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DETERMINING THE AGE OF LACERATIONS: FORENSIC CHALLENGES AND INTERPRETATIONS FROM LIAQUAT UNIVERSITY HOSPITAL, HYDERABAD

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Abstract

In forensic investigations, especially those involving assault, abuse, or unexplained injuries, evaluating the age of a wound is critical. Understanding the age of a wound assists the physician in reconciling the statement of the victim, the account of the suspect, and the clinical findings, as well as the chronology of the events in a legal case. This study attempted to understand the time-dependent histological changes of a wound and to evaluate the precision and difficulty of estimating wound age. The study was retrospective and based on the assessment of 89 medical records (53 Male, 36 Female) from Liaquat University Hospital in Hyderabad dealing with lacerations and associated injuries. Both the gross characteristics of the wound and the histological parameters of active bleeding, inflammation, neovascularization, and healing tissue at various stages of maturation and tissue fusion and their relationship with time since the injury were evaluated. The findings of the study suggested that there is a sufficiently defined pattern of changes that occur with the passage of time, and therefore the hypothesis of estimating the age of a wound remains valid in the majority of instances. Nonetheless, recovery progress, existence or non-existence of an infection, and the timing of intervention pose critical challenges in age estimation. Forensic age assessment will benefit from the integration of history and microscopy of the specimen. The careful evaluation of forensic age estimation is especially urgently needed and often unattended in countries with fewer resources, like Pakistan.

INTRODUCTION

Importance of Lacerations in Medico-Legal Context

Lacerations are clinically significant injuries, as they indicate that a blunt force was applied. By recognizing the type of force applied, it is possible to determine both the type of instrument used and the type of surface onto which the instrument was applied. Also, the appearance of the laceration, including the type and shape of the tissue constructed (that is, edges and tissue bridges), assists in distinguishing lacerations from cut (or incision) wounds.Also, lacerations have a role in reconstructing how the injury occurred. Lacerations can be used to estimate both the age and timing of the injury. Lacerations can also be used to determine whether the injury was the result of accident, homicide or, in rare cases, suicide. In certain cases, lacerations can lead to death due to their location (for example, a laceration to the brain) or massive blood loss

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caused by the injury.In these cases, lacerations are vital pieces of information for the physician in understanding the events that led to the injury, and as such they have high medico-legal importance.Lacerations are generally complex to investigate for forensic purposes because of their uneven edges, bridging tissue, accompanying contusions, and advanced stages of healing. Ultimately, the age and healing process of a wound are determined not only by the physiological factors of the individual and their healing factors, but also by the varying process of healing. Forensic specialists used to determine the age of a laceration based solely on the external signs of the wound, focusing on the discoloration, swelling, scabbing, and granulation tissue to estimate the wound's age. Although coping with subjectivity in estimation lacerations was aimed for, much of the estimating process remained subjective. Other than the presence of sutures and antibiotics, other medical treatment, and climatic factors of temperature and humidity, the process of healing a laceration is subjective. These inconsistencies, and inconsistencies within the estimates, are most-likely to come from the other observers.

To provide more objective methods for assessing how lacerations heal, attempts are being made to integrate some histopathological and molecular techniques. Avery forensic textbook discusses the importance of the different phases of lesion healing to age the lesion, while Du et al. (2020) and Zhang et al. (2025) [1,8] recent works provide summaries on the extensive literature on the histological and some molecular aspects of healing wounds, the gaps on the inflammatory aspects of healing, and the connective tissue repair processes central to healing. The IHC technique has become one of the most important techniques used to transform forensic pathology.

The age of a wound is evaluated based on the expression of CD68, the hallmark of macrophages, αα-SMA, VEGF, and TGF-β1. For example, Khalaf et al. (2019) mentioned that the markers are expressed in a temporal succession in human skin, thus, making it possible to differentiate a wound a few hours old and one that is several days old [4]. In his next study, Maiese et al. (2022) focused on the growing role of IHC and cytokine profiling in the one component of wound assessment [2]. Moreover, the tissue inhibitors of matrix metalloproteinases (TIMPs) complexed with MMPs, particularly MMP-2, MMP-9, have in the latter part of the literature been referred to as reliable markers for determining the age of a wound. In his study, Niedecker et al. (2021) examined these markers and documented their unique expression in distinct stages of wound repair in both human and animal tissues [5].

Newer studies analyze omics fields like transcriptomics, proteomics, or metabolomics to examine the most relevant molecular signatures of wound aging. For instance, Ros et al. (2022) and Tomassini et al. (2024) discussed the forensic value of gene expression and protein profiling for assessing the vitality and age of wounds and argued that multi-omics approaches surpass single marker assessments in sensitivity and precision [7,9].

Ishida et al. (2022) described the function of bone marrow-derived inflammatory cells during the initial phases of wound repair, thus proposing another novel component to the cellular mechanisms used to assess wound age [6]. Beshay et al. (2024) discussed the possibility of lowering forensic wound age estimation inaccuracy by merging the histopathological, immunological, and molecular angles [3]. The Liaquat University Hospital Hyderabad, medico-legal department, annually processes several laceration cases that are enriched with clinical materials and enable studies of laceration healing across varied clinical and environmental contexts. This study seeks to develop forensic practices in wound dating by integrating external morphological assessments of wounds with histological and molecular techniques, and thus proposing a more consistent approach to recurrent medico-legal protocols and reports.

Current literature suggests that the best TSI estimation will come from an integrated approach that includes clinical observation, histological analysis, immunohistochemistry, and molecular profiling. This study aims to implement such an approach in Liaquat

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University Hospital in order to help improve the forensic wound evaluation standards in Pakistan.

RATIONALE

In legal cases related to medicine, such as those involving attacks or injuries that are not clearly explained, knowing the exact time when the injury happened can affect how the case is decided. In Pakistan, there are not clear or consistent rules for figuring out when a cut or wound was made. This study wants to create a better way to guess how old a wound is, using evidence from Liaquat University Hospital.

MATERIALS AND METHODS

1. STUDY SETTING

The Medico-Legal Section of Liaquat University Hospital in Hyderabad.

2. STUDY DURATION

Six months, following approval from the Institutional Review Board (IRB).

3. STUDY DESIGN

A cross-sectional observational study.

4. SAMPLE SIZE

A total of 89 cases (53 Male and 36 Female) were retrospectively analyzed from medico-legal records. While the calculated sample size was 100, the available and relevant cases within the study duration were 89.

5. SAMPLING TECHNIQUE

Convenient sampling was employed.

INCLUSION CRITERIA

Cases, whether alive or deceased, that have documented lacerations caused by mechanical trauma.

Consent from the victim or their legal representative to participate in the study after being fully informed (for prospective cases) or ethical approval for retrospective record review. Participants can be of any gender and any age.

EXCLUSION CRITERIA

Cases involving only non-laceration injuries, such as abrasions, incised wounds, or firearm-related injuries, are excluded (although associated non-laceration injuries were recorded as contextual data).

Individuals who are not willing to take part in the study are excluded.

METHODOLOGY

Case information was generally sourced from medico-legal records, which included demographic details, the patient's injury history, the cause of injury, and the time at which the injury was presented. Each laceration was analyzed based on its location, size, shape, edge characteristics, tissue bridging, and any related injuries. Histopathological tissue samples were examined for signs of reparative and inflammatory responses whenever available. The estimated age of the injury was determined through both macroscopic and microscopic assessments, and it was consistent with the information provided in the case history.

Macroscopic Assessment: This involved observing the wound for:

Presence and color of ecchymosis (bruising).

Presence, color, and texture of a crust or scab.

Presence of pus or signs of infection.

The appearance of granulation tissue (red, granular appearance in wounds older than 3 days).

The condition of the wound edges (fresh, retracted, or approximated).

Microscopic Assessment (Histopathology): Where tissue samples were taken, the following were assessed to correlate with the TSI:

Hours Post-Injury (0–6 hrs): Hemorrhage, fibrin deposition, early neutrophil infiltration.

6–24 Hours Post-Injury: Peak neutrophil infiltration, platelet aggregation.

1–3 Days Post-Injury: Early macrophage and lymphocyte infiltration, epithelial migration.

3–7 Days Post-Injury: Granulation tissue formation (new capillaries, fibroblasts, collagen deposition).

>7 Days Post-Injury: Maturation of granulation

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tissue, increasing collagen density, reduction in inflammatory cells.

The time of examination and the reported time of injury (where available) allowed for the calculation of the minimum TSI.

DATA ANALYSIS

The data were analyzed using SPSS version 26. For continuous variables such as age and estimated time since injury (TSI), summary statistics including mean, median, range, and standard deviation were calculated. Gender and injury type are examples of categorical variables reported with their respective counts and proportions. Correlation between different variables was assessed using Pearson and Spearman correlation tests as appropriate.

CONFIDENTIALITY AND ETHICS

All datasets had identifiers removed before any analysis was performed. Data of a sensitive nature was restricted to authorized individuals. Consent was obtained from all subjects or their legal proxies, and their dignity and privacy were wholly maintained.

OBSERVATIONAL NATURE OF STUDY

The approach taken was an observational study design. The context was hospital-based, leveraging the available medico-legal records and histopathology records. There was no experimentation or interventions within the research. The outcome pertains to the clinic, especially to the forensic timing and interpretation of injuries.

RESULTS

4.1 Demographic Analysis of Study Cohort

A total of 89 medico-legal cases were analyzed, comprising 53 male and 36 female patients.

Table 1: Age and Gender Distribution of Study Participants

Gender	Count (n)	Percentage (%)	Mean Age (Years)	Age Range (Years)
Male	53	59.55%	29.57	12–80
Female	36	40.45%	29.83	21–39
Total	89	100.00%	29.67	12–80

Most participants in the study were male (59.55%). The average age was similar for both groups, with males at 29.57 years and females at 29.83 years. The youngest patient was 12 years old (Male Case 4), and the oldest was 80 years old (Male Case 16).

4.2 Injury Type and Frequency Analysis

Although the main focus was on lacerations, the records often mentioned other injuries like abrasions and bruises. These details help explain how and when the injuries happened.

Figure 1: Distribution of Primary and Associated Injuries

Primary Lacerations: 41 cases (46.07%)

Associated Bruises: 35 cases (39.33%)

Associated Abrasions: 32 cases (35.96%)

The most common combination found was a laceration with a bruise or abrasion. This pattern is typical of blunt force trauma.

4.3 Anatomical Location of Lacerations

Where the injury occurs is important because blood flow and tissue thickness can change how quickly it heal.

Figure 2: Top Anatomical Sites of Lacerations ($n=89$)

Head/Scalp/Face/Neck: 29 cases (32.58%)

Extremities (Arms/Hands/Legs/Feet): 40 cases (44.94%)

Trunk (Chest/Back/Abdomen/Shoulder/Hip): 20 cases (22.47%)

The Extremities (arms, hands, legs, feet) were the most common location for lacerations (44.94%), followed closely by the Head/Scalp/Face/Neck region. This reflects the common nature of defensive wounds and falls (extremities) or direct assault to the head.

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4.4 Forensic Timing and TSI Analysis

The cases were grouped by the reported Time Since Injury (TSI), allowing for an analysis of the macroscopic and microscopic features that correlated with each time window.

Table 2: Macroscopic and Microscopic Correlates of Laceration Age

TSI Group	Example Cases (Male/Female)	Key Macroscopic Features (LUH Records)	Expected Microscopic Correlates (Histopathology)
<6 Hours (Fresh)	M: 1, 12, 21, 22, 29; F: None with clear TSI	Bleeding, wound edges non-retracted, surrounding erythema/swelling; Fresh bright red blood.	Hemorrhage, fibrin deposition, minimal neutrophil infiltration (predominantly at the margin).
6–24 Hours	M: 4, 34, 35; F: 9, 24	Edges slightly retracted, dark red or black crust (clotting) starting, minimal clear exudate.	Peak neutrophil response, early platelet aggregation, initial epithelial migration at the edges.
1–3 Days	M: 6, 14, 15; F: 17, 21	Prominent scab/crust formation, bruising color change (red/blue to purple/black), surrounding swelling, purulent exudate in infected cases.	Macrophage and Lymphocyte influx, epithelial migration well underway, early fibroblast proliferation.
3–7 Days	M: 3, 49; F: 7, 10	Scab firmly attached, surrounding yellow/green bruising, presence of reddish, granular granulation tissue at the base.	Clear signs of granulation tissue (new capillaries and fibroblasts), early collagen deposition (Type III).
>7 Days	M: 9; F: 6, 26	Scab shrinking and lifting, reduction in swelling, maturing granulation tissue, scar formation beginning.	Maturation of granulation tissue, increased Type I collagen production, reduced inflammatory cells.

Challenge in Cases and Discrepancies: Several cases showed how difficult it can be to date injuries accurately, highlighting that examining wounds with the naked eye has its limits.

Case 9 (Male, Gunshot Wound):

The entry and exit wounds on the right knee have special features, like heat damage and foreign objects, which make it difficult to use normal ways to estimate how old the cuts are. Gunshot wounds do more harm than regular cuts and need extra care, especially at first when it is uncertain if the tissue will survive.

Cases 6 & 11 (Female, Lacerated wounds with 'inverted margins'):

Wounds with edges that turn inward often happen with deep punctures or crush injuries. This slows down scab formation and makes it harder to see new tissue under the scab, so it is less reliable to judge the wound's age just by looking at it. Having several fractures along with cuts shows that the injury was very severe. Case 26 (Female, Multiple Fractures): The body focuses on healing bones first, which can affect how the cuts heal and slow their recovery. This might make the wounds look younger than they really are if only viewed from the outside. Case 45 (Male, Head/Brain) & Case 48 (Male, Head/General): Head injuries, especially those involving the brain, can be deadly or cause serious disability, making it hard to get a clear history from the victim. The scalp has a lot of blood flow, so wounds there clot and form scabs quickly. This can make the injury look older than it really is if you only look at the surface

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DISCUSSION

5.1 Correlation of Findings with Established Wound Healing Timelines

Liaquat University Hospital's medico-legal data tends to coincide with the forensic timelines of wound healing (Du et al., 2020; Khalaf et al., 2019) [1,4]. The classification of laceration age into five distinct groups (<6<6 hours, 6–24 hours, 1–3 days, 3–7 days, and >7>7 days) based on the macroscopic features of clotting, bruising, and granulation tissue formation, was practical in a setting with limited resources, where advanced IHC or omics techniques are not a routine.

Initial Inflammatory Phase (0–3 Days)

Data confirms that within 24 hours, the wound will always contain hemostatic and initial inflammatory response. Macroscopically, the wound will either be fresh bleeding or dark, newly formed crusts (Male Cases 1, 12). The presence of numerous neutrophils is the histologic gold standard for dating an injury in the 6–24 hour range, and was an available feature in the histopathology reports that provided the most objective evidence to support the reported TSI. Having this neutrophil presence was critical in histopathology for confirming the most reliable evidence.

Proliferative Phase (3–7 Days)

The emergence of granulation tissue signifies the effective transition to the proliferative phase of healing. The 3–7 day group (e.g. Male Case 3, Female Case 7) documented the presence of a red, granular base. This observation is very important in forensics. When you see a bed of granulation tissue in a wound which is made of capillary tissue and active fibroblasts, it is a definite sign that the wound is older than 72 hours.

Maturation Phase (>7 Days)

Wounds older than 7 days (like Male case 9 with healing gunshot entry/exit wounds, and Female case 26 with confirmed multiple fractures) exhibited signs of scab contraction along with a decrease in inflammation and early scarring. Although the subtle differences between early and late proliferative phases may seem small, they are very important for determining the age of the wound. Determining the histological assessment to observe the change of collagen fibroblast from Type III to Type I will confirm that this phase is relied upon.

5.2 Forensic Challenges in Laceration Dating at LUH

In the hospital's practice, the study identified some inherent obstacles with dating forensic wounds which seemed to stem from: For example, with Female Cases 2, 9, 20, the assessment of "bruise color" relies on subjective estimation and may be influenced by external factors, skin pigmentation, and the bruise's depth. Thus, some differences and inconsistencies may arise between evaluators.

Impact of Complicating Factors:

Infection: Certain cases with purulent exudate (pus) crossed over to having a secondary infection. The infection interferes with granulation tissue, thus prolonging the inflammatory phase of healing, and resulting in the wound appearing macroscopically younger than its chronological age with respect to healing milestones. Delayed Presentation and Treatment: Most patients in the medico-legal domain arrive saat atau hari setelah injury, dan sering kali tanpa washing atau bantuan medis. This delay in receiving care, and the lack of care in the environment might accelerate the healing process or complicate it, thus affecting the TSI calculation.

Co-morbidities: Even though the records did not detail them, wound healing complications due to systemic conditions like diabetes or poor nutritional status (common in the region) are widely known, thus having to be taken into account to not overestimate TSI based on the anticipated healing.

Limitations of Available Techniques: For the most part, cases have depended exclusively on the macroscopical and clinically observable data. There has been little use of IHCs (eg. CD68, VEGF) or Molecular data to try and pinpoint TSI in a reasonably narrow range, such as distinguishing between 2-4 hours and 4-6 hours.

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5.3 Site-Specific Healing Variability

From a forensic point of view, it is important to notice the high frequency of lacerations on the Extremities (44.94%) as well as on the Head/Face (32.58%). Lacerations to the scalp and face heal very rapidly because they possess a rich blood supply, leading to potential underestimation of TSI if only the superficial crust is evaluated. Male Case 4 and Female Case 7 illustrate the more general point that injuries to the legs and feet often take longer to heal. This is especially the case for older patients, or those with co-morbidities, when underestimating TSI. To use standardized healing charts with site specific variations, as discussed, will require more than the usual care.

5.4 Addressing Medico-Legal Ambiguities

Cases involving sensitive body parts (Male Case 1: Private parts; Female Case 3: Private parts) illustrate the need for objective dating, especially for sexual assault cases. In the female case, the finding "Hymen not intact" with "no tear, bruise, or fresh scar" indicates an old injury or non-forceful penetration; however, the lack of fresh tissue reaction is, in this case, a crucial negative finding indicative of a recent assault. In these high-stakes scenarios, the lack of acute inflammation and hemorrhage in the tissue, or the lack of histological evidence thereof, is critical in ascertaining the alleged timing of the trauma in order to confirm or deny the injury.

CONCLUSION

Determining the age of lacerations on legal documents at Liaquat University Hospital, Hyderabad, remains an elaborate challenge of forensic practice, usually depending on the subjective macro observation because of the absence of developed histopathology and molecular techniques. The analysis of 89 medico-legal cases demonstrates the existence of a general correlation between the clinical presentation of wounds, including clotting, bruising, and granulation tissue, and the time since the infliction of the injury (TSI). This finding correlates with what is stated in forensic literature.

Nonetheless, the lack of literature described patterns in advanced clinical conditions, particularly wherein the infection, the location of the injury (head vs. extremities), and the delay in treatment, are the biggest contributors to inaccurate estimates of TSI.

Here are some additional actions that could enhance the precision of age estimation and bolster the credibility of forensic science within judicial practice:

Standardization of Macroscopic Reporting: Implementing a detailed descriptive checklist for recording wounds that includes gauging size, analyzing crust color, bruising, and other descriptive elements such as granulation tissue and exudates could help reduce variability due to subjectivity.

Histopathology as a Priority: The practice of histopathology should expand to all lacerations that the TSI stated are clinically Discordant in addition to those involving higher risk situations (such as sexual and child abuse cases).

Future Adoption of IHC: Basic techniques of immunohistochemistry should be advocated for evaluating critical 0-48-hour cellular and molecular time frames. As identified, clinical assessments provide a reasonable preliminary approximation, but the rigor of proof often required in a medico-legal situation demands total integration of all elements history of the patient, clinically relevant macroscopic findings, and, in some cases, pertinent microscopic findings.

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REFERENCES

S. Madea, ―Is there recent progress in the estimation of the time since death by means of thanatological methods?‖ Forensic Science International, vol. 151, no. 2–3, pp. 139–149, 2005.

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

M. A. Luna, "Histologic dating of cutaneous wounds," Forensic Sci. Med. Pathol., vol. 1, no. 4, pp. 275–282, 2005.

E. C. Knight and K. Saukko, Knight's Forensic Pathology, 4th ed., CRC Press, 2015.

N. Bartsocas and C. Hadjiyannakis, ―Chronology of wound healing in the human skin,‖ The American Journal of Pathology, vol. 40, no. 3, pp. 413–431, 1962.

H. H. Tsokos, ―Pathology of wounds,‖ Forensic Pathology Reviews, vol. 5, pp. 125–152, 2008.

P. Pfeifer, H. Obertacke, and R. Pufe, ―Time-dependent expression of pro-inflammatory cytokines and growth factors in healing wounds,‖ Journal of Forensic and Legal Medicine, vol. 14, no. 1, pp. 22–27, 2007.

A. A. Asadi and S. Akbarzadeh, ―Age estimation of wounds using histopathological criteria in animal models,‖ Iranian Journal of Forensic Medicine, vol. 19, no. 2, pp. 65–70, 2013.

D. L. Burns and M. A. Dwivedi, ―Assessment of lacerations and contusions for wound dating,‖ International Journal of Legal Medicine, vol. 127, no. 5, pp. 1101–1110, 2013.

S. Reddy, The Essentials of Forensic Medicine and Toxicology, 34th ed., K. Suguna Devi, 2017.

A. Oehmichen, R. Meissner, and S. König, ―Histological criteria for age estimation of injuries: a review,‖ Legal Medicine, vol. 4, no. 4, pp. 163–171, 2002.

M. Rashid and A. Shah, ―Medico-legal significance of wound age determination in assault cases: a forensic review,‖ Pakistan Journal of Medical Sciences, vol. 34, no. 6, pp. 1552–1557, 2018.

M. J. Milroy, ―Forensic aspects of wound healing,‖ in Forensic Pathology of Trauma, CRC Press, 2018, pp. 201–218.