A Radiographic Study of the Head of a Child from Graeco-Roman Egypt

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Abstract: In the case described, a request to ascertain the age at death of a Graeco-Roman mummified head by dental radiographic means revealed some unexpected and interesting information. The radiographic study revealed extensive dental caries, an unexpected low level of wear on the teeth, and evidence of possible interceptive orthodontic treatment having been carried out on the child's teeth prior to death. The authors argue that the latter may have contributed to the death.

Key words: Orthodontics radiography mummification CT scanning diet

Introduction

The mummified head of a Graeco-Roman child belonging to the Australian Institute of Archaeology was to be prepared for exhibition purposes. The curators contacted the Forensic Odontology Unit at the University of Melbourne, Australia, requesting assistance. A facial reconstruction of the child's head as it would have appeared in life was to be made to enhance the exhibition. For an accurate reconstruction, it was necessary to know the age of the child at death. Plain and tomographic radiographs of the head enabled the developmental stages of several teeth to be examined and allowed a reliable estimation to be made. During the investigation, some interesting dental aspects of the specimen were observed which warranted further study. Computerised tomographic studies were conducted and the resultant images combined to form a three dimensional model. (Craig & Davey 1997: 37 –39)

Description of the Specimen

The specimen was purchased or acquired by the founder of the Australian Institute of Archaeology Walter Beasley, possibly in the 1960's, and is of unknown provenance. Beasley began collecting antiquities of Egypt in the early part of the Twentieth Century and is known to have purchased ancient Egyptian artefacts from Lady Hilda Petrie the widow of William Matthew Flinders Petrie (Crocker 1990:65-67). Unfortunately records of the acquisition of the child's remains have not been found in the Institute's archives to date. The head had been on display in the Egyptian Gallery at the Institute's museum, Ancient Times House, for many years.

Initial non-invasive, non-destructive investigations of the unwrapped, mummified head show a child of seven to eight years old from the pre Christian, Graeco-Roman Period when the standards of mummification were believed to be declining (Walker 1997:12). The child's fringed hairstyle, the liberal application of resin and the flakes of gold leaf on the facial skin, possibly in lieu of a gold mask, are typical of the period when the Greeks and later the Romans influenced the burial practices of ancient Egypt. (Corcoran 1995: 2 – 3).

Figure 1: *Head of a mummified child with post mortem damage to the nose and face. Flakes of gold leaf are still visible on the skin*

The child's hair is relatively short with a fringe over the forehead, but it is not known whether this was a male or female hairstyle. Henna appears to have been used to dye the hair giving it a deep ginger hue. The condition of the existing hair provides a clue to the time of mummification after death. If decomposition had begun hair could be easily pulled out at that time or later, particularly during removal of linen bandages. In fact the child's hair is almost totally intact and in places where the resin is missing in small sections, the hair moves if exposed to circulation of air. (Figure 2)

Figure 2: *Close up view of loose strands of henna coloured hair that have not be covered with resin.*

A tiny oval shaped object is attached to the hair by the resin and has not been identified. Initially it was incorrectly thought to have been insect remains or insect infestation. The object does not appear to be jewellery or any other identifiable adornment. (Figure 3)

Two other observations worthy of note are on the skin of the mummy. Firstly, the facial skin shows a number of tiny holes that are perfectly round. Pathological investigation has determined that insect infestation of the body has not caused the holes. Secondly one of the ears has a dry powdery white substance near the ear canal that may have been residue left from the mummification process or due to recent fungal infestation. The substance has not yet been scientifically analysed. (Figure 4)

The specimen is in excellent condition with the features remarkably well preserved which also confirms little decomposition before mummification. The skin has the appearance of leather due to the application of resin, a practice used extensively in the Graeco/Roman Period to facilitate the preservation of tissue (Ikram & Dodson 1998:106). Remnants of linen adhere to the back of the mummified head. (Figure 5)

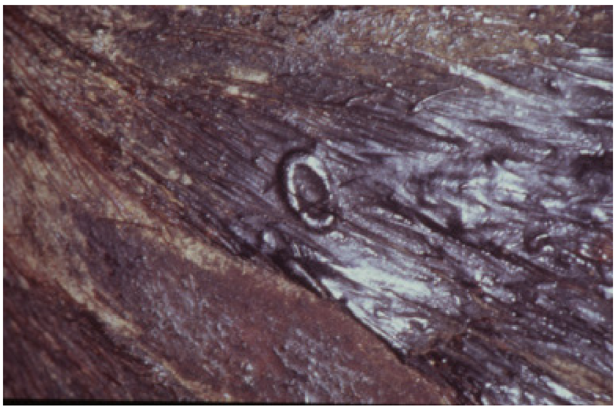

Figure 3: *Unidentified object trapped in resin on the mummified child's hair.*

Figure 4 *Left profile showing a facial split and a dry white substance near the ear canal. The disarticulation and cutting of the neck are obvious.*

Large facia1 splits in the skin of the cheek and damage to the lips possibly occurred during subsequent drying of tissue after burial and are not considered to be pre-mortem injuries. There is a possibility that the damage to the upper lip, below the nose, was caused during the removal of the brain as part of the mummification process. The pressure of the mummy bandages on the nose appears to have caused some damage to the soft tissue and cartilage, post mortem. (Figure 6)

The neck is angled forwards indicating that the odontoid peg of the second cervical vertebra had been fractured post-mortem. This allowed the head to be forced into an unnatural position, probably retained by tight bandaging. The purpose of this procedure is unknown, but may have been for ritual purposes to allow the deceased to look towards the East side of the River Nile and the living. The head has been severed from the torso by a machete type blade in recent times, possibly to facilitate sale to a collector of ancient Egyptian mummified remains.

Figure 5: *Back of the child's head showing a piece of linen attached to the resin on the hair.*

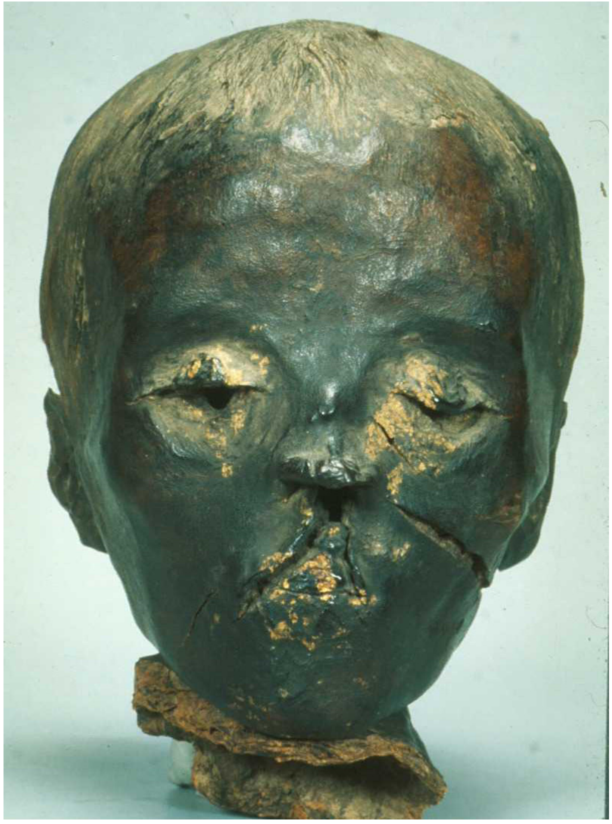

Figure 6: *Post mortem damage to facial area.*

Radiographic Survey

Radiography is an excellent imaging modality for the investigation of hard tissue, although it must be always borne in mind that one is viewing a two dimensional image of a three dimensional structure. Plain radiographic films utilise a unidirectional beam and a film placed at right angles to the central ray of the beam. Normal anatomy, any variations, and the relationship of the structures can then be interpreted by varying the angle from which the image is taken and comparing the images.

Tomography utilises a moving x-ray beam and film arranged in such a way as to blur out all structures other than those of interest. The field of interest is termed the focal trough. Computerised tomography uses a computer to collate the results of multiple digitised tomographic scans. Results can then be viewed at an apparent right angle to the direction of the beam. The multiple images can be arranged digitally to form three-dimensional images by stacking them one on top of one another. This reconstruction can, with the aid of appropriate computer software, be rotated, cut in sections or segmented.

An x-ray of the teeth, known as an orthopantomogram (OPT), was taken to facilitate the estimation of the age of the specimen at death. Several technical difficulties faced the operator during the exposure of these films due to the extreme state of desiccation of the tissues.

The orthopantomogram posed further difficulties insofar as it was impossible to remove the cervical spine from the path of the x-ray beam and the view of the anterior region was somewhat obscured as the beam passed through this area. Additionally, the machine did not allow sufficient adjustment of the kilo-voltage or milli-amperage in order to get a film of sufficient contrast to reveal all the structures. A satisfactory contrast was finally obtained by using a single sided mammography film placed backwards in the cassette, a medium intensifying screen and an exposure time of 13.3 seconds at 60 Kilovolts, and 9 milliamps.

Three plain skull films were exposed. These comprised a lateral cephalogram, an antero-posterior cephalogram and a modified antero-posterior view (occipito-mental). The lateral cephalogram was taken using a dental cephalostat, an x-ray machine attached to a gantry designed to produce standardised images that are used to measure facial growth for orthodontic purposes. The lateral cephalogram was then analysed according to the method of Bolton. Measured angles and distances were compared with published norms (Rakowsi 1982).

Finally a computerised tomographic (CT) Helical scan was conducted, which provided further information as to the position of the structures seen in the plain films. The specimen was arranged in a supine position and the gantry of the machine altered to allow the x-ray beam to pass approximately parallel to the dental arch. The resultant images were examined visually and subsequently processed on a Toshiba 3D Alatoview workstation to produce a multi-planar reconstruction and movable 3D image (Pratt 1991). Subsequent 3D reconstructions were produced using a GE Light Speed Plus CT scanning machine and a workstation equipped with a GE Advantage

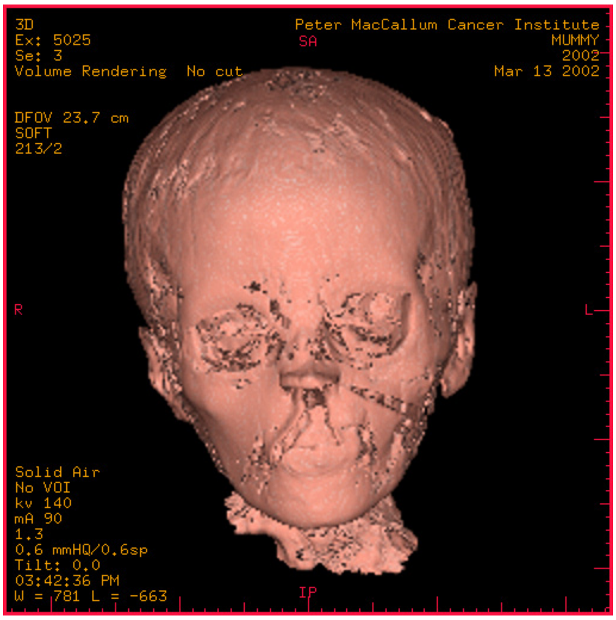

Figure 7: *3D reconstruction produced using a GE Light Speed Plus CT scanning machine and a workstation equipped with a GE Advantage Windows 4.0 program.*

Windows 4.0 program. (Figure 7)

Interpretation of the Radiographs

The orthopantomograph (OPT) was the best source of information as to the age of the child at death. The radiograph shows an expanded view of the entire dentition including both erupted and unerupted teeth. The child was in the "mixed dentition" stage of development, as both primary and permanent teeth are present in the mouth. The teeth are in varying stages of development and the age at death can be estimated by comparing these stages of development with that of a contemporary population of children (Moorees, Fanning & Hunt 1963:490-1502). (Figure 8)

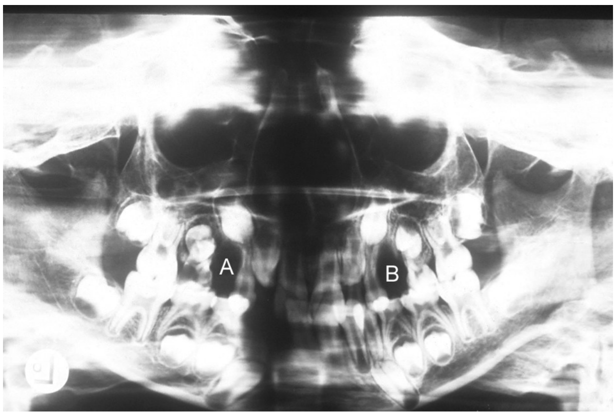

Figure 8: *Orthopantomographic (OPT) image of the complete dentition of the unwrapped child's head. Note the dark spaces (A and B) where teeth have been removed from both sides of the upper jaw. Features in the midline were obscured by the abnormal position of the neck.*

In this case, the stage of development of the first permanent molar teeth, the 1ower permanent canines and the lower second permanent molar teeth was consistent with that of a modern child of approximately 7 to 8 years of age (Ciaparelli 1963:22-44). For the purposes of facial reconstruction, the age of this child at death was estimated at somewhere around eight years of age. (Figure 9)

Several teeth were missing from the dentition. The lower left latera1 incisor tooth was missing and the socket was intact. The upper first primary molars and the underlying first permanent pre-molars were missing with no evidence of either the sockets of the molars or the crypts of the developing pre-molars. There was no bone present in the area. Dental decay was present on the occlusal surfaces of the first permanent molars and the proximal surfaces of several of the primary molars.

There was very little wear on the primary molars. Primary teeth wear rapidly due to the relative thinness of the enamel and it is not uncommon for a primary tooth to be worn almost away by the time of exfoliation. Given the differences in diet between the Graeco-Roman times and the modern era, one would expect the wear rate to be higher, not lower than that of a modern child (Berkovitz 1977:313).

Discussion

Although an age of 8 years was thought to be the most reliable for the purposes of facial reconstruction, it is always difficult to extrapolate contemporary statistical information and relate it to a growth situation that existed 2000 years ago. Factors such as heredity, maternal and infant nutrition, environment, the incidence of acute chronic disease and infestation, and climatic conditions, all have an influence

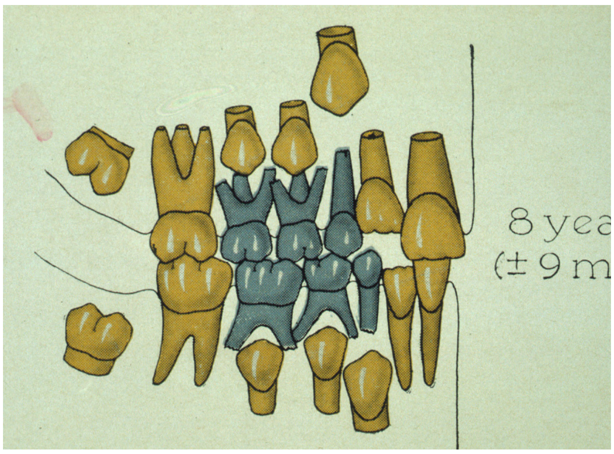

Figure 9: *Diagram of teeth of an eight-year-old child as seen from a lateral aspect. Permanent teeth are numbered, primary teeth are labelled alphabetically. 1, 2 incisors; 3, C permanent and primary canines; 4, 5 premolars; D, E, primary molars; 6, 7 permanent molars. The teeth missing from the specimen are unshaded. The condition is identical on the other side of the child's mouth. (Diagram adapted from Schour I., & Massler, M. 1941).*

Figure 10: *Computer enhanced model of the child's head using forensic cranio-facial reconstruction techniques. Eye and hair colour were chosen before research into the original colour of the child's hair was completed. Forensic Sculptor Ronn Taylor.*

on the rate of growth and development. For that reason, a standard deviation above the modern mean was used, but if two deviations were used, the age could be increased further. For the purposes of the reconstruction, eight years was deemed appropriate.

It can be seen from the OPT that several teeth are missing from the dentition. (Figure 10) The lower left lateral incisor tooth is missing and the socket is intact. An intact socket with no evidence of bone regrowth suggests that the tooth was lost peri-mortem. It would not be unreasonable to assume that the lower incisor tooth may have fallen or been knocked out prior to, or during the mummification process. This is a common occurrence with single straight rooted teeth, as decomposition of the soft tissue allows the tooth to simply drop out. (Figure 11)

An examination of the plain radiographs for the missing incisor failed to find it, but did reveal an odd object in the neck adjacent to the second cervical vertebra, which exhibited the same radio-opaque qualities as a tooth. It was not until a CT scan of the area was conducted that the object was identified as the missing tooth that was revealed lying horizontally and medially in the back of the pharynx.

A most unusual feature is the absence of the first upper primary molars and their unerupted permanent successors,

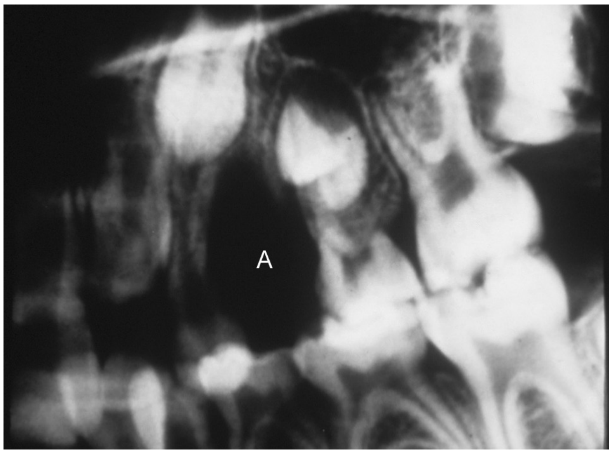

Figure 11: *An enlargement of the OPT on the right hand side showing the area where the teeth are missing (A) and dark areas where dental decay is present (arrows).*

the first premolars. The loss of a primary tooth prematurely from the arch due to decay or root resorption is not an uncommon occurrence. It is more difficult to explain the loss of the two upper first primary molars given the fact that the first permanent premolars are also missing. (Figure 12)

At the age of 8 years, the developing tooth bud lies between the three flared roots of the primary predecessor. The congenital lack of a developing permanent tooth beneath a primary tooth is rare. When this does occur it is confined to the last member of each group of teeth, whether it be the second incisor, or second pre-molar. This condition, known as hypodontia, mainly affects the permanent third molar, the second pre-molar and the lateral incisor in the population worldwide (Reprecht, Batniji & el Neweithi 1986:43-46). As there are no published figures citing the incidence of missing upper first pre-molars, nor are there

Figure 12: *3D AlatoView Workstation reconstruction of unwrapped child's head with missing lower left lateral incisor.*

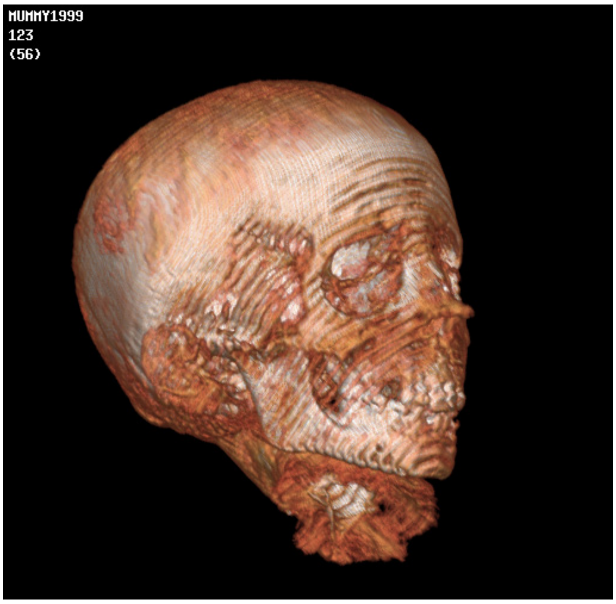

Figure 13: 3D AlatoView Workstation reconstruction of unwrapped child's head showing missing upper first primary molar and unerupted first premolar.

any reports in the literature describing such a case, it may be concluded that this would be extremely rare.

If the tooth buds had not developed, alveolar bone would be present in the area in their place. The lack of bone indicates that something else had occupied the space some short time prior to death. Subsequent to the presumed loss, there had been insufficient time for the healing process of reparative infill of bone to occur prior to death. Examination of the CT scans confirmed the lack of alveolar bone in the area of the first pre-molar tooth buds. There was no evidence of the walls of the bony crypts in which they would have developed. The edges of the defects appeared rough and jagged, the shape of the defect corresponding roughly to that of the first primary molar and the underlying first permanent pre-molar together. (Figure 13)

The occipito-mental skull view provided a better image of the upper and lower anterior teeth than was possible on the OPT. The centra1 incisors are erupted, the lateral incisors are erupting and the unerupted permanent canines can be seen within their crypts. The four upper incisor teeth are somewhat imbricated and the erupting upper lateral incisors are rotated. The unerupted upper canines are well forward of their expected position at 8 years of age. The angulation of the crowns would indicate that had eruption occurred some 4 years later, the canines would have occupied a labia1 and anterior position, giving the child a "vampire" appearance. (Figure 14)

The overall appearance of these anterior teeth is that of severe crowding of the upper dental arch. This theory was borne out by the results of analysis of the lateral cephalometric image. Cephalometric analysis measures the relationship of the teeth and their supporting bones to the base of the skull. It demonstrated mathematically that the child had an extremely crowded dentition set back somewhat from the base of the skull. The length of the upper and lower jaws is extremely short and would have been unable to accommodate a full complement of 32 teeth without some of the teeth being pushed out of the arch as they erupted into the mouth. Even though the jaw grows in length, there would never have been enough room for all the teeth. Therefore had the child grown to adulthood the facial complex could not have accommodated all the teeth, the child's physical appearance would have been compromised and the teeth would not have occluded correctly. (Figure 15)

The usual form of treatment for tooth crowding in modern times is to selectively reduce the number of teeth in the arch by extraction, thereby allowing the remaining teeth to fit into the available arch length. Although tooth banding to assist the teeth to move into their final position usually follows this initial treatment, satisfactory results can be obtained without this if the timing of the extractions is correct.

There is no evidence from the literature that physicians of the Graeco-Roman Period practiced cosmetic procedures of any kind, let alone preventive orthodontics. A decision to deliberately remove these teeth in order for the canine teeth to fit into their proper place during development implies knowledge of tooth development patterns and the likely results to be expected from treatment. In the days before modern anaesthesia and aseptic techniques, this would have been a serious undertaking.

The removal of primary first molar teeth together with the developing tooth buds beneath them is a surgical procedure. It requires sterile operating conditions if healing is to occur without complications. The most common complication is localised osteitis, an inflammatory process that is self-limiting; the familiar "dry socket" that occasionally follows tooth extraction. If an individual is immunologically compromised for any reason, or the invading bacteria are

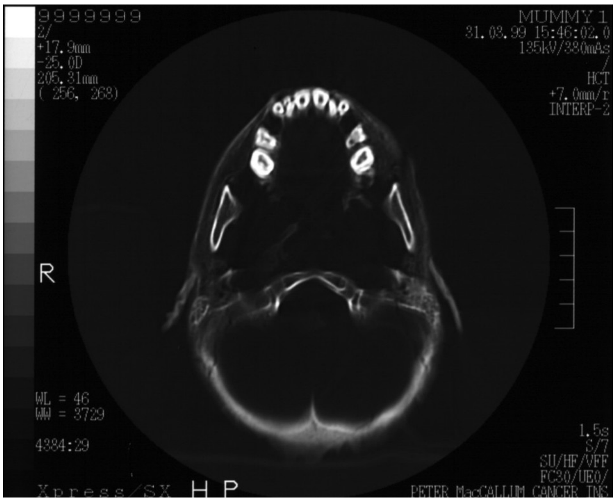

Figure 14: *CT scan slice through the upper teeth. The outline of the empty sockets can be seen bi-laterally.*

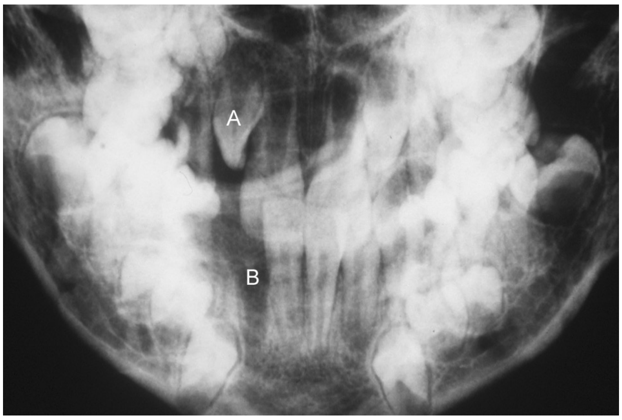

Figure 15: *Angled (occipito-mental) view of the anterior teeth shows the upper lateral incisor A) and the socket of the missing lower incisor (B).*

particularly virulent, osteomyelitis may result. This is an acute condition characterised by high fever, prostration and pain. If left untreated, general septicaemia may result in death. This unfortunate consequence of surgery was a common cause of death in the days before antibiotics.

The sockets do not appear to have healed, and therefore it can be assumed that the operation occurred shortly before death. Whether or not it contributed to death is uncertain. It is only possible to say that there is a consistency between the evidence from the radiographs and the known course of complications following surgery in a non-sterile environment.

It was observed that the child suffered from dental decay. Decay appears on a radiograph as a radiolucent (dark) area within the tooth structure either in the contact area between the teeth or beneath the enamel on the crowns where the grooves have harboured bacteria and sugars. Dental decay is a disease reliant on both the presence of bacteria and a very high frequency of fermentable carbohydrate in the diet. From a review of the literature (Filce Leek 1972:126) it would appear that dental decay was somewhat of a rarity in Pharaonic Egypt where the cleaning of teeth was practiced and the diet was relatively sugar free (David & Tapp 1992:118; Filce Leek 1967:53). By the Graeco-Roman Period the incidence of dental decay had increased significantly and the diet was such that fermentable carbohydrate was unusual but not unknown. This was partially due to the foreign influence on the ancient Egyptian diet (Nunn 1997:203). Evidence of the consumption of beer, wine, honey, fruit juices and dried fruits has survived in tombs indicating their use in daily life (Poole 2001:177). The use of honey as a sweetener and for medicinal purposes is well documented. Sugar cane had been known in the Greek world since the fourth century BCE although it was not grown in Egypt unti1 the Arab Conquest in the seventh century CE (Lucas 1989:24-25; Bowman 1986:40).

As was the case in Pharaonic Egypt, severe denta1 conditions were prevalent in the community as a whole. These included pulpal necrosis and periapica1 abscesses, which occurred subsequent to the rapid wear of the dentition (David & Tapp 1984:104-131). Tooth wear has been attributed to two factors: firstly the habit of grinding grain in stone quern thus accidentally incorporating particles of stone in the flour, and also to the general sandy environment which would have permeated the food eaten by the entire community. The fact that this child exhibits no wear on the erupted permanent molars may not be an unusual occurrence given the fact that the teeth had been in function in the mouth for only 2 years. However, one would have expected a great dea1 more wear on the occlusal surfaces of the primary molars. Wear on the primary molars is not an uncommon occurrence amongst modern children. This occurs due to the relative thinness of the primary tooth enamel, abrasive food in the diet and the tooth grinding habits of many young children.

Therefore this child can be assumed to have consumed a diet that was somewhat out of the ordinary for the time. In all probability it was a diet that was low in abrasive qualities and high in fermentable carbohydrates, which caused decay in the teeth. There may have been a medical condition that precluded the consumption of some forms of solid food.

In addition, the child may have been breast fed for a prolonged period. Prolonged breastfeeding for convenience and supplementary birth control was not uncommon in ancient Egypt and occurred among all classes either by the natural mother or by a wet nurse until the period of weaning was reached. After infancy, breast milk alone contains insufficient calories for growth, and the child would have required other sources of nutrient to aid his development (Short 1992:12).

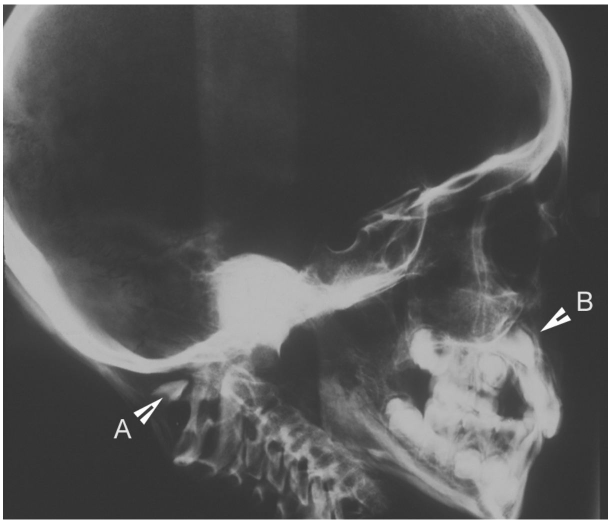

Figure 16: *Lateral cephalogram showing the disarticulation of the cervical spine and the missing lower incisor (A) that has fallen into the back of the pharynx. The anterior position of the canine teeth (B) and the areas where the teeth have been removed are clearly visible.*

Conclusion

From a radiographic study of the mummified head of a child, a number of inferences can be made concerning the composition of childhood diet in Graeco-Roman Egypt, and the treatment of dental malocclusions among the more affluent classes. It is unfortunate that the literature does not contain further information from which it was possible to quote precedent. It will not be until further specimens that have been subject to a similar radiographic study to be sure whether or not cosmetic dentistry in the form of interceptive orthodontics was an established practice in Graeco-Roman Egypt.

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