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Chapter 9.6. Forensic Facial Reconstruction

by Caroline Wilkinson

Following initial reassembly of the conserved skulls from Burials 2, 4 and 5 by the Archaeological Conservation Laboratory at National Museum Cardiff, the Unit of Art in Medicine at the University of Manchester was approached in December 2000 about the potential of three-dimensional facial reconstruction. The reconstruction process started in 2001 and was completed in 2002.

Context

Facial reconstruction from skeletal remains is the process utilised to predict the facial appearance of an individual following scientific interpretation of the skull (Wilkinson, 2010) and is a forensic tool that significantly enhances the chances of identification. In Britain, Neave pioneered a technique (Prag and Neave, 1997) that became known as the Manchester method, which incorporated both anatomical and anthropometrical standards (Wilkinson, 2004). This method has been taken up globally by practitioners and has been further developed over the last 30 years (Wilkinson, 2010; Wilkinson and Rynn, 2012) to include the study of facial anatomy, expression, anthropometry, anthropology and a dedicated period of training and study.

The increased access to CT imaging and advances in digital technology has made it possible to assess the accuracy of these techniques using morphometric comparison between the surfaces of the reconstruction and the face of a living subject. Two blind studies compared facial surfaces using 3D reverse modelling software (Wilkinson et al., 2006; Lee, Wilkinson and Hwang, 2011) and demonstrated that the nose, eyes, jaw line, forehead and chin can be reconstructed reliably (< 2 mm error), with the mouth and ears showing the most errors. It is not possible to produce an exact portrait and there are many non-anatomical details of the face that cannot be determined from the skull, especially age-related changes, soft tissue modifications and eye/skin/hair colours.

The facial depiction of people from the past is a useful tool for the social interpretation of archaeological remains. Visualising the face of someone from the past helps the public connect to their ancestors, perpetuating affective bonds and sustained interest (Buti et al., 2016). Therefore, the demand for facial depiction in archaeological research has increased over the last 20 years with interdisciplinary studies performed worldwide to rebuild faces from the past. Ancient faces allow us to make comparisons with contemporary faces and judgements on status, character and lifestyle (Wilkinson, 2010). In this way, facial depictions have contributed to changing views of the media and the public in relation to historical figures (Wilkinson, 2013; Introna et al., 2018; Day, 2013) and assisted in our understanding of ancient migration and geographical patterns (Gaspar and Santos, 2010; Shreeve, 2015; Moon, 2018). In addition, where the human remains are anonymous, facial depiction can expose a personal narrative and prevent classification as museum objects/artefacts (Charlier, 2010), whilst manifesting scientific evidence and playing an active part in phylogenic debate. However, although a facial depiction may be based upon an established body of scientific knowledge, subjective interpretation will inevitably be utilised when there is insufficient evidence – this is a common dilemma for practitioners. In these circumstances, there is a greater possibility that the facial depiction will negatively influence the course of scientific research by contributing to and perpetuating confirmation bias (Wilkinson, 2021).

Whilst research has shown good accuracy in relation to the prediction of face shape from skeletal structure (Wilkinson et al., 2006; Lee et al., 2012), the addition of reliable colour, texture and detail is notoriously difficult to achieve. Studies suggests that different surface detail, such as hairstyle (Wright and Sladden, 2003) or glasses and facial hair (Lewis, 1997), can have an alarmingly strong effect upon facial appearance and recognition levels. In archaeological investigations, experts will typically suggest the most probable hairstyle, hair colour, skin colour and eye colour based on the historical textual and/or pictorial evidence. With all this in mind, it is important not to consider a facial depiction as a portrait or definitive image, as it can only visualise the information available at the time of production.

Facial Reconstruction Standards

The principles of facial reconstruction are based on the theory that the shape of the soft tissues of the head are directly related to the skeletal morphology of the skull, since the craniofacial complex is a functional matrix and the relationship between the bone and soft tissues is reciprocal and responsive (Kau, Richmond, Savio, and Mallorie, 2006; Rynn, Balueva, and Veselovskaya, 2012).

Facial anthropology standards are based on early anatomical dissection research augmented by more recent clinical imaging, anthropometry and surface scan research.

The relationship between the morphology of the eye and the orbital bones was determined through anatomical dissection studies (Whitnall, 1912) that described eyeball position, the palpebral ligaments of the eyelids, canthal angle/position and the lateral orbital (or Whitnall's) tubercle, and numerous research studies confirmed and supplemented these standards (Gerasimov, 1955, 1971; Couly, Hureau, and Tessier, 1976; Angel, 1978; Krogman and İşcan, 1986; Fedosyutkin and Nainys, 1993; Wilkinson and Mautner, 2003; Stephan and Davidson, 2008; Rynn, Balueva and Veselovskaya, 2012).

Traditionally, the nose was the most difficult facial feature to accurately predict due to its cartilaginous structure. Therefore, there have been many studies assessing the relationship between the configuration of the nasal soft tissues with shape of the nasal aperture (Gray, 1965; Seltzer, 1944; George, 1993; Gerasimov, 1955; Glanville, 1969; Macho, 1986; McClintock Robison, Rinchuse, and Zullo, 1986; Prokopec and Ubelaker, 2002; Schultz, 2005; Stephan, Henneberg, and Simpson, 2003; Tandler, 1909; Virchow, 1912 Cerkes, 2011 Davy-Jow, Decker, and Ford, 2012). Early anatomical standards were confirmed and augmented in a clinical imaging study of living subjects (Rynn, 2006). Rynn and colleagues (2010) blind-tested a set of guidelines for nasal shape prediction, developing three cranial measurements to predict six soft nose measurements with a high level of accuracy. Due to these standards, the nose is probably now the most accurately predicted facial feature in facial reconstruction.

Orthodontic and anatomic literature demonstrate that mouth morphology is related to dental occlusion (Rudee 1964; Roos, 1977; Koch, Gonzalez, Witt, 1979; Waldman, 1982; Holdaway, 1983; Denis and Speidel, 1987; Talass, Tollaae, and Baker, 1987; Wilkinson, Motwani, and Chiang, 2003), dental pattern (Subtelny, 1959; Angel, 1978; Krogman and İşcan, 1986; Stephan and Henneberg, 2003) and facial profile (Gerasimov, 1955; Balueva and

Veselovskaya, 2004), and standards even exist to predict mouth shape for edentulous skulls (Stephan and Murphy, 2008). However, the exact shape of the vermillion line has not been related to any dental pattern and accuracy studies suggest that lip shape is one of the most error-prone areas of reconstruction (Wilkinson, Rynn, Peters *et al*., 2006).

There have been some studies (Gerasimov, 1955; Guyomarc'h and Stephan, 2012; Renwick, 2012) relating to ear morphology, but this feature remains the least predictable from skeletal interpretation.

Facial reconstruction utilises tissue depth data as guidance for the soft tissues of the face. Throughout the 20th century clinical imaging methods have been utilised to measure living subjects, inclduing craniographs, Computed Tomography, Magnetic Resonance Imaging and ultrasound. More recent advances in the 21st century have included the use of low dose Cone-Beam Computed Tomography (Fourie, Damstra, Gerrits, and Ren, 2010; Hwang, Park, Lee *et al*., 2012). There are many sets of data available from different *in vivo* ethnic groups across the world for use in craniofacial analysis. Collations of these datasets can be found in some publications (Wilkinson, 2004; Wilkinson and Rynn, 2012) and websites (Stephan, 2023).

Skull assessment

The reconstructions utilised age estimates presented in 2001. The final, more recent, calculations of age have only minor changes with little impact on the final facial appearance. All facial feature assessment followed the standards described in the 'Facial Reconstruction Standards' section above.

Burial 1 (context 652/654): adult female, aged about 18-25 years (2001 estimate); final age range about 12-16 years (2012 estimate).

The skull was presented in many fragments, with too many fragments missing to attempt re-assembly for reconstruction. All teeth were present, and the remains suggested a square face shape. The nasal bones demonstrated mild signs of guttering at the nasal base and the nasal spine was horizontal, wide and flat. The jaw line was square and the chin was cleft. The skull traits were consistent with a White European population.

Burial 2 (context 733): adolescent male, aged about 10-15 years (2001 estimate); final age range about 12-13 years (2012 estimate).

The skull was presented in many fragments. The missing areas included: the sphenoid bones, a portion of the right zygomatic bone, left lateral nasal bone, left lateral orbital bone, occipital bone, right side of the frontal bone and both zygomatic arches. The maxilla and mandible were intact and all teeth were present. The skull was reassembled using dental wax and the missing areas remodelled using wax; where the missing area was a bilateral feature, the present feature on the other side of the skull was mirrored; where the missing area was totally absent, it was modelled in sympathy with the surrounding bone. The skull traits were consistent with a White European population.

The face shape was square with wide cheek bones. The forehead was smooth with no apparent brow ridges. The cranium exhibited an occipital bulge and parietal bossing. The small rectangular shaped orbits suggested horizontal fissures and normal eyeball protrusion. There were supra-orbital notches visible on the supra-orbital margin. The nasal spine was horizontal, flat and wide, suggesting a moderately wide soft tissue nose. The teeth demonstrated normal occlusion and suggested thick upper and lower lips and a flat upper lip shape. The jaw line was square with visible gonial flaring. The mastoid processes were directed inferiorly, suggesting adherent ears. The profile appeared upright, and strong muscle attachments were seen at the temporalis, masseter, levator labii superioris, levator anguli oris and mentalis muscles.

Burial 3 (context 735): adult male, aged 25-35 years (2001 estimate); final age range about 25-35 years (2012 estimate).

The skull was presented in many fragments and was consistent with a White European population. The missing areas included: the right sphenoid, left lateral nasal, left lateral supra-orbital, both zygomatic arches and some small sections of the frontal bone. The maxilla and mandible were intact, and all teeth were present, except the left maxillary 2nd and 3rd molars, right maxillary 2nd molar and left mandibular 2nd molar. The skull was reassembled using dental wax and the missing areas remodelled using wax; where the missing area was a bilateral feature, the present feature on the other side of the skull was mirrored; where the missing area was totally absent, it was modelled in sympathy with the surrounding bone.

There was trauma visible at the left orbit consistent with an angled blow from above across the orbit and into the left lateral nasal bone. This blow may have been peri or post-mortem. The face was square, the forehead exhibited supra-orbital ridges and the cranium exhibited an occipital bulge and sagittal ridge. The small rectangular shaped orbits suggested horizontal fissures, and deep eyeball protrusion. There were supra-orbital notches visible on the supra-orbital margins. The nasal bones showed mild signs of guttering at the base and the nasal spine was horizontal, and the nose was moderately wide, with oblique low alae. The teeth demonstrated normal occlusion and suggested a thinner upper than lower lip and a flat upper lip shape. The jaw line was square with visible gonial flaring. The mastoid processes were directed inferiorly, suggesting adherent ears. The profile appeared upright. No nasolabial or mental creases were suggested, but strong muscle attachments were seen at the temporalis, masseter, levator labii superioris, zygomaticus minor, levator anguli oris and mentalis muscles.

Burial 4 (context 737): juvenile male, aged 10-15 years (2001 estimate); final age range about 9.4-14 years (2012 estimate).

The skull was consistent with a White European population and presented in many fragments. The missing areas included: the left lateral nasal, left supra-orbital, left parietal, left sphenoid, occipital, right sphenoid, right temporal and right infra-orbital bones. The maxilla and mandible were intact, and all teeth were present, except the maxillary 2nd premolar. The skull was reassembled using dental wax and the missing areas remodelled using wax; where the missing area was a bilateral feature, the present feature on the other side of the skull was mirrored; where the missing area was totally absent, it was modelled in sympathy with the surrounding bone.

The face shape was oval with wide cheek bones. The forehead was smooth with no apparent brow ridges. The cranium exhibited an occipital bulge, frontal bossing and parietal bossing. The small, rounded orbits suggested horizontal fissures and deep eyeball protrusion. There were supra-orbital notches visible on the supra-orbital margin. The nasal bones showed mild signs of guttering at the base and a flat, wide nasal spine. The nasal spine was upward sloping and the nose was moderately wide with rounded alae. The teeth demonstrated a class 2 occlusion with an overjet of the upper teeth over the lower teeth and mild prognathism. The teeth suggested thick upper and lower lips and a flat upper lip shape. The jaw line and chin were square. The mastoid processes were directed inferiorly, suggesting adherent ears. No nasolabial or mental creases were suggested, but strong muscle attachments were seen at the masseter, levator labii superioris, levator anguli oris and zygomatic minor muscles.

Burial 5 (context 739): adult male, aged 35-45 years (2001 estimate); final age range about 33-45 years (2012 estimate).

The skull was consistent with a White European population and presented in many fragments. The missing areas included: all the nasal bones, zygomatic bones, lateral orbital bones, zygomatic arches and portions of the frontal bone. The maxilla and mandible were intact, and all teeth were present, except the right mandibular 3rd molar. The skull was reassembled using dental wax and the missing areas remodelled using wax; where the missing area was a bilateral feature, the present feature on the other side of the skull was mirrored; where the missing area was totally absent, it was modelled in sympathy with the surrounding bone.

The face shape was oval. The forehead exhibited moderate brown ridges. The vault exhibited an occipital bulge and parietal bossing. There were supra-orbital notches visible on the supra-orbital margin. The nasal spine was horizontal, and the nose was moderately wide. The nasal bones had a sharp border and a flat wide nasal spine. The teeth had normal occlusion and suggested thick upper and lower lips and a flat upper lip shape. The jaw line was square with visible gonial flaring. The mastoid processes were directed inferiorly, suggesting adherent ears. The profile appeared upright and strong muscle attachments were seen at the masseter and mentalis muscles.

Summary assessment

Some of the skulls showed similar features, including:

- Horizontal eye fissures (burials 2,3 and 4)
- Mild signs of guttering at the nasal base (burials 1, 3 and 4)
- Square jaw and gonial flaring (burials 2, 3 and 5)
- Adherent ears (burials 2-5)
- Wide and flattened nasal spine (burials 1,2,4 and 5)
- Supra-orbital notches (burials 2-5)

Supra-orbital notches (rather than foramina), mild guttering at the nasal base, adherent ears and a wide flattened nasal spine are less common, genetically determined traits. In 2002, a possible genetic relationship between the individuals was considered, such as familial or population specific. In light of the stable isotope data, this conclusion was reconsidered (see below).

Facial reconstruction technique

Following assessment and reassembly of the skulls from Burials 2-5, plaster copies were utilised for the facial reconstruction procedure whilst referring to the original specimens. Each skull cast was mounted on a pole in the Frankfurt Horizontal Plane. Following the data presented in relation to sex and age of the individuals, appropriate sets of tissue depths were chosen. For Burial 2, White European juvenile male data was used in the 15 to 16-year age range (Wilkinson, 2002), for Burials 3 and 5, White European adult male data was used in the 30 to 39-year age range (Helmer, 1984), and for Burial 4, White European juvenile male data was used in the 11 to 12-year age group (Wilkinson, 2002).

In all cases, holes were drilled into the skull at ninety degrees to the bone surface at the appropriate 21-34 anatomical points (dependant on the database) using a 3 mm drill bit, and wooden pegs were cut (using Mitutoyo 0-150mm digital callipers) and inserted into holes in the skull. In this way a set of guides for tissue depth across each skull were attached.

For Burial 2 and 5, the plaster eyeballs were set into the orbits at normal protrusion, taken as the cornea positioned 3.5mm posterior to a tangent drawn from superior to inferior margins of the orbit (Wilkinson and Mautner, 2003). For Burials 3 and 4 the plaster eyeballs were set into the eye sockets at deep protrusion, taken as the cornea touching a tangent drawn from superior to inferior margins of the orbit (Wilkinson and Mautner, 2003).

The muscles of the head and neck were modelled onto the skull in clay following anatomical guidelines (Wilkinson, 2010). The details of the facial features were modelled with respect to the skull assessment as detailed in the 'Facial Reconstruction Methodology' section above. Adherent ears were modelled and attached to the sides of the head using the external auditory meatus to determine the position.

Skin strips were rolled, shaped and placed over the muscle structure to create the finished face. The layer mirrored the shape of the muscles below. During this process the tissue depth pegs were used as guides. The surface of the face was smoothed to achieve the final sculptural finish.

Hair was modelled in an appropriate style, informed by a later (12th century) description of a typical Welsh hairstyle (Giraldus Cambrensis, *Descriptio* I, 11; Thorpe 1978, 238): 'Both the men and women cut their hair short and shape it round their ears and eyes'.

The heads of Burials 2, 4 and 5 were then cast in a bronze resin. For Burial 3, the head was cast in wax with blue-grey prosthetic eyes and a 3D artist added paint and hair to the cast to create a realistic finish, following a brief provided by the museum. The hair was dark brown and in an untidy, straight, neck-length style with a rough fringe. The hair was shaped around the ears and slightly receding. The skin tone was rugged and weather beaten with a ruddy complexion. Hair was then modelled onto the clay head in a similar style to the wax head, and this head was then also cast in bronze resin.

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Draft Figure suggestions:

Fig. 1. The different stages of reconstructing the skull of Burial 2: a, as initially reconstructed at National Museum Cardiff; b. reconstruction of skull in wax by Caroline Wilkinson; c-d musculature and skin added to a plaster cast of the head of burial 2. (a, © National Museum of Wales; b-d © Unit of Art in Medicine, University of Manchester).


Burial 2a [DAL 43006-7]


Burial 2b [DAL 47896]

Burial 2, Fig. 1c

Burial 2, Fig. 1d

(images on old shared drive)

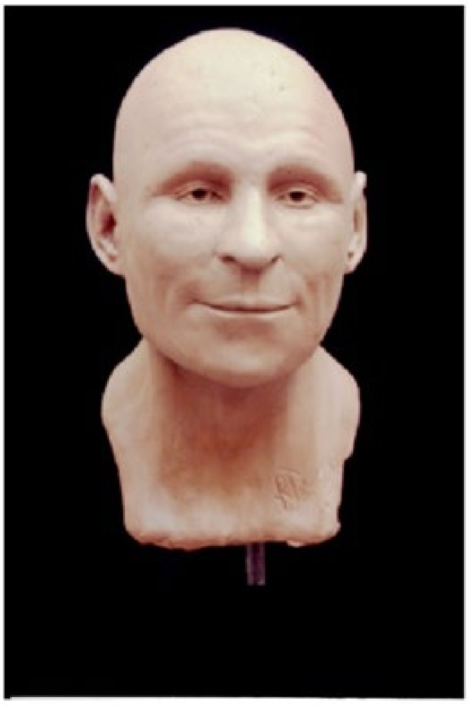
Fig. 2. The final resin cast of the facial reconstruction of Burial 2. (© National Museum of Wales)

Fig. 3. The different stages of reconstructing the skull of Burial 3: a, as initially reconstructed at National Museum Cardiff; b. reconstruction of skull in wax by Caroline Wilkinson; c musculature added to a plaster cast of the head of burial 3. (© Unit of Art in Medicine, University of Manchester).

Burial 3, Fig. 3a [DAL 43271]

Burial 3, Figs 3b, c

Fig. 4. The final facial reconstruction of Burial 3: a, skin added to a plaster cast of the head of burial 3, minus hair (this stage was cast for a wax version); b, resin cast of final version of Burial 3 (a, © Unit of Art in Medicine, University of Manchester; b, © National Museum of Wales)



Burial 3, Fig. 4a

Burial 3, Fig. 4b [DAL 46805]

Fig. 5. The different stages of reconstructing the skull of Burial 4; a, as initially reconstructed at National Museum Cardiff; b. reconstruction of skull in wax by Caroline Wilkinson; c-d musculature and skin added to a plaster cast of the head of burial 2. (a, © National Museum of Wales; b-d © Unit of Art in Medicine, University of Manchester).


Burial 4, Fig. 5a [DAL 43022]


Burial 4, Fig. 5a [DAL 43023]

Fig. 5b-d

Fig. 6: Final resin cast of Burial 4. (© National Museum of Wales).

Burial 4 [DAL 46083-4]

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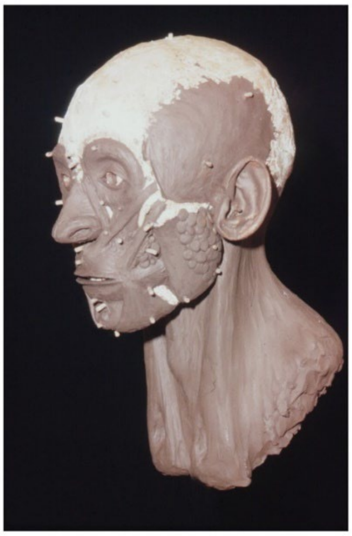
Fig. 7. The different stages of reconstructing the skull of Burial 5; a, as initially reconstructed at National Museum Cardiff; b. reconstruction of skull in wax by Caroline Wilkinson; c-d musculature and skin added to a plaster cast of the head. (a, © National Museum of Wales; b-d © Unit of Art in Medicine, University of Manchester).


Burial 5, Fig. 7a [DAL 43028]


Burial 5, Fig. 7a [DAL 43029]


Burial 5, Fig. 7a [DAL 47754]

Burial 5, Fig. 7b



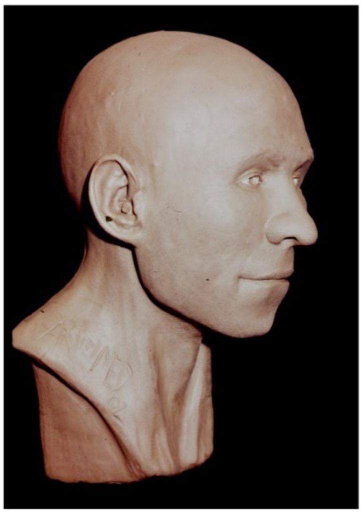


Fig. 8: Final resin cast of Burial 5. (© National Museum of Wales).

Burial 5 [DAL 46806]

Fig. 9. Facial reconstruction, bronze resin cast and wax version of the head of Burial 3, with conjectural hair and skin colour. The hair is based loosely on observations by Giraldus Cambrensis some 200 years later than the date of the burial (© National Museum of Wales)

[DAL 32228]

Fig. 10. Final facial reconstructions by Caroline Wilkinson of (L-R) Burials 3, 5, 4 and 2, in a cast resin with bronze finish. (© National Museum of Wales)

[DAL 32558]