheral blood or the inability to acquire marrow material, commonly known as a "dry tap."[3,4,6] These factors can make BMA less efficient and may require additional diagnosis.

BMB is the definitive method for assessing bone marrow assessment.[4,7] It provides the details of marrow architecture, including aplastic anemia, myelofibrosis, granulomatous inflammation, and metastatic tumor infiltration. However, BMB is time consuming because it involve sample processing and histological preparation.[8]

BMI can be act as a bridge between the BMA and BMB.[9] BMI smears are prepared by gently pressing the biopsy core onto glass slides. This allows visualization of marrow cells.[10] BMI is particularly advantageous when aspiration smears are insufficient or diluted. It is also useful in cases of metastatic infiltration.[6,11] The integrated analysis of BMA, BMI, and BMB improves diagnostic efficacy of bone marrow pathology, especially in intricate clinical scenarios like pancytopenia.[12,13]

The study aimed to assess the diagnostic accuracy of BMI as compared to the BMA and BMB to evaluate the role of BMI as a supplementary diagnostic method in standard hematological practice.

MATERIALS AND METHODS

Study Design and Setting: This study was a retrospective study included 102 cases over a two-year period from January 2024 to December 2025. The study population consisted of all patients recommended for BMA and BMB to assess suspected hematological disorders during the study period. The study excluded cases with incomplete documentation, poorly preserved or insufficient touch imprint smears, or the absence of either BMA or BMB.

Data Collection and Variables: Data were collected retrospectively from bone marrow registers, histopathology and cytology reports, the hospital information system (HIS), and patient medical records. The data gathered encompassed demographic information, including age and sex; clinical details, such as the indication for bone marrow examination and provisional diagnosis. The laboratory metrics, including hemoglobin level, total leukocyte count, platelet count, and peripheral smear findings were also recorded. Bone marrow-related variables encompassed findings of BMA, BMB and BMI.

Bone Marrow Procedure and Smear Preparation: BMA and BMB were conducted in accordance with established institutional protocols. The patient received local anesthesia by 2% lidocaine injected into the area. A 16-gauge Salah bone marrow aspiration needle was used to take a sample of bone marrow, and the sample was then used to make a smear. The wedge (push) technique or the crush (squash) technique was used to make smears. The rest of the aspirate was put in a tube with EDTA for more testing. At least 8 to 10 aspiration smears were made for each case and left to dry in the air. A Jamshidi needle (8–11 gauge for adults and 13 gauge for children) was used to do the BMB. After the biopsy core was taken out, BMI smears were made by gently rolling the fresh, unfixed biopsy core onto clean glass slides. For each case, at least 4–6 touch imprint smears were made and left to dry in the air.

Staining and Microscopic Examination: Leishman stain and Field stain were used to stain both BMA and BMI smears. All slides undergo microscopic analysis. A thorough evaluation was done, looking at the overall cellularity of the marrow, the percentage of blasts, the shapes of the erythroid, myeloid, and megakaryocytic lineages, and the presence of abnormal or infiltrative cells. The diagnosis was made according to standard hematopathological guidelines, and important microscopic findings were recorded using digital photomicrography.

RESULTS

Total 102 patients were included the study. The mean age of the patients was 44.90 ± 20.82 years. Most of patients belong to age group of 41–60 years (34, 33.3%), followed by 21–40 years (27, 26.5%) and >60 years (26, 25.5%). The majority of the study population were males (59, 57.8%), whereas females comprised 43 cases (42.2%). The mean age of male patients was 46.05 ± 21.14 years, and the mean age of female patients was 43.33 ± 20.53 years. [Table 1]

Table 1: Demographic Distribution of Study Population

Age Group (years)	Male n (%)	Female n (%)	Total n (%)
<20	10 (9.8)	5 (4.9)	15 (14.7)
21–40	12 (11.8)	15 (14.7)	27 (26.5)
41–60	22 (21.6)	12 (11.8)	34 (33.3)
>60	15 (14.7)	11 (10.8)	26 (25.5)
Total	59 (57.8)	43 (42.2)	102 (100)

Anemia was the most common of the defined indications of bone marrow examination, with 19 cases (18.6%), followed by bicytopenia with 14 cases (13.7%) and pancytopenia with 8 cases (7.8%). Thrombocytopenia represented 3 cases (2.9%). [Table 2]

Table 2: Indications for Bone Marrow Examination

Indication	Number	Percentage
Anemia	19	18.6
Bicytopenia	14	13.7
Pancytopenia	8	7.8
Thrombocytopenia	3	2.9
Others	58	56.9
Total	102	100

A peripheral blood smear examination revealed that pancytopenia was the predominant finding in 43 cases (42.2%), succeeded by bicytopenia in 19 cases (18.6%). Anemia was observed in 3 cases (2.9%), whereas 37 cases (36.3%) exhibited additional hematological abnormalities. [Table 3]

Table 3: Peripheral Blood Smear Findings

Peripheral smear finding	Number	Percentage
Pancytopenia	43	42.2
Bicytopenia	19	18.6
Anemia	3	2.9
Others	37	36.3
Total	102	100

BMA yielded a diagnosis in 70 of 102 cases, whereas 22 cases remained indeterminate, chiefly due to hemodiluted marrow and one dry tap in myelofibrosis. The greatest incidence of BMA failure occurred in megaloblastic anemia (12 cases) and suspected hypersplenism (3 cases), succeeded by dimorphic anemia, iron deficiency anemia, and acute myeloid leukemia. BMI and BMB, on the other hand, were able to get a diagnosis in all cases (100%). [Table 4]

Table 4: Comparison of BMA, BMI, and BMB Diagnoses

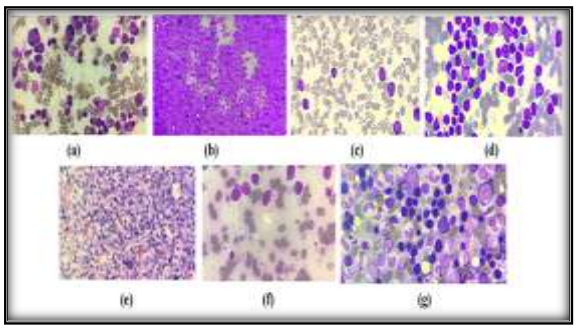
Diagnosis	Cases	BMA Diagnosed	BMA Failed Reason	BMA Failed Cases	BMI Diagnosed	BMB Diagnosed
Dimorphic anemia	12	10	Hemodiluted marrow (no opinion possible)	2	12	12
Aplastic anemia	2	2	—	0	2	2
Megaloblastic anemia	31	19	Hemodiluted marrow (no opinion possible)	12	31	31
Iron deficiency anemia	14	12	Hemodiluted marrow (no opinion possible)	2	14	14
Suspected lysosomal storage disease (Gaucher/Niemann–Pick)	1	1	—	0	1	1
Myelofibrosis (fibrotic phase)	1	0	Dry tap (no opinion possible)	1	1	1
ITP (peripheral destruction type)	5	5	—	0	5	5
Acute myeloid leukemia	6	4	Hemodiluted marrow (no opinion possible)	2	6	6
Suspected acute lymphoblastic leukemia	4	4	—	0	4	4
Suspected chronic myeloid leukemia (CML)	2	2	—	0	2	2
Suspected reactive myeloid hyperplasia	1	1	—	0	1	1
Erythroid hyperplasia with dyserythropoiesis	1	1	—	0	1	1
Suspected hypersplenism	6	3	Hemodiluted marrow (no opinion possible)	3	6	6
Suspected chronic lymphocytic leukemia (CLL)	4	4	—	0	4	4
Essential thrombocythemia	1	1	—	0	1	1
Suspected hemophagocytic syndrome	1	1	—	0	1	1
Suspected plasma cell neoplasm	3	3	—	0	3	3
Other	7	7	—	0	7	7
Total	102	70	—	22	102	102

Table 5: Diagnostic Accuracy of Touch Imprint (Biopsy as Gold Standard)

Parameters	Biopsy Positive	Biopsy Negative
Imprint Positive	2	0
Imprint Negative	0	99
Sensitivity	100% (95% CI: 15.81% to 100.00%)	

Specificity	100% (95% CI: 96.34% to 100.00%)
Accuracy	100.00% (95% CI: 96.41% to 100.00%)

Representative cytomorphological findings observed in the study are illustrated in Figure 1. Bone marrow aspiration smears demonstrated dimorphic erythroid maturation with the presence of both micronormoblasts and megaloblasts in cases of dimorphic anemia. Cases of leukemia showed diffuse infiltration by blast cells on bone marrow imprint and aspiration smears, which correlated with the presence of circulating blasts on peripheral smear. In addition, bone marrow biopsy revealed diffuse plasma cell infiltration in cases of plasma cell neoplasm, while peripheral smear findings in multiple myeloma showed circulating plasma cells with characteristic rouleaux formation. Touch imprint cytology also proved useful in diluted marrow aspirates by demonstrating erythroid predominance with micronormoblastic maturation. [Figure 1]



[Figure 1]: (a) Bone marrow aspiration smear showing dimorphic maturation with presence of both micronormoblasts and megaloblastic (x100, Leishman stain) (b) Bone marrow imprint smear showing hypercellular marrow with diffuse infiltration by blasts (x40, Leishman stain); (c) Peripheral smear showing blast cells (x100, Leishman stain); (d) Bone marrow aspiration showing infiltration by blast cells (100x, Leishman stain); (e) Bone marrow biopsy showing plasma cell neoplasm with diffuse infiltration by plasma cells (x40, Hematoxyline eosin stain); (f) Peripheral smear of Multiple myeloma showing presence of circulating plasma cells and characteristic rouleaux formation (x100, Leishman stain); (g) Bone marrow imprint cytology in a case of diluted marrow showing erythroid predominance with micronormoblastic maturation.

DISCUSSION

The present study evaluated the diagnostic utility of bone marrow touch imprint smears as an adjunct to bone marrow aspiration and trephine biopsy in the assessment of hematological disorders. A bone marrow examination is still one of the most important tests for finding a wide range of hematological disorders. Using BMI, BMA and BMB together gives better results overall. The results of this study emphasize the supplementary function of BMI, especially in cases where BMA smears are diluted or insufficient.

There were 102 patients in total, and the average age was 44.90 ± 20.82 years. Most of them were males (57.8%). 33.3% of the patients in the study were between the ages of 41-60 years. Verma et al. reported a mean age of 38.4 years with males constituting 56.8% of cases, while Baskota et al. observed a mean age of 40.75 years with 58% males.[3,14] Agale et al. reported a higher male predominance of 78.5%. These findings are comparable to the present study, indicating a consistent demographic trend across studies.[15]

In the present study, anemia (18.6%) was the most common indication for bone marrow examination, followed by bicytopenia (13.7%) and pancytopenia (7.8%). Verma et al. reported anemia as the most common indication in 31% of cases, followed by suspected malignancy (20%) and pancytopenia (13%).[14] Similarly, Agale et al. observed anemia in 40.5% of cases, followed by pyrexia of unknown origin (30.9%) and pancytopenia (21.4%).[15] These results align with the current study.

BMA exhibited a diagnostic yield of 68.6%, whereas 21.6% cases were inconclusive due to hemodilution and one dry tap. Baskota et al. reported a diagnostic accuracy of 87.0% for BMA, which is higher than this study.[3] The low diagnostic yield in this study may due to an increased prevalence of hemodiluted samples. This study found the highest failure rates in megaloblastic anemia and suspected hypersplenism (3 cases). Previous studies have documented similar difficulties, especially in cases of fibrosis or packed marrow resulting in dry taps or insufficient samples.[14,15]

In this study, BMI and BMB were able to find the correct diagnosis in all cases (100%). Baskota et al. found that BMI smears had a diagnostic accuracy of 92.0%, which was better than BMA smears, which had a diagnostic accuracy of 87.0%.[3] Chandra and Chandra similarly reported a diagnostic accuracy of 83.7% for BMI, in contrast to 77.5% for BMA and 99.2% for BMB.[2] These results align with the current study, which demonstrated that BMI possesses significant diagnostic utility.

In this study, BMI exhibited 100% diagnostic accuracy, achieving full concordance with BMB results. Chandra and Chandra found that BMI and BMB were positively correlated 84.3% of the time, while BMI was only positively correlated 78% of the time.[2] Baskota et al. also exhibited high diagnostic efficacy of BMI compared to BMA.[3]

In this study, imprint cytology effectively yielded diagnostic information in cases where BMA was unsuccessful. Baskota et al. documented 11 cases of dry tap, all diagnosed through BMI.[3] Chandra and Chandra also pointed out that BMI found several

hematological cancers that BMA missed, showing how important they are in these cases.[2]

BMI found to have significant role in this study when the aspirates are in low quantity or dry tap. There are some limitations with the study. Major limitation is the small sample size dut to which the findings of this study could not be generalized. Additional multicentric, prospective studies with larger sample sizes are necessary to confirm these findings and to elucidate the role of BMI in standard hematological practice.

CONCLUSION

BMI is a useful addition to the diagnosis of blood disorders. The current study exhibited total concordance of BMI with BMB. It was especially helpful in cases where the aspirates were hemodiluted or not enough. BMA and BMB is still the primary diagnostic methods and BMI, on the other hand, works well with both of these methods to improve the accuracy of diagnoses. It is suggested that BMI be used regularly, especially when aspiration is not enough, to improve the accuracy of diagnoses and help doctors make decisions quickly.

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