TECHNICAL NOTE

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Forensic Significance of the Polymorphism of Hyoid Bone Shape

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ABSTRACT: The reasons why some hyoids fracture in strangulation and others do not may relate to anatomic features of the hyoid bone. On this basis, we studied the dimensions and shape of hyoid bones (n = 100) originating from the Terry collection, National Museum of Natural History, Smithsonian Institution. The hyoid bones were extensively polymorphic in both dimensions studied, the span or breadth, and the length of the cornua. There was no linear relationship between the breadth and length dimensions of the bone. Based on qualitative assessment, hyoid bones could be classed as either hyperbolic (55%) or parabolic (45%) in shape. Hyperbolic hyoid bones could be distinguished from hyoid bones with a parabolic configuration on the basis of the metric data although there was considerable overlap in the dimensions of hyoid bones of both configurations. Female hyoid bones tended to be smaller in both dimensions than male hyoid bones. The metric parameters of fractured hyoid bones from 10 cases (8 female, 2 male) of strangulation were compared with the dimensions of hyoid bones in this study. The metric features of the fractured hyoid bones were attributable to the predominance of females in the group of fractured hyoid bones studied, an observation that is anticipated because the majority of strangulations involve female decedents. On this basis, we conclude that variables other than the shape and dimensions of the hyoid bone are more relevant in determining if hyoid fracture occurs during strangulation.

KEYWORDS: forensic science, strangulation, hyoid bone, forensic science, forensic anthropology

Fracture of the hyoid bone is a well recognized indicator of strangulation (1). Despite the association of hyoid fracture and strangulation, the absence of this observation does not preclude the diagnosis of strangulation. It is reported that only 34% of all cases of manual strangulation have a fractured hyoid bone (2). Many variables likely determine if a hyoid bone will fracture during strangulation including: magnitude of force applied to the neck; position of the force applied to the neck; rigidity of the hyoid bone; age of the victim; nature of the physical process of neck compression (e.g., hands or ligature), and possibly the shape of the hyoid.

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Recent studies (3,4) compared the case profiles and xeroradiographic appearance of the hyoids of 20 victims of strangulation with and without hyoid fracture (n = 10, each). The fractured hyoids occurred in older victims of strangulation (~40 years) when compared to the victims with unfractured hyoids (~30 years). The age-dependency of hyoid fracture correlated with the degree of ossification or fusion of the hyoid synchondroses. The hyoid was united in older victims of strangulation whereas ununited hyoids were found in the younger victims. In addition, the hyoid bone was ossified or united in 70% of all fractured hyoids, but, only 30% of the unfractured hyoids were united. The shape of the hyoid bone was also found to differentiate fractured and unfractured hyoids (4). Fractured hyoids were longer in the anterior-posterior plane and were more steeply sloping when compared with unfractured hyoids.

In this study, the spectrum of anatomic variation in hyoid shape and dimension were assessed in a series of hyoid bones from the Terry Collection in the National Museum of Natural History, Smithsonian Institution. In addition, the metric parameters of fractured hyoid bones from 10 cases (8 female, 2 male) of strangulation were compared with the dimensions of hyoid bones obtained from this study.

Materials and Methods

Randomly selected united hyoid bones (n = 100, 50 female, 50 male) from the Terry Collection, Department of Anthropology of the Natural Museum of Natural History, Smithsonian Institution, Washington, DC were used for the study. Two specific variables, implicated from previous studies (4) were measured for each specimen: (i) the breadth defined as the distance between the distal ends of the greater cornu, and (ii) the length defined as the distance separating a line through the distal ends of the greater cornua and the center of the hyoid body, as previously described (4). Measurements were obtained using standard digital calipers.

Hyoid bones were also classified into hyperbolic or parabolic shape categories based on the appearance in the coronal plane. Hyperbolic hyoid bones were considered to be U-shaped (i.e., steeply sloping cornua) whereas the parabolic shaped bones had a more distinctive V-shape (i.e., less steeply sloping cornua) (Fig. 1). The parameters from 10 fractured hyoid bones (8 female, 2 male) from cases of strangulation, from a previous study (4), were compared with the data obtained in this analysis. For all hyoid bones analyzed, length and breadth parameters were plotted and trends associated with shape, sex, and fracture were studied from the pooled data.

FIG. 1—*Diagrammatic representation of parabolic: (A) and hyperbolic, (B) hyoid bone shapes.*

Results

There was a wide variation in the length (range, 30–60 mm) and breadth (range, 25–45 mm) dimensions of the hyoid bones with near normal distribution of dimensions (Fig. 2). There was no linear correlation between the length and breadth dimensions. However, metric trends were observed for hyoid bones with either a hyperbolic (n = 55) or parabolic (n = 45) shape. Hyperbolic hyoid bones tended to have quantitatively similar breadth and length dimensions whereas parabolic bones tended to have greater breadths than lengths (Fig. 3). However, there was some overlap in the metric features of both parabolic and hyperbolic hyoid bones.

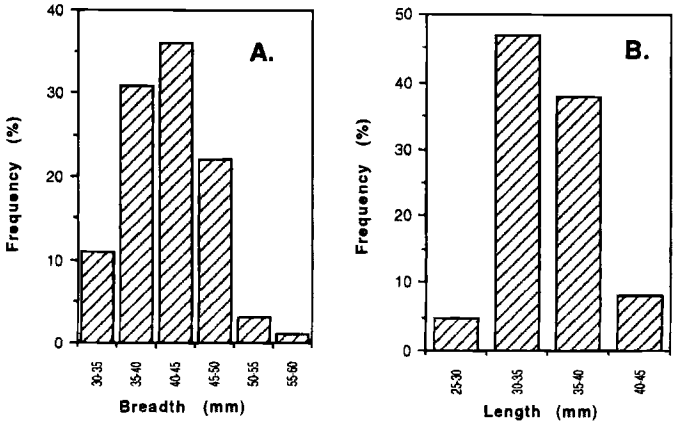

FIG. 2—*Frequency distribution of breadth (A) and length (B) of a spectrum of hyoid bones* (n = *100).*

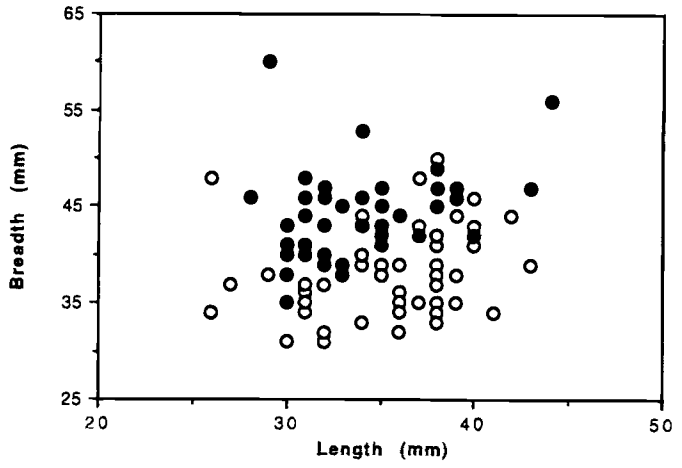

FIG. 3—*Scatterplot of hyoid bone dimensions for hyperbolic (clear) and parabolic (solid) hyoid bones.*

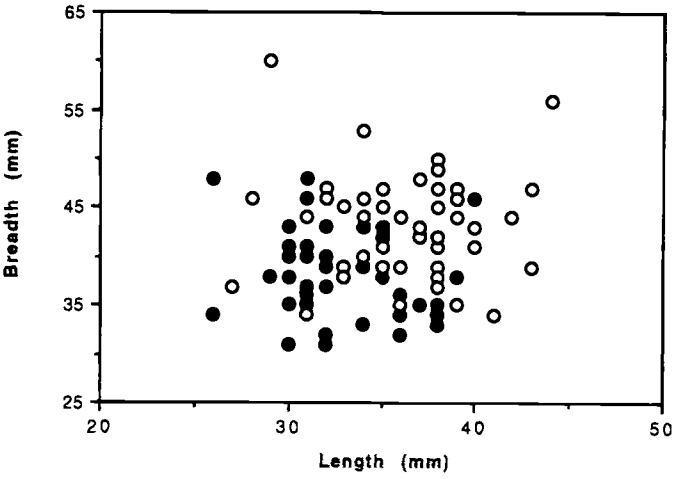

FIG. 4—*Scatterplot of hyoid bone dimensions for hyoid bones of both sexes: male (clear) and female (solid).*

Females tended to have smaller hyoid bones in both dimension parameters (Fig. 4) although there was considerable overlap with the dimensions obtained from male hyoid bones. However, there was no preferential distribution in hyperbolic or parabolic configuration among males and females. The length and breadth dimensions of fractured hyoid bones from cases of strangulation were compared with metric parameters obtained from hyoid bones in the current investigation. On the basis of this comparison, the fractured hyoid bones tended to be small in both dimensions, and clustered in the female region of the metric data (Figs. 4 and 5). This is an expected observation because most of the fractured hyoid bones were from women. Although only 10 fractured hyoid bones were studied, there was no apparent preferential involvement of hyperbolic or parabolic configuration among the fractured bones.

Discussion

This study was indicated because previous work has shown that fracture of the hyoid bone in strangulation may, at least in part, be determined by hyoid bone shape and size. The main findings in this study are that hyoid bones were extensively polymorphic

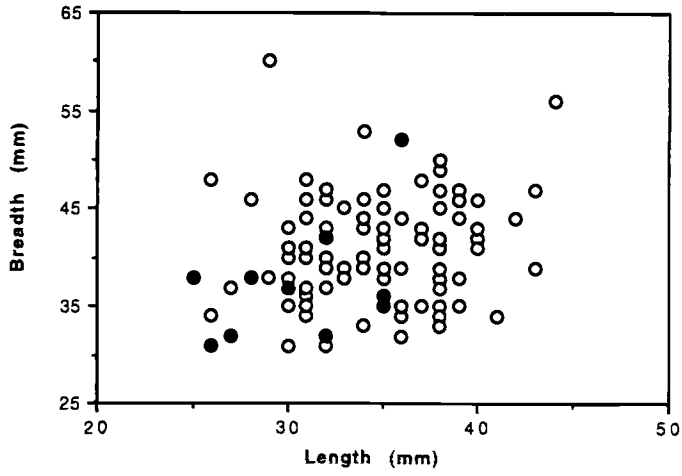

FIG. 5—*Scatterplot of hyoid bone dimensions for a normal spectrum of hyoid bones (clear) and hyoid bones fractured in strangulation (solid).*

although certain metric trends could be related to shape and sexual dimorphism. The dimensions of fractured hyoid bones from 10 cases of strangulation were compared with the dimensions of hyoid bones in this study. No specific feature could be identified to differentiate a subset of hyoid bones vulnerable to fracture. The metric trends observed in the data obtained from the fractured hyoid bones of strangulation cases are explained by the predominance of females in that group.

The overall survey of the metric and shape characteristics of the human hyoid bone show that there is wide morphologic variation. Hyperbolic and parabolic configurations each account for about half the hyoids in this study. The metric associations found with hyoids of different shape is expected although there was considerable overlap in the dimensions for hyoid of both shapes. One unexpected finding is the lack of correlation between the magnitude of the length and breadth parameters of the hyoid bone. This may be explained by independently coordinated growth of the hyoid bone in orthogonal dimensions. Specifically, the synchrondroses involved in the growth of the greater cornua and body of the hyoid bone may be differentially regulated during skeletal maturation. Because there is no association between the breadth and length parameters is likely that, unlike long bones that work in a gravitational field, there is no allometric relationship between these dimensions.

In a previous study, fractured hyoid bones from victims of strangulation were longer in the anterior-posterior plane than unfractured hyoid bones (4). In this study, however, the same fractured hyoid bones were not among the longest hyoid bones in the series of normal hyoid bones studied.

The forensic implication of the current work is that factors other than hyoid bone shape and size may ultimately prove to be more important determinants of fracture. Clearly, it is well known that united hyoid bones are more vulnerable to fracture that are ununited or unfused ones. This is explained by the flexibility for the latter and that a rigid cornua is more likely to fracture than a pliable cornua which can be deformed under mechanical distortion. Therefore, the most important intrinsic feature of the hyoid bone that determines fracture is likely the state of ossification. The ossification process of the hyoid bone has been well studied (5) and age-associated ossification of the hyoid bone correlates with the increased frequency of hyoid fracture in older victims of strangulation (4). Perhaps the most important variables relevant to hyoid fracture in strangulation are mechanical factors related to force magnitude and distribution on the neck, and the time interval of neck injury-to-death.

In summary, we have presented evidence that normal hyoid bones appear to be highly polymorphic in two specific dimensions and the shape of the cornua. It is likely that extrinsic factors involved in the strangulation process such as magnitude of compressive force, and position of the applied force are more important variables for determining hyoid fracture than specific dimensions of the cornua.

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