Original Article

Study of Histopathological Spectrum of Leprosy with Special Reference to Bacteriological Index in a Tertiary Care Centre

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Abstract

Leprosy, caused by *Mycobacterium leprae*, remains a challenge in endemic regions despite declining global incidence. Its clinical and histopathological spectrum reflects the host's immune status, ranging from the paucibacillary tuberculoid form to multibacillary lepromatous leprosy. This study retrospectively analyzed 75 skin biopsy specimens from clinically suspected leprosy cases at a tertiary care centre. Using routine hematoxylin and eosin (H&E) and modified Fite–Faraco staining, the lesions were classified according to the Ridley–Jopling spectrum. The results revealed that lepromatous leprosy (LL) was the most common subtype (32%), followed by borderline tuberculoid (BT; 28%), borderline lepromatous (BL; 13.33%), mid-borderline (BB; 9.33%), tuberculoid (TT; 9.33%), and indeterminate leprosy (IL; 8%). The mean patient age was 36.52 years with a slight male predominance (61.33% male). Overall clinico-histopathological correlation was 72%, with 100% agreement in TT cases and only 42.86% in BB. Fite–Faraco staining was positive in 62.66% of cases, with strong acid-fast bacilli detection in LL and BL lesions (BI scores up to grade 6) and negativity in TT. These findings support the integration of clinical evaluation, histopathology, and bacteriological index determination for accurate diagnosis and effective treatment planning in leprosy.

Keywords: Bacteriological Index, Clinicopathological Correlation, Fite–Faraco, Histopathology, Leprosy, Ridley-Jopling

Introduction

Leprosy is a chronic infectious disease which is caused by a bacteria Mycobacterium Leprae, which was demonstrated in 1873 by a Norwegian Physician Armauer Hansen.[1] The infection mostly affects the skin, the peripheral nerves, mucosal surfaces of the upper respiratory tract and eyes.[2] Although the global incidence of leprosy has declined, it remains endemic in countries such as India, which accounts for more than half of the world's cases.[3] Clinically, the disease shows a wide spectrum: at one end, tuberculoid

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leprosy (TT) reflects a strong cell-mediated immune response with granulomatous inflammation and scant bacilli; at the other, lepromatous leprosy (LL) is characterized by weak immunity, numerous foamy macrophages, and high bacillary load. Borderline forms—including borderline tuberculoid (BT), mid-borderline (BB), and borderline lepromatous (BL)—delineate an intermediate immunological spectrum, often posing diagnostic challenges.[4]

Histopathological examination is vital for confirming clinical findings in leprosy, especially when lesions are ambiguous.[5] The H&E stain demonstrates the inflammatory response and cellular architecture, while the modified Fite–Faraco stain is a critical tool to detect acid-fast bacilli. Moreover, the bacteriological index (BI) calculated on the basis of Ridley's logarithmic scale further quantifies the load of *M. leprae*, thereby guiding treatment decisions.[6]

The main objectives of this study were to assess histopathological spectrum of leprosy and correlate histopathological diagnosis with clinical diagnosis.

By combining clinical evaluation with histopathological and bacteriological techniques, a more accurate diagnosis can be achieved, leading to timely and effective therapy.

Materials and Methods

Study Design and Setting

A retrospective hospital-based observational study was carried out in the Department of Pathology at Muzaffarnagar Medical College & Hospital, Uttar Pradesh, India from October 2023 to March 2025. The study spanned 18 months, with 12 months dedicated to data collection and 6 months for analysis.

Study Population and Sampling

Seventy-five patients with clinically suspected leprosy who underwent skin biopsy were included using purposive sampling. All specimens were collected from the Department of Dermatology, Venereology, and Leprology after informed consent was obtained. Cases with inadequate or poorly preserved specimens were excluded.

Histopathological Procedure

Biopsy specimens were fixed in 10% buffered formalin, processed routinely, and embedded in paraffin. Serial sections (4–5 µm thick) were stained with:

- **H&E stain:** To evaluate tissue architecture, granuloma formation, and inflammatory infiltrate.
- **Modified Fite–Faraco stain:** To detect acid-fast bacilli of *M. leprae* following a protocol involving dewaxing, rehydration, staining with carbol fuchsin, decolorization with 1% sulfuric acid in 25% alcohol, and counterstaining with methylene blue.[7]

Bacteriological Index (BI)

BI was determined according to Ridley's logarithmic scale as follows:

- BI = 0: No bacilli observed.
- BI = 1: 1–10 bacilli in 10–100 high-power fields (hpf).
- BI = 2: 1–10 bacilli in 1–10 hpf.
- BI = 3: 1–10 bacilli per hpf.
- BI = 4: 10–100 bacilli per hpf.
- BI = 5: 100–1,000 bacilli per hpf.
- BI = 6: More than 1,000 bacilli or globi observed per hpf.

Data Analysis

Clinical and histopathological data—including age, sex, lesion characteristics, clinical and histopathological diagnosis, Fite staining results, and BI scores—were recorded in Microsoft Excel and analyzed using SPSS version 17/20. Descriptive statistics (mean, standard deviation, and percentages) were calculated, and the Chi-square test and one-way ANOVA were applied as necessary. A Cramér's V test was used to assess the strength of associations.

Ethical Clearance

The study was approved by the Institutional Ethics Committee of Muzaffarnagar Medical College. (Ref. No. MMC/IEC/2023/237) dated 20/03/2023.

Results

1. Histopathological Spectrum

Skin biopsies were classified as per the Ridley–Jopling system. Table 1 summarizes the distribution.

Table 1. Histopathological Spectrum of Leprosy (n = 75)

Subtype	Number of Cases	Percentage (%)
Lepromatous Leprosy (LL)	24	32.0
Borderline Lepromatous (BL)	10	13.33
Mid-borderline (BB)	7	9.33
Borderline Tuberculoid (BT)	21	28.0
Tuberculoid Leprosy (TT)	7	9.33
Indeterminate Leprosy (IL)	6	8.0
Total	75	100.0

LL was the most common histopathological type (32%), indicating a higher bacillary load and diminished immune response.

2. Demographic Characteristics

The age of patients ranged from 14 to 81 years with an overall mean age of 36.52 ± 13.66 years. There was a slight male predominance (46 males, 61.33% vs. 29 females, 38.67%). Table 2 shows the age and sex distribution.

Table 2. Age and Sex Distribution (n = 75)

Age Group (years)	Total Patients	Males n (%)	Females n (%)
0–9	0	0 (0%)	0 (0%)
10–19	3	2 (66.7%)	1 (33.3%)
20–29	23	16 (69.6%)	7 (30.4%)
30–39	25	16 (64.0%)	9 (36.0%)
40–49	15	5 (33.3%)	10 (66.7%)
50–59	2	2 (100%)	0 (0%)
60–69	4	2 (50.0%)	2 (50.0%)
70–79	2	2 (100%)	0 (0%)
80+	1	1 (100%)	0 (0%)
Total	75	46 (61.33%)	29 (38.67%)

3. Distribution of Leprosy Subtypes by Age

The frequency of different subtypes varied by age group. Table 3 provides this distribution.

Table 3. Distribution of Leprosy Subtypes by Age Group

Age Group (years)	LL(%)	BL(%)	BB(%)	BT(%)	TT(%)	IL(%)
0–9	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
10–19	2 (8.33%)	0 (0%)	0 (0%)	1 (4.76%)	0 (0%)	0 (0%)
20–29	12 (50%)	2 (20%)	2 (28.6%)	5 (23.8%)	1 (14.3%)	1 (16.7%)
30–39	6 (25%)	3 (30%)	2 (28.6%)	8 (38.1%)	4 (57.1%)	2 (33.3%)
40–49	1 (4.17%)	5 (50%)	0 (0%)	6 (28.6%)	2 (28.6%)	1 (16.7%)
50–59	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	2 (33.3%)
60–69	2 (8.33%)	0 (0%)	1 (14.3%)	1 (4.76%)	0 (0%)	0 (0%)
70–79	0 (0%)	0 (0%)	2 (28.6%)	0 (0%)	0 (0%)	0 (0%)
80–89	1 (4.17%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)

4. Mean Age of Each Subtype

One-way ANOVA demonstrated a statistically significant difference in the mean age among subtypes ($p < 0.0001$) (see Table 4).

Table 4. Mean Age ± SD by Histopathological Subtype

Subtype	Mean Age (years) ± SD
Lepromatous Leprosy (LL)	33.46 ± 15.60
Borderline Lepromatous (BL)	36.90 ± 7.92
Mid-borderline (BB)	47.43 ± 22.26
Borderline Tuberculoid (BT)	35.57 ± 10.61
Tuberculoid Leprosy (TT)	34.14 ± 7.01
Indeterminate Leprosy (IL)	41.50 ± 13.05
Overall	36.52 ± 13.66

5. Sex Distribution Among Subtypes

The sex distribution varied among the leprosy types. Table 5 summarizes these findings.

Table 5. Sex Distribution by Leprosy Subtype

Subtype	Males n (%)	Females n (%)	Total n (%)
Lepromatous Leprosy (LL)	15 (62.5%)	9 (37.5%)	24 (32.0%)
Borderline Lepromatous (BL)	9 (90%)	1 (10%)	10 (13.33%)
Mid-borderline (BB)	7 (100%)	0 (0%)	7 (9.33%)
Borderline Tuberculoid (BT)	5 (23.8%)	16 (76.2%)	21 (28.0%)
Tuberculoid Leprosy (TT)	4 (57.1%)	3 (42.9%)	7 (9.33%)
Indeterminate Leprosy (IL)	6 (100%)	0 (0%)	6 (8.0%)

M:F ratio was 1.58:1

6. Clinico-Histopathological Correlation

Overall, 54 out of 75 cases (72%) showed concordance between the clinical and histopathological diagnoses; the remaining 21 cases (28%) did not. Table 6 provides a breakdown by subtype.

Table 6. Clinicopathological Correlation

Subtype	Total Cases (Histopathology)	Concordant Cases(%)	Discordant Cases (%)
Lepromatous Leprosy (LL)	24	20 (83.33%)	4 (16.67%)
Borderline Lepromatous (BL)	10	8 (80%)	2 (20%)
Mid-borderline (BB)	7	3 (42.86%)	4 (57.14%)
Borderline Tuberculoid (BT)	21	16 (76.19%)	5 (23.81%)
Tuberculoid Leprosy (TT)	7	7 (100%)	0 (0%)
Indeterminate Leprosy (IL)	6	0(0%)*	6(100%)*
Total	75	54 (72%)	21 (28%)

*Note: Indeterminate lesions were not clinically categorized, hence no clinical correlation is obtainable.

7. Fite–Faraco Staining and Bacteriological Index (BI)

Modified Fite–Faraco staining was positive in 47 out of 75 cases (62.66%). The distribution of BI scores is detailed in Table 7.

Table 7. Fite–Faraco Positivity and BI Scores by Subtype

Subtype	Total Cases	Fite-Positive (%)	BI Grades Observed (Number of Cases)
Lepromatous Leprosy (LL)	24	24 (100%)	BI 1: 4; BI 2: 2; BI 3: 3; BI 4: 4; BI 5: 6; BI 6: 5
Borderline Lepromatous (BL)	10	10 (100%)	BI 2:5; BI 3: 3; BI 4: 2
Mid-borderline (BB)	7	5 (71.43%)	BI 0: 2; BI 1: 3; BI 2:1; BI 3:1
Borderline Tuberculoid (BT)	21	5 (23.81%)	BI 0: 16; BI 1: 5
Tuberculoid Leprosy (TT)	7	0 (0%)	BI 0: 7
Indeterminate Leprosy (IL)	6	3 (50%)	BI 0: 3; BI 1: 2; BI 2: 1
Total	75	47 (62.66%)	–

LL and BL subtypes demonstrated consistently high BI scores, reflecting a higher bacillary load, whereas TT cases were uniformly negative.

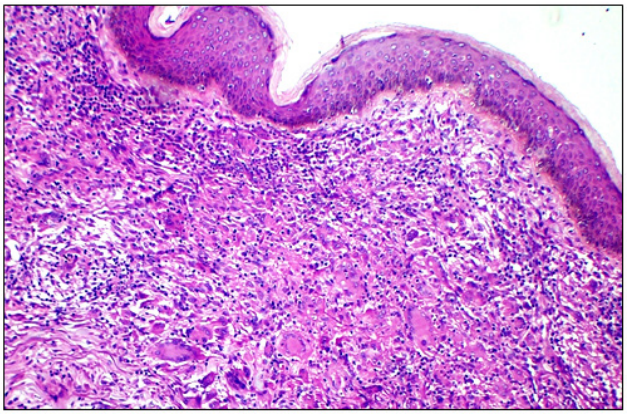

Image 1: Borderline Tuberculoid Leprosy- Photomicrograph showing granulomas with lymphocytic infiltrates and variable number of Langhans giant cells in the dermis. (H&E, 100X)

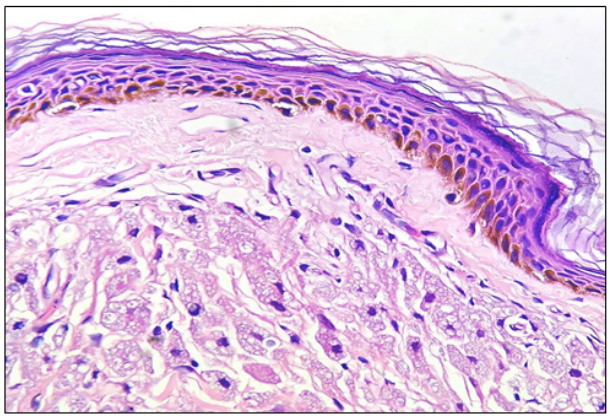

Image 2: Lepromatous Leprosy- - Photomicrograph showing epidermal atrophy, clear subepidermal grenz zone and infiltrating foam cells. (H&E 400X)

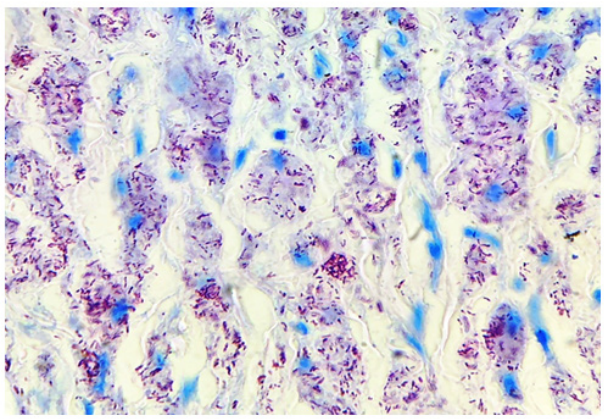

Image 3: Lepromatous Leprosy- Photomicrograph showing numerous lepra bacilli, BI=6 (FF, 1000X)

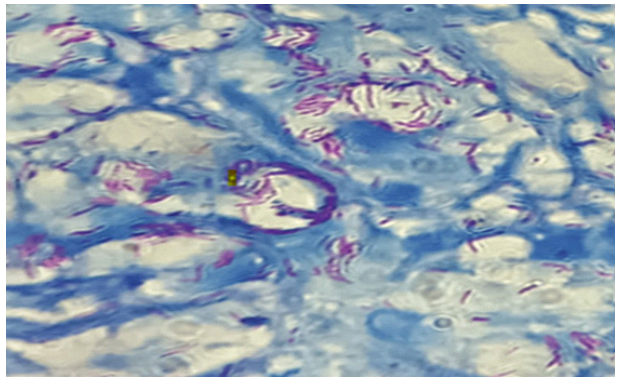

Image 4: Lepromatous Leprosy- Photomicrograph showing numerous lepra bacilli, BI=5 (FF, 1000X)

Discussion

This study analyzed 75 skin biopsies from patients with clinically suspected leprosy, classifying them according to the Ridley–Jopling criteria. LL was the most common subtype (32%), which is indicative of a predominant multibacillary disease burden in our tertiary care setting. Previous studies have shown variable distributions, with some reporting a higher incidence of BT.[8] Variations may be due to regional epidemiology and differences in health-seeking behavior.

The overall mean age (36.52 years) and male predominance (61.33%) are consistent with earlier studies.[9] The findings in Table 2 reveal that patients in their 20s and 30s are most affected, thereby emphasizing the disease's impact on economically productive age groups.

Table 3 illustrates that LL was most commonly observed in the 20–29 age group, whereas TT and BT forms were seen in older age groups. A statistically significant difference in mean age among subtypes ($p < 0.0001$) suggests that the host's immune response to *M. leprae* may change with age.

Clinico-histopathological correlation reached 72% overall (Table 7), with 100% correlation in TT and 83.33% in LL. However, the mid-borderline group (BB) showed only 42.86% concordance. The lower concordance in BB may result from overlapping features along the immunological spectrum. The indeterminate cases, not clinically categorized, further highlight the challenge in early diagnosis.

The Fite–Faraco stain proved critical in detecting acid-fast bacilli; all LL and BL cases were positive, and a high BI (up to grade 6) was recorded in LL. In contrast, TT cases were uniformly negative, supporting the paucibacillary nature of such lesions. [6] These findings have significant therapeutic implications, given that high BI scores are associated with greater transmission potential and may require closer treatment monitoring.

Our study, while robust, has some limitations. The retrospective nature and hospital-based sample may introduce selection bias, and the absence of molecular diagnostic techniques such as PCR limits the detection sensitivity in paucibacillary cases. Future studies should incorporate prospective designs with larger cohorts and utilize molecular methods for improved diagnostic accuracy.

Conclusion

This study underscores the heterogeneity of leprosy and highlights the critical role of histopathological examination and bacteriological index determination in its diagnosis. With LL being the most common subtype and exhibiting high BI scores, the importance of early diagnosis and aggressive treatment is emphasized—especially in multibacillary cases to interrupt transmission. Clinicopathological in 72% cases supports the integration of clinical, histopathological, and microbiological findings in establishing a definitive diagnosis. Further research employing molecular tools could enhance early detection of indeterminate and borderline forms, thereby contributing to more effective management and control of leprosy.

Limitations

This study has several limitations that should be acknowledged. Firstly, as a hospital-based study, it cannot be considered representative of the entire population. There is an inherent selection bias as the sample consists only of individuals who sought medical attention at the hospital. This may not accurately reflect the prevalence and distribution of leprosy in the broader community.

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Conflict of interest: None

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