Case Report

Facial reconstruction of an 11-year-old female resident of 430 BC Athens

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ABSTRACT

Although modern standards of ideal proportions and facial esthetics are based mostly on observations of human faces as depicted in Classical Greek masterpieces of art, the real faces of ordinary ancient Greeks have, until now, remained elusive and subject to the imagination. Objective forensic techniques of facial reconstruction have never been applied before, because human skeletal material from Classical Greece has been extremely scarce, since most decent burials of that time required cremation. Here, the authors show stage by stage the facial reconstruction of an 11-year-old girl whose skull was unearthed in excellent condition from a mass grave with victims of the Plague that struck Athens of 430 BC. The original skull was replicated via three-dimensional modeling and rapid prototyping techniques. The reconstruction followed the Manchester method, laying the facial tissues from the surface of the skull outward by using depth-marker pegs as thickness guides. The shape, size, and position of the eyes, ears, nose, and mouth were determined according to features of the underlying skeletal tissues, whereas the hairstyle followed the fashion of the time. This is the first case of facial reconstruction of a layperson residing in Athens of the Golden Age of Pericles. It is ironic, however, that this unfortunate girl who lived such a short life in ancient Athens, will now, 2500 years later, have the chance to travel and be universally recognizable in a world much bigger than anybody in ancient Athens could have ever imagined. (*Angle Orthod.* 2011;81:171–179.)

KEY WORDS: Facial reconstruction; Ancient Greece; Craniofacial morphology; Plague of Athens

INTRODUCTION

It is beyond doubt that the standards pertaining to ideal proportions and facial esthetics of modern times are based mostly on observations of human faces depicted in masterpieces of art, for example, statues, friezes, frescoes, pottery, and even coins,[1–5] deriving from the Classical period of ancient Greek art. However, even when artistically standardized, these images may not be considered as realistic representations of the lineaments of the average ancient Greeks since, in most cases, they express the ideal features and proportions as conceived by the cultural and artistic mainstream of the time. Scarce relevant evidence-based scientific data are available in the literature that comprise conclusions from anthropological observations[6,7] and cephalometric investigations on skulls and comparisons of craniofacial traits between ancient and modern Greeks.[8,9] Thus, the real face of the ordinary ancient Greek remained until now elusive and more or less liable to the subjective imagination. Only forensic techniques of facial reconstruction on recovered skulls can assist toward resolving this question.

Human skeletal material from Classical Greece is scarce because most burials of that time implemented cremations, leaving skeletal remains that are extremely difficult, and almost impossible, to be reconstructed with accuracy in their detail. Reconstructions have

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Figure 1. The original skull of Myrtis.

been attempted only in the case of some outstanding royalties, including King Philip II of Macedonia and King Midas of Phrygia.[10,11] However, no such attempt has been recorded for any layperson living in ancient Greece.

A relatively recent excavation conducted on the outskirts of Kerameikos, a cemetery of ancient Athens, provided for the necessary skeletal material. A mass grave was dug up on the site, containing some 150 skeletons, and was dated by archaeologists to circa 430 BC, which coincides with the time of the siege of Athens by the Spartans during the Peloponnesian War. It was when the notorious Plague of Athens broke out. Certain characteristics of the mass grave led to the assumption that the dead were actually victims of the lethal epidemic.[12] Besides providing the material for testing working hypotheses toward identifying the true etiology of the Plague,[13,14] the skeletal material comprising intact skulls of the hapless Athenians could also help in identifying their actual lineaments. Some of the skulls in the mass grave were almost intact, bearing all their teeth, thus facilitating their thorough anthropological and dental examination.

One of the skulls belonged to an 11-year-old girl, given the name "Myrtis" by the archaeologists in charge (Figure 1). The name was chosen from a list of common ancient Greek names. It means a branch of the plant myrtle and is still used in modern Greek. The age and sex of Myrtis were determined via anthropological examination. Her craniofacial, skeletal, and dental characteristics have already been described in a recently published article, in which limited dental pathology and orthodontic problems have been diagnosed and described, such that today would certainly refer her for orthodontic treatment.[15]

Following the increased interest of the public and the scientific community in her case, it was decided to perform a complete facial reconstruction of Myrtis, with the intent to create an item to be included in the permanent exhibition of a renowned archaeological museum of Athens. This article describes the method for the step-by-step accomplishment of the project.

CASE REPORT

The physical manipulation of the original skull during the reconstruction process involved great risk of damaging it. Therefore, the construction of an exact replica was necessary, whereupon the facial reconstruction would follow. However, casting techniques traditionally used for this purpose also carry a risk of damaging the original item since they require contact of invasive casting material with it. To avoid any risk of damage, three-dimensional (3D) modeling and rapid prototyping techniques were used to produce the replica. Although 3D laser scanning techniques could be applied to create a 3D model of the exterior surface of the original skull,[16] they could not remodel the interior surface, which is not visible in the laser scan. Overcoming such difficulties, the latest reverse-engineering technique is becoming the standard for medical modeling, using computed tomography (CT) images to reconstruct the anatomy of interest.[17]

A GE Medical Systems Lightspeed VCT (GE Healthcare, Waukesha, Wis) scanner was employed for the noninvasive extraction of high-resolution anatomic information of Myrtis' skull (the CT acquisition parameters were 120 KVp, 364 mAs, 21.2 cm field of view, 650 slices, slice increment 0.3 mm, 0.414 pixel size, and 512×512 image matrix size; Figure 2), while the Materialise Mimics (Materialise, Leuven, Belgium) software was used to produce the skull model segmentation from the CT images. Three-dimensional visualization was performed by means of triangulation of a segmented 3D area. Since the series of CT images covering the head were closely spaced (0.3-mm slice spacing), the 3D reconstructed model of the skull reproduced very fine details of the original. The surface of the final 3D-reconstructed model was discretized with 2×10^6 triangles (Figure 3).

Rapid prototyping techniques have been employed in several medical applications for the production of dimensionally accurate physical models from 3D medical images.[18,19] In this study, the 3D model reconstructed from the CT images was converted to

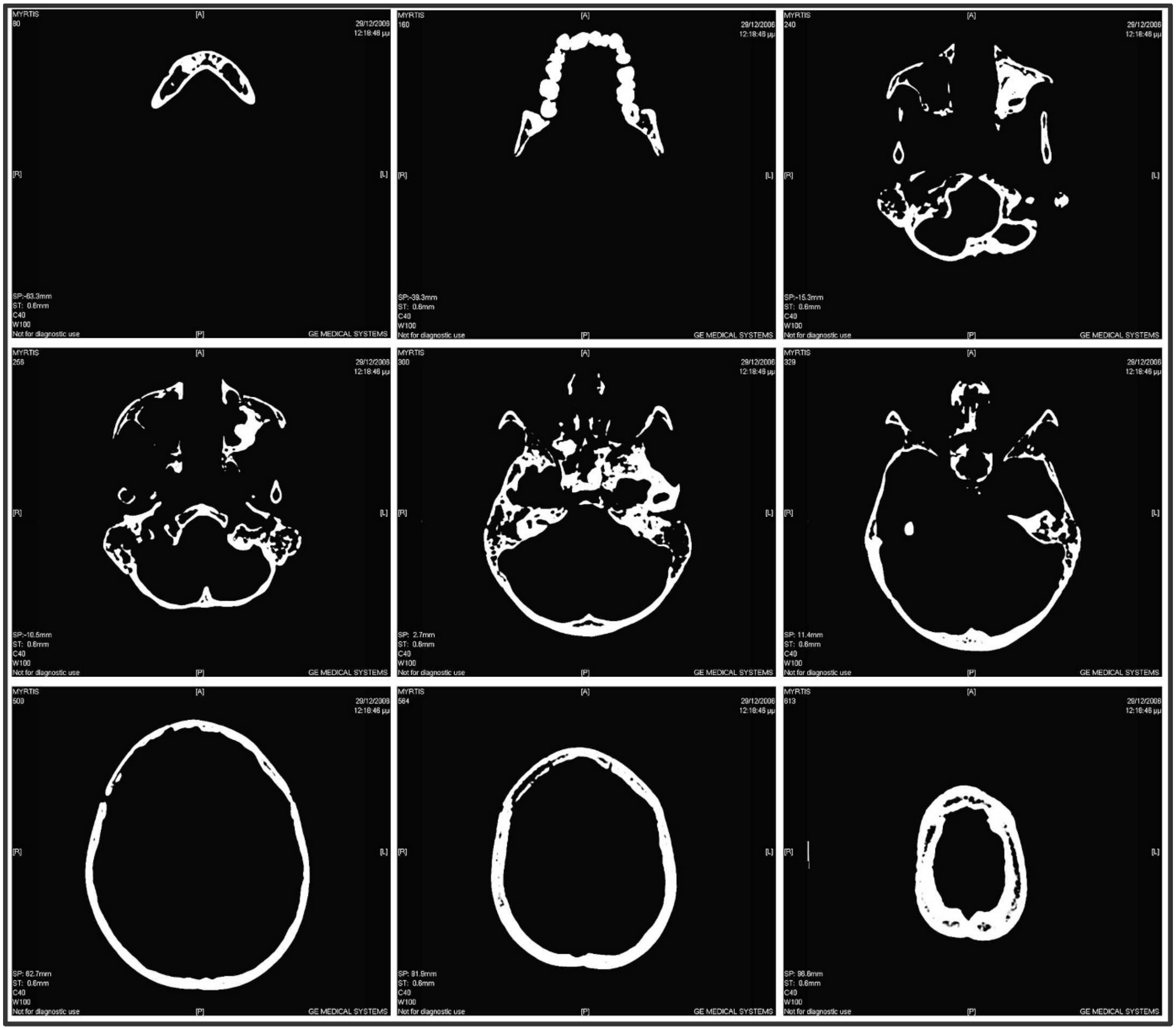

Figure 2. Computed tomography–acquired images of the skull of Myrtis.

a stereo lithography (STL) 3D print-ready model. A Dimension SST 778 3D printer (Stratasys Inc, Eden Praire, Minn) was used for the construction of the physical 3D replica. The volume of the skull was 446 cm^3 and required about 64 hours to complete. At the end of this process, the exact replica of the ancient skull of Myrtis was created and became the basis for the facial reconstruction that followed (Figure 4). The craniofacial characteristics and the dimensions of the original and the replicated skull were examined and compared physically with radiographs and were found to be precisely the same (Figure 5).

The technique employed for the reconstruction of the face of Myrtis is known as the Manchester method.[11] This technique relies on two combined methods: one using tissue-depth markers or pegs, reflecting the average tissue depth of the face, with consideration given to origin, sex, nutritional condition, and age, and the other sculpting the underlying muscles of the face, ensuring that the face grows from the surface of the skull outward. Simply put, following the Manchester method of facial reconstruction, the muscles and other tissues of the face are sculpted, while the pegs are used as a basic site-specific guideline, defining how thickly the sculpting clay should be applied.

The size and shape of the eyes, nose, and mouth were estimated in accordance with the proportions, size, and shape of the underlying respective recipient sites of the skull. A study of tissue depth reflecting the sex, age, race, and nutritional condition was the basic guideline in the rebuilding of Myrtis' face. These

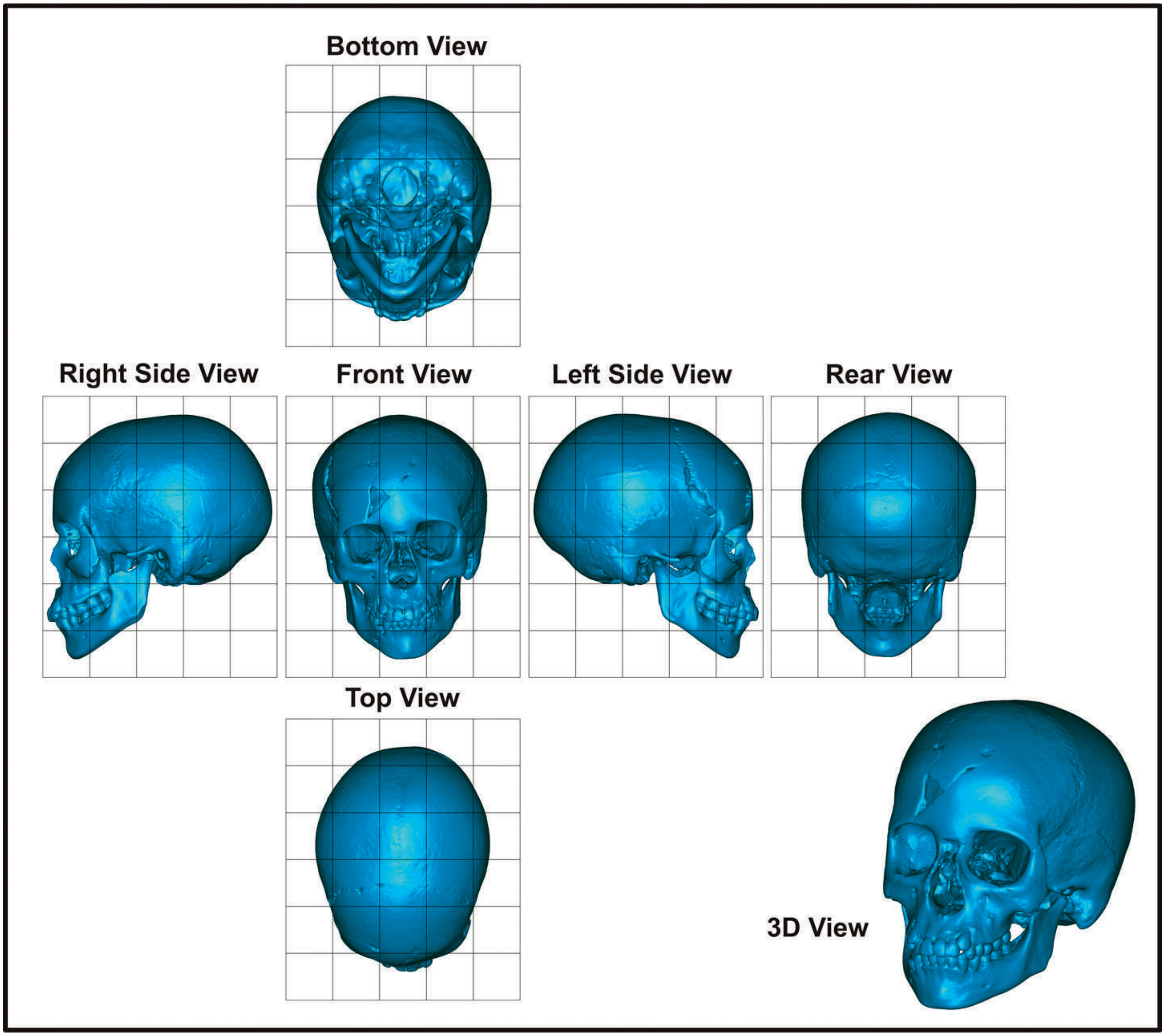

Figure 3. Three-dimensional digital views of the skull of Myrtis.

measurements were determined according to standard tables of studies on human facial tissue thickness, showing average tissue thicknesses on specific points of the skull, with consideration given to the above parameters.[20]

The exact measurements of the average tissue depth on 30 specific points of the skull were then transferred and marked on 3-mm wooden pegs. The points were located on the skull of Myrtis, and holes were made with a small drilling machine. The pegs were carefully glued into the holes, all the while making sure that the exact measurements were established. At this point, artificial prosthetic eye bulbs were selected for Myrtis. Taking Myrtis' origin into account, the color of her eyes was arbitrarily decided to be brown. The bulbs were placed into the orbits. The shape, surface, and depth of the orbits indicated how deep the eyes should be set.[21]

The next step was to build the face, muscle after muscle, using plasticine clay (Figure 6). A total of 20 different muscles were sculpted, carefully considering their shape, size, and function. The first muscles that were built were the temporalis and the masseter muscles, followed by the muscles around the mouth. The width of the mouth and the thickness of the lips were estimated by the pattern of the dentition and the skeletal craniofacial attributes of the area.[21]

The orbicularis oculi muscles of the eyes are flat and circular and were then sculpted covering her eyes. The shape of Myrtis' orbits was carefully studied, as this

Figure 4. The replicated model of the skull of Myrtis.

influences the shape and direction of the eyelids and eyebrows. The shape of the nasal aperture dictated the size and width of the nose. Particular attention was given to the direction of the nasal bones and the anterior nasal spine, as these indicate how much the nose projects from the skull.[22]

The muscles spanning the space between the nose and the mouth accompanied by the zygomaticus muscles were the next to be shaped. These were gently sculpted, as some of them are quite delicate.

Then the occipito-frontalis muscle was sculpted, covering the forehead, followed by the sterno-cleido-mastoid and the trapezius muscle that constitute the most prominent of the major muscles of the neck. At this stage, the parotid gland was also built.

Special consideration was given to the building of the external part of the ears since, lacking an osseous base, they are always the most speculative features in any facial reconstruction. The size and position as well as the angle of the auricle of the ears were determined, following the proportions of the underlying skeletal tissue and the angle of the jaw, respectively. Thus, Myrtis' ears were sculpted to harmonize with the rest of the face. As Myrtis was a child at the time of her death, quite a lot of subcutaneous fat was sculpted to cover parts of the underlying muscle structure. Strips of clay were rolled out and placed over the muscle structure to represent the skin layer. The texture and details of the skin were further developed to give a realistic impression.

As teeth are an important key feature when the reconstruction method is used to identify unknown children, it is often advisable to make the teeth visible, protruding a little when the subject is a child. To ensure this, Myrtis' face was provided with a faint smile, which also gave her a more childish expression.

The hairstyle of Myrtis was decided after studying sculptures and pictures of children contemporary with Myrtis. The pigmented silicon casting of the reconstruction with inserted hair provide for Myrtis' vivid look at her future display in the museum (Figure 7). The lateral cephalometric radiograph of the casting provided for the soft tissue profile analysis of Myrtis, which completed the cephalometric analysis that was recently published[15] (Figure 8).

DISCUSSION

In this study, a full facial reconstruction of an ancient skull is presented, corresponding to an 11-year-old girl who resided in Athens at around 430 BC, died from the Plague that devastated her home city, and was anonymously and hastily thrown into a mass grave among more than 150 other victims of the epidemic. No specific information about her was available, so she was arbitrarily named by the archaeologists in charge as Myrtis, a common ancient Greek feminine name. Her skull was found in excellent condition, bearing a complete mandible, and all of her teeth were intact. After a thorough description of the dental and orthodontic treatment needs of Myrtis, her case attracted so much attention from the scientific community and the general public that it was decided to perform the facial reconstruction of her skull.[15] Although there are several similar cases published presenting facial reconstructions of outstanding ancient Greek personalities, such as King Philip II and King Midas, to the authors' knowledge, this was the first time ever that the real face of a lay ancient Greek person was presented.[10,11]

The accuracy of the reconstructed face of Myrtis might be a matter for scientific debate. The general form and shape of the major features of her face followed the osseous structure of her skull and therefore can be considered more or less precise.[11] Thus, the remolding of the craniofacial musculature and related structures modeled according to anatomical guidelines is considered adequately reproducible and reliable. An exception to this rule is the facial expression musculature: since it lacks skeletal support, its reproduction involves some artistic interpretation irrespective of the reconstruction technique.[23]

In addition, it is a fact that the color of Myrtis' eyes and hair was arbitrarily selected to match a common color for a Greek female, irrespective of historical period. More important, there are some reservations regarding the thickness of the facial tissues and

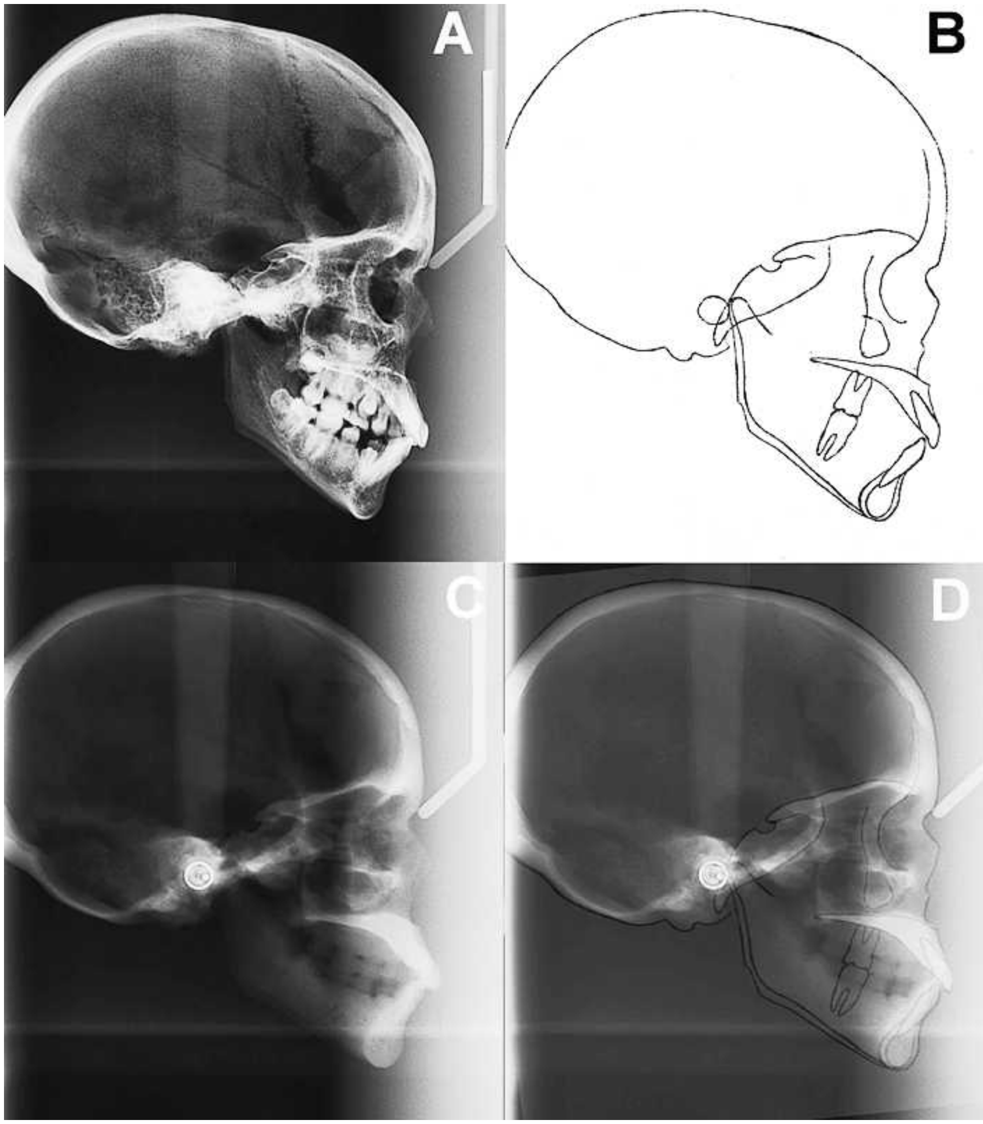

Figure 5. (A) The lateral cephalometric radiograph of the original skull, (B) the tracing of the lateral cephalometric radiograph of the original skull, (C) the lateral cephalometric radiograph of the replicated model of the skull taken on standardized conditions with the original, (D) and the tracing of the lateral cephalometric radiograph of the original skull placed on the cephalograph of the replicated model.

especially of the facial muscles of Myrtis. These were determined according to average values taken from respective reference tables for age, sex, and race.[20] It is true that precise relevant available data (ie, for Greek nationals) are still very limited, thus affecting the accuracy of the reconstruction. Other approximations of the reconstructed face of Myrtis regard the form of her nose, lips, and ears. Unlike other facial features, the auricles of the ears are not supported by bone, whereas the nasal bone is typically missing. Lacking a standard reference point of a supportive bone tissue, the ears, lips, and nose are created with some artistic subjectivity in their form and shape.[23] In any case, the auricular size as determined by reference tables and also the exactness of placing the auricles around the auditory meatus should be considered accurate and may not be argued.[21]

The reconstructed face of Myrtis should undoubtedly not be compared with the images of persons who are idealistically depicted in masterpieces of the classical period of ancient Greek art. It is true that Myrtis' case, had she lived in modern times, would warrant orthodontic treatment. Considering her dentoskeletal pattern, her facial features would not look more realistic if the reconstruction were made to camouflage her underlying orthodontic problems. Sculpting the lips of Myrtis in repose discloses her protruding and crowded upper front teeth, while the area of the chin, in addition to the deep grooving and the pressing forward from the edge masseter muscle, was sculpted

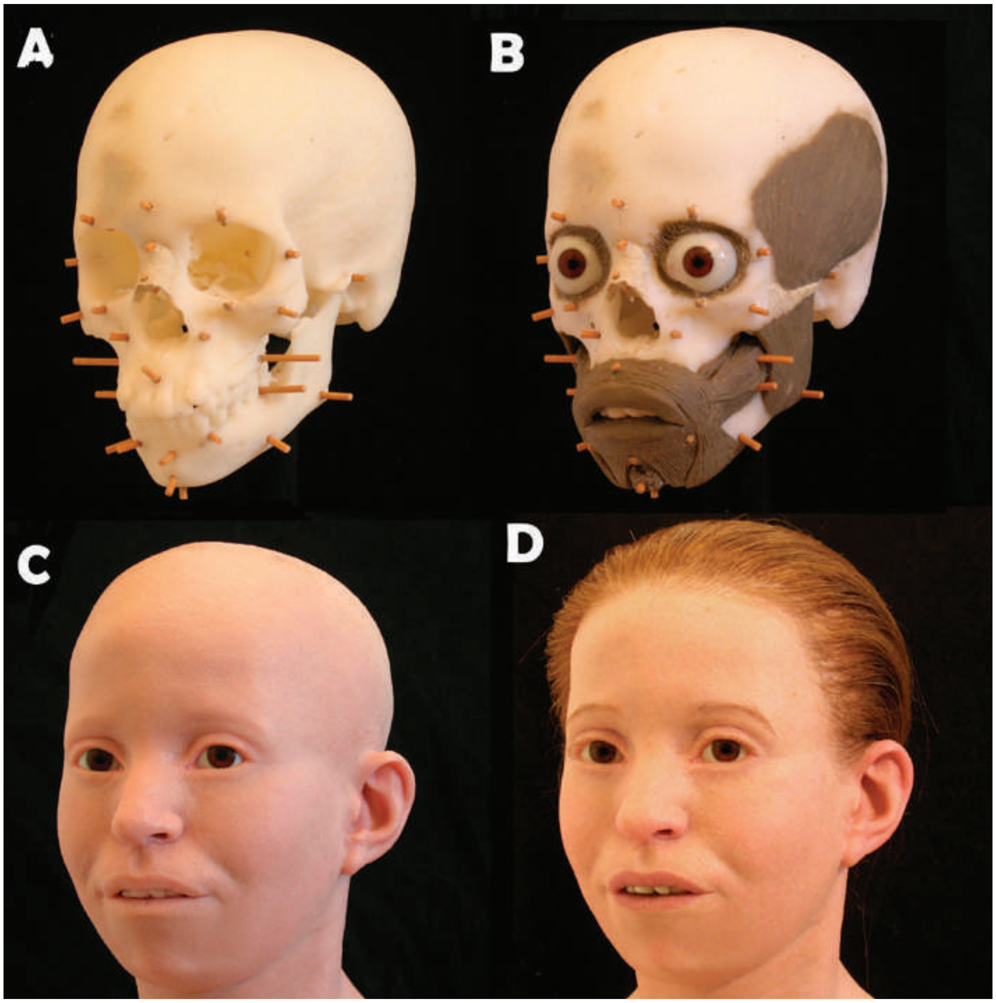

Figure 6. Stages of the facial reconstruction of the replicated skull of Myrtis. (A) After the placement of the pegs showing tissue thickness. (B) After the placement of the eyes. (C) After the placement of the dermis. (D) The face of Myrtis, fully reconstructed.

Figure 7. The (A) lateral view of the reconstructed face of Myrtis and (B) frontal view.

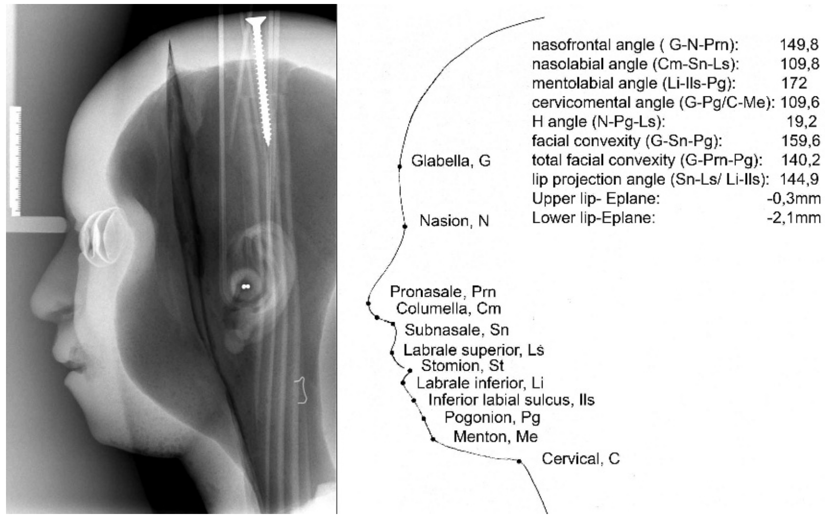

Figure 8. Lateral cephalometric radiograph of the silicone casting of Myrtis and its soft tissue profile analysis.

to intensify and not cover up the skeletal nature of her orthodontic problems. It is quite common for a child of Myrtis' age to have the facial muscles of the respective areas covered by a lot of subcutaneous fat. If such an option were adopted, Myrtis' face would look more rounded in shape and thus completely cover the underlying orthodontic discrepancy of her osseous facial structures. Nevertheless, the intentions of the authors were not to produce a face matching a preconceived assumption of the average ancient Greek face but to put trust in the method that was followed, stage by stage, bringing out the individual features of Myrtis according to the master plan of her skull itself.

Computer-based facial reconstruction systems that have been introduced as alternative methods for reconstructing ancient faces (most of them regarding Egyptian mummies) also employ some arbitrary and artistic interpretation for soft tissues that do not have skeletal support.[23] Egyptian mummies are therefore reconstructed following the Manchester method,[11] as the latter results in producing facial expressions more vivid and close to reality than the computer-produced images.[23]

Overall, despite some accuracy issues in the facial reconstruction method followed in this article, the result of this project was the reconstruction, as close to reality and truth as possible, of the face of a young resident of Athens of the Golden Age of Pericles. This reconstruction, with all methodology compromises considered, offers the chance to the scientists as well as to the general public to come face to face with a lay Athenian female youngster, who, even though she was born at the most glorious time of ancient Athens and witnessed the completion of the Acropolis, did not have the chance to grow up because of her untimely death from the notorious Plague that contributed to the ending of the Athenian predominance in the ancient world.

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