Mummified Child – A Further Investigation

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Abstract: An Australian Institute of Archaeology mummified child from the Graeco/Roman Period of ancient Egypt has been re-investigated using Computerised Tomography (CT) scan images loaded into a Vitrea Workstation. The Vitrea Workstation produces volume rendered images and three dimensional (3D) reconstructions from the original CT scan data and allows for a more complete examination of the mummy within the wrappings. Most results from the original report published in this journal have been confirmed, some may have alternate explanations and there are a number of new findings. The child's injuries are more extensive than first reported and may suggest death due to traumatic injury. The body's preparation for burial is unusual with the inclusion of supporting panels of an inorganic material.

Introduction

Mummification of children in the Graeco/Roman Period (c. 332 BCE – c 395 CE) was not remarkable and appears to reflect the wealth of the parents or guardians (Ikram and Dodson 1998: 12). Elaborate rhomboid or diagonal bandaging, gold leaf decoration on tissue, cartonnage masks embellished with gold leaf and decorative body panels have been found and published (Walker 1997). Within the wrappings, many of the child mummies have been preserved to the elaborate standard recorded in Herodotus' account in *The Histories* (Herodotus 1954). There are some variations on this standard in individual mummies and this may suggest regional differences in mummification practices or changes due to Hellenistic or Roman influences (Ikram and Dodson 1998: 164-165).

All mummies examined to date, by the authors, have been wrapped in linen of varying thicknesses and quality. There is no definitive evidence of cotton or other fabrics having been used in mummy bandages in the Graeco/Roman Period or in the previous periods of ancient Egyptian history.

The majority of Graeco/Roman child mummies arrived in museums without provenance and in most cases, without any identifying documentation such as the name of the deceased on external bandages or recorded on external cartonnage decoration (Dawson 1968: 29-39). Some of these mummies may be attributed to a particular region of ancient Egypt on stylistic grounds; however this is reliant entirely on the external decoration rather than provenance.

Very little is known of the lives and cause of death of children from the Graeco/Roman Period. Modern medical and scientific methods offer the means to investigate the mummified remains in order to determine conditions that occurred peri-mortem or post-mortem (Notman, Tashjian et al. 1986). In the case to be discussed questions to be answered relate to the type of mummification, the age of the child and to any injuries that may have caused death. These questions were initially addressed in the report of a study by a multi-disciplinary team on the Australian Institute of Archaeology mummified child, Figure 1 (Davey and Craig 2003). Since that report imaging technology has advanced justifying the re-scanning of the mummy in 2005 and a new analysis with the assistance of Vitrea Workstation software.

Figure 1: *The child mummy at the Australian Institute of Archaeology. Photo: Rudy Frank*

Figure 2: *A three dimensional computer image of the child mummy and the adult sized mask.*

Description of the Specimen

Records of Sotheby and Company sales show that on the twenty sixth of April 1965 the mummy was purchased in London for the collection of the Australian Institute of Archaeology (Sotheby 1965: 26). Unfortunately the sales records do not include any information that could indicate provenance.

Linen bandages of varying quality and thickness encase the mummy of a small child, of unknown provenance. A cartonnage mask, which is of adult size and a chest panel cut to size, adorn the upper part of the body, Figure 2.

A decorated linen panel covering the lower section of the body complements these upper pieces of cartonnage, Figure 3. This panel is richly decorated with polychrome images of ancient Egyptian deities that are rendered in fine detail. Although the quality of the lower panel is in reasonably good condition, the cartonnage panels are of lesser quality with much of the paint in a very poor state and in some areas the detail is lost. Visual inspection of the mummy indicates that its condition is poor in some areas and in particular in the mid posterior region where there is extreme damage to the linen bandages which exposes the substance that lies beneath the linen. In moving the mummy for a number of scientific and medical examinations, it was noted that the remains were relatively heavy and the reason for this was unknown.

The mask is unusual and has been described by Mann, who suggests that the cartonnage mask and body panels may be securely dated to the Graeco/Roman period and various sites in ancient Egypt, for example the mask is from Akhmin, the lower body panel is from Kharga Oasis, suggesting that recycling was taking place at the time (Mann 2006).

Although the body accoutrements have been stylistically identified, this does not necessarily mean that the child's remains are neither from the area noted nor from a particular time period. Dr John Taylor, Assistant Keeper in the Department of Ancient Egypt and the Sudan at the British Museum, originally suggested that the mask is that of an adult and has possibly been added to enhance the commercial value of the mummy; during a period when there was a trade in mummified human remains (Taylor 2004a).

Figure 3: *The lower body panel decorated with fine images of ancient Egyptian deities.*

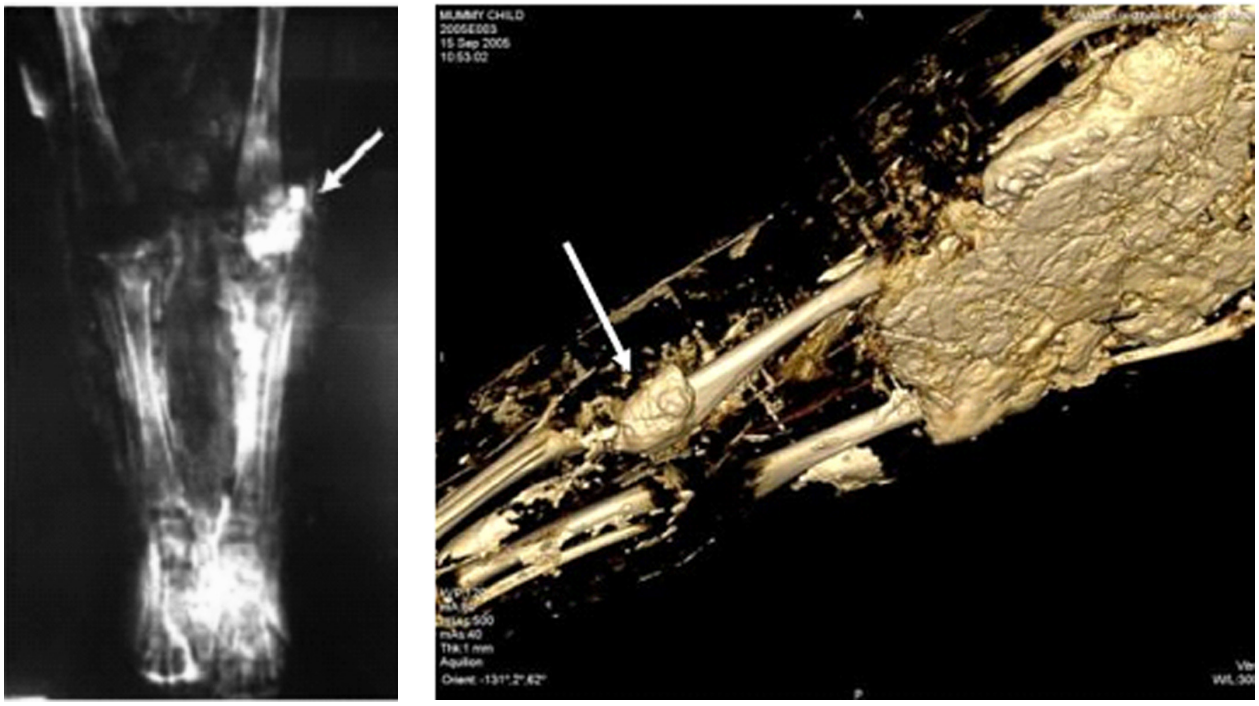

Figure 4: Two views of the opaque material that lies posterior to the left knee (see arrows), comparing the plain film image (left) and the Vitrea Workstation 3D reconstruction.

Radiography

Radiography has been used for non-invasive studies of ancient Egyptian mummies since shortly after its invention by Wilhelm Roentgen in 1895 (Boni 2004). The plain film x-rays provided a unique modality to study ancient Egyptian mummified bodies non-invasively. Plain films are an excellent two dimensional imaging method for viewing the internal structure of mummies and artefacts without interfering with the linen bandages or burial accoutrements. They can provide sufficiently high detail to identify injuries, inclusions and genetic defects, however, there are limitations due to the production of x-ray images from a static x-ray source and film with resultant superimposition of anatomical features (O'Brien, Battista et al. 2008). This superimposition gives rise to difficulties in interpretation of some images and although these images are useful in mummy research they have largely been superseded by CT generated images (Hoffman and Hudgins 2002). The virtual removal of sections of mummies is not possible with plain film x-rays although they are valuable in initial studies particularly when deciding if a mummy is suitable for CT scanning as in the case of the mummy being described. A CT scanner produces volumetric image data as there is a dynamic x-ray beam that rotates around the object. The volumetric data has an assigned grey scale number (Hounsfield number) that varies according to density, with the densest structures appearing as white (Hounsfield 1976).

Manipulation of the raw data from the machine by the software, enables images to be obtained at any angle, with cross-sectional and structural information which can then be interpreted. Specialist software can also enable the production of 3D volumetric reconstructions pertaining to bony or soft tissue structures, assigning various colours to the Hounsfield numbers and producing an image that is visually easy to interpret.

A 'fly through' function on the Vitrea workstation allows the operator to view the internal organs in sequence. This function produces virtual endoscopic images and replaces the extremely intrusive manual endoscopic examination (Wildsmith 2008). Using the workstation it is possible to virtually remove bandages or tissue to view the skeletal system and any foreign objects or artefacts.

Previous Investigation of Mummy

The mummified and wrapped child mummy discussed in this paper, was first CT scanned in 1995 at the Peter MacCallum Cancer Institute and again in the late 1990's, at the same location. CT scan and plain film x-rays from these investigations were reported in the 2003 paper published in this journal (Davey and Craig 2003). In 2005, the mummy was scanned for a third time at the Victorian Institute of Forensic Medicine using a Toshiba Aquilion 16 slice helical scanner set for 0.5mm slices. The fine slice function was selected to produce images of high quality and the images were reconstructed then transferred to the Vitrea Workstation. The Workstation produces volume-rendered images and 3D reconstructions from the original scan data, as described above. The Vitrea images facilitated a more accurate interpretation of the body, skeleton and inclusions within the wrappings. Access to various aspects of the mummy, in the 3D images, has provided new information that was not available previously.

An example of this is where an object of significant density, in the area of the child's left knee, was tentatively identified as adipocere; commonly know as 'grave wax' which is the putrefaction changes of fat, post mortem. The Vitrea workstation images show that the dense object is posterior to the left knee and is therefore extra- corporeal. It could possibly be a piece of dried soil similar to that found elsewhere on the body. Two views of the density near the left knee comparing the plain film and the Vitrea Workstation 3D reconstruction, Figure 4.

Dimensions

A function of the Vitrea workstation allows for the measurement of various parts of the body within the wrappings. The body of the child within the wrappings is approximately 748 mm from the crown of the head to the heels. As the cranial cavity is in disarray, it was not possible to determine the exact apex of the skull. The circumference of the skull is approximately 135mm. The length of the left foot is approximately 102mm. The body is compressed and flattened along its length, to 20.8 mm at mid thorax, 11.9 mm at the abdomen and 32.8 in the area of the lower abdomen. It must be remembered and taken into account that the body has been mummified and desiccation removes the fat and moisture within the body, so that any measurements relate to the dimensions of the skeleton. The mummification bandages vary in thickness depending on the area measured. At the thickest it is 65.5 mm above the thorax and then decreases to 49mm above the legs and 43.4 mm above the pelvis. The linen under the body is approximately 8mm in thickness which may be due to compression by the mass of the body, the inorganic support material and the weight of the upper section of linen bandages.

Mask

The 3D images show that the adult sized cartonnage mask is supported by extra linen bandages and in some sections it appears that the fabric is attached to the linen that encases the body. This suggests that possibly the extra linen was placed under the mask at the time of wrapping the body and therefore the placement of the mask is ancient rather than modern; as was previously thought (Davey and Craig 2003). The purpose of the linen packing under the mask probably represents a support for the mask which stands above the body and may have deteriorated or collapsed without the padding.

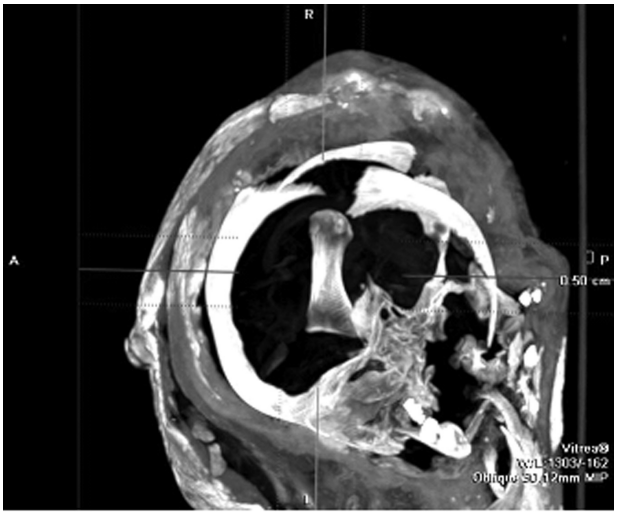

Figure 5: *A view of the adult first metatarsal (centre) and linen packing within the cranium*

Skull

The previous medical and scientific study of this mummified child by the present authors suggested that there had been extreme trauma to the cranial cavity. It is not possible to determine whether or not this was ante-mortem or post mortem. If post-mortem, it may have been due to rough handling by the morticians or that the child had been buried and subsequently exhumed before being mummified (Davey and Craig 2003). The re-formatted 3D reconstructions indicated that there is more extensive damage than had been previously thought. The left side of the cranial cavity is in extreme disorder and may have been caused by injury prior to death. The cranium is not complete. The anterior cranial fossa is present and intact. The cribriform plate of the ethmoid bone is also intact indicating that the brain was not removed via this route contrary to usual practice (Herodotus 1954: 127). With the extreme trauma to the cranium it is not possible to determine if the brain was removed via any other route. Remnants of a desiccated brain are not visible within the cranial cavity; however there is significant packing of fabric. The first metatarsal of an adult foot is seen in association with the intracranial bandages and it measures 49mm in length, Figure 5.

The pituitary fossa is shallow. The right petrous temporal bone is present, but the left cannot be identified. The posterior cranial fossa is missing. An examination of the facial bones showed no evidence of a direct facial fracture. There is a misalignment of the right zygomatic arch, but no fracture of the maxillary bones (Martini 2006: 209-211). The mandible is present and intact however the left condyle of the temporomandibular joint is not visible and there is possibly a subcondylar fracture. The right condyle is in normal position in the glenoid fossa.

The body of the mandible rests on the chest in the unnatural position that is seen in all Graeco/Roman child mummies that have been studied by the authors to date. The reason for this is unknown and appears to be peculiar to the Graeco/Roman Period

Thoracic Cavity and Abdomen

No organs are visible within the thorax or abdomen. There is a traumatic diastasis of the pubic symphysis with a separation approximately 31mm between the pubic bones together with antero-posterior compression of the pelvis. The genitalia are not visible.

The posterior aspect of the sternum has also been compressed towards the anterior aspect of the vertebral column.

Figure 6: *A view of the thorax and abdomen showing disorder of the ribs.*

There is significant damage to the thoracic cavity with most ribs in disarray, Figure 6. The degree of disorder suggests a possible antemortem injury of extreme severity.

Position of Hands

The child's arms are complete and in correct anatomical position and the hands are loosely clenched with the right hand adjacent to the lateral aspect of the right thigh and the palmar aspect of the left hand is resting on the anterior aspect of the left upper thigh. The position of the hands suggests that the soft tissue is intact, Figure 7. The cartilaginous growth centres of the bones of the hands are unusually radio-opaque for a growing child (Cain 2009).

Inclusions

A modern screw sits outside the linen wrapping and is posterior to the right ulna, Figure 8. In previous x-ray examination it appeared that the screw was sitting directly behind the ulna however the Vitrea images show that it lies in a different position and does not appear to form any function associated with the mummified body.

Two previously undetected inclusions are those of some type of extra corporeal material lying posterior and anterior on either side of the child's body. A large panel of this material is posterior to the body and extends from the upper thorax to below the genital region. The second panel lies anterior to the thoracic and abdominal areas, extending

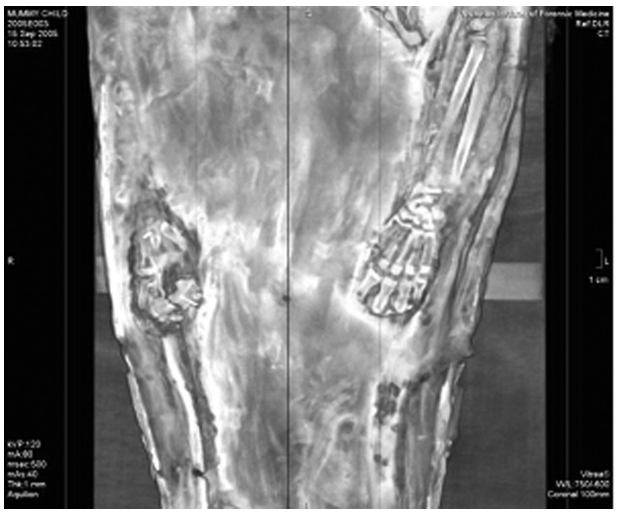

Figure 7: *The child's hands shown in relaxed positions.*

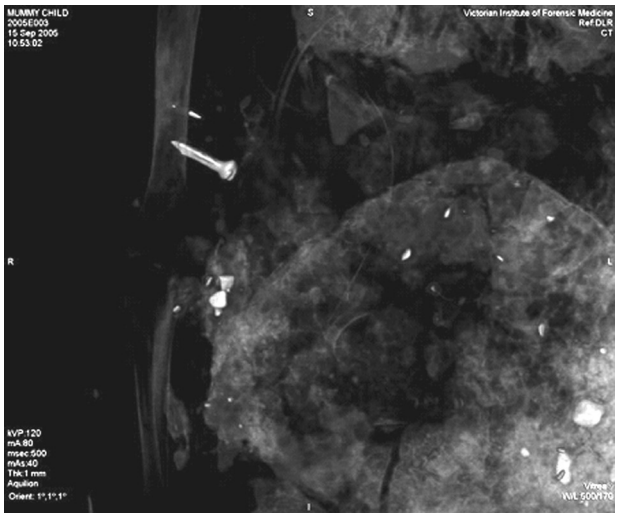

Figure 8: *A modern screw (arrowed) lies posterior to the body and wrappings.*

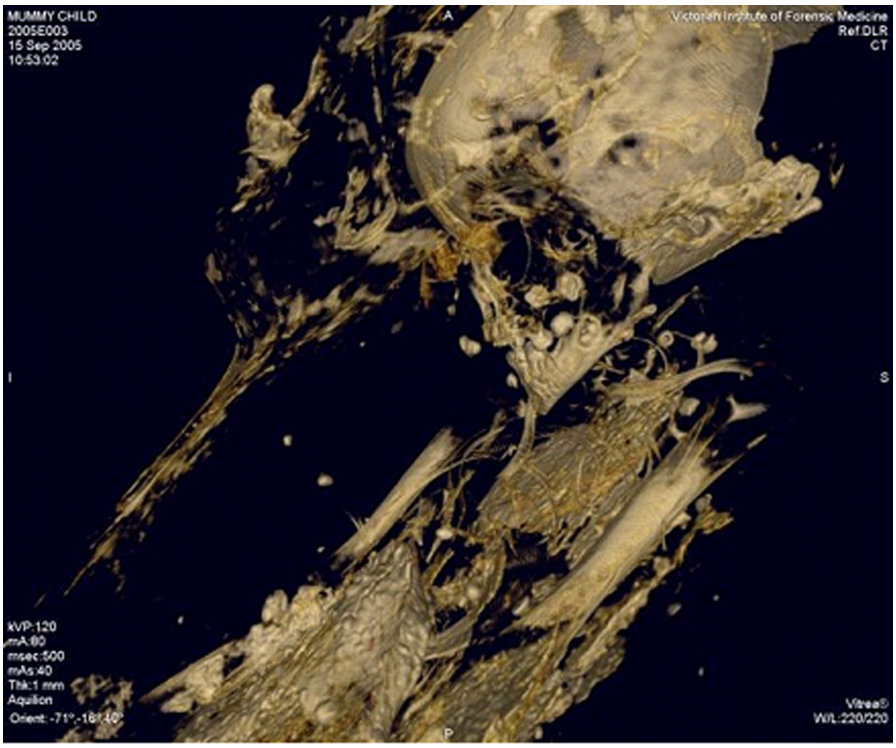

Figure 9: *All teeth are visible either in the mouth or in the surrounding area.*

from the mid thorax to slightly below the genital area. In the original plain films it was not possible to identify the extent or nature of these radio-opacities. In the area of the upper thorax there is another panel of inorganic material that sits between the linen on the body and the linen packed under the mask. A smaller slightly irregular piece of inorganic matter lies approx 57 mm below the head of the femur towards the region of the knee.

Legs and Feet

The tibia appears bowed but the cortication of the diaphysis of the tibia and femur appears macroscopically of normal radio-opacity. The right foot appears higher than the left foot and is on a slight angle. The feet are in good anatomical order and do not appear to be damaged, suggesting that the soft tissue is intact. The length of the left foot from the heel to the big toe is approximately 108 mm. The radio-opacities in the epiphyses are similar to those observed in the hands.

Teeth

The teeth are largely intact and in position in the mandible but many tooth crowns can be seen to be scattered throughout the cranial, cervical and thoracic regions, Figure 9. Manipulation of the bone algorithm in the 3D reconstructed images allowed the teeth to be easily seen. In addition a tomographic reconstruction of the maxilla and mandible allowed all teeth, both deciduous and their permanent successors to be identified and the dental age re-assessed confirming the earlier estimation of an age of four to four and a half years.

Discussion

The child mummy may be securely dated to the Graeco/Roman Period by the position of the mandible on the upper thorax. The possibility that the wrapped and mummified child was adorned, at time of death, with a Graeco/Roman mask appears to carry some weight now that linen packing has been identified under the mask. This tends to indicate that although the mask was originally constructed and possibly used for an adult mummy it had been modified to fit the child mummy. The two body panels cannot be confidentially identified as being placed on the mummy at time of mummification as there is no evidence to support this theory.

The hypothesis suggesting that the child's body had been buried and exhumed prior to mummification seems unlikely due to the identification of a number of injuries that suggest a violent or traumatic death rather than compression injuries caused by burial under soil or sand. These injuries include a compressed skull fracture and sub-condylar mandibular fracture which in themselves would be sufficient to cause death. The chest injuries may have occurred at the same time but this is difficult to determine as the ribs of a child are easily disarranged.

It has not been possible to identify any internal organs which may mean that they have been removed as part of the mummification process or that they are now unidentifiable within the thorax and abdomen. These areas of the body have been flattened and this may been caused by the mass of the linen bandages above the body. The relative decompression of the bandages under the body is difficult

to explain. There is a possibility that the body was not completely desiccated and there may have been a level of residual moisture that leaked into the linen facilitating the flattening of the lower bandages.

Although soft tissue is difficult to identify, the hands, arms, legs and feet are in good anatomical order which would not be possible if the soft tissue had decomposed. The relaxed position of the hands is unusual, as most Graeco/Roman child mummies have them arranged in a more rigid style with the fingers stiffly extended.

The opacities at the epiphyses of the phalanges are puzzling as this is not expected in a young child (Greulich and Pyle 1959: 84-92). That the mummification process has caused this opacity is a possible explanation but the testing of this hypothesis would require more extensive investigation than is proposed for this study. It is more likely that this is due to some disease process than a taphonomic or post-mortem process. It has not been observed previously .

The brain is not visible which may mean that it was removed or it may have desiccated but is now not visible in the radiographs due to the extreme trauma to the skull and the inclusion of fabric packing. There is no evidence of exacerbation via the cribriform plate of the ethmoid bone, as it is intact. There is a possibility that the brain may have been removed via another route such as the fractured and missing petrous temporal bone but the damage to the skull does not allow for any further investigation into this matter. The inclusion within the cranium is not unusual in mummified bodies (Raven and Taconis 2005: 189). What is extremely unusual is the inclusion of an adult first metatarsal; the purpose of which is unknown and may be accidental, for example the toe bone was lying within the linen before it was inserted into the cranial cavity, accidentally being included in the packing. Another example of a possible unexplained inclusion is found in the remains of British Museum mummy Nesperennub which was discovered to include a pottery bowl that had been left within the wrappings after becoming attached to the cranium during the mummification process (Taylor 2004b: 38-39).

The scattered teeth are easily explained. Exfoliating deciduous teeth and developing permanent successors have no roots and are therefore liable to dislodgement once the soft tissues of the periodontal tissues disintegrate. Rough handling of the body will allow these teeth to fall from their sockets into neighbouring structures. The previous study concluded that the child has a dental age of between four and four and a half years by modern standards of dental development (Scheuer and Black 2004: 174-177). In estimating the child's age it must be taken into consideration that this child lived approximately two thousand years ago and children's development may have been different from modern children (Davey and Craig 2003).

Conclusion

The use of the Vitrea Workstation software in conjunction with high definition CT scans has allowed for a more thorough and extensive investigation of the mummified child that was not previously possible. Many of the previous observations have been confirmed and where there were uncertainties in identifying sections of the remains, it was now possible to view areas that were not accessible with earlier x-ray examinations. Interpretation of the data has been a key component of this study and the expert opinion of various medical and scientific colleagues has been relied upon where there were uncertainties.

The cause of the child's death cannot be determined, however, the previous hypothesis of the body being exhumed from a permanent or temporary grave may be discarded. The Vitrea workstation software has allowed for a more thorough investigation of the evidence and it appears that the child suffered severe trauma and died as a result of the injuries. Although there is head injury it can be determined that some form of mummification or preservation of the body was carried out by ancient embalmers. It is possible that the extra corporeal material and the linen packing within the cranial cavity provided some stability to the child's remains. The provenance of the body remains unclear although it does seem probable that the adult sized mask was attached to the body at the time of mummification.

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