

## Study of Nature of Ligature Material, Knot type and Pattern of Ligature Mark in Death Cases Caused by Hanging and Compression of Neck

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Received: 28-04-2023 / Revised: 29-05-2023 / Accepted: 30-06-2023

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Conflict of interest: Nil

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### Abstract:

**Introduction:** Hanging is a significant cause of suicide and unnatural deaths globally, and it remains a major public health concern in India. Understanding the modus operandi and associated factors in hanging cases is crucial for developing preventive measures and support strategies for mental health. Accurate determination of the cause of death and analysis of ligature materials and marks are essential for medico-legal implications.

**Material and Methods:** This retrospective study analyzed data from 100 subjects who had undergone medico-legal autopsy at GMERS Medical College and Hospital in Morbi, Gujarat, India. Information on the deceased, including details on ligature materials, knot types, and ligature mark patterns, was collected from autopsy reports and case records. The data were analyzed using Microsoft Excel for comprehensive evaluation.

**Results:** The study included 100 subjects (53 males, 47 females) with varying age groups and marital status. Socioeconomic classes were represented among the subjects. Complete suspension was the most common hanging scenario (84%), with nylon rope being frequently used by males and odhani/sari by females. Atypical knot positions prevailed over typical positions, and ligature mark patterns were observed in 19% of cases. Slip knots and fixed knots were identified, and ligature material was present in 97% of cases. Ligature marks were predominantly above the thyroid cartilage, with varying degrees of encirclement. Grooving on the neck skin and thyroid cartilage fractures were observed in a small percentage. Ligature mark breadth ranged from less than 1cm to over 3cm, with the majority falling in the 1-2cm range.

**Conclusion:** In conclusion, this study sheds light on the diverse aspects of hanging cases, such as ligature materials, knot types, and ligature mark patterns. The findings emphasize the importance of considering gender, age, marital status, socioeconomic class, and the presence of ligature marks in understanding the dynamics of hanging incidents.

**Keywords:** Hanging, Ligature Material, Knot Type, Ligature Mark.

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## Introduction

Hanging is a prevalent method of suicide and a significant cause of unnatural deaths worldwide. In India, hanging is a major public health concern, with statistics from the National Crime Records Bureau highlighting its substantial contribution to suicide deaths in the country.[1] According to the National Crime Records Bureau (NCRB), the number of suicides in India reached a total of 1,64,033 in 2021, indicating a 7.2% increase compared to the previous year.[2] Understanding the modus operandi and associated factors in hanging cases is crucial for forensic experts, law enforcement agencies, and policymakers to develop preventive measures and support strategies for mental health.[3] The cause of death in hanging is primarily attributed to mechanical asphyxia, resulting from the closure of the airway and obstruction of blood flow to and from the brain.[4] However, other factors such as neck fractures may also play a role in certain cases.[5] Accurate determination of the cause of death is vital for medico-legal implications, criminal investigations, and insurance claims.[6]

Hanging cases can be categorized into different types based on various factors, including complete suspension hanging, partial suspension hanging, and positional hanging, among others. Each type exhibits distinct characteristics that influence the pattern of injury, formation of ligature marks, and associated post-mortem findings.[7] The choice of ligature material in hanging cases can vary significantly, reflecting cultural and regional practices.[8]

Investigating the nature of ligature materials used in India provides insights into prevalent practices, helps identify patterns and trends, and contributes to establishing potential risk factors for hanging incidents. Ligature marks, impressions left on the skin due to pressure from the ligature material, offer valuable information during autopsies. The analysis

of ligature marks includes examining their location, morphology, color, and associated injuries. These findings aid in determining the manner of death and differentiating between suicidal, homicidal, or accidental hangings.[9–11]

Autopsy examination plays a pivotal role in understanding the circumstances and mechanisms of death in hanging cases.[12] A thorough examination of the body, with a focus on the neck region, internal organs, and associated injuries, is crucial. Comprehensive data collection during autopsies ensures accurate classification, documentation, and interpretation of hanging deaths.[13] Given the prevalence and medicolegal significance of hanging cases in India, this study aims to analyze a dataset of 100 hanging cases, focusing on the nature of ligature material, knot types, and pattern of ligature marks. By studying these parameters, we aim to enhance our understanding of hanging incidents, contribute to existing knowledge, and provide insights for forensic experts, law enforcement agencies, and policymakers.

## Material and Methods

This study was conducted at GMERS Medical College and Hospital, Morbi city of Gujarat state, in the Department of Forensic Medicine during the period of Dec 2021- Nov 2022. The research protocol was reviewed and approved by the institutional ethics and research committee. A total of 100 subjects were included in this retrospective study, which aimed to investigate the nature of ligature material, knot types, and patterns of ligature marks in death cases caused by hanging. The cases were selected from individuals brought to the department for medico-legal autopsy.

Detailed information regarding the deceased and the circumstances of death was collected from the police and relatives of the deceased. In certain cases, additional information was obtained through site visits or examination of photographs of the scene

of occurrence. External and internal inspections of the bodies were performed during the autopsies. Ligature materials were examined whenever present, categorizing them into two types: hard ligature materials (e.g., ropes, metallic chains) and soft ligature materials (e.g., sarees, dupattas, lungis, towels).

The examination of ligature marks involved an external examination of the neck. The skin above the ligature mark was collected for histological investigation to determine the timing of the ligature mark (antemortem or postmortem). The collected specimens were preserved in 10% formalin and subjected to histopathological examination after staining with hematoxylin and eosin.

During the autopsy, a meticulous local external examination of the neck was conducted, noting the appearance, impression, pattern, color, course, type of knot, level of ligature, and associated skin changes. Other external injuries, if present, were also documented. Dissection of the neck was performed with a 'Y' shaped incision, consisting of incisions made on either side of the neck converging diagonally at the manubrium sterni. Gross findings were noted, and a portion of the skin and subcutaneous tissue from the site of the ligature mark was excised and preserved for further histopathological examination.

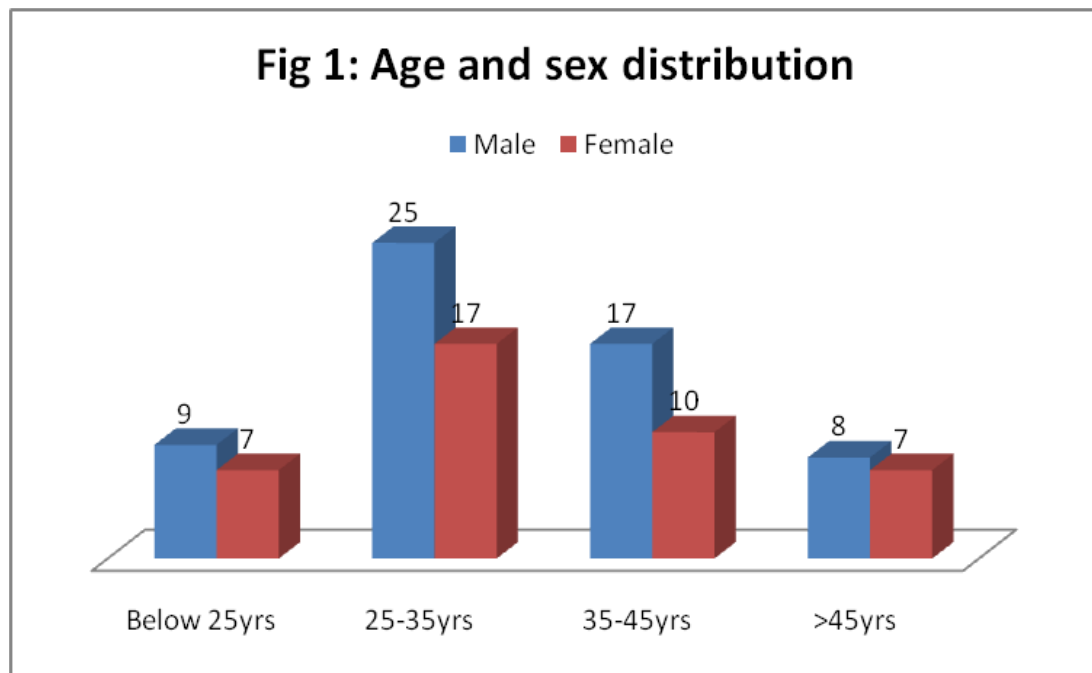
The excised specimens were examined by a panel of pathologists who stained them with hematoxylin and eosin. The slides were thoroughly examined, and the findings were recorded and correlated for comprehensive evaluation. Data collected during the study were compiled and analyzed using Microsoft Excel and SPSS software 25. The observations were

presented in tabular forms and further discussed. By employing these methods, the study aimed to investigate and document the characteristics of ligature materials, knot types, and patterns of ligature marks in hanging-related deaths in the region.

## Results

The study included a total of 100 subjects, with 53 males and 47 females. The subjects were divided into different age groups. The highest representation was seen in the 25-35 years age group, with 25 males and 17 females. The lowest representation was in the >45 years age group, with 8 males and 7 females. (Fig 1) Among the male subjects, 14 were married, while 39 were unmarried. For the female subjects, 11 were married, and 36 were unmarried. This information provides insights into the relationship between marital status and hanging cases, suggesting that both married and unmarried individuals are affected by this tragic form of self-harm.

The analysis of the study revealed that among the male subjects, approximately 17 individuals belonged to the lower socioeconomic class, 22 individuals were from the middle socioeconomic class, and the remaining 14 represented the higher socioeconomic class. Similarly, for the female subjects, approximately 15 individuals were from the lower socioeconomic class, 20 individuals were from the middle socioeconomic class, and the remaining 12 represented the higher socioeconomic class. These findings demonstrate the distribution of socioeconomic classes among the subjects involved in the study on suicidal hanging cases.



**Figure 1: Age and Sex Distribution**

The degree of suspension, which refers to the extent of support or hanging, was assessed in the hanging cases. The results indicate that a majority of the cases (84%) involved complete suspension, where the body was fully suspended in the air. This suggests a higher risk and likelihood of death due to hanging in such instances. On the other hand, partial suspension, where the body was partially supported or in contact with a surface, accounted for 16% of the cases. The study examined the ligature materials used in cases of hanging,

categorized by gender. Among the male cases (n=53), nylon rope was the most commonly observed ligature material (43%), followed by shela (a male neck cloth) (6%), cotton material (8%), electric wire (17%), and others (11%). For the female cases (n=47), odhani (a female neck cloth) was the predominant ligature material (40%), while sari accounted for 35% of the cases. These findings highlight the gender-specific patterns in the choice of ligature materials for hanging cases. (Table 1)

**Table 1: Ligature material used for hanging**

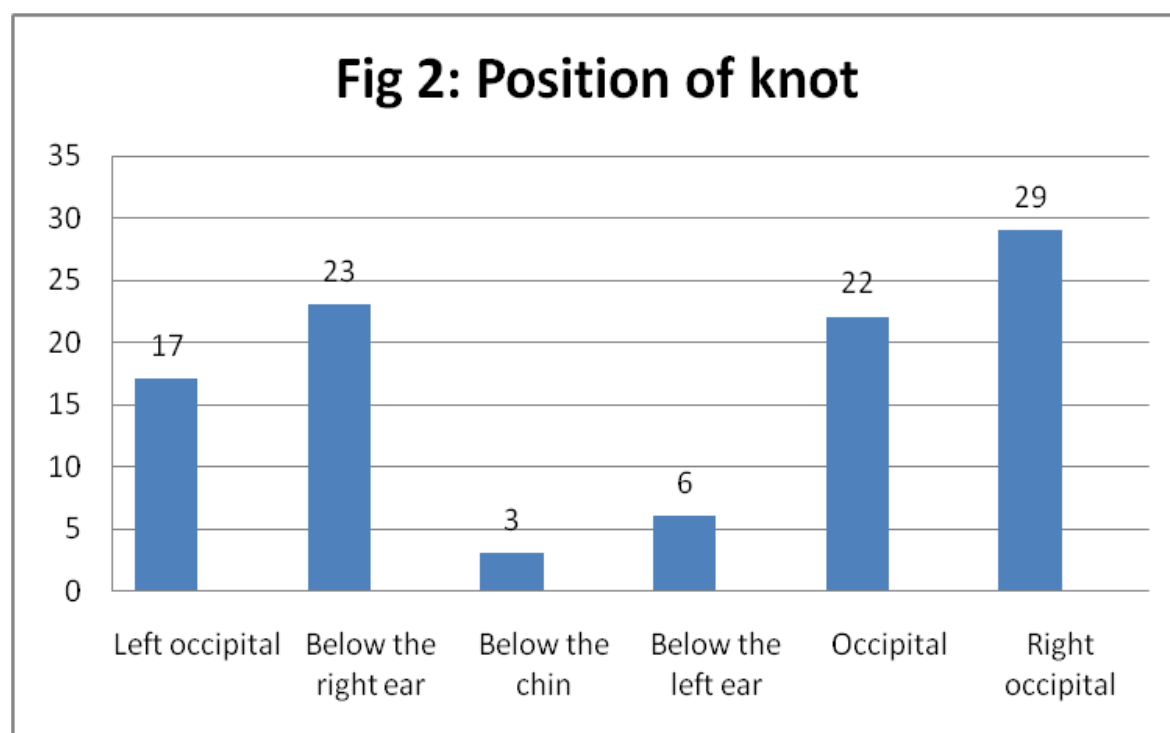
Ligature Material	Male Cases (%)	Female cases (%)	Total cases
Nylon rope	23 (43%)	4(8%)	27
Shela (male neck cloth)	03(6%)	4(8%)	03
Odhani (female neck cloth)	01(2%)	19(40%)	20
Cotton Material	04(8%)	5(11%)	09
Sari	00	16(35%)	16
Shawl	7(13%)	00	07
Electric wire	9(17%)	01(2%)	10
Others	6(11%)	2(4%)	08
Total	53(100%)	47(100%)	100

The position of the knot in hanging cases varied among the subjects. The most common positions observed were below the

right ear with 23 cases (22%), occipital with 22 cases (21%), and right occipital with 29 cases (30%).

Other positions included left occipital with 17 cases (16%), below the left ear with 6 cases (9%), and below the chin with 3 cases (2%). The majority of the cases exhibited atypical knot positions, accounting for 79 cases (85%), while 21 cases (15%) demonstrated a typical knot position.

These findings suggest that there is no fixed pattern for knot placement in hanging cases, as it can occur in different positions around the neck. It is important to note that the majority of cases (85%) exhibited atypical knot positions, while only a smaller percentage (15%) displayed a typical knot position.



**Figure 1: Position of knot**

In our study of 100 patients, we investigated ligature mark patterns in hanging cases. Approximately 19% of cases exhibited a ligature mark pattern. The majority (82%) showed a single ligature mark, while a few (18%) had multiple rows of marks. Slip knots were found in 26% of cases, fixed knots in 15%, and in 59% of cases, no specific knot was discernible. Most marks (90%) were above the thyroid cartilage, with 8% at the level and 4% below. About 15% displayed a complete encirclement, while 85% showed partial encirclement. Grooving on the neck skin was observed in 29% of cases, and 4 cases had a fractured thyroid cartilage.

The majority of ligature marks were prominent (88%), while a small percentage

appeared faint (12%). Internal findings during dissection showed that haemorrhage in the strap muscle was present in 21% of cases, and there were instances of hyoid bone fracture in 2% of cases. Regarding the presence of ligature material in situ, it was found in 97% of cases, while in 3% of cases, it was absent. These findings provide valuable insights into the characteristics of ligature marks in our study population.

Table 2 presents the distribution of ligature mark breadth in our study. Out of the total cases, 5% had a ligature mark with a breadth of less than 1cm, while the majority of cases (66%) had a mark with a breadth of 1-2cm. Additionally, 19% of cases had a breadth of 2-3cm, and 10% had a mark with a breadth greater than 3cm.

**Table 2: Breadth of Ligature Mark**

<b>Breadth of Ligature Mark</b>	<b>Cases</b>	<b>Percentage</b>
<1cm	5	5
1-2cm	66	66
2-3cm	19	19
>3cm	10	10

## Discussion

In our study, which included a total of 100 subjects, with 53 males and 47 females, we investigated the nature of ligature material, knot types, and patterns of ligature marks in cases of death caused by hanging and neck compression. Comparing our findings to other relevant studies, it becomes apparent that gender distribution varied across the studies. While our study showed a relatively equal distribution between males and females, with 53% and 47% respectively, other studies demonstrated a male predominance. Pednekar et al.[14] reported that males accounted for 60% of the cases, whereas females accounted for 40%. Prasad et al.[15] found that the majority of cases (44.5%) belonged to the third decade (21-30 years), with males being the most common victims, accounting for 62.6% of the cases. Kamle et al.[11] also showed a male predominance with 79.74% male victims and 20.25% female victims among their 316 cases. These findings collectively suggest a consistent trend of male predominance in cases of hanging and neck compression, although the specific proportions may vary across studies.

In our study, both married and unmarried individuals were affected by hanging cases. Among males, 26.4% were married, while 73.6% were unmarried. For females, 23.4% were married, and 76.6% were unmarried. This aligns with Prasad et al.'s[15] study, which also showed a higher incidence of hanging among married individuals. Our findings, consistent with Sai Sudheer and Nagaraja[16], indicate that marital status and socio-economic factors play a role in hanging cases and aligning with previous findings that suggest family-related issues

and financial difficulties contribute to increased suicidal tendencies in these populations.

In our study, the majority of hanging cases (84%) involved complete suspension, where the body was fully suspended in the air, indicating a higher risk of death. Partial suspension, where the body was partially supported or in contact with a surface, accounted for 16% of the cases. This pattern of partial hanging was also observed in the Chowdhury et al.[9] and Üzün et al.[17] studies. However, studies by M Ahmad[18], T. Saisudheer[16], Pednekar et al.[14], Yadukul et al.[19], Kamle et al.[11], and Suarez-penaranda et al.[20] reported varying proportions of complete and partial hanging cases. These differences highlight the variability in hanging incidents across studies, emphasizing the need to consider multiple factors and circumstances to understand the nature of hanging-related deaths.

In present study, the most common ligature material used in hanging cases among males (n=53) was nylon rope (43%), followed by electric wire (17%). Among females (n=47), odhani (40%) and sari (35%) were the predominant ligature materials. Similar findings were reported in the studies conducted by Pednekar et al.[14], Prasad et al.[15], Kamle et al.[11], and Yadukul S[19] studies., which also identified nylon rope, sari, and other soft materials as commonly used ligatures. However, differences were observed in the studies conducted by Udhayabanu R et al.[21] and Jayaprakas et al.[22], where the use of synthetic saree and dupatta, respectively, was more prevalent. These variations highlight the influence of regional and cultural factors on the choice

of ligature materials in hanging cases.[11,14–16,20]

In our study, the diverse positions of the knot in hanging cases indicate the variability and individuality of the act. The common occurrence of atypical knot positions highlights the complexity of ligature placement and suggests that individuals may employ different techniques or utilize available materials in unique ways. The most common positions were below the right ear (22%), occipital (21%), and right occipital (30%). Atypical knot positions were observed in the majority of cases (85%), while typical knot positions were seen in 15% of cases. Similar findings were reported in the studies conducted by Chowdhury et al.[9], Sharma et al.[23], Saini et al.[24], and Prasad et al.[15], emphasizing the prevalence of atypical knot positions across different populations and settings. However, it is noteworthy that Prasad et al.'s[15] study identified specific knot positions on both the right and left sides of the neck, indicating the potential influence of cultural or anatomical factors. Similarly, Kamle et al.'s[11] study highlights the predominance of typical knot positions at the back of the neck, but also underscores the occurrence of atypical positions on either side. Overall, these collective findings contribute to our understanding of the varied knot positions in hanging cases and underscore the need for comprehensive investigations to unravel the factors influencing knot placement in different individuals and contexts.

In our study of 100 patients investigating ligature mark patterns in hanging cases, approximately 19% of cases exhibited a ligature mark pattern. The majority (82%) showed a single ligature mark, while 18% had multiple rows of marks. Slip knots were found in 26% of cases, fixed knots in 15%, and no discernible knot in 59% of cases. These findings align with observations from Chowdhary et al.[9], who reported the position of ligature marks above, below, or

overriding the thyroid cartilage, as well as variations in color and breadth of the ligature mark. Similarly, Pednekar et al.[14] observed atypical ligature marks, different knot types, and minimal fractures of the thyroid cartilage and hyoid bone, consistent with our findings. Kamle et al.[11] reported the presence of fixed and running nooses, imprints of ligature material, and complete or incomplete ligature marks, supporting the diversity of ligature mark patterns observed in our study.

In our study, we investigated ligature mark patterns in hanging cases and found that approximately 19% of cases exhibited a ligature mark pattern. This percentage aligns with the findings of Chowdhary et al.[9], who also observed ligature marks in a similar proportion of cases. However, it is important to note that the presence of a ligature mark pattern does not necessarily indicate death by hanging, as other factors need to be considered in the overall forensic analysis.

Regarding the characteristics of the ligature marks, our study and the studies by Chowdhary et al.[9], Pednekar et al.[14], and Kamle et al.[11] provide valuable insights. We observed variations in the level of ligature marks, with some above the thyroid cartilage, below the thyroid cartilage, or overriding the thyroid cartilage. These observations are consistent with the findings of Chowdhary et al.[9], who reported similar patterns in their study and identified these patterns in other relevant literature.

The color and breadth of the ligature marks were also examined in our study. We found that ligature marks were predominantly dark brown, which is in line with previous research findings.[15,20] The color of the ligature mark can be influenced by factors such as the duration of suspension and the complexion of the individual. Similarly, the breadth of the ligature mark depends on the width and multiplicity of the ligature

material, and our findings are consistent with those reported by several other authors.[9,15,21]

In terms of knot types, slip knots were identified in a significant proportion of cases in our study (26%), while fixed knots were present in 15% of cases. These findings resonate with the study by Kamle et al.[11], who also reported the presence of fixed and running nooses. However, it is worth noting that in a substantial number of cases (59%), no specific knot was discernible. This highlights the variability in knot usage in hanging cases and suggests that the absence of a discernible knot should not exclude the possibility of death by hanging.

Furthermore, fractures of the hyoid bone and thyroid cartilage were assessed in our study. We observed a low incidence of fractures, consistent with the findings of Pednekar et al.[14], who reported minimal fractures in their investigation. However, Nantana Charoonnate et al.[25] reported a higher frequency of fractures in their study. These varying findings emphasize the importance of considering multiple studies and conducting further research to gain a comprehensive understanding of the occurrence and significance of fractures in hanging cases.

In our study, we also examined the presence of ligature material in situ and observed that it was present in 97% of the cases. This finding is consistent with the studies conducted by Chowdhary et al.[9] and Kamle et al.[11], which reported the presence of ligature material in the majority of cases. However, in 3% of our cases, ligature material was absent. This absence of ligature material raises interesting questions and warrants further investigation to understand the circumstances surrounding these cases and the potential implications for the forensic analysis. Furthermore, the breadth of the ligature marks in our study population was analyzed.

We found that a small percentage (5%) of cases had ligature marks with a breadth of less than 1cm, indicating a narrow ligature material. The majority of cases (66%) had ligature marks with a breadth of 1-2cm, which aligns with the findings of previous studies.[8,19,21]

Additionally, 19% of cases exhibited a ligature mark breadth of 2-3cm, and 10% had marks with a breadth greater than 3cm. These variations in ligature mark breadth highlight the diverse nature of ligature materials used in hanging cases and emphasize the importance of considering the physical characteristics of the ligature mark during forensic analysis.

Overall, our study contributes to the existing body of knowledge on ligature mark patterns in hanging cases. The similarities in findings between our study and the studies by Chowdhary et al.[9], Pednekar et al.[14], and Kamle et al.[11] reinforce the validity and reliability of our results.

Our study has certain limitations that should be acknowledged. Firstly, the sample size was small, which may affect the generalizability of our findings. Secondly, our study focused on a specific population, limiting its applicability to other populations. Additionally, retrospective data collection and subjective interpretation of ligature marks may introduce biases. Finally, advanced forensic techniques were not employed, potentially limiting the depth of our analysis. Further research with larger samples and diverse populations is needed to address these limitations.

## Conclusion

In conclusion, our study provides valuable insights into the characteristics of ligature materials, knot types, and ligature mark patterns in cases of hanging and neck compression.

We found a relatively equal gender distribution, with marital status and socio-



economic factors influencing hanging cases. Complete suspension was the predominant scenario, indicating a higher risk of death. Nylon rope was commonly used by males, while odhani and sari were predominant among females. Atypical knot positions were more common than typical positions, indicating individual variations in ligature placement. Ligature mark patterns were observed in around 19% of cases, with slip knots and fixed knots being frequently identified. Fractures of the hyoid bone and thyroid cartilage were minimal, and ligature material was present in 97% of cases.

These findings contribute to our understanding of the variability and individuality of these cases, highlighting the importance of considering multiple factors in forensic analysis.

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