

Review of Phineas Gage's Oral and Maxillofacial Injuries

Abstract

A large iron rod weighing 13.25 pounds passed through Gage's head and surprisingly he lived 12 years with this injury. Though Gage survived this injury, his personality changed drastically. "Gage was no longer Gage", he changed from an even tempered man to being "fitful, irreverent, indulging at times in the grossest profanity". These events helped establish the relationship between personality and the frontal region of the brain.

However, his maxillofacial injuries are seldom noted. In this study, we reviewed previous texts and journal articles to enable a mapping of the trajectory of the iron rod through his maxillofacial region.

The iron rod first pierced through his left cheek, lateral to the mandible, anterior to the masseter muscle, and anterior to the parotid gland, therefore not penetrating the oral cavity. The zygomatic bone was then fractured and laterally displaced. The rod continued into the infratemporal fossa, apparently anterior to the pterygoid plexus and then entered the posterior orbit. It penetrated the cranial fossa through the frontal bone: Its trajectory was anterior to the cavernous sinus. It then penetrated the orbital portion of the frontal lobe before exiting the skull.

Although Phineas Gage's brain injuries are important, it is equally important to look at his maxillofacial injuries. The iron rod missed some major venous plexuses that could have possibly caused fatal bleeding.

Introduction

In 1848 Phineas Gage was a railroad foreman, an iron rod that he was using to pack explosive powder blew up [1,2]. The iron rod was 43 inches long, 1.25 inches in diameter and weighed 13.25 pounds shot upward and penetrated Phineas Gages' skull. Luckily Phineas Gage survived this injury and he lived 12 years with this injury. However after this accident "Gage was no longer Gage." Phineas Gage used to be an even tempered, and he changed to "uttering the grossest profanity", and showed "little deference for his fellows."

Phineas Gage became the most famous patient of neuroscience because he showed a link between brain injury and personality.

Methods

Multiple journal articles, and books were analyzed in order to determine what structures the iron rod could have possibly penetrated. Some of the information provided was indicated by journal articles, however most of the pathway was indicated by projecting the possible structures that the iron rod penetrated. We have constructed a review outline to define the injuries that he suffered.

Results and Discussion

Table 1: The iron rod first pierced his left cheek, lateral to the mandible, and anterior to the masseter muscle, and parotid gland, it may have lacerated the buccinator muscle, penetrating the oral cavity. We can't confirm that it knocked out a maxillary molar.

| Source | Possible Structures Affected |
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| The Boston Medical and Surgical Journal (1848) [1] | Taking a direction upward and backward toward the median line, it penetrated the integuments, the masseter and temporal muscles, passed under the zygomatic arch, fracturing the temporal portion of the sphenoid bone, and the floor of the orbit of the left eye, entered the cranium, passing through the anterior left lobe of the cerebrum, and made its exit in the median line, at the junction of the coronal and sagittal sutures, lacerating the longitudinal sinus, fracturing the parietal and frontal bones extensively, breaking up considerable portions of the brain, and protruding the globe of the left eye from its socket by nearly one half its diameter. |
| Dr. Harlow's Case of Recovery from the passage of an Iron Bar through the head. (1993) [3] | I asked him where the bar entered, and he pointed to the wound on the left cheek, which I had not before discovered; this was a slit running from the angle of the jaw forward about one and a half an inch it was very much stretched laterally. A linear cicatrix of an inch in length occupies the left ramus of the jaw near its angle. A little thickening of the soft tissues is discovered about the corresponding malar bone. The eyelid of this side is shut, and the patient is unable to open it. The eye considerable more prominent than the other, offers a singular confirmation of the pints illustrated by the prepared skull described below. It will be there seen that the parts of the orbit necessarily cut away are those occupied by the levator palpebrae superioris, the levator oculi and abducens muscles. In addition to a ptosis of the lid, the eye is found to be incapable of executing with the outward or upward motion; while the other muscles animated by the motor communis are unimpaired. |



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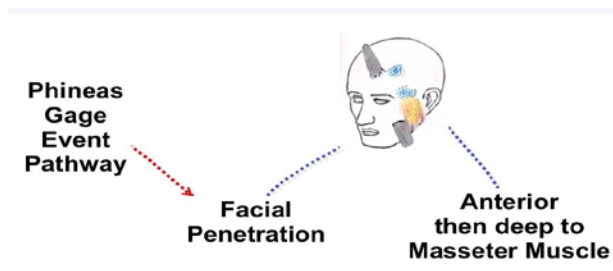
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| <p>An Odd Kind of Fame (2000) [4]</p> | <p>Boston Courier and Daily Journal original newspaper: The iron entered on the side of his face, shattering the upper jaw, passing back of the left eye and out of the top of the head.</p> <p>Vermont Mercury: The charge in the hole exploded and the bar entered the man's face anterior to the angle of the lower jaw, passed up outside of the teeth of the upper jaw, entered the bone of the cheek on its under surface, without, however destroying the shape of the face, and passed out just behind where the frontal and two parietal bones meet, that is, near the top of the head.</p> <p>Christie Reflector and Christian Watchman: it entered on the left cheek, just over the jaw bone, and under the cheek bone, and passed back of the left eye, and came out on the top of the head, a little forward of the centre, and almost precisely where the skull is found unclosed in an infant's head... The wound on his cheek has entirely healed, and the larger one on the top of his head is apparently doing well, discharges freely, but has a healing and healthy appearance.</p> <p>North Star: Striking him on the face, just below the cheek bone, it forced itself through the skull near the top of the head, passing directly through what phrenologists call the organ of veneration.</p> <p>Letter in the National Eagle: The bar struck the left side of the operator's face, entering just above the upper teeth, about mid-way between the nose and the ear- passed under the cheek bone, back of the left eye which it destroyed and came out on the top of the head at a point lying about an inch back of the centre of a straight line drawn from the middle of the top of the forehead to the left angle of the forehead.</p> <p>Bigelow's first intervention: A drill nearly three feet in length and averaging an inch in diameter passed in the region of the upper jaw, and out near the sagittal suture, being shot clear through- the patient is now well.</p> <p>Public Ledger and Daily Transcript: The story in brief is that the person and the tampering iron, three feet seven inches in length and an inch and a quarter in diameter, weighing thirteen and a quarter pounds, passed through the left cheek, just behind and below the mouth, ascended into the brain behind the left eye, passed from the skull, which it shattered and raised up...</p> <p>It shattered the left zygoma as the metal rod penetrated the face several centimeters anterior to the left tragus.</p> <p>Harlow's account: The powder exploded, driving the iron against the left side of the face, immediately anterior to the angle of the inferior maxillary bone. Taking a direction upward and backward toward the median line, it penetrated the integuments, the masseter and temporal muscles passed under the zygomatic arch and fracturing the temporal portion of the sphenoid bone and the floor of the orbit of the left eye entered the cranium.</p> |
| <p>In Phineas Gage: A Gruesome but True Story about Brain Science (2002) [2]</p> | <p>The rod entered under the left cheekbone, pass behind his left eye, through the front of the brain and out of the middle of his forehead just above the hair line.</p> <p>The slit was running from the angle of the jaw forward about one and a half inch.</p> <p>He was bleeding freely from his forehead and inside his mouth.</p> <p>- There was a hole where the iron passed upward through the roof of his mouth.</p> |
| <p>The Tale of Phineas Gage, Digitally Remastered (2004) [5]</p> | <p>The zygomatic process of the left maxilla must have fractured in continuation with the orbit.</p> |
| <p>Mapping the Connectivity Damage in the Case of Phineas Gage (2012) [6]</p> | <p>To satisfy the observed anatomical constraints with the mouth closed would result in a greater right-sided inclination of the rod. Yet, as Harlow originally noted, Gage was in the act of speaking to his men at the moment of the injury and, thus, his mouth was likely open. We observe that with the jaw opened, the best-fit rod trajectory satisfying all constraints does not intersect or cross the superior sagittal sulcus and the injury is specific to the left frontal lobe.</p> <p>The 13 lb. iron struck the interior wall of the hole causing a spark to ignite the powder which, in turn, launched the pointed iron rod upwards, through the left cheek of Mr. Gage just under the zygomatic arch, passing behind his left eyeball, piercing his cranial vault under the left basal forebrain, passing through his brain, and then exiting the top and front of his skull near the sagittal suture. The 13 lb. iron struck the interior wall of the hole causing a spark to ignite the powder which, in turn, launched the pointed iron rod upwards, through the left cheek of Mr. Gage just under the zygomatic arch, passing behind his left eyeball, piercing his cranial vault under the left basal forebrain, passing through his brain, and then exiting the top and front of his skull near the sagittal suture.</p> <p>In particular, we concur with Ratiu et al. that Mr. Gage had his jaw open at the moment of the accident. Harlow reports Gage looking over his right shoulder and saying something to his crew at critical moment of the blast. In the casting of possible rod trajectories, the most likely position of the jaw was determined to be -15° in pitch (downward) and 5° in yaw (to the right) relative to the closed position of the jaw. This position allowed the unhindered passage of 1.303×10^3 out of 1×10^9 viable rod trajectories inclusive through the skull. With this jaw position, in contrast to the suspicion of Bigelow, we noted no contact between the rod and that of Mr. Gage's coronoid process [7].</p> |

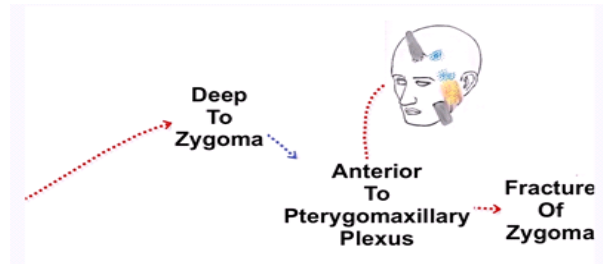
Discussion

The projected trajectory is:

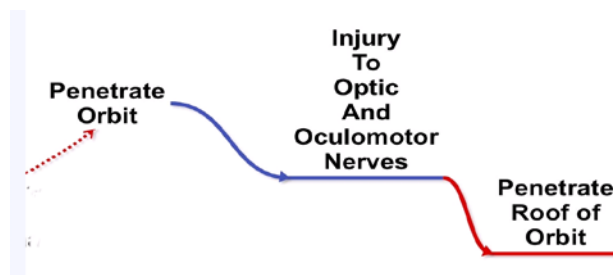
1) The iron rod first pierced his left cheek, lateral to the mandible, and anterior to the masseter muscle, and parotid gland, it may have lacerated the buccinator muscle, penetrating the oral cavity. We can't confirm that it knocked out a maxillary molar.



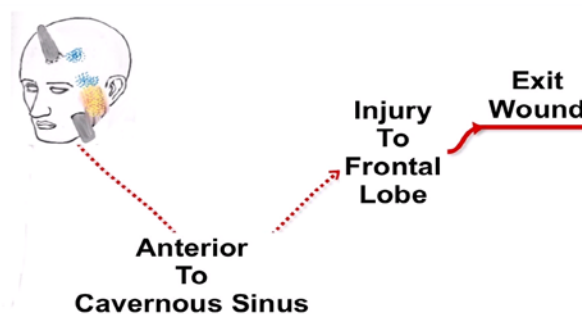
2) The zygomatic bone was then fractured and laterally displaced.



3) The rod continued into the infratemporal fossa, anterior to the pterygoid plexus and then entered the posterior orbit. The optic nerve remains intact however there is ptosis of Gage's eye indicating a damaged cranial nerve III.



4) It penetrated the cranial fossa through the frontal bone: Its trajectory was anterior to the cavernous sinus.



5) It then penetrated the orbital portion of the frontal lobe before exiting the skull.

Conclusion

Phineas Gage is a major landmark case in neuroscience. It is surprising how Gage was able to survive this accident and live 12 years later. Phineas Gage's oral and maxillofacial injuries were rarely noted. It is amazing how the iron rod penetrated the oral cavity, and caused limited intraoral damage. If the iron rod's path was different and it penetrated the pterygoid plexuses or the cavernous sinus Phineas Gage could have bled to death.

References

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