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Original Article

Accuracy of Visual Identification of Contusions Across Skin Tones- A Cross-Sectional Study in A Tertiary Care Centre in South India

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ABSTRACT

Background: Accurate identification of contusions is a critical component of forensic autopsy practice, as these injuries often provide key evidence of blunt force trauma. While abrasions and lacerations are usually apparent on external examination, contusions may be difficult to recognize visually, particularly in individuals with darker skin tones. Reliance solely on external inspection may therefore lead to underestimation of trauma.
Objectives: To evaluate the accuracy of visual identification of contusions across different skin tone categories and to assess the diagnostic yield of specialized soft tissue dissection in confirming underlying hemorrhage.
Methods: A prospective observational study was conducted on 200 medicolegal autopsy cases involving individuals aged 5 years and above. Skin tone was classified using the Massey–Martin NIS skin color scale. Cases with dissection findings confirming soft tissue hemorrhage were included. Accuracy of visual identification was calculated for each skin tone group, and the yield of specialized dissections was assessed across anatomical regions.
Results: Soft tissue hemorrhage was confirmed in 193 cases, while contusions were visually identified in only 98 cases. Visual identification accuracy declined progressively with increasing skin tone, from 65.4% in intermediate skin tone groups to 0% in the darkest category. Specialized dissections demonstrated the highest yield in the upper extremities (45.6%), followed by the torso (34.0%), lower extremities (29.5%), and neck (9.6%).
Conclusion: Visual inspection alone substantially underestimates contusions, particularly in darker skin tones. Selective use of specialized soft tissue dissection improves detection of occult injuries and supports more accurate and equitable forensic assessment.

Keywords: *forensic pathology; contusion; skin tone; blunt force trauma; soft tissue dissection.*

INTRODUCTION

Blunt force trauma is a common finding in forensic practice and plays a critical role in determining the cause and manner of death. [1] External examination of the body remains a fundamental component of the autopsy, with particular emphasis on identifying injuries such as abrasions, lacerations, and contusions. [2] While abrasions and lacerations are often readily apparent, contusions may be subtle and can be difficult to recognize, especially when discoloration of the skin is minimal or masked by other postmortem changes. [3] Accurate detection of contusions is essential, as these injuries frequently provide important evidence of physical assault, abuse, or self-inflicted harm. [4]

Visual assessment of the skin is influenced by multiple factors, including lighting conditions, postmortem interval, lividity, and individual variations in skin pigmentation. [5] In individuals with darker skin tones, the color changes associated with underlying hemorrhage may not be easily discernible on surface inspection alone. [6] As a result, reliance solely on visual examination can lead to underestimation of the presence and extent of blunt force injury. [7] This limitation has important

forensic implications, particularly in cases where external injuries are minimal or absent despite significant internal trauma. [8]

Skin tone represents a continuous spectrum rather than discrete racial categories, and objective classification systems provide a more precise framework for its assessment. [9] Stratifying skin tone using standardized scales allows for systematic evaluation of how pigmentation influences the visibility of contusions. [10] Such an approach facilitates a more nuanced understanding of diagnostic limitations in external examinations and helps avoid assumptions based on race or ethnicity. [11] In forensic investigations, this distinction is particularly important to ensure equitable and accurate injury assessment across diverse populations. [12]

When visual identification of contusions is uncertain, additional techniques may be employed to improve diagnostic accuracy. Among these, specialized soft tissue dissection is widely regarded as a reliable method for confirming the presence of underlying hemorrhage. [13] By reflecting the skin and examining the subcutaneous tissues and musculature, occult injuries that are not evident externally can be identified. However, routine performance of extensive dissections in all cases may not be feasible due to time constraints and resource considerations, highlighting the need for targeted application of such techniques. [14]

Understanding the relationship between skin tone and the reliability of visual injury detection can help inform decisions regarding the selective use of specialized dissections. [15] Identifying specific skin tone groups in which visual inspection is less accurate may allow forensic pathologists to adopt a more tailored approach, ensuring that potentially significant injuries are not overlooked. [16] This is particularly relevant in medicolegal contexts, where missed contusions can influence interpretations of trauma severity and manner of death.

In this context, the present study examines the accuracy of visual identification of contusions across different skin tone categories using a standardized skin tone scale, with confirmation through post-dissection evaluation of soft tissue hemorrhage. Additionally, the study evaluates the diagnostic yield of specialized soft tissue dissections across various anatomical regions. By correlating external findings with internal confirmation, this work aims to contribute to a more objective and equitable approach to injury assessment in forensic pathology.

AIMS AND OBJECTIVES

Aim

To evaluate the accuracy of visual inspection in identifying contusions across different skin tone groups and to assess the utility of specialized soft tissue dissection in confirming underlying hemorrhage in an autopsy-based population.

Objectives

- To determine the accuracy of visual identification of contusions across Massey–Martin skin tone categories by comparing predissection findings with post-dissection confirmed soft tissue hemorrhage.
- To assess the diagnostic yield of specialized soft tissue dissections in detecting occult hemorrhage across different anatomical regions.

MATERIALS AND METHODS

Study Design and Setting

This was a prospective observational study conducted in the Department of Forensic Medicine of in tertiary care centre in Tamilnadu.

Study Population

The study population consisted of decedents who underwent medicolegal autopsy during the study period on one year and in whom evaluation for blunt force trauma was clinically indicated.

Inclusion and Exclusion Criteria

Inclusion criteria

- Cases with suspected or documented blunt force trauma
- Autopsies in which specialized soft tissue dissection of one or more anatomical regions was performed

Exclusion criteria

- Cases with advanced decomposition or severe postmortem changes obscuring skin evaluation
- Decedents with extensive burns or charred bodies
- Deaths due to sharp force injuries without associated blunt force trauma
- Cases in which only neck dissection was performed without examination of other anatomical regions

Sample Size and Sampling Technique

A total of 200 autopsy cases meeting the eligibility criteria were included in the study. A convenient sampling technique was employed, wherein all eligible cases during the defined timeframe were included until the desired sample size was achieved.

Study Procedure
Dissection was done as per regular guidelines. Skin tone was assessed using the Massey–Martin NIS skin color scale, and each decedent was assigned a skin tone category based on consensus evaluation. [17]

Visual assessment of contusions was performed using predissection and the presence and approximate location of contusions were recorded. Postdissection finidngs were reviewed to confirm the presence or absence of soft tissue hemorrhage, which was considered the reference standard for contusion identification. Specialized dissections included reflection of the skin and examination of subcutaneous tissue and musculature of the torso, upper extremities, lower extremities, and neck, as indicated.

Operational Definitions
- Contusion: A localized area of soft tissue hemorrhage resulting from blunt force trauma, confirmed by postdissection examination.
- Visually identified contusion: A contusion suspected on external inspection of intact skin prior to dissection.
- Confirmed soft tissue hemorrhage: Presence of hemorrhage in subcutaneous tissue or muscle identified after skin and soft tissue dissection.
- Accuracy of visual identification: Proportion of confirmed contusions that were correctly identified on predissection visual examination.
- Yield of specialized dissection: Proportion of dissected cases in which soft tissue hemorrhage was detected.
- Skin tone: Degree of skin pigmentation categorized using the Massey–Martin NIS skin color scale.

Statistical Analysis
Data were entered in Microsoft excel and analysed using SPSS version 26. Descriptive statistics were mentioned as mean, standard deviation and frequencies, percentages. Data were represented by tables and charts wherever necessary.

Ethical Consideration
Institutional approval was obtained from the Institutional Ethical Committee and permission was granted by the department to access medico-legal records. Confidentiality of decedent information was strictly maintained, and all data were anonymized prior to analysis. The study adhered to ethical principles governing research involving human biological material and medico-legal data.

RESULTS
In the present study, a total of 200 decedents were included in the analysis. The study population was predominantly male, comprising 142 individuals (71.0%), while 58 decedents (29.0%) were female. All participants were classified as Asian (100%). With respect to the manner of death, assault-related deaths constituted the largest proportion (n = 98; 49.0%), followed by self-inflicted deaths (n = 62; 31.0%) and suspected abuse cases (n = 40; 20.0%). The age of the decedents ranged from 5 to 94 years, with a mean age of 32.1 years (SD = 17.9). (Table 1)

Table 1. Demographic Characteristics of the Study Population (N = 200)

Characteristic	Frequency (n)	Percentage (%)
Sex		
Male	142	71.0
Female	58	29.0
Race / Ethnicity		
Asian	200	100.0
Manner of Death		
Assault-related	98	49.0
Self-inflicted	62	31.0
Suspected abuse	40	20.0
Age (years)		
Range	5–94	
Mean ± SD	32.1 ± 17.9	

The distribution of decedents according to the Massey–Martin skin tone scale is presented in Table 2. The majority of decedents were classified within the intermediate skin tone categories, with skin tone group 5 being the most frequent (n = 48; 24.0%), followed by group 4 (n = 46; 23.0%) and group 3 (n = 32; 16.0%). Skin tone group 6 accounted for 30 decedents (15.0%). Lighter skin tones were less common, with groups 1 and 2 comprising 6 (3.0%) and 14 (7.0%) decedents,

respectively. Darker skin tone categories were relatively infrequent, with groups 7 and 8 accounting for 14 (7.0%) and 8 (4.0%) decedents, respectively, while group 9 included 2 decedents (1.0%). No decedents were classified under skin tone group 10. Overall, the distribution demonstrated a predominance of mid-range skin tones within the study population.

Table 2. Distribution of Decedents According to Massey–Martin Skin Tone Scale

Massey–Martin Skin Tone Group	Frequency (n)	Percentage (%)
1	6	3.0
2	14	7.0
3	32	16.0
4	46	23.0
5	48	24.0
6	30	15.0
7	14	7.0
8	8	4.0
9	2	1.0
10	0	0.0
Total	**200**	**100.0**

The comparison between visually identified contusions and post-dissection confirmed soft tissue hemorrhage across Massey–Martin skin tone groups is summarized in Table 3. Overall, soft tissue hemorrhage was confirmed in 193 decedents, whereas contusions were visually identified in only 98 cases, indicating substantial under-recognition on external examination alone. Among lighter skin tone groups, visual identification was relatively higher, with 7 of 12 cases in group 1 and 12 of 20 cases in group 2 being detected on predissection examination. In intermediate skin tone groups, although the absolute number of confirmed hemorrhages was higher—particularly in groups 4 (n = 38) and 5 (n = 40)—the proportion of contusions identified visually declined, with 22 cases in group 4 and 21 cases in group 5 recognized prior to dissection. This decline was more pronounced in darker skin tone categories, where only 12 of 28 cases in group 6, 5 of 16 cases in group 7, and 2 of 9 cases in group 8 were visually identified. Notably, no contusions were visually identified in skin tone group 9, despite four cases showing confirmed soft tissue hemorrhage on dissection, and no cases were classified under group 10. These findings demonstrate a progressive reduction in the reliability of visual inspection for detecting contusions with increasing skin tone darkness.

Table 3. Comparison of Visually Identified Contusions and Post-Dissection Confirmed Soft Tissue Hemorrhage Across Skin Tone Groups

Massey–Martin Skin Tone Group	Decedents With Confirmed Soft Tissue Hemorrhage (n)	Visually Identified Contusions (n)
1	12	7
2	20	12
3	26	17
4	38	22
5	40	21
6	28	12
7	16	5
8	9	2
9	4	0
10	0	0
Total	**193**	**98**

The accuracy of visual identification of contusions, stratified by Massey–Martin skin tone group, is presented in Table 4. Visual detection accuracy was highest in the lighter and intermediate skin tone categories, with accuracy rates of 58.3% in group 1, 60.0% in group 2, and a peak accuracy of 65.4% in group 3. In groups 4 and 5, which comprised a substantial proportion of the study population, accuracy declined to 57.9% and 52.5%, respectively. A marked reduction in accuracy was observed with increasing skin tone darkness, with accuracy rates of 42.9% in group 6, 31.3% in group 7, and 22.2% in group 8. Notably, no contusions were visually identified in group 9, despite the presence of confirmed soft tissue hemorrhage, resulting in an accuracy of 0%. No cases were classified under skin tone group 10. Overall, these findings demonstrate a clear inverse relationship between skin tone darkness and the accuracy of visual identification of contusions. (Chart 1)

Table 4. Accuracy of Visual Identification of Contusions Stratified by Skin Tone

Massey–Martin Skin Tone Group	Confirmed Contusions (n)	Correctly Identified Visually (n)	Accuracy (%)
1	12	7	58.3

2	20	12	60.0
3	26	17	65.4
4	38	22	57.9
5	40	21	52.5
6	28	12	42.9
7	16	5	31.3
8	9	2	22.2
9	4	0	0.0
10	0	0	—

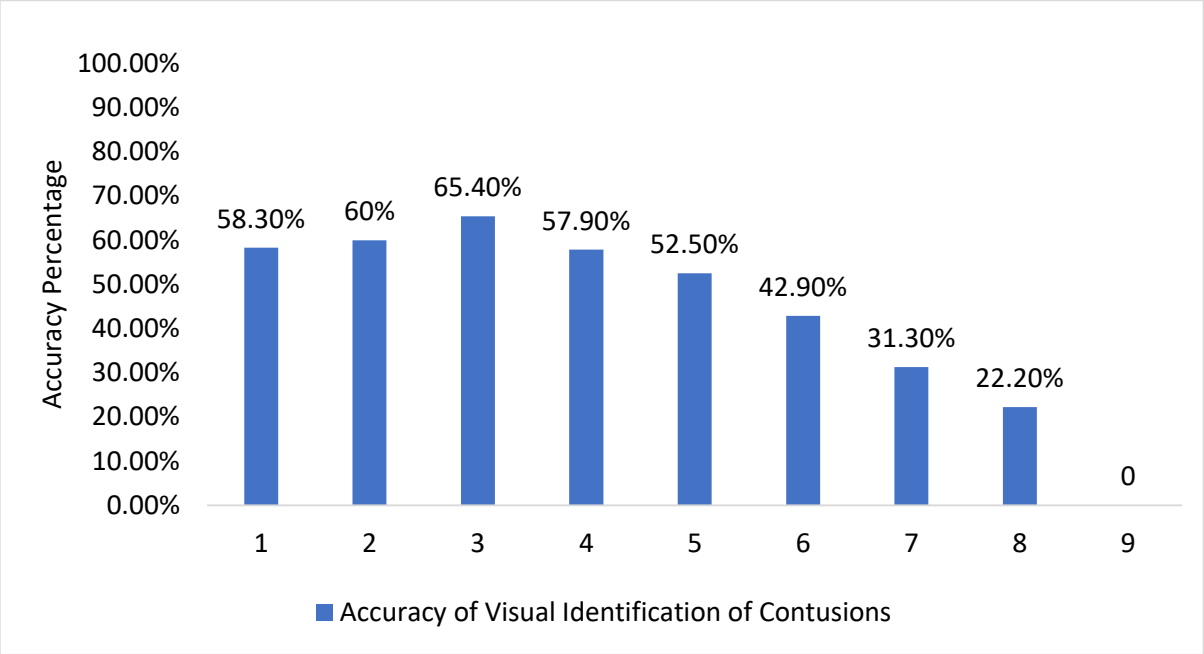

Chart 1. Accuracy of Visual Identification of Contusions Stratified by Skin Tone

The yield of specialized soft tissue dissections by anatomical region is summarized in Table 5. Specialized dissections were most frequently performed on the torso (n = 188; 94.0% of cases), with 64 cases (34.0%) demonstrating confirmed soft tissue hemorrhage. Dissections of the upper extremities were conducted in 180 cases (90.0%) and yielded the highest detection rate, with 82 cases (45.6%) showing underlying hemorrhage. The lower extremities were dissected in 176 cases (88.0%), revealing soft tissue hemorrhage in 52 cases (29.5%). Dissections of the neck were performed less frequently (n = 146; 73.0%) and demonstrated the lowest yield, with confirmed hemorrhage identified in 14 cases (9.6%). Overall, specialized dissections substantially enhanced the detection of occult soft tissue hemorrhage, particularly in the extremities, underscoring their diagnostic utility beyond external visual examination alone.

Table 5. Yield of Specialized Soft Tissue Dissections by Anatomical Region

Anatomical Region	Cases With Specialized Dissection (n)	% of Total Cases	Cases With Confirmed Soft Tissue Hemorrhage (n)	Yield (%)
Torso	188	94.0	64	34.0
Upper extremities	180	90.0	82	45.6
Lower extremities	176	88.0	52	29.5
Neck	146	73.0	14	9.6

DISCUSSION

The demographic profile of the present study, characterized by male predominance and a younger mean age, is comparable to findings reported by Du et al., who observed similar patterns in autopsy-based evaluations of blunt force trauma [1]. Santiago et al. also reported a higher representation of males in trauma-related deaths, attributing this to increased exposure to interpersonal violence and risk-prone behaviors [2]. Sommers et al. emphasized that demographic factors can influence injury documentation and detection, particularly in forensic contexts where subtle injuries may be overlooked [3]. Bradford et al. further highlighted the importance of demographic context in differentiating true traumatic lesions from dermatological conditions that may mimic injury [10].

The predominance of intermediate Massey–Martin skin tone groups in the present study is consistent with standardized skin tone distributions described by Du et al., supporting the use of objective scales over racial categorization [1]. Forsyth et al. noted that individuals with mid-range to darker skin tones are frequently underrepresented in diagnostic research despite constituting a large proportion of many populations [4]. Gunowa et al. similarly identified significant gaps in wound care literature related to darker and intermediate skin tones, emphasizing the need for broader representation [5]. Pusey-Reid et al. reinforced that insufficient inclusion of diverse skin tones contributes to diagnostic bias and reduced clinical accuracy [6].

The marked discrepancy between visually identified contusions and post-dissection confirmed soft tissue hemorrhage in this study parallels findings reported by Du et al., who demonstrated substantial under-recognition of contusions on external examination alone [1]. Santiago et al. similarly documented fewer blunt force injuries recorded in individuals with darker skin tones despite comparable injury mechanisms [2]. Benjamin et al. reported that several contusions were clinically missed and only detected using adjunctive techniques, underscoring limitations of surface inspection [9]. Wilk et al. further demonstrated that advanced imaging modalities revealed bruises not apparent on routine visual examination, supporting the present findings [14].

The progressive decline in accuracy of visual identification with increasing skin tone darkness observed in this study closely aligns with the inverse relationship reported by Du et al. between skin tone and injury detection accuracy [1]. Sommers et al. demonstrated that darker skin pigmentation, rather than race, was a significant predictor of reduced injury detection in forensic examinations [3]. Sonenblum et al. similarly reported diminished visibility of erythema and discoloration in darker skin tones, highlighting inherent limitations of visual assessment [7]. Forsyth et al. emphasized that reliance on visible color changes leads to diagnostic inequities in darker skin, reinforcing the need for alternative assessment strategies [4].

The high diagnostic yield of specialized soft tissue dissections observed in this study is consistent with findings by Du et al., who recommended targeted dissections to identify occult contusions in darker skin tones [1]. Scafide et al. demonstrated that adjunctive methods such as alternate light sources significantly improved bruise detection compared to white light examination alone [8]. Benjamin et al. reported that infrared imaging successfully revealed hidden contusions later confirmed on incision, paralleling the benefits of dissection demonstrated in the present study [9]. Perold et al. further emphasized that supplemental examination techniques enhance detection of soft tissue injuries in assault-related deaths, supporting a multimodal approach to forensic injury assessment [16].

Limitations

The uneven distribution of cases across darker skin tone categories may have limited the precision of subgroup comparisons.

Conclusion and Recommendations

This study demonstrates that the accuracy of visual identification of contusions decreases progressively with increasing skin tone, despite the presence of underlying soft tissue hemorrhage confirmed on dissection. Visual examination alone was found to substantially underestimate blunt force injuries, particularly in darker skin tone groups, while specialized soft tissue dissection significantly improved detection across multiple anatomical regions. These findings highlight the limitations of external examination and underscore the importance of correlating surface findings with internal confirmation to ensure accurate forensic interpretation.

Based on the findings, selective use of specialized soft tissue dissections is recommended, particularly in individuals with darker skin tones where visual identification of contusions is less reliable. Incorporation of standardized skin tone assessment into routine forensic practice may aid in identifying cases that warrant additional examination. Further prospective, multi-center studies with larger representation across skin tone categories are recommended to validate these findings and to develop evidence-based guidelines for equitable and accurate injury assessment in forensic pathology.

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