TECHNICAL NOTE

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The Location of Hyoid Fractures in Strangulation Revealed by Xeroradiography

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ABSTRACT: The location of 19 fractures of 15 hyoid bones was studied from 13 cases of manual strangulation and two cases of hanging. The precise location of the fractures were determined by xeroradiography of isolated hyoid bones. To classify the location of the fractures, the greater cornu was divided into anterior, middle, and posterior thirds and the frequency of fracture occurrence in these locations was determined. In addition, the angle of curvature of the greater cornu was determined at the fracture site to ascertain if specific points along the greater cornu were more susceptible to fracture. Fractures were found with equal frequency in the posterior and middle thirds of the hyoid greater cornu (9/19, 47% for both posterior and middle) but were rare in the anterior portion (1/19, 5%). However, all fractures occurred between 30° and 60° of curvature of the hyoid and most fractures (~60%) were found at ~50°. These results indicate that fractures of the hyoid occur at vulnerable angles of curvature of the hyoid bone which, due to anatomic variation in hyoid shape, do not necessarily occur at specific segments of the hyoid bone. On this basis, although the presence of the hyoid fracture in strangulation is determined by the rigidity of the bone, the specific location is determined by the shape of the greater cornu.

KEYWORDS: pathology and biology, strangulation, hyoid bone, forensic science

Fracture of the hyoid bone is a well recognized indicator of strangulation, particularly manual strangulation [*1,2*], and has been less frequently reported in ligature strangulation and hanging [*3*]. Although fracture of the hyoid is strongly associated with strangulation, the absence of this observation does not preclude the possibility of manual strangulation. In a recent review of the literature, Ubelaker reported that only 34% of all cases of manual strangulation have hyoid fracture [*4*]. Many variables determine if a hyoid bone will fracture during strangulation including: (1) magnitude of force applied to the neck; (2) precise position of the force applied to the neck; and (3) rigidity of the hyoid bone. For example, the hyoid is seldom fractured in children because the hyoid is not extensively ossified [*5*]. Similarly, the low frequency of hyoid fracture in hanging can be related to the position of the ligature and other mechanical factors including suspension height [*3*].

In strangulation, various locations in the hyoid may be the site of fracture. Since there is individual anatomic variability in the hyoid shape and rigidity we assessed the frequency of fracture in the hyoid bone at different segments of the hyoid. In addition, we studied whether the unique curved structure of the hyoid determines if fractures occurred at specifically vulnerable sites along the curvature of the greater cornu. The results indicate that the precise site of hyoid fracture is determined by the curvature of the hyoid.

Materials and Methods

The forensic radiography files between 1983–1994 at the Office of the Chief Coroner of Ontario were reviewed to identify cases of strangulation with a demonstrated fractured hyoid. A total of 19 fractures of 15 hyoid bones were studied from 13 cases of manual strangulation and two cases of hanging. All hyoids had been dissected from the larynx, and xeroradiographed in the superior-inferior plane. Briefly, xeroradiography was used preferentially over routine radiography because of superior resolution of bone density pattern with the former method, facilitating the identification of fractures. For xeroradiography, a photoreceptor plate is exposed to X-rays which charge the plate. To visualize the latent image an electrostatic blue powder is sprayed onto the charged plate, creating an image resulting from the deposition of the powder in varying intensity. Xeroradiographs were taken using a voltage of 65 KvP and an exposure of 30 mAs. The hyoid fractures identified in the xeroradiographs were classified by position in the greater cornu by presence in the anterior, middle or posterior segment. The anterior portion of the hyoid represented the region near the normal fusion center of the greater cornu to the body of the hyoid. The middle and posterior segments represent the remaining equidistant portions of the hyoid extending to the distal end of the greater cornu. In addition to classifying the location of the fractures, the angle of curvature of the hyoid cornu was determined. The angle of curvature was determined as the angle of inclination of the fracture from the center of the body of the hyoid (see inset of Fig. 2).

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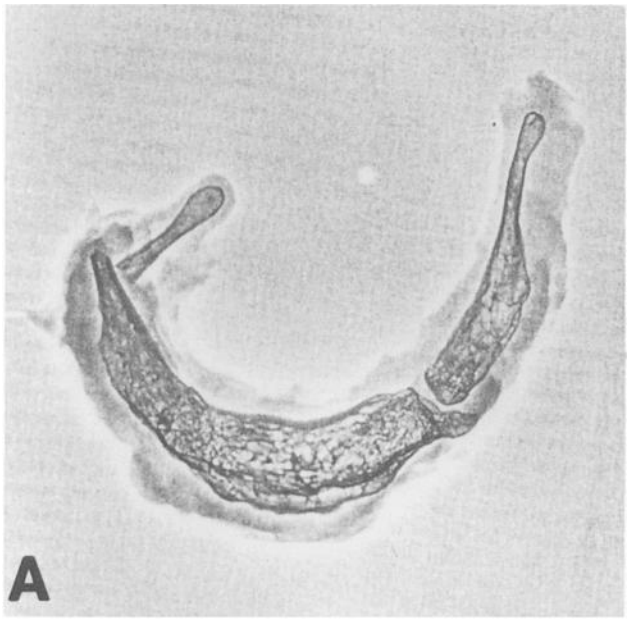

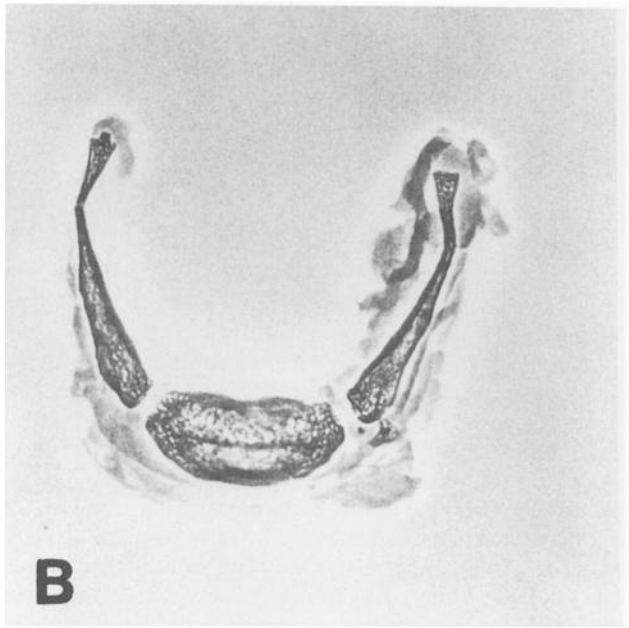

FIG. 1—*Xeroradiographs of fractured hyoids showing unilateral hyoid fracture in an extensively ossified hyoid* (A), *and bilateral symmetrical hyoid fracture in a non-fused hyoid (B).*

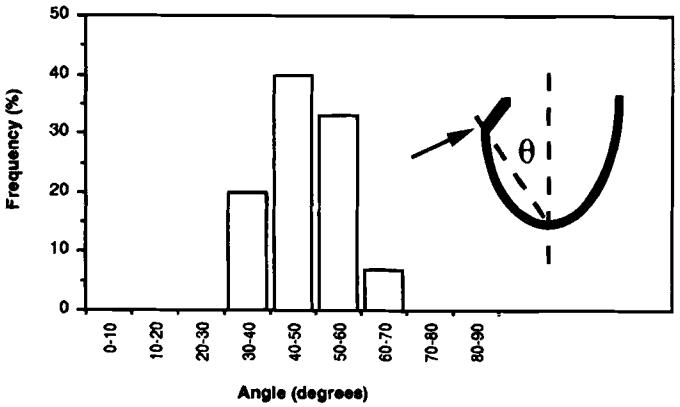

FIG. 2—*Frequency distribution of angle of curvature at the fracture site of 19 individual fractures in 15 cases of strangulation. The angle of curvature at the fracture site is restricted to 30° to 60° with ~50° representing most frequent angle of curvature. The distribution of angles indicates that the curvature of the hyoid bone produces a mechanically vulnerable site at ~50°. Inset shows the determination of the angle of curvature (θ) of the hyoid at the fracture site. The angle of curvature is determined as the angle produced by a line connecting the fracture* (arrow) *to the center of the hyoid relative to the midline.*

Results and Discussion

Eleven of the 15 cases had unilateral hyoid fractures (6/11 - right; 5/11 - left) (Fig. 1) and four of the 15 cases had bilateral symmetrical fractures of hyoid (Fig. 1). The shape of the hyoid bones were variable with some hyoids showing steeply sloping or hyperbolic greater cornu while others had a parabolic shape. Fractures were found with equal frequency in the posterior and middle segments of the hyoid greater cornu (9/19, 47% for both posterior and middle) but were rare in the anterior portion (1/19, 5%). In the single case with a fracture of the anterior segment, the fracture was located in the ossification site between the greater cornu and the body of the hyoid. Despite the lack of a defined pattern in the location of the fracture sites, all fractures occurred between 30° and 60° of curvature of the hyoid and most fractures (~60%) were found at ~50° (Fig. 2).

The main finding of this study is that hyoid fractures in strangulation occur at preferentially vulnerable angles of curvature of the hyoid bone rather than involving specific anatomic segments (anterior, middle or posterior orientation). The angle of curvature at the fracture site was not correlated with the anatomic position of the fracture. The widely *different* location of fractures at *similar* angles of curvature indicates that individual hyoids fracture at specific susceptible angles of curvature along the greater cornu. On this basis, it seems likely that the variation in hyoid shape determines where the hyoid will fracture. Most fractures were unilateral, which indicates that asymmetry of the hyoid may play a role in determining the location of the fracture. In addition, experimental hyoid distortion studies using interferometry showed asymmetrical displacement of hyoids under applied loads [*6*].

The hyoid fractures in hanging could not be distinguished from those in manual strangulation on the basis of the two parameters studied. However, in cases of hanging with hyoid fractures, the mechanical forces on the neck appear to be similar to those that occur during manual strangulation and that this may relate to an unusually high position of the ligature or the ligature knot. Clearly, the location of hyoid fractures in additional cases of hanging need to be assessed due to the low numbers of cases of hanging in the present study. Since the shape of the greater cornu determines the location and laterality of the hyoid fracture, it is possible that some hyoid-shapes may be more prone to fracture in manual strangulation. This may explain why the majority of rigid hyoids of adult victim of strangulation are unfractured. A follow-up study to compare the curvature properties of the greater cornu in adult victims of manual strangulation with fractured and unfractured hyoids could address this possibility.

This study was facilitated by the use of xeroradiography, which provides high-resolution images of the isolated hyoid. In at least one of the cases a fracture was missed by gross examination but was detected by xeroradiography. On this basis, we routinely apply this method to assess the status of the hyoid in all cases of suspected manual strangulation.

Conclusion

In summary, we have applied a highly sensitive radiographic method to study the location of hyoid fractures in strangulation. The findings indicate that hyoid fractures occur most frequently at ~50° indicating that this angle of curvature is particularly vulnerable to mechanical injury. The shape of the hyoid may not only explain the location of hyoid fracture in adults, but, also if the hyoid will fracture during manual strangulation.

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