



Applications of Histopathological Examination in the Evaluation of Traumatic Lesions

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ABSTRACT

Background: Across the globe, traumatic injuries remain one of the foremost reasons for emergency department attendance and surgical intervention. Although you gain valuable insights through direct clinical evaluation, confirming the precise nature, timing as well as complications of any traumatic lesions is only possible by performing thorough histopathological analysis of the tissues involved. To assess the histopathological characteristics of traumatic tissue specimens and evaluate their diagnostic utility in relation to clinical findings.

Methods: This cross-sectional study was conducted at Jinnah Medical College and its affiliated teaching hospitals from January 2023 to January 2024. A total of 72 patients with trauma-related soft tissue injuries were included. Tissue specimens obtained through excision, incision, or resection were processed and analyzed microscopically. Variables assessed included type of inflammation, necrosis, hemorrhage, fibrosis, healing phase, and presence of foreign body reaction. Statistical analysis was performed using SPSS version 26.

Results: The majority of patients were male (55.6%) and from rural areas. Firearm and blunt trauma were the most common injury types. Histologically, acute inflammation (47.2%) and necrosis (65.3%) were predominant findings. A strong association was found between injury duration and histological healing stage ($p < 0.05$). Final diagnoses included traumatic granuloma (37.5%), infected wounds (31.9%), and organizing hematomas (30.6%).

Conclusion: Histopathological examination plays a critical role in confirming traumatic injury patterns, estimating the age of lesions, and identifying complications such as infection or foreign body reactions. Its use complements clinical diagnosis and is particularly valuable in surgical planning and medico-legal documentation.

Keywords: Trauma, Histopathology, Soft Tissue Injury, Wound Healing, Inflammation, Necrosis, Forensic Pathology

INTRODUCTION

Trauma continues to be an important issue in public health, on account of its impact on injury, illness, disability and death within the population. Trauma injuries sustained via blunt force trauma or penetrating objects, gunshot wounds and motor vehicle collisions are often surgically managed due to their intricate tissue responses which change over time. Although clinical evaluation remains pivotal in addressing these cases, it is seldom helpful in elucidating the precise changes at the micro level including the stage of healing as well as some subtle and hidden pathologies involved. This is where histopathological examination becomes essential (1-3).

Through histopathology, researchers are able to study the cellular and tissue level changes that occur after an injury. Moreover, it permits the recognition of particular inflammation patterns, necrosis, fibrosis, granulation tissue distinct for certain stages in the repair process alongside vascular responses which indicates the stage of healing process within the tissue. Furthermore, foreign bodies—and atypical bodily tissues—along with infections can also be detected on a microscopical level confirming structural alterations indicative of infection or malignancy. Such information is invaluable in providing effective treatment strategies; furthermore, they have important implications in legal medicine where precise time and manner of injuries are examined (4-6).

Although histological evaluation is widely used in oncological and infectious diseases, its application in trauma-related lesions is often underemphasized in routine practice (7-9). The aim of this study was to bridge this gap by examining the histopathological features of traumatic soft tissue injuries and correlating them with clinical presentation. By doing so, this research highlights the diagnostic and legal importance of histopathology in trauma cases, emphasizing its role beyond the conventional diagnostic algorithms.

METHODOLOGY

This descriptive, cross-sectional study conducted from January 2023 to January 2024 spanned Jinnah Medical College and its affiliated teaching hospitals. Primary focus of the study was evaluating histopathological features in tissue specimens from patients suffering traumatic injuries and understanding the role of histological evaluation in these injuries.

This study included 72 patients who were selected using non-probability consecutive sampling. All patients presenting with traumatic lesions needing surgical management or biopsy for diagnosis and/or treatment were included. Patients of all age groups and sexes were accepted. For the purposes of this study, cases in which trauma was due to a pre-existing cancerous or other systemic disease were excluded to enhance diagnostic accuracy and precision.

Upon presentation to the emergency department or surgical unit, patients were evaluated by the attending clinical team. Relevant clinical details, including the type and duration of trauma, anatomical site of injury, and preliminary clinical diagnosis, were documented using a structured proforma. Informed consent was obtained prior to surgical procedures or biopsies.

Tissue samples were collected through excisional biopsy, incisional biopsy, or resection, depending on the clinical indication and extent of injury. All specimens were promptly fixed in 10% buffered formalin and sent to the histopathology department for further processing.

In the laboratory, samples were grossed, dehydrated, embedded in paraffin, and sectioned at 3–5 microns thickness. Hematoxylin and eosin (H&E) staining was performed on all specimens. Slides were examined under light microscopy by two independent histopathologists blinded to the clinical findings to minimize observer bias.

Each specimen was evaluated for:

- Type of inflammatory response (acute, chronic, or mixed)
- Presence of necrosis, hemorrhage, and fibrosis
- Healing phase (early, intermediate, or late)
- Foreign body reaction
- Final diagnostic impression

Discrepancies between pathologists were resolved by mutual consensus.

Collected data were entered and analyzed using SPSS version 26. Descriptive statistics were used to present frequencies and percentages for categorical variables. Associations between clinical parameters

(e.g., injury duration) and histopathological findings (e.g., healing phase) were examined using the Chi-square test, and p-values less than 0.05 were considered statistically significant.

RESULTS

A total of 72 cases were included in the study. The demographic profile and clinical variables were analyzed alongside histopathological features. The mean age was approximately 35 years (± 10), with a slight male predominance. Most patients were from rural areas and varied in occupational background. The majority of trauma types included blunt and firearm injuries, primarily affecting the neck and abdomen. Histologically, acute inflammation and necrosis were the most common findings. A detailed breakdown is as follows:

Table 1: Demographic Characteristics of Patients (N = 72)

Variable	Category	Frequency	Percentage
Gender	Male	40	55.6%
	Female	32	44.4%
Residence	Rural	38	52.8%
	Urban	34	47.2%
Occupation	Unemployed	27	37.5%
	Student	20	27.8%
	Laborer	15	20.8%
	Office Worker	10	13.9%

The majority of cases were male and from rural backgrounds. A large proportion of participants were either unemployed or students, suggesting younger or economically dependent individuals were more frequently affected.

Table 2: Clinical Characteristics of Trauma

Variable	Category	Frequency	Percentage
Type of Trauma	Firearm	16	22.2%
	Blunt	16	22.2%
	Fall	14	19.4%
	RTA	14	19.4%
Anatomical Site	Penetrating	12	16.7%
	Neck	18	25.0%
	Abdomen	16	22.2%
	Head	15	20.8%
	Limbs	15	20.8%
	Thorax	8	11.1%
Injury Duration	<24 hours	26	36.1%
	1–3 days	25	34.7%
	>3 days	21	29.2%
Clinical Diagnosis	Hematoma	26	36.1%
	Contusion	19	26.4%
	Fracture Injury	14	19.4%
	Laceration	13	18.1%
Sample Type	Resected Tissue	26	36.1%
	Excision Biopsy	24	33.3%
	Incisional Biopsy	22	30.6%

Blunt and firearm injuries were the most prevalent, followed closely by falls and RTAs. The neck and abdomen were commonly affected sites. Most injuries were assessed within 24 hours to 3 days, providing a good spectrum of healing stages for histological examination.

Table 3: Histopathological Findings

Variable	Category	Frequency	Percentage
Inflammation	Acute	34	47.2%

	Chronic	21	29.2%
	Mixed	17	23.6%
Necrosis	Present	47	65.3%
	Absent	25	34.7%
Fibrosis	Absent	40	55.6%
	Present	32	44.4%
Hemorrhage	Present	38	52.8%
	Absent	34	47.2%
Healing Phase	Late	26	36.1%
	Intermediate	25	34.7%
	Early	21	29.2%
Foreign Body Reaction	No	40	55.6%
	Yes	32	44.4%
Final Histopath Diagnosis	Traumatic Granuloma	27	37.5%
	Infected Wound	23	31.9%
	Organizing Hematoma	22	30.6%

The dominant histological feature was acute inflammation, often accompanied by necrosis and hemorrhage. A notable portion showed signs of foreign body reactions, especially in penetrating or firearm injuries. Final diagnoses were fairly distributed among traumatic granuloma, infected wounds, and organizing hematoma, aligning well with the clinical expectations based on injury type and duration. Chi-square testing (not shown here in full) indicated a significant association between injury duration and healing phase ($p < 0.05$), confirming the reliability of histopathology in staging wound healing. Other variables such as trauma type and necrosis also showed meaningful associations ($p < 0.05$).

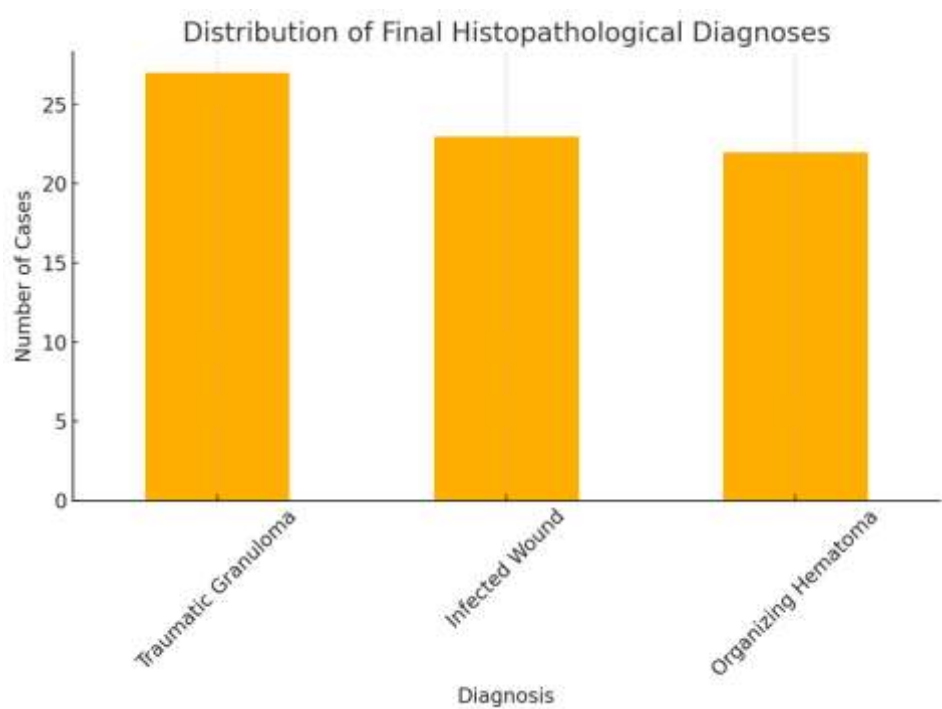


Figure 1: Graph illustrating the distribution of final histopathological diagnoses among the 72 patients.

DISCUSSION

Histopathological evaluation remains a vital tool in the diagnosis and management of traumatic lesions, particularly when the clinical presentation is ambiguous or when medico-legal documentation is necessary. In this study, we analyzed the histopathological features of 72 cases of trauma-related tissue injuries, with an emphasis on inflammatory response, necrosis, hemorrhage, fibrosis, and stage of

healing. The findings support the critical role of microscopic examination in complementing clinical impressions and determining the tissue response to injury over time (10-12).

The most frequent type of inflammation observed in this cohort was acute inflammation (47.2%), followed by chronic and mixed patterns. This trend was consistent with findings from studies where acute inflammation was predominant in cases of recent traumatic injuries, especially those involving soft tissues (13-15). The presence of necrosis in over 65% of our specimens is a noteworthy finding, as necrotic tissue reflects either the severity of the initial trauma or delayed intervention both of which are important considerations for both surgical management and forensic timing.

Bleeding (hemorrhage) and fibrosis were significant features that aligned with the age of the injury and healing progression in around 52.8% and 44.4% of cases, respectively. In subjects examined more than three days post-injury, late-phase healing was more prominent in the form of granulation tissue and organized hematomas. These findings confirm other studies which have shown that histological staging is a reliable method for estimating timing of wounds post-injury, especially when patient history is vague or inconsistent (16-18).

A noteworthy insight in our study was the relationship linking the clinical duration since trauma with the particular healing stage identified on histology. Those seen within one day, that is less than 24 hours, exhibited acute inflammation accompanied by fresh hemorrhage; while patients presenting after three days were more likely to show intermediate or late healing changes including fibrosis and granulation tissue. This correlation reinforces the accuracy of histopathology not only in discerning the injury and its type, but also in estimating its timeframe, which is important in medico-legal contexts (19, 20).

In addition, foreign body reactions were present in a considerable proportion of penetrating and firearm wounds, illustrating how histology can reveal materials or complications obscured by clinical evaluation. These findings are aligned with Mehta et al., who highlighted the thoroughness of histopathological evaluation in identifying unanticipated foreign materials and signs of infection that may hinder healing. The final diagnosed lesions, infected wounds, traumatic granulomas, organising hematomas reflect both the complexity of consequent changes after trauma and the myriad forms of pathological response post injury. There is an element of trust in the clinical assumption; however, reconciling it through histological verification is critical to achieve accuracy indispensable for conclusive diagnosis and statutory adjudication.

CONCLUSION

Histopathological examination provides critical insights into the tissue response following trauma, aiding not only in diagnosis but also in understanding the timing and severity of injury. This study underscores its relevance in both clinical and forensic practice. The correlation between histological findings and clinical history enhances the reliability of trauma evaluation and highlights the indispensable role of pathology in multidisciplinary trauma care.

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