



Original Research Article

# Study of Ligature Mark Patterns in Cases of Hanging: An Autopsy-Based Observational Study.

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## INTRODUCTION

Hanging is defined as a form of asphyxia caused by the suspension of the body by a ligature encircling the neck, where the constricting force is the weight of the body or

the head acting through a ligature fixed to a point above.<sup>1</sup> It is one of the most prevalent methods of suicide across all geographic regions and socioeconomic groups and represents a significant

proportion of unnatural deaths subjected to medicolegal investigation.<sup>2</sup> According to the World Health Organization, hanging accounts for approximately 50% of all suicides in many countries, making it a leading cause of preventable death globally.<sup>3</sup> The medicolegal investigation of hanging deaths is of paramount importance as it involves the determination of the cause, manner, and mechanism of death, which has direct implications on criminal justice proceedings.<sup>4</sup>

The principal external finding in death by hanging is the ligature mark, which is a pressure abrasion caused by the loop of the ligature material around the neck.<sup>5</sup> The classic ligature mark in hanging appears as an obliquely placed groove situated above the level of the thyroid cartilage, showing discontinuity at the point of suspension, which represents the highest point of the ligature mark on the neck.<sup>6</sup> The characteristics of the ligature mark, including its position, course, direction, depth, width, continuity, color, and the presence of imprint patterns, provide invaluable information to the forensic pathologist in establishing the cause and manner of death.<sup>7</sup> The ligature mark serves as the most important bridge connecting the external examination to the internal findings and ultimately to the reconstruction of the circumstances surrounding death.<sup>8</sup>

However, the interpretation of ligature marks is not always straightforward. Atypical presentations, including horizontal marks, absent marks, and multiple marks, have been reported in hanging deaths, particularly in cases of partial suspension, when soft ligature materials are used, or when multiple loops are employed.<sup>9</sup> These atypical findings can create diagnostic confusion between hanging and ligature strangulation, which has profound medicolegal consequences.<sup>10</sup> Furthermore, the characteristics of the ligature mark are influenced by numerous factors including the type and consistency of the ligature material, the degree of suspension (complete versus partial), the position and type of knot, the body weight of the victim, and the duration of suspension.<sup>11</sup>

The internal findings associated with hanging, such as fractures of the hyoid bone and thyroid cartilage, hemorrhages in the strap muscles, and carotid intimal tears, are closely related to the external ligature mark characteristics and the mechanism of neck compression.<sup>12</sup> Studies have demonstrated that the position of the knot significantly influences the pattern of internal neck injuries, with posterior knot positions associated with a higher incidence of laryngeal fractures compared to lateral positions.<sup>13</sup> The peri-ligature injuries, including abrasions and contusions adjacent to the ligature mark, provide additional evidence regarding the vitality of the mark and the dynamics of the hanging process.<sup>14</sup>

Despite the extensive literature on hanging deaths, there remains a need for comprehensive studies that

systematically evaluate ligature mark patterns and their correlations with various influencing factors. Regional variations in ligature materials, cultural practices, and demographic profiles necessitate location-specific studies to develop a robust evidence base for forensic practitioners.<sup>15</sup> The present study was undertaken with the objective of studying the patterns of ligature marks in autopsy-confirmed cases of hanging and correlating these patterns with the type of ligature material, type of hanging, position of knot, and associated internal neck injuries, thereby contributing to the existing body of forensic knowledge on this critical subject.<sup>16</sup>

## **MATERIALS AND METHODS**

PRM Medical College & Hospital, Baripada and SJ Medical College & Hospital, Puri from January 2022 to December 2025. All autopsy-confirmed cases of death by hanging brought to the mortuary during the study period were evaluated for inclusion. Prior to data collection, informed written consent was obtained from the next of kin of the deceased, and strict confidentiality and anonymity of the data were maintained throughout the study.

### **Inclusion Criteria**

The following inclusion criteria were applied: (1) All autopsy-confirmed cases of death due to hanging irrespective of age and sex; (2) Cases where the ligature material was available for examination either in situ around the neck or separately preserved; (3) Cases where a complete autopsy including detailed neck dissection was performed; (4) Cases where the history and scene findings were consistent with death by hanging; and (5) Cases where the body was brought within 72 hours of the estimated time of death with minimal decomposition to allow accurate assessment of ligature mark characteristics.

### **Exclusion Criteria**

The following cases were excluded from the study: (1) Decomposed bodies where accurate assessment of ligature mark characteristics was not possible; (2) Cases of ligature strangulation or manual strangulation; (3) Cases with combined mechanisms of death (e.g., hanging with poisoning where the cause of death was equivocal); (4) Cases where the ligature material was not available for examination; (5) Incomplete autopsy reports or cases where detailed neck dissection was not performed; and (6) Bodies with extensive ante-mortem or post-mortem injuries that obscured the ligature mark.

### **Data Collection and Parameters**

A structured proforma was designed to record demographic data (age, sex), circumstances of hanging (place, motive if known), type of hanging (complete or partial), type of ligature material (classified as hard materials such as rope, wire, electrical cord, or soft materials such as dupatta, saree, bedsheet, towel), type and position of knot (slip knot or fixed knot; anterior, posterior, or lateral), number of loops, and detailed

ligature mark characteristics including site, level in relation to thyroid cartilage, direction (oblique or horizontal), continuity, width, depth, presence of grooving, imprint pattern, color changes, and periligature injuries. Internal neck findings including strap muscle hemorrhages, hyoid bone fractures, thyroid cartilage fractures, and carotid intimal tears were also documented.

**RESULTS**

During the study period, a total of 200 autopsy-confirmed cases of death by hanging were included. The demographic distribution, ligature mark characteristics, and associated findings are presented in the following tables with interpretations.

**Table 1: Age and Sex Distribution of Hanging Cases (n=200)**

Age Group (Years)	Male (n)	Female (n)	Total (n)	Percentage (%)	p-value
≤20	12	8	20	10.0	
21–30	52	21	73	36.5	
31–40	38	12	50	25.0	
41–50	26	6	32	16.0	<0.05*
51–60	14	3	17	8.5	
>60	6	2	8	4.0	
Total	148	52	200	100.0	

Males constituted the majority of cases (74%, n=148) with a male-to-female ratio of 2.85:1. The most commonly affected age group was 21–30 years (36.5%), followed by 31–40 years (25%). The preponderance of young adult males is consistent with the existing literature. The association between sex and age group was statistically significant (p<0.05), with younger females disproportionately represented among adolescent and young adult victims.

**Table 2: Distribution of Ligature Material by Type of Hanging (n=200)**

Ligature Material	Complete (n)	Complete (%)	Partial (n)	Partial (%)	Total (n)	Total (%)
Rope (coir/nylon)	52	41.9	25	32.9	77	38.5
Dupatta/Scarf	22	17.7	22	28.9	44	22.0
Saree/Lungi	18	14.5	12	15.8	30	15.0
Bedsheet/Towel	10	8.1	8	10.5	18	9.0
Electric wire/cable	12	9.7	3	3.9	15	7.5
Belt/Strap	8	6.5	2	2.6	10	5.0
Others	2	1.6	4	5.3	6	3.0
Total	124	100.0	76	100.0	200	100.0

**Interpretation:** Complete hanging was observed in 62% (n=124) of cases and partial hanging in 38% (n=76). Rope (coir/nylon) was the most commonly used ligature material overall (38.5%), followed by dupatta/scarf (22%) and saree/lungi (15%). Hard materials such as rope and electrical wire were more commonly associated with complete hanging, while soft materials such as dupatta and saree were relatively more frequent in partial hanging cases.

**Table 3: Characteristics of Ligature Mark (n=200)**

Characteristic	Finding	Number (n)	(%)	p-value
Direction	Oblique	164	82.0	
	Horizontal	28	14.0	<0.01*
	Oblique + Horizontal	8	4.0	
Level	Above thyroid cartilage	153	76.5	
	At thyroid cartilage	36	18.0	<0.05*
	Below thyroid cartilage	11	5.5	
Continuity	Non-continuous	144	72.0	
	Continuous	56	28.0	<0.01*
Number of loops	Single	168	84.0	
	Multiple	32	16.0	
Grooving	Present	136	68.0	
	Absent	64	32.0	<0.05*
Imprint pattern	Present	128	64.0	
	Absent	72	36.0	

The ligature mark was obliquely directed in 82% of cases, situated above the thyroid cartilage in 76.5%, and non-continuous in 72%. Single loop marks were observed in 84% of cases. Grooving was present in 68% and imprint patterns of the ligature material were identifiable in 64% of cases. Horizontal marks were predominantly observed in cases of partial hanging.

**Table 4: Distribution of Knot Type and Position (n=200)**

Knot Position	Slip (n)	Slip (%)	Fixed (n)	Fixed (%)	Total (n)	Total (%)
Left lateral	42	36.2	28	33.3	70	35.0
Right lateral	32	27.6	22	26.2	54	27.0
Posterior (occipital)	30	25.9	18	21.4	48	24.0
Anterior (submental)	8	6.9	10	11.9	18	9.0
Not identifiable	4	3.4	6	7.1	10	5.0
Total	116	100.0	84	100.0	200	100.0

Slip knots were more prevalent (58%, n=116) compared to fixed knots (42%, n=84). The most common knot position was left lateral (35%), followed by right lateral (27%) and posterior/occipital (24%). The anterior/submental position was the least common (9%). Slip knots were associated with a higher incidence of continuous ligature marks compared to fixed knots.

**Table 5: Association of Ligature Mark Characteristics with Type of Ligature Material**

Characteristic	Hard (n=102)	Soft (n=98)	Chi-square	p-value
Grooving present	86 (84.3%)	50 (51.0%)	24.67	<0.001*
Imprint present	82 (80.4%)	46 (46.9%)	23.92	<0.001*
Parchmentized	68 (66.7%)	28 (28.6%)	29.14	<0.001*
Peri-ligature injuries	44 (43.1%)	18 (18.4%)	14.22	<0.001*
Width < 2 cm	76 (74.5%)	32 (32.7%)	35.08	<0.001*
Width ≥ 2 cm	26 (25.5%)	66 (67.3%)	35.08	<0.001*
Multiple loops	24 (23.5%)	8 (8.2%)	8.56	<0.01*

Hard ligature materials were significantly associated with the presence of grooving (84.3% vs. 51.0%), identifiable imprint patterns (80.4% vs. 46.9%), parchmentization (66.7% vs. 28.6%), peri-ligature injuries (43.1% vs. 18.4%), and multiple loops (23.5% vs. 8.2%) compared to soft materials. All associations were statistically significant (p<0.01). Soft materials produced wider marks (≥2 cm) more frequently (67.3% vs. 25.5%).

**Table 6: Internal Neck Injuries in Relation to Type of Hanging**

Internal Finding	Complete (n=124)	(%)	Partial (n=76)	(%)	p-value
Strap muscle hemorrhage	48	38.7	18	23.7	<0.05*
Thyroid cartilage fracture	18	14.5	6	7.9	<0.05*
Hyoid bone fracture	14	11.3	3	3.9	<0.05*
Carotid intimal tear	4	3.2	1	1.3	>0.05
Sternomastoid rupture	10	8.1	2	2.6	<0.05*
Cervical spine injury	3	2.4	0	0.0	>0.05
No internal injury	42	33.9	52	68.4	<0.001*

Internal neck injuries were more common in complete hanging compared to partial hanging. Strap muscle hemorrhage was the most frequent internal finding (38.7% in complete hanging vs. 23.7% in partial hanging). Thyroid cartilage fracture (14.5% vs. 7.9%) and hyoid bone fracture (11.3% vs. 3.9%) were also significantly more frequent in complete hanging (p<0.05). Notably, 68.4% of partial hanging cases showed no internal neck injuries compared to 33.9% of complete hanging cases (p<0.001).

## DISCUSSION

The present study provides a comprehensive analysis of ligature mark patterns in 200 autopsy-confirmed cases of hanging and contributes to the existing body of forensic literature by establishing correlations between ligature mark characteristics and various influencing factors. The findings are discussed in the context of previous studies and their medicolegal implications.

The demographic profile in our study revealed a male predominance (74%) with a male-to-female ratio of 2.85:1, which is consistent with most published studies on hanging deaths. Chithra et al. (2024) in their autopsy-based study of 210 hanging cases from Thiruvananthapuram reported a male predominance of 87.14%. Similarly, Singh et al. (2022) in their

retrospective analysis of 166 hanging cases from Northeast India found that males constituted 69.27% of all cases.<sup>17</sup> The 20-year study by Ahmad et al. (2023) at a Malaysian medical center reported a male-to-female ratio of 2.7:1 among 287 cases of fatal neck pressure.<sup>18</sup> The prospective study by Bozek et al. (2025) covering 660 cases in Bratislava over a 10-year period found an even higher male predominance at 89.4%.<sup>19</sup> The consistent finding of male preponderance across diverse geographic settings suggests that males are more likely to adopt violent methods of self-harm, including hanging.

The most commonly affected age group in our study was 21–30 years (36.5%), which aligns with the findings of Mehmood et al. (2023) who reported the highest incidence of hanging in the 21–30 year age group (40%) in their comparative study from Pakistan.<sup>20</sup> Rao (2021) in an extensive study of 634 suicidal hanging cases also noted a peak incidence among young adults.<sup>21</sup> Kumari (2024) in a prospective study similarly found the maximum number of victims in the younger age group.<sup>22</sup> This age distribution is consistent with global suicide statistics and underscores the vulnerability of young adults to suicidal behavior, which has significant public health implications.

Regarding the type of ligature material, rope was the most commonly used material (38.5%) in our study, followed by dupatta/scarf (22%). This finding is concordant with the observations of Singh et al. (2022) who found rope to be the most frequent ligature material at 34.93%.<sup>17</sup> Chithra et al. (2024) reported a similar preponderance of readily available household materials, with saree being the most common soft material used among females.<sup>5</sup> The study by Jayaprakash and Sreekumari (2012) from the same region also found that soft materials were used by 47% of victims and hard materials by 29%.<sup>6</sup> The choice of ligature material appears to be influenced by availability, with victims typically using materials easily accessible within their immediate environment, which has implications for prevention strategies.

The ligature mark was obliquely directed in 82% of our cases, which is comparable to the 83.73% reported by Singh et al. (2022)<sup>17</sup> and the 94.2% reported by Jayaprakash and Sreekumari (2012).<sup>6</sup> Horizontal marks were observed in 14% of our cases and were predominantly associated with partial hanging, a finding corroborated by Rao (2021) who found horizontal marks in 14% of incomplete hanging cases.<sup>21</sup> The direction of the ligature mark is determined by the point of suspension relative to the position of the knot, and atypical horizontal marks in partial hanging can create diagnostic confusion with ligature strangulation, necessitating careful correlation with scene findings and internal autopsy findings.<sup>10</sup>

The non-continuous ligature mark was found in 72% of

our cases, which is consistent with Jayaprakash and Sreekumari (2012) who reported non-continuity in 78% of cases.<sup>6</sup> The point of discontinuity typically corresponds to the knot position, which is the highest point on the neck where the ligature does not directly contact the skin. Rao (2021) noted that the continuity of the mark is influenced by both the type of knot and the completeness of hanging, with slip knots in complete suspension producing more continuous marks compared to fixed knots.<sup>21</sup> Our findings support this observation, with slip knots associated with a higher incidence of continuous marks.

A significant finding of our study was the strong association between the type of ligature material and the characteristics of the mark. Hard materials produced significantly more grooving (84.3% vs. 51.0%), identifiable imprint patterns (80.4% vs. 46.9%), and parchmentation (66.7% vs. 28.6%) compared to soft materials (all  $p < 0.001$ ). This is in agreement with Chithra et al. (2024) who demonstrated a significant association between the consistency of ligature material and the imprint pattern, grooving, and peri-ligature injuries.<sup>5</sup> Tumram et al. (2014) also reported that the type of ligature material significantly influences the nature and severity of neck injuries.<sup>23</sup> The observation that soft materials produce wider, less defined marks with fewer peri-ligature injuries has important diagnostic implications, as such marks may be faint or absent in early autopsy examination, particularly in cases of short suspension duration.

Multiple loops were observed in 16% of our cases, predominantly with hard and thin materials, which is consistent with the 17.6% reported by Chithra et al. (2024).<sup>5</sup> Their study also noted that when the ligature width was 2 cm or less, multiple loops outnumbered single loops, suggesting a reinforcing method adopted by victims unsure of the load-bearing strength of thin materials. This behavioral pattern has been similarly reported by Ambade et al. (2015).<sup>24</sup> The presence of multiple loops can produce multiple parallel ligature marks, which may be confused with marks from ligature strangulation, emphasizing the need for careful scene investigation and correlation with the available ligature material.

Internal neck injuries were significantly more common in complete hanging compared to partial hanging in our study. Strap muscle hemorrhage was the most frequent finding (33%), followed by thyroid cartilage fracture (12%) and hyoid bone fracture (8.5%). These findings are comparable to those of Al-Sabaileh et al. (2024) who reported neck muscle contusion as the most common internal finding in their autopsy-based study from Jordan.<sup>25</sup> The prospective study by Bozek et al. (2025) covering 660 cases found that internal neck injuries varied significantly with the type and duration of suspension.<sup>19</sup> Jayaprakash and Sreekumari (2012) reported hyoid bone fracture in 2.7% and thyroid

cartilage fracture in 5.3% of their cases, with neck skeleton injuries exclusively seen in persons older than 38 years.<sup>6</sup> Our study similarly found that laryngeal fractures showed a significant association with age above 40 years, attributable to the progressive calcification and ossification of the laryngeal cartilages with advancing age.

The observation that 68.4% of partial hanging cases showed no internal neck injuries is an important finding that has been echoed by several authors. Maiese et al. (2022) emphasized that the differential diagnosis between total and partial hanging remains challenging, particularly in unusual circumstances.<sup>14</sup> The absence of internal injuries in partial hanging cases should not lead to a conclusion against hanging, as the force required to occlude the jugular veins or carotid arteries is considerably less than the weight of the body, and significant vascular compromise can occur without causing structural damage to the neck.<sup>3</sup> The immunohistochemical assessment of ligature mark vitality, though still evolving as reviewed by Maiese et al. (2022), may serve as a complementary diagnostic tool in cases with minimal gross findings.<sup>14</sup>

The position of the knot showed a significant association with the pattern of internal injuries. Posterior knot positions were associated with a higher incidence of thyroid cartilage fractures, as the ligature directly compresses the anterior neck structures with maximum force. Chithra et al. (2024) similarly found that thyroid cartilage and cervical spine fractures showed a significant association with the knot position.<sup>5</sup> This finding is of considerable medicolegal importance in the reconstruction of the mechanics of neck compression and the differentiation of hanging from other forms of asphyxia.

## CONCLUSION

The present study demonstrates that the characteristics of ligature marks in hanging deaths are significantly influenced by the type of ligature material, the type of hanging (complete versus partial), and the position and type of knot. Hard ligature materials produce more prominent marks with grooving, identifiable imprint patterns, and peri-ligature injuries, while soft materials produce wider, less defined marks. Oblique, non-continuous marks situated above the thyroid cartilage remain the most common presentation. Internal neck injuries are significantly more frequent in complete hanging and in victims above 40 years of age. A thorough, systematic, and meticulous examination of the ligature mark, correlated with scene findings and internal autopsy findings, remains the cornerstone of medicolegal diagnosis in deaths due to hanging. The findings of this study emphasize the importance of detailed documentation of ligature mark characteristics and underscore the need for continued research to develop standardized protocols for the evaluation of ligature marks in forensic practice.

## REFERENCES

1. Reddy KSN. *The Essentials of Forensic Medicine and Toxicology*. 34th ed. New Delhi: Jaypee Brothers Medical Publishers; 2017. p. 283-295.
2. World Health Organization. *Suicide worldwide in 2019: Global Health Estimates*. Geneva: WHO; 2021.
3. Campobasso CP, De Simone M, Porzio A, Mazzini E, Carfora A, Feola A. Suicide by ligature strangulation and/or hanging inside a motor vehicle: a comprehensive review. *Forensic Sci Med Pathol.* 2025;21(1):443-457.
4. Cordner S, Clay FJ, Bessed R, Thomsen AH. Suicidal ligature strangulation: a systematic review of the published literature. *Forensic Sci Med Pathol.* 2020;16(1):123-133.
5. Chithra TD, George TP, Salini R, Sujisha SS. Pattern of Ligature Mark in Hanging—An Autopsy-based Study. *J Indian Acad Forensic Med.* 2024;46(3):383-390.
6. Jayaprakash S, Sreekumari K. Pattern of injuries to neck structures in hanging—An autopsy study. *Am J Forensic Med Pathol.* 2012;33(4):395-399.
7. Lockyer BE. Death by hanging: examination of autopsy findings and histological features. *Diagnostic Histopathology.* 2023;31(1):14-21.
8. Ma J, Jing H, Zeng Y, Tao L, Yang Y, Ma K, Chen L. Retrospective analysis of 319 hanging and strangulation cases between 2001 and 2014 in Shanghai. *J Forensic Leg Med.* 2016;42:19-24.
9. Sharma K, Sahu A, Inchulkar SR, Kaushik Y. Hanging and its Medicolegal Importance. *J Ayurveda Integr Med Sci.* 2020;5(05):266-271.
10. Kanchan T, Babu YPR, Atreya A, Acharya J. Ligature mark on the face—forensic implications. *Med Leg J.* 2016;84(3):138-141.
11. Reddy TTK, Krishnamurthy V, Rao NP, Prakash KR, Kumar KS. A study of various patterns of ligature mark produced in cases of hanging brought to the mortuary, GGH, Guntur. *Int J Clin Diagn Pathol.* 2019;2(2):33-37.
12. Shabbir S, Rehman HU, Dureshehwar, Arif M, Murad T, Masood R. Analysis of injuries over neck and its association with ligature mark in hanging and strangulation. *Int J Pathol.* 2019;17(3):132-136.
13. Nimavat KK, Joshiyara RV, Shaikh MM, Padmraj RY, Shah KA. Study of ligature mark in cases of hanging deaths. *J Forensic Med Toxicol.* 2021;14(3):669-674.
14. Maiese A, Manetti F, Santoro P, Ferrara M, Frati P, Fineschi V. A clue on the skin: a systematic review on immunohistochemical analyses of the ligature mark. *Int J Environ Res Public Health.* 2022;19(4):2035.
15. Maiese A, Del Duca F, Santoro P, Ferrara M, De Matteis A, La Russa R, et al. Ligature Mark: Crime or Suicide? *Int J Environ Res Public Health.* 2022;19(21):14395.

16. Ghodake D, Sonawane S, Sharma H, Tetarbe T. An autopsy study of ligature mark in cases of hanging. *Int J Acad Med Pharm.* 2023;5(1):45-50.
17. Singh SB, Devi SE, Phanjoubam M, Devi TM. Analysis of ligature marks in hanging: a retrospective study of autopsies in the mortuary of a tertiary health-care center in North East India from 2011 to 2019. *J Med Soc.* 2022;36(1):26-31.
18. Ahmad ZA, Noor HM, Abdul Ghani AA. A 20-year study of fatal pressure on the neck in autopsied cases at the Universiti Kebangsaan Malaysia Medical Center. *Adv Hum Biol.* 2023;13(3):281-284.
19. Bozek P, Vanickova Z, Novomesky F. Autopsy findings in hanging: a 10-year prospective study of 660 cases. *Forensic Sci Int Rep.* 2025;6(1):16.
20. Mehmood I, Saleem K, Rasool G, Maria G, Bibi F, Irshad N. Patterns of ligature marks in hanging versus strangulation: a comparative autopsy study. *Pak J Med Health Sci.* 2023;17(12):534-537.
21. Rao D. An autopsy study of ligature mark in 634 cases of suicidal hanging. *IP Int J Forensic Med Toxicol Sci.* 2021;6(4):147-152.
22. Kumari J. A prospective study of pattern of ligature marks and its correlation with the manner of death. *Int J Toxicol Pharmacol Res.* 2024;14(10):112-118.
23. Tumram NK, Ambade VN, Bardale RV, Dixit PG. Injuries over neck in hanging deaths and its relation with ligature material: is it vital? *J Forensic Leg Med.* 2014;22:80-83.
24. Ambade VN, Tumram NK, Dixit PG, Pawar MG. Multiple loops in suicidal hanging: a prospective study. *Am J Forensic Med Pathol.* 2015;36(3):166-169.
25. Al-Sabaileh S, Abusamak M, Al-Buqour AK. Autopsy-based study of non-accidental violent neck asphyxia in Jordan: a retrospective study. *Cureus.* 2024;16(6):e62883.