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OPTICAL DENSITY MEASUREMENTS OF THE JFK AUTOPSY X-RAYS and A NEW OBSERVATION BASED ON THE CHEST X-RAY

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For the first time, the autopsy X-rays of President John F. Kennedy have been examined by optical densitometry. This technique measures the transmission of light through selected points of the X-ray film. In the X-ray film, areas of greater transmission (lucent areas or whiteness) represent dense tissues such as bone. When exposed to X-rays these denser tissues absorb more photons, thus leaving fewer to strike the film at these sites. In the developing process, these areas become more lucent. On the final X-ray film, therefore, whiter areas represent denser tissues in the original subject and darker areas represent tissues of lower density such as air, fat or other soft tissues. During this optical density study, points were selected on the X-ray film for measurement. The numbers obtained permit assessment of the relative amount of tissue in the original subject. These measurements are expected to fall within a normal biological range. Any values outside this range -- especially those which are unnaturally far outside-- raise questions of authenticity.

Anomalous Optical Density Measurements

Measurements were made during three separate studies in October 1993 at the National Archives. The instrument used was a TBX Transmission Densitometer made by Tobias Associates. The instrument readings are in optical density. Optical density (OD) is defined as

$$OD = \text{Log}_{10} (I_o / I),$$

where I_o is the incident light intensity and I is the transmitted intensity. The inverse relationship, which gives the transmission as a function of OD, is

$$\text{transmission} = I / I_o = 10^{-OD}$$

An OD of 1 would therefore represent transmission of 1/10; an OD of 2, is a transmission of 1/100; an OD of 3 is a transmission of 1/1000. Most diagnostic X-ray films have an OD range of about 0.4 to 2.0, and are usually centered about 1.0. This range is chosen visually by radiologists for maximum ease of discriminating among human tissue densities.

We turn next to the JFK autopsy X-rays. In the posterior portion of the lateral skull X-ray is an obvious large white area readily seen on both left and right lateral skull X-rays. By way of contrast, in the frontal area the X-ray is unusually dark. This has led some observers, based on prints of these X-rays as reproduced in popular books, to state that bone is absent in this dark area. However, direct inspection of this area on the original films, especially with the assistance of a bright light, reveals that most of this area does contain bone, except for a small area near the vertex. Under the bright light, fractures can even be seen within this dark area. A series of OD measurements were made in both the light and dark areas on the lateral X-rays. Within the posterior lucent area on the right lateral, these measurements ranged between .57 and .69, with a mean of .61. This corresponds to a transmission of 24.5 %. In the dark area the OD range was 3.22 to 3.78, with a mean of 3.52. These latter measurements were all taken in the area where the bone was visibly present. The corresponding transmission in this dark area is then 0.030%. The ratio of transmissions is 24.5 % / 0.030% = 820. In other words, the posterior white area transmits much more light than the very dark anterior area -- by nearly a factor of 1000! Because these differences are seen on both lateral skull X-rays, and because they are located in similar, but not identical, areas, technical artifacts such as processing cannot explain this enormous difference in transmission. These white areas are, in addition, distinctly different in shape and size, an outcome which would not be expected from a technical etiology. Similar measurements made on X-rays of patients seen in the clinic show ODs in the posterior area in the ranges of 1.06 to 1.17 (transmissions of 7 to 9 %), whereas the slightly darker frontal areas were .91 to .94 (transmissions of about 12 %). The ratio of these transmissions is almost always less than a factor of 2. Compared to this small ratio, the ratio of nearly 1000 found in the JFK autopsy X-rays is exceedingly -- and unnaturally -- high. It is, in fact, far too high to be explained by any naturally occurring differences in human tissues. As a point of reference in the JFK X-rays, the transmission of the white area in the posterior skull was measured to be nearly as high as that measured through the extremely dense petrous bone, which surrounds JFK's ear canal. Not only is the normal petrous bone very dense, but it extends from one side of the skull to the other. In order for the white area in the posterior skull to match the density of petrous bone, all of the brain in this posterior area would need to be replaced by very dense bone, and the bone would have to extend from one side of the skull to the other. Since no human skull is constructed in this fashion, these measurements are inexplicable by normal human anatomy.

Also available for review from the National Archives was an 8 x 10 inch black and white print of a pre-mortem lateral skull X-ray of JFK. As readily judged by the

human eye, the previously seen enormous range of black to white is not seen in this X-ray print. On the contrary, except for mild density changes as a result of the printing process, it appears to be typical of patient X-rays as seen in the clinic. It certainly does not show the enormous black to white range as seen on the post-mortem X-rays. This print was shown to other radiologists who promptly concurred with this assessment. Unfortunately, these pre-mortem X-rays are kept at the JFK Presidential Library in Massachusetts and were not made available for optical density measurements.

There is at least one more odd feature of this large posterior white area on the lateral skull X-rays. If this white area truly represented a normal bone fragment, it should have the same general contour on both left and right lateral X-rays, allowing, of course, for small differences in perspective. In fact, however, the superior border has a distinctly different contour on these two laterals: a small, but distinct peninsula juts upward at one point on the left lateral X-ray where no similar feature is seen on the right lateral X-ray. Such a discrepancy is not seen (and should not be seen) on the other more normal appearing bone fragments in these X-rays.

This remarkable posterior white area is somewhat wider on the left lateral (the side nearest the X-ray film). If this white area represents tissue which was actually present in the body as it was originally X-rayed, then its higher magnification requires that it be located closer to the right side of the skull (farther from the film). Such an unusually dense object should have been very easy to see in the corresponding area on the anterior-posterior (AP) skull X-ray. However, no evidence for such an object could be found.

On the AP skull X-ray, projecting within the right orbit, is a 6.5 mm nearly round "bullet" fragment. On the lower border of this fragment, at about the 5 o'clock position, a large segment is absent. The left to right width of this object at this lower level is therefore less than the central width by at least a factor of 2. This same object is purportedly seen on the lateral X-ray, where it appears to be embedded in the outer table of the posterior skull, near the so-called cowlick area. Optical density measurements taken at different levels through this object as seen from the side (using the lateral X-ray film), would be expected to show a distinct range, with greater light transmission at the center (consistent with more metal) and much less at the bottom. In fact, the measurements show just the opposite: they imply distinctly more metal at the bottom. As a reference point, the OD of the immediately surrounding bone was 1.83 (transmission of 1.5 %). The OD through the center of this object was 1.55 (transmission of 2.8%) whereas the supposedly thinner inferior portion was 1.42 (transmission of 3.8 %). This is a truly extraordinary result: the transmission through the inferior portion should have

been distinctly less than that measured through the center. This "bullet" fragment does not behave like an object which was physically present in the originally X-rayed skull.

This inconsistency between the AP and lateral cannot be explained as a processing error. The many other measured ODs on both X-rays films do not display this anomaly. In particular, there is a 7 x 2 mm metal fragment located just above the right frontal sinus which is seen on both AP and lateral views. On the lateral view, this object has an OD of 1.60 which remains nearly constant over the entire height. This homogeneity is what would be expected from the shape as seen on the AP view. It therefore appears to be real. It was, in fact, removed at the autopsy by the pathologists. The much larger and more obvious 6.5 mm round object was not removed -- nor was it even described by the pathologists.

An explanation which readily encompasses all of the above anomalies is that these X-rays are composites, i. e., constructed of more than one image. Most likely, one image is an authentic X-ray. The authenticity of many unique features of the skull, including dental work, sinus details, and other finely textured bone structures have been previously verified by experts for the House Select Committee on Assassinations (HSCA). Many of these same structures could be compared in this study and the same conclusions were reached regarding authenticity. After a copy of the first image was exposed on the X-ray copying machine, a second image could then be superimposed on the first, before development, by a second exposure on the same machine. The degree of contrast could be controlled by the exposure time of the second image. Or, if necessary, individual exposure times of each image could be adjusted by a process of trial and error until a satisfactory composite image was obtained. The same approach could have been used to add the 6.5 mm object to the AP X-ray. In this latter case, the visible inhomogeneity of the 6.5 mm object as seen on the AP would almost certainly not be consistent with the apparent thickness as obtained from the OD measurement on the lateral X-ray. Because optical density measurements are rarely, if ever, performed on X-rays in this setting, it is unlikely that anyone who prepared such a composite would have tried to make the AP and lateral X-rays consistent with each other for optical density. We conclude, therefore, that the range of aberrations seen in these X-rays is so wide that no explanation can properly encompass them except the explanation that these are composites. It is hardly surprising that no one has ever noted this before because such X-rays are not seen in clinical practice.

A Search for the Posterior Bullet Entry Site in the Skull

The House Select Committee on Assassinations (HSCA) concluded that a bullet entered the posterior skull approximately one cm above the 6.5 mm object seen on the AP skull X-ray. This opinion was reached exclusively from observations of the lateral X-ray. The HSCA placed the entry site near the cowlick area at the site of a depressed fracture. Little consideration, if any, was paid to the AP X-ray. In the present study of the AP skull X-ray, the area above the 6.5 mm fragment was carefully scanned for optical density, looking for a suitable bullet hole. No evidence for such an entry site could be found. At 2 millimeters above this "bullet" the OD was 1.73. Beginning at about 5 mm above this object there is a dark transverse slit where the OD was 2.16. The total height of this slit, however, is only about 3 mm, not nearly large enough to pass a 6.5 mm bullet. Progressing more superiorly, the superior orbital ridge is encountered next: its OD is 1.54, suggesting more bone, as would be expected. Superior to this is a rather large bone island in which the density is about 1.77. No entry hole was found in this island that would be anywhere close to the site proposed by the HSCA. Areas lateral to this vertical line were also scanned, but no evidence for a bullet entry could be seen. In fact, the absence of an entry hole anywhere in the vicinity indicated by the HSCA is fairly apparent even to the unaided eye.

HSCA concluded a posterior entry wound using lateral X-ray only for the 6.5 m fragment / no entry wound detectible for A-P X-ray

On the lateral X-ray, the site chosen by the HSCA for the bullet entry is coincident with a depressed fracture along the posterior border of the skull. It is most likely that the large transverse fracture which is seen just above the left superior orbital ridge on the AP view, and which lies entirely on the left side of the skull on this view, corresponds to the depressed fracture which is seen on the lateral X-ray. It is outside the scope of this work to detail the correlation of landmarks seen on the lateral to those identical landmarks as seen on the AP X-ray. There is, however, remarkably strong evidence for a correlation in which the AP X-ray is regarded as a modified Waters' view. This author is not the only one to reach this conclusion. The fact that this conclusion was reached independently by other qualified persons is, however, strong corroboration for it. Because this fracture line does not extend into the right side of the skull as seen on the AP view, this correlation then implies that the depressed fracture lies entirely on the left side of the posterior skull. Therefore, on the lateral X-ray, if this depressed fracture lies entirely on the left side of the midline, it obviously cannot be interpreted as an entry site for a bullet on the right side of the midline. That odd position was actually taken by the HSCA, without, however, directly confronting these issues.

How did left superior orbital ridge fracture get there?

on lateral X-ray depressed fracture that HSCA enter on right side of midline is actually on the left side HSCA never explained this

An alternate interpretation of the AP X-ray is that the relatively large bone island which projects above the right supra-orbital rim is actually on the anterior skull surface and therefore could not be expected to show a posterior bullet hole. If that is correct, however, then there is no bone at all visible on the posterior skull. This obvious asymmetry is readily evident by comparison with the mirror image area on the left side. Such a large posterior defect would be a strong suggestion that a bullet had exited through the posterior skull, leaving behind it a large defect. Even if this conclusion is not accepted, the mere absence of bone in the posterior skull obviously leaves no bone to hold an identifiable hole of any kind. So, no matter where this bone island is placed, the bullet entry site described by the HSCA cannot be confirmed.

An alternate, much lower entry site, was emphatically described by the autopsy pathologists in their official HSCA testimony and was recently confirmed in their interviews with the Journal of the American Medical Association (JAMA). Unfortunately, optical density searches for an entry at this lower site on the AP skull X-ray are hampered by dense overlying bone in the anterior skull. If, however, this lower site is correct -- and it is generally agreed that there are no other candidates for this bullet entry site --then a serious dilemma arises. There is then no satisfactory explanation for the obvious and numerous metallic fragments near the vertex of the skull, at least 10 cm higher than the lower entry site. These lie about 3 cm inferior to the skull vertex and are almost parallel to the vertex. This collection extends across the entire width of the skull, measuring 13.4 cm long on the right lateral and 15.8 cm on the left lateral. What is most peculiar -- even disturbing -- is that these very obvious and numerous fragments were not described by the pathologists in their testimony nor were they even mentioned in the autopsy report. The radiology technologist, Jerroll Custer, has, however, assured this author that these metal objects were readily evident on the X-rays which were viewed in the autopsy room on November 22, 1963. Their presence this far above the proposed low occipital entry site (10 cm higher on the posterior skull) is inexplicable by a bullet entering at this lower level.

If the lower entry site is accepted as authentic, as JAMA concluded in its recent interviews with the pathologists, then this superiorly located metal debris can reasonably be explained only by a second bullet. Without further analysis of the distribution of the fragments, however, no firm conclusion can be drawn about the direction of this bullet. What is quite clear, however, is that no one has proposed that two bullets struck the head from the rear. This scenario would, in any case, pose essentially insurmountable timing problems for a lone posterior gunman. A desire to limit the number of head shots to one may be one reason that the HSCA moved the posterior bullet entry site nearly 10 cm

higher, so that the entry would be more compatible with this superiorly located debris. Even after this elevation of the entry site, though, many observers noted that the debris still seemed oddly too high to fit with the HSCA entry site.

The optical density measurements in this study argue very strongly against an entry site at the higher level selected by the HSCA. If this conclusion is accepted, then only the much lower site, the one strongly affirmed by the pathologists, can be the authentic site. It is noteworthy that in the recently released HSCA testimony of Dr. Pierre Finck (the gunshot wounds expert at the autopsy), he again adamantly argues for this lower site. If this lower site is accepted, however, a single bullet at this level can provide no rational explanation for the superior collection of debris. This obvious dilemma has never been addressed by any of the autopsy pathologists nor was this conflict even raised in the recent issues of JAMA. Unless this issue is resolved, a requirement for a second head shot is unavoidable.

The Chest X-ray

This final short section deals not with optical density measurements but rather with simple measurements of the JFK autopsy chest X-ray and the conclusions which follow. The total width of the spine at the seventh cervical vertebra (including the transverse processes) was measured directly on the X-ray as 7.0 cm. According to Jerroll Custer, the film cassette was placed directly in contact with the back. The X-ray source-to-skin distance was 44 inches (112 cm). Under these conditions, the magnification is slight, about 6%. The AP thickness of the body at this level (14 cm) was supplied by the HSCA. This thickness has been measured by the author on many patients and is well within the expected range. The distance of the upper back wound from the midline (4.5 to 5.0 cm) was supplied by the HSCA and was measured independently in this study from the photograph of the back. This photograph contains a centimeter ruler pressed against the skin at the level in question. All of these measurements were then placed onto a cross section of the body at this level. The exit site used was the anterior midline, a location described by the Parkland doctors. The nick on the necktie, often cited as evidence for a transiting bullet, was said by the HSCA to lie on the left edge of the knot. This more leftward location of the proposed exit site would make the following argument even stronger. All observers agree that, if a bullet transited the body at this level, then it did so without deflection. The entry and exit sites were therefore connected by a straight line. It was immediately apparent that the "magic" bullet could not exit near the midline of the throat without passing directly through some portion of the seventh cervical vertebra. If

For left edge of necktie knot exit, bullet would have had to have been undeflected this impossible, as would have to pass through some portion of the seventh cervical vertebra

the finite width of the bullet is taken into account, this trajectory becomes even more untenable. Such a trajectory must unavoidably cause major trauma to the spine and this trauma would be very obvious on the chest X-ray. No major trauma of this type is seen.

If the bullet entered more superiorly the argument is unchanged. The width of the immediately superior vertebrae is essentially the same. Furthermore, the cervical transverse processes constitute a very tight vertical barrier: there is virtually no space for anything to pass between adjacent processes. If, on the other hand, the first thoracic vertebra is considered as a transit level, the difficulties become even greater. The total width of this vertebra, including transverse processes, was measured to be 9.5 cm. Again there is no gap in the vertical direction for passage of a bullet. If an even more inferior level is considered for transit, lung is encountered. Since the lung lies immediately adjacent to the spine, any bullet transiting at this level would necessarily cause a pneumothorax. The pathologists reported the absence of a pneumothorax and the X-rays also show no pneumothorax.

The horizontal angle of the bullet through the body, measured with respect to a midsagittal plane, is 20 degrees. On a detailed scale model of Dealey Plaza, the angle between the sniper's nest and torso of JFK at Zapruder frame 224 (the recently proposed denouement of the "magic" bullet) is slightly less than 10 degrees. No one has explained this obvious discrepancy between 10 and 20 degrees, a rather large difference. If a smaller angle is proposed to more closely agree with the Dealey Plaza measurement, the trajectory would pass even closer to the center of the spine. If a larger angle is selected to make it more likely that a bullet would miss the spine, the gunman is thereby moved considerably westward of the sniper's nest. This would suggest a second posteriorly located gunman.

It may be suggested that if JFK's torso were significantly rotated this dilemma might possibly be resolved. The photographs of JFK show his torso to be facing very nearly straight forward at this time. The photographic consultants for the HSCA examined multiple photographs and concluded that any rotation was slight, surely not more than 5 degrees. By this line of reasoning therefore, the actual rotation is not likely to resolve this serious discrepancy. Actually, however, the degree of rotation is irrelevant. It should clearly be noted that the angle measured through the body is determined solely by the entry and exit sites and has nothing at all to do with the rotation of the torso. The relative positions of the critical anatomic structures near the midline should not be affected by even significant degrees of rotation. The body can be rotated almost anyway one wishes with respect to a gunman and any bullet which transits the body must still obey these strict anatomic constraints.