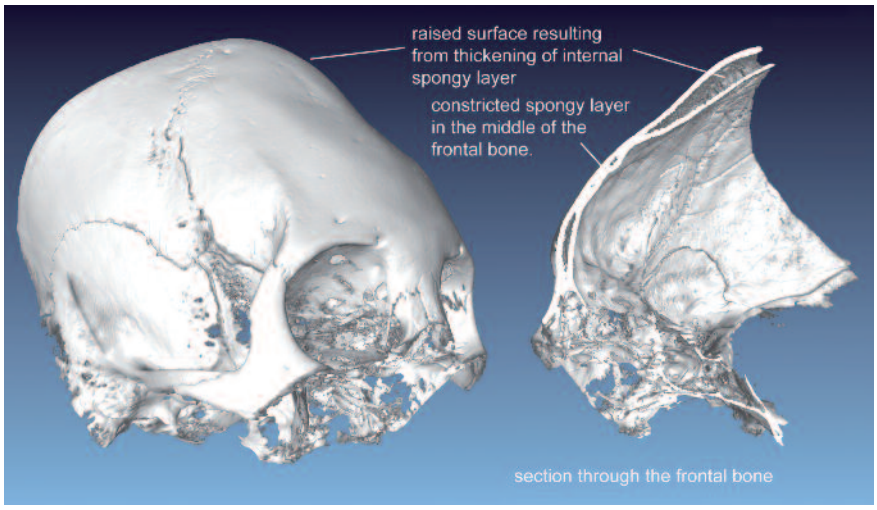

3D reconstruction from micro CT data by Matt Tighe and Peter Brown

Figure 1. Modifications in the shape of a human frontal bone resulting from the binding of a child's head during infancy. The frontal bone becomes elongated, is somewhat concave and the vault bone is of irregular thickness.

Head Shape Modification Explains the Origin of the First Australians

BY PETER BROWN

Abstract required

For more than a century there has been a protracted debate over the origins of Australia's first human inhabitants and what was their biological and cultural relationship with earlier populations in the Asian region. This discussion has also been relevant to the broader debate concerning the evolution and dispersion of humans globally, including the relationship between Neandertals and modern humans in Europe.

Ideally, tests of these models can be provided by comparing genetic and cultural information from past and present populations. However, there is rarely adequate data to provide certainty, and lengthy disputes over the interpretation of details are common. It also does not help that there are more palaeoanthropologists than there are data worth interpreting.

Australian researchers have been particularly interested in finding evidence of the initial movement of people from the Sunda Shelf, through the Indonesian archipelago and into greater Australia during the late Pleistocene. Archaeological evidence indicates that humans had become established over a large part of Australia at least 40,000 years ago, with slightly younger dates for modern human occupation from Niah Cave in Borneo, Timor, New Britain and New Ireland.

Current archaeological and fossil skeletal evidence indicates that earlier bipeds *Homo erectus* and *Homo floresiensis* were able to move through the Indonesian islands as far as Flores, but were unable to traverse the larger water barriers to reach the Sahul Shelf or Timor. *Homo erectus* may have lived on Java for around 1 million years, with some research suggesting they could have survived until 35,000 years ago, overlapping with the dispersion of *Homo sapiens* and surviving the Toba volcano eruption around 70,000 years ago.

Although there is absolutely no cultural or biological evidence consistent with the presence of *Homo erectus* in Australia, there has been a long-held belief among some anthropologists that the first Australians were the descendents of these early Javan bipeds. This formed part of the multiregional interpretation of modern human origins, whereby *Homo sapiens* evolved from geographically distinct populations of *Homo erectus*.

Evidence in support of this scenario was argued from a perceived continuity of specific anatomical features through time. For instance, in the Australasian region it was argued that crania from Indonesian *Homo erectus* and terminal Pleistocene and more recent Australian *Homo sapiens* shared a receding frontal bone, with distinctive areas of thickening and raised ridges on the external surface. As the expression of these anatomical features was thought to be primarily under genetic control, the higher frequency of these features in the Australasian fossil record, compared with East Asia or Europe, indicated evolutionary continuity between populations in Java and Australia.

However, in 1975 the perceptive British anthropologist, Donald Brothwell, questioned whether the perceived similarities in cranial anatomy were the result of a cultural practice. Up until the late 1800s it was common for mothers in many parts of the world to gradually alter the shape of the heads of their newborn infants (see box).

When a child is born, the bones of the cranial vault are very thin, the frontal bone is divided into two halves and there are soft, uncalcified areas called fontanelles on the frontal bone and base

of the skull. It is common for an infant's head to distort slightly during birth but to regain normal shape over the following month.

However, if continual pressure is applied to the front or back of an infant's skull, or if growth is redirected by the use of restricting bands or caps, it is possible to permanently alter the shape of a child's head.

Brothwell was particularly concerned about the shape of the frontal bone and contours of other bones in skulls found at Kow Swamp, a late Pleistocene site in northern Victoria. Previously Dr Alan Thorne of the Australian National University had emphasised the similarity of these skulls to Javan *Homo erectus*, but Brothwell thought he was wrong and argued that the people from Kow Swamp had had their head shape modified when they were infants.

The Nacurrie Skeleton

In 1949 a heavily mineralised skeleton was accidentally dragged to the surface when rabbit burrows were being ripped near Nacurrie in northern Victoria. It was subsequently radiocarbon dated to approximately 11,000 years.

This skeleton, along with those from the nearby terminal Pleistocene sites at Kow Swamp and Coobool Creek, were repatriated to Aboriginal communities for reburial in the late 1980s. However, they were recorded in detail before this occurred.

Although the Nacurrie skeleton had been broken when it was dragged to the surface, it remains the best-preserved and most complete terminal Pleistocene skeleton recovered from Australia. It has recently become pivotal in discussions about the evidence for cranial modification in Australia, evolutionary continuity with *Homo erectus*, and the significantly greater body mass of the terminal Pleistocene Australians than the mid-Holocene counterparts who followed them.

When the skeleton was cleaned and reconstructed in the early 1980s it was apparent that it was from a relatively tall and robustly built man who had had an active, combative and at times extremely painful life. He would have been close to

Cranial Reshaping in Modern Times

Historical or ethnographic records show that modern humans have altered the shape of their children's heads for reasons ranging from community expectations over the most aesthetic appearance to beliefs about the association between head shape and intelligence or a desire to distinguish one group of people from another.

Most recently the shape of an infant's head has accidentally been altered, with posterior flattening, because mothers have positioned their infants on their back while sleeping to reduce the possibility of sudden infant death syndrome. The flattening of the skull that may result is not considered aesthetic, and in extreme cases remedial head moulding may follow. Where there is a need to correct head shape, the use of special cap-like orthotic devices can modify head shape within 6 months.

Perhaps more often, clinical studies indicate that mothers from diverse ethnic backgrounds in North America may subtly alter the shape of their infants heads to reach what they consider is a more aesthetic shape by repeated moulding pressure with their hands. There is no evidence that the child is injured by this process, and the mothers would argue that they have the best interests of their child in mind.

While it's not all that different from many of the other forms of body modification that human societies employ, it is a lot more permanent than a hair cut or piercing, and it is very unfortunate if fashions change during your lifetime.

180 cm tall and weighed approximately 83 kg. This compared with an average height of 160 cm and weight of 60 kg for indigenous men in the early 1900s in the same region.

Nacurrie had poorly healed bilateral fractures of both forearms, a healed depressed fracture of the skull, and a healed fracture of the fibula that was fused to the tibia. Similar fractures of the forearm and cranial vault are often present in prehistoric male and female Aboriginal skeletal material as a result of traditional methods of settling disputes.

To add to his discomfort, tooth wear had exposed the pulp chambers of many of his teeth, resulting in abscesses. He also had an arthritic jaw, and repeated ear infections had probably damaged his hearing. For Nacurrie, life involved considerable struggle, a common circumstance for indigenous Australians living traditional lifestyles in south-eastern Australia.

More exceptional was the unusual shape of his head, particularly the profile and contours of the forehead and parietal regions of his cranial vault. In particular the frontal bone, rather than being gently curved, was somewhat concave, with a raised area of bone at the rear of the frontal bone. The parietal bones, which form the sides and roof of the cranium, were also more curved than expected.

A Closer Look

As the growth, development, size and shape of the bones that comprise the human skull have been recorded in detail, it is comparatively easy to distinguish what is normal from what is not. When the normal growth of an infant's skull is modified, either intentionally or accidentally, the subsequent effects on the shape and dimensions of the adult cranium are also well-understood. For example, if you compare lateral X-rays of a normal skull with someone whose head shape was altered shortly after birth, the differences in the shape of the major vault bones are obvious (Fig. 1).

Figure 2. Peter Brown during micro CT scanning of an intentionally modified human cranium at the University of New England. Photo: David Elkins.

This can be examined in more detail using a micro CT scanner like the one recently installed at the University of New England (UNE). A standard hospital CT scanner typically gives an X-ray slice interval of approximately 1mm. Three-dimensional reconstructions from these CT scanners are usually adequate for medical purposes, but they lack fine anatomical detail. However, micro CT scanners may have a resolution as fine as 5 μm, and as the process is not destructive there are many biological applications.

For instance, UNE's micro CT scanner is proving particularly valuable in soil science applications. Using this technology you can examine the habitat–microbe interaction that controls most soil processes, including the creation and release of greenhouse gases, the protection of the world's greatest reservoir of biodiversity and all our land-based food production. For the first time, you can look inside soils three dimensionally and observe the interaction between these microhabitats and root development. As a non-specialist it was fascinating for me to observe the interaction between pellets of fertiliser, leeching and root growth in tube stock, and be convinced of the advantages of particular fertiliser compounds.

Fortunately the micro CT scanner is also large enough to be able to scan human crania with a resolution of only 0.3 mm. This method was recently used to examine the effects of one form of cranial shape modification on bone growth (Fig. 2).

In the 1930s the British anthropologist Beatrice Blackwood documented the process of binding an infant's head to permanently modify its head shape. After birth, the child's head was firmly wrapped around the forehead and back of the skull with bandages and twine. These bandages were adjusted and reapplied regularly during the first year of life. As a result, the forehead and rear of the skull were flattened and the parietal region, between them, was drawn upwards, increasing in curvature.

The change in shape becomes permanent if the wrapping remains in place until the fontanelles have hardened and the vault bones become less flexible. This does not have any impact on the brain as can continue to grow; it just expands in a different direction.

The Arawe people of New Britain (Papua New Guinea) modified their head shapes for aesthetic reasons and to distin-

Figure 3. The Nacurie 1 cranium provides evidence that mothers intentionally modified the shape of their infants' heads in the Murray River region of south-eastern Australia during the terminal Pleistocene. Photo: Peter Brown

guish themselves from other groups like the Tolai, who did not. Depending upon the expertise and diligence of the mother, and perhaps changes in social pressure for a uniform head shape (fashion), there was a great deal of variation in the extent of modification.

Three-dimensional images of one of the micro CT-scanned Arawe crania highlight the impact of head binding on the normal shape and growth of the frontal bone. The frontal bone becomes elongated and somewhat convex in the middle, with a corresponding constriction of the usual layer of spongy bone in this region. However, at the rear of the frontal bone, where the anterior fontanelle was located, the spongy bone is greatly expanded, separating the inner and outer tables of the vault and producing a pronounced bump on the external surface. There are also symmetrical depressions on either side of the middle of the frontal bone, and a depressed area of bone at the front of the parietal bones. None of these features are present in unmodified human crania, or *Homo erectus*.

Ancient Cranial Modification

The distinctive features of the Arawe people are also present in some terminal Pleistocene Australian crania, including Nacurrie (Fig. 3), as well as those from Kow Swamp and Coobool Creek. Each of these burial sites is close to the Murray River, and separated on a north-west to south-east transect by about 100 km.

While Nacurrie is the oldest directly dated example, radiometric dates from the other sites indicates that this cultural practice may have been in use between 13,000 and 9000 years ago before being abandoned. There is no evidence of the continuity of this behaviour in this region through the Holocene, and human crania from cemeteries dated to the past 7000 years are of normal, unmodified shape.

The most detailed ethnographic account of indigenous Australians modifying the shape of their infant's heads was recorded in Cape York in 1852 by naturalist John Macgillivray in his *Narrative of the Voyage of HMS Rattlesnake*: "Pressure is made by the mother with her hands... one being applied to the forehead and the other to the occiput, both of which are thereby flattened, while the skull is rendered proportionally broader and longer than it would naturally have been".

However, corroborating skeletal evidence of this behaviour is not present in the limited skeletal evidence in museum collections from northern Australia or the published literature on cranial morphological variation in the north-eastern part of the continent. Head pressing produces a more subtle change in head shape than the use of fixed appliances like bandages, caps or cradleboards.

I have argued that this is consistent with the evidence from Nacurrie, where extreme modification is largely confined to the frontal bone. In particular, if the head had been bandaged for a long period it would be unusual not to find greater distortion of the parietal bones.

The Nacurrie skeleton, and those from the other terminal Pleistocene Murray River cemeteries at Kow Swamp and Coobool Creek, provide evidence of evolutionary and cultural change in the Murray River region over the past 13,000 years. Terminal Pleistocene Australians had a much larger body mass than people living in the same region in the mid-Holocene and at European contact. A similar change in body mass has been recorded for human populations in parts of the Old World over the same time period. The reasons for this change in body size, including increased population densities, sedentism, competition for resources or climatic change, are still debated.

Why these early Australians modified the shape of their children's heads, for aesthetic reasons or otherwise, will always remain a matter for speculation. However, it is clear that earlier claims that the anatomy of their frontal bones demonstrated a biological connection with Indonesian *Homo erectus* is not supported by the skeletal evidence.

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