THE MECHANISM OF SKULL FRACTURE

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Until recently, the mechanism of the production of linear skull fracture was not accurately understood since the over-all deformation patterns of the skull due to a blow were not known. Previous investigators have stated that a local deformation results in a depressed fracture and that general deformations result in linear fractures. This concept cannot be verified by a study of the actual deformation patterns. All impacts upon the skull result in local and general deformations of varying intensity if the energy expenditure is adequate. The production of a depressed fracture depends mainly upon the velocity of the injuring object, and to a less extent, its size and shape. A single linear fracture will result if the velocity of the blow is below a critical value and the energy available is between certain limits.

Aran,\(^4\) in 1844, described his irradiation theory of fractures. He stated that a fracture of the vault from impact on the vertex reached the base through the shortest possible route, implying that fracture started at the point of impact. Félixet,\(^5\) in 1873, stated that fractures result when an impact flattens out the curved surface of the skull. The fracture may then be guided by the presence of buttresses. He also observed that separation of buttresses, one from the other, due to an impact, may result in a fracture between them. His classical description of the buttresses of the skull is frequently quoted. He described single mid-frontal and mid-occipital and paired fronto-sphenoid and parieto-petrous buttresses. Bruns,\(^6\) in 1854, working with static loads found that compression of the skull resulting in shortening of the diameter in one direction, produced an increase in the diameter in the direction at right angles with the former. He also noted that although there was a certain degree of elasticity, the skull never returned to its former shape following static loading. He showed that the skull might be compressed from side to side, resulting in a shortening of its side-to-side diameter by as much as 12 to 14 mm. without failure. He found that when the load was removed, the side-to-side diameter was 4 to 5 mm. less than before its application. It was Bruns’ theory that pressure applied along one diameter would result in tearing apart forces in the portions of the skull at right angles to the direction of the force. In other words, that part of the skull where the radius of curvature decreased or where outbending took place eventually cracked. Obviously, compression when carried too far also resulted in fractures and depression at the point of application of the force. Rawling,\(^7\) in 1905, described his concepts of the mechanism of fractures involving the base of the skull. He stated that fractures of the base result from the force
of the blow actually splitting the skull in the same manner that a hatchet can split a piece of board along its grain. This again implied that the fracture started at the point of impact. The work of LeCount and Apfelbach, in 1920, is also interesting in that they more or less substantiated some of the former concepts enunciated by Aran, Félixet, Bruns, and Rawling. In a recent text on head injury by Rowbotham, essentially the above material is given for the mechanism of skull fracture. For instance, the author speaks of local deformations resulting in depressed fractures and generalized deformations producing linear fractures.

In the next few paragraphs it will be shown that all blows to the head result in local deformations as well as general deformations. In the production of a linear fracture, the local deformation from an impact is elastic, the bone rebounding after the blow. In the depressed fracture, the bone fails locally at or about the point of impact.

CERTAIN ANATOMICAL CONSIDERATIONS OF THE SKULL

The skull is made up of vault and base. The vertex through its greatest extent consists of two layers of bone with an intervening cancellous structure constituting the diploë. Certain anatomical variations may occur in the vertex. Although most frequently the outer table is thicker than the inner table, at times the inner table may be quite thick due to the presence of certain diploic ramifications through the outer table of the skull. These variations in the anatomy of the flat bones of the skull may be important in the resultant deformation patterns, particularly as concerns fracture of the inner table. The base of the skull consists of membranous bone and it appears to be extremely brittle under impact. Many foramina are found at the base and these are areas of stress concentration and fractures usually extend toward foramina. Battle, Rawling and others recognized foramina as regions of weakness at the base.

Most injuries to the skull are due to blows over the vertex and along the junction of the vertex with the base. A few injuries undoubtedly result from impacts so delivered as to cause the spinal column to extend into the cranial cavity. Injuries may result from blows toward the base, such as a blow on the lower jaw, thrusting the condyloid processes of the jaw against the base of the skull. Occasionally, the head may be compressed between objects (such as a car and the ground).

OBSERVATIONS

Time Period of Disturbance Following Blunt Impact. With the use of modern techniques, it has been possible to determine the time period of disturbance following impact upon the human head and to study the deformation patterns that result from impact. The total time period of disturbance following impact is in the neighborhood of 1/250 of a second.*

* This work was described in the paper “The mechanism and management of injuries of the head,” by E. S. Gurdjian and J. E. Webster, J. Amer. med. Ass., 1947, 134: 1073–1076, and is based upon strain gauge studies of deformations of the skull in human autopsy heads.