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Assessing the Reliability of Injury Age Determination in Medico-Legal Clinical Settings

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Abstract

Background: Injury age estimation is a vital component of medico-legal practice, aiding the correlation of clinical findings with alleged timelines of events. However, variability in wound healing due to multiple factors can affect the accuracy of clinical estimation.

Aim: To assess the accuracy of injury age estimation in clinical medico-legal practice.

Materials and Methods: This hospital-based cross-sectional study was conducted at Sri Balaji Vidyapeeth (Deemed to be University), Puducherry, over one year. A total of 50 medico-legal cases with known time of injury were included. Injuries such as abrasions, contusions, and lacerations were clinically examined, and injury age was estimated based on standard medico-legal criteria. The estimated time was compared with the actual time of injury. Accuracy was defined as estimation within ±6 hours for recent injuries and ±12 hours for older injuries. Statistical analysis was performed using SPSS, and a p-value < 0.05 was considered statistically significant.

Results: Overall accuracy of injury age estimation was 64%, with 36% showing discrepancies. Abrasions showed the highest accuracy (80%), while lacerations showed the lowest (50%) ($p = 0.04$). Accuracy was highest within 24 hours (75%) and decreased with increasing duration of injury ($p = 0.03$). The kappa value of 0.58 indicated moderate agreement between estimated and actual injury time.

Conclusion: Clinical estimation of injury age demonstrates moderate accuracy and is influenced by the type of injury and duration since occurrence. While useful in medico-legal practice, it should be interpreted as an approximate guide rather than an exact measure. Incorporation of standardized criteria and adjunct methods may improve accuracy.

Keywords: Injury age estimation, medico-legal practice, wound healing, abrasions, contusions, cross-sectional study.

Introduction

Injury age estimation plays a crucial role in medico-legal practice, particularly in cases involving assault, abuse, accidents, and disputed timelines. Determining the approximate time since injury is essential for correlating clinical findings with alleged events and for providing objective evidence in legal proceedings. Accurate estimation can significantly influence the outcome of medico-legal cases [1]. The assessment of injury age is primarily based on clinical examination of wound characteristics, including color changes, swelling, scab formation, and healing stages. Different types of injuries, including abrasions, contusions, and lacerations, exhibit characteristic temporal changes that can be used to estimate the time [2].

However, injury healing is influenced by several factors, including age, nutritional status, comorbidities, severity of injury, and environmental conditions. These factors can introduce variability in the healing process, making precise estimation challenging in clinical practice [3]. Contusions, for example, show progressive color changes due to hemoglobin breakdown, while abrasions undergo stages of scab formation and epithelialization. Although these changes provide useful clues, overlapping features may limit accuracy, especially in the early and late phases of healing [4]. In medico-legal settings, inaccurate estimation of injury age can lead to misinterpretation of events and may affect judicial outcomes. Therefore, evaluating the reliability and accuracy of clinical methods for estimating injury age is of great importance [5].

Several studies have attempted to correlate clinical findings with known timelines of injury, but variability remains a major concern. There is a need for systematic evaluation of accuracy in real-world clinical settings to understand the limitations and improve medico-legal assessments [6]. Cross-sectional studies provide valuable insights into the agreement between clinical estimation and actual injury timing in routine medico-legal practice. Such studies help in identifying the accuracy, limitations, and areas for improvement. Therefore, the present study was undertaken to assess the accuracy of injury age estimation in clinical medico-legal practice in a cross-sectional study setting [7].

Materials & Methods

Study Design and Setting

This hospital-based cross-sectional study was conducted over a period of one year in the Department of Forensic Medicine in collaboration with the Department of of Forensic Medicine and Toxicology at Sri Balaji Vidyapeeth (Deemed to be University), Puducherry, India. The study aimed to assess the reliability of clinical injury age determination in medico-legal practice.

Sample Size

A total of 50 medico-legal cases were enrolled using consecutive sampling. The sample size comprised all eligible cases presenting during the study period who fulfilled the selection criteria.

Study Population

The study included medico-legal cases aged ≥18 years with a documented history of injury and a known time of occurrence. Patients presenting with recent abrasions, contusions, and lacerations were evaluated to compare clinically estimated injury age with the documented time of injury.

Inclusion Criteria

Patients aged 18 years and above presenting with recent medico-legal injuries, including abrasions, contusions, and lacerations, with a clearly documented history and known time of injury were included in the study.

Exclusion Criteria

Patients with an uncertain history regarding the timing of injury, infected or chronic wounds, burns, and conditions known to alter wound healing, including diabetes mellitus, immunocompromised states, and severe malnutrition, were excluded.

Study Tool

Data were collected using a predesigned structured proforma that included demographic details, injury history, and clinical findings. Each participant underwent a detailed medico-legal examination, during which injury characteristics including type, size, colour, swelling, scab formation, and stage of healing were systematically documented. The age of injury was estimated clinically by experienced forensic clinicians using standard medico-legal criteria. The estimated injury age was subsequently compared with the documented time of injury obtained from the patient history and corroborated using available medical and medico-legal records. Estimation was categorized as accurate when the difference between the estimated

and actual injury time was within ±6 hours for recent injuries and ±12 hours for older injuries.

Data Collection

Following written informed consent, detailed clinical and medico-legal information was recorded for each participant. Injury examination was performed using a standardized assessment protocol, and all findings were documented at the time of evaluation. The primary outcome measure was the accuracy of clinical injury age estimation. Secondary outcomes included variation in estimation accuracy according to injury type and identification of factors influencing the reliability of clinical assessment.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using the Statistical Package for the Social Sciences (SPSS) software version 26.0 (IBM Corp., Armonk, NY, USA). Continuous variables were expressed as mean ± standard deviation, while categorical variables were presented as frequencies and percentages. Agreement between clinically estimated and actual injury age was assessed using Cohen's kappa statistic. Associations between estimation accuracy and injury characteristics were analyzed using the Chi-square test. A two-tailed p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was approved by the Institutional Ethics Committee of Sathya Sai Medical College and Research Institute, Kanchipuram, prior to commencement. Written informed consent was obtained from all participants before enrolment. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki, and confidentiality of all participant information was maintained throughout the study.

Results

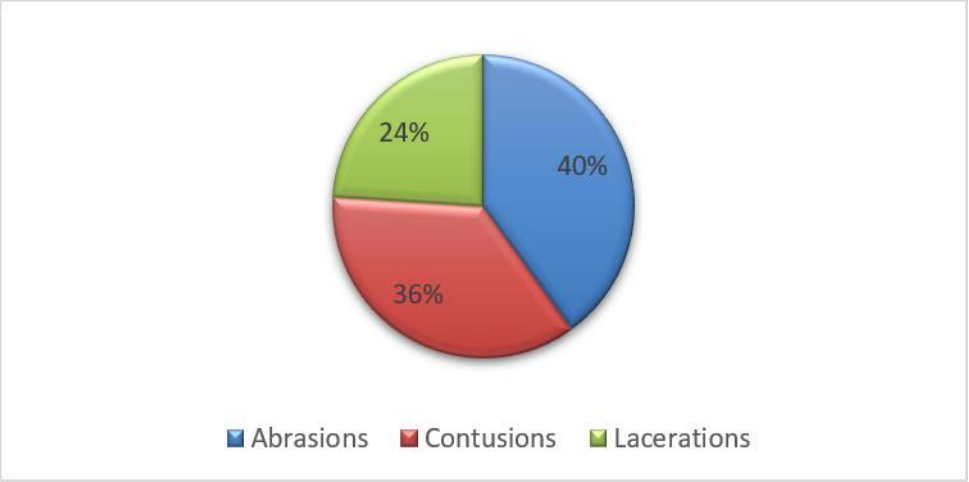
A total of 50 medico-legal cases with known time of injury were included in the study.

Table 1: Demographic Characteristics of Study Participants (n = 50)

Variable	Frequency (%)
Mean age (years)	34.6 ± 10.8
Male	32 (64%)
Female	18 (36%)

The study population predominantly consisted of young to middle-aged adults, with a mean age of 34.6 ± 10.8 years, indicating that individuals in the active and working age group are more frequently involved in medico-legal injury cases. There was a male predominance (64%), which may be attributed to higher exposure of males to outdoor activities, occupational hazards, and interpersonal violence. This distribution suggests that demographic factors such as age and gender play an important role in the occurrence of injuries encountered in medico-legal practice.

Figure 1: Type of Injuries Observed



Abrasions were the most common type of injury observed (40%), followed by contusions (36%) and lacerations (24%). This indicates that superficial injuries are more frequently encountered in medico-legal examinations.

Table 2: Accuracy of Injury Age Estimation

Category	Frequency (%)
Accurate estimation	32 (64%)
Inaccurate estimation	18 (36%)

Clinical estimation of injury age was accurate in 64% of cases, indicating moderate reliability of clinical assessment in medico-legal practice. However, a considerable proportion (36%) showed discrepancies between estimated and actual time, highlighting the inherent limitations of clinical judgment.

Table 3: Accuracy Based on Type of Injury

Type of Injury	Accurate (%)	Inaccurate (%)	p value
Abrasions	16 (80%)	4 (20%)	0.04
Contusions	10 (55.6%)	8 (44.4%)	
Lacerations	6 (50%)	6 (50%)	

The accuracy of injury age estimation varied significantly with the type of injury ($p = 0.04$). Abrasions showed the highest accuracy (80%), likely due to their predictable healing stages such as scab formation and color changes. Contusions showed moderate accuracy (55.6%), as color changes may overlap and vary between individuals. Lacerations demonstrated the lowest accuracy (50%), possibly due to variability in wound depth, healing response, and external factors such as contamination. The statistically significant association indicates that type of injury is an important determinant of estimation accuracy.

Table 4: Accuracy Based on Duration of Injury

Duration	Accurate (%)	Inaccurate (%)	p value
< 24 hours	18 (75%)	6 (25%)	0.03
24–72 hours	10 (62.5%)	6 (37.5%)	
> 72 hours	4 (40%)	6 (60%)	

Accuracy of injury age estimation decreased progressively with increasing duration of injury ($p = 0.03$). Estimation was most accurate within the first 24 hours (75%), as early inflammatory changes are more distinct and easier to interpret. Between 24–72 hours, accuracy declined due to overlapping healing features. Beyond 72 hours, accuracy further decreased (40%), likely due to variability in healing processes and influence of external factors. This statistically significant trend indicates that time since injury is a critical factor affecting estimation reliability.

Table 5: Agreement Between Estimated and Actual Injury Time

Parameter	Value
Kappa value	0.58
Interpretation	Moderate agreement

The kappa value of 0.58 indicates moderate agreement between clinically estimated and actual time of injury. This suggests that while clinical assessment provides a reasonable approximation, it is not highly precise. The moderate agreement reflects variability in wound healing and subjectivity in interpretation. Therefore, injury age estimation should be considered as an approximate guide rather than an exact measure in medico-legal practice

Discussion

The present cross-sectional study evaluated the accuracy of injury age estimation in clinical medico-legal practice and demonstrated that clinical assessment provides moderate reliability, with accuracy influenced by type of injury and duration since occurrence. In the present study, the majority of cases were young to middle-aged individuals with male predominance. Similar findings were reported by Knight B et al [8], who observed that medico-legal injuries are more common among males due to higher exposure to trauma and violence. Abrasions were the most common type of injury observed, followed by contusions and lacerations. This is consistent with Reddy KSN et al [9], who reported that superficial injuries are frequently encountered in medico-legal examinations and are easier to evaluate.

The overall accuracy of injury age estimation in this study was 64%, indicating moderate reliability. Similar findings were reported by Simpson K et al [10], who emphasized that clinical estimation provides only an approximate time frame rather than an exact duration. The present study demonstrated that abrasions showed the highest accuracy (80%), whereas lacerations had the lowest accuracy (50%), with a statistically significant association ($p = 0.04$). This finding is supported by DiMaio VJ et al [11], who highlighted that abrasions have more predictable healing patterns compared to deeper injuries.

Accuracy of estimation was highest within the first 24 hours (75%) and decreased significantly with increasing duration of injury ($p = 0.03$). This is in agreement with Gordon I et al [12], who reported that early inflammatory changes are more distinct, while later stages of healing show overlapping features. The kappa value of 0.58 in the present study indicates moderate agreement between estimated and actual injury time. Similar observations were reported by Saunders E et al [13], who demonstrated moderate inter-observer agreement in injury age estimation.

Variability in healing due to factors such as individual physiology, environmental conditions, and wound characteristics contributes to inaccuracies. Spitz WU et al [14] emphasized that multiple factors influence wound healing and limit precise estimation. Clinical judgment remains essential in medico-legal practice; however, reliance solely on visual assessment may not be sufficient. Madea B et al [15] highlighted the need for adjunct methods and standardized criteria to improve accuracy.

Recent advances suggest the potential role of biochemical and histological markers in improving injury dating. Oehmichen M et al [16] reported that microscopic examination can provide additional insights into wound age. Furthermore, Kondo T et al [17] and Langlois NE et al [18] emphasized the importance of combining clinical findings with scientific methods to enhance reliability in medico-legal evaluations.
Overall, the findings of the present study indicate that injury age estimation in clinical practice has moderate accuracy and is influenced by injury type and duration. While clinical assessment remains valuable, it should be interpreted cautiously, considering its limitations and variability.

Strengths: The study compared clinically estimated injury age with documented injury timing, providing an objective assessment of the reliability of medico-legal age estimation. The use of standardized clinical criteria and corroboration with available records enhanced the validity of the findings.

Limitations: The relatively small sample size and single-center design may limit the generalizability of the study findings. In addition, clinical assessment of injury age is inherently subjective and may vary among examiners despite the use of standard medico-legal guidelines.

Conclusion

The present cross-sectional study demonstrated that clinical estimation of injury age in medico-legal practice has moderate accuracy, with an overall accuracy of 64% and a kappa agreement of 0.58. The accuracy of estimation was significantly influenced by the type of injury and duration since occurrence. Abrasions showed higher accuracy, while lacerations were less reliably estimated ($p = 0.04$). Similarly, estimation was more accurate within the first 24 hours and decreased with increasing duration of injury ($p = 0.03$). These findings indicate that although clinical assessment is a useful tool in estimating injury age, it has inherent limitations and should be interpreted as an approximate guide rather than an exact measure. Incorporation of standardized criteria and adjunct diagnostic methods may improve accuracy in medico-legal evaluations.

Declaration

Conflict of interest: Nil

Funding Source: Nil

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