Facing society : A study of identity through head shaping practices among the indigenous peoples of the Caribbean in the ceramic age and colonial period

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2 CRANIAL MODIFICATION

The varieties of cranial deformation are so numerous that they are bewildering.
Hooton (1940:273)

The human skull is a complex structure with a range of important biological functions, principally the protection of the human brain. However, the head also occupies an important social position supporting facial recognition of individuals and complex systems of human interaction, including verbal and nonverbal forms of communication, and rich cultural meaning is often attributed to it. Accordingly, the alteration of facial and cranial features, through a mechanism like the practice of intentional cranial modification, will have profound biological, social, and cultural implications on numerous levels.

This chapter discusses the biological aspects of the altered head shapes encountered in the archaeological record. In order to fully understand the practice of intentional cranial modification and its biological and social implications, knowledge regarding the normal developmental patterns of the human skull is required. This chapter will present standard cranial development and morphology and contrasts it with deviations from this pattern that produce abnormal skull shapes. The focus will be on those medical conditions and environmental factors that can reasonably be expected to affect skull shape within an archaeological assemblage. Furthermore, attention in this chapter will be first and foremost on those conditions and factors that create a head shape that could be confused with the results of intentional cranial modification and as a result could skew investigations into the social motivations behind head shaping.[1]

Attention will then turn to head shaping practices and the various ingenious ways humans have developed to influence the natural growth of the human skull. The terminology used throughout this dissertation will be presented, followed by a discussion on different typologies and the various devices used to create the altered head shapes. Finally, the consequences of cranial modification will be discussed,

1 The medical literature describes a wide range of pathological conditions which can create abnormal human skull shapes. Some of these conditions are extremely rare, however, and the chances of encountering them within an archaeological assemblage are very small indeed. Others produce distinctive cranial shapes that cannot be confused with the results of cranial modification.

including the ramifications for cranial morphology, non-metric traits, and potential side-effects purported to have been caused by head shaping.

2.1 HUMAN CRANIAL DEVELOPMENT

The human skull is an extremely complex composite structure, which protects the fragile human brain and supports the respiratory system and digestive tract (Moriss-Kay and Wilkie 2005). A full description of the embryology and development of the different cranial elements is beyond the scope of this dissertation and for this the reader is referred to several excellent texts (Friede 1981; Moriss-Kay and Wilkie 2005; Moss and Young 1960; Scheuer and Black 2000, 2004; Tubbs et al. 2012). However, a brief summary will be provided here.

The embryonic skull consists of two regions: the viscerocranium (face) and the neurocranium (braincase). The neurocranium can be further subdivided into the chondrocranium (cranial base) and the cranial vault. The viscerocranium, with the exception of the nose, forms in membranous tissue as do the bones of the cranial vault. The cranial base and the majority of the nose, on the other hand, are formed in cartilage (Moriss-Kay and Wilkie 2005; Moss and Young 1960; Scheuer and Black 2004; Tubbs et al. 2012; White and Folkens 2005). Despite these distinct developmental trajectories and the different functions of certain cranial components, the regions of the skull grow in an integrated manner (Lieberman et al. 2000; Moss and Young 1960). The growth process of the neurocranium is primarily driven by the expansion of the brain, which develops rapidly in utero and during the first years of life. The growth of the viscerocranium is directed by the development of sensory organs and dental eruption patterns, which occur later (Bronfin 2001; Ridgway and Weiner 2004; Ross and Williams 2010; White and Folkens 2005). As a result, at birth the cranial vault has already achieved 65% of adult size and is almost fully grown at 95% by the age of 10. In contrast, the face of a newborn is only 40% of adult size and reaches 65% by the 10th year indicating a protracted growth trajectory (Bronfin 2001).

Human cranial growth is driven by the ontogeny of the infant skull, which is composed of forty-five distinct elements at birth (White and Folkens 2005). The articulations of the bones that compose the vault are called cranial sutures. At the intersection of sutures are fontanelles, open spaces made of cartilaginous membrane (see Figure 1). During the growth process, bone is deposited at the margins of these fontanelles and sutures until the cranial sutures interlock by the age of two. Growth continues to take place along these sutures – albeit at a slower rate – and they remain open until ossification commences in adulthood. The articulations between the bones of the base are known as cartilaginous synchondroses. These remain open until the growth of the skull has been completed in early adult life (Moriss-Kay and Wilkie 2005; Ridgway and Weiner 2004; White and Folkens 2005).

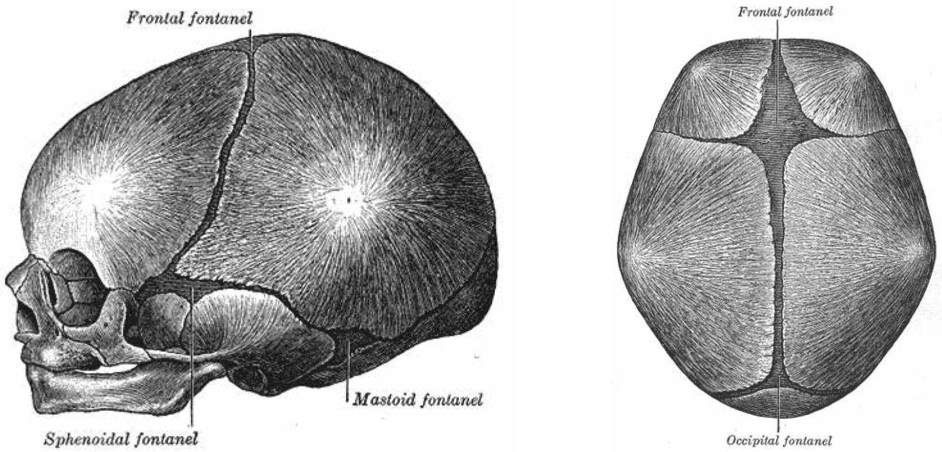

Figure 1 **Lateral and superior view of the infant skull showing the cranial sutures and fontanelles (Gray 1918).**

Although the growth of the human skull is completed during late adolescence or early adulthood, the process of cranial development never fully halts. Several investigations have found subtle changes in cranial morphology taking place during adulthood (Akgül and Toygar 2002; Ross and Williams 2010; Sarnas and Solow 1980).

Each human face is a unique composition of features and the same can be said for the underlying skull. There is a wide range of natural variation in human cranial morphology, resulting from genetic, epigenetic, and environmental influences. An example of this diversity is the cranial index, a ratio of cranial length to breath, which varies between different populations from dolichocephalic (long and narrow) to brachycephalic (broad) (Bass 1987; Martin 1928). This natural variety in cranial morphology based in the interaction of genetic and environmental factors should be kept in mind when studying cranial pathologies and dysmorphologies (Bronfin 2001; Mooney and Siegel 2002; Ridgway and Weiner 2004).

2.2 DEVIATING CRANIAL GROWTH PATTERNS

The complex and intricate nature of human skull growth and development can be disrupted by a variety of genetic and environmental factors. Cranial dysmorphology can be classified into malformations or deformations based on the aetiology of the primary or earliest defect. Malformations are morphological defects that result from an abnormal developmental process. Deformations are the result of pre- and/or post-natal mechanical forces, which disturb the otherwise normally developing cranial features or regions (Mooney and Siegel 2002; Ridgway and Weiner 2004). Certain types of cranial malformations and deformations can create abnormal cranial shapes, which are similar to the results of intentional cranial modification.

Malformations

Of the multitude of cranial and craniofacial malformations known to medical science, only one type of pathology can create a skull shape that could readily be mistaken for the results of intentional cranial modification. Craniosynostosis is the premature fusion of one or multiple cranial sutures (Bronfin 2001; Moriss-Kay and Wilkie 2005; Ridgway and Weiner 2004; Tubbs et al. 2012). This developmental abnormality currently occurs at a rate of approximately 1 in every 2500 neonates (Bronfin 2001). Craniosynostosis is described as simple if a single suture is involved and compound if multiple sutures have closed prematurely. Furthermore, cases are also divided into isolated craniosynostosis, where the infant presents no other abnormalities and syndromic, where premature fusion of the suture is one of several associated anomalies (Bronfin 2001; Ridgway and Weiner 2004; Tubbs et al. 2012). The syndromic variant is less prevalent, representing approximately 20% of all cases despite the fact that over 150 syndromes are known to produce craniosynostosis (Tubbs et al. 2012).

The aetiology and pathogenesis of craniosynostosis are relatively complex. A wide range of both genetic and environmental factors have been established as the cause, though a single gene or chromosomal defect is the most common aetiology (Cohen 1993; Moriss-Kay and Wilkie 2005; Tubbs et al. 2012). Environment-based determinants are much more rare, but can include exposure to various teratogens (disruptors of embryonic and foetal development), a range of metabolic and hematologic diseases, and abnormalities of ossification (Bronfin 2001; Moriss-Kay and Wilkie 2005; Tubbs et al. 2012). Investigation has also indicated that intrauterine head constraint may predispose the infant to craniosynostosis (Ridgway and Weiner 2004). Finally, malformations of the cranium linked to a lack of brain growth can also result in the condition (Bronfin 2001; Cohen 1993).

The mechanism by which the premature fusion of a cranial suture can create an abnormal skull shape was first described by Otto and Virchow in the 19th century (Jane et al. 2000; Ridgway and Weiner 2004). The prematurely fused suture halts the growth of the brain at this articulation, causing brain growth to be redirected and creating an abnormal head shape. Compensatory growth tends to be greatest at the nearest open sutures and the volume of the brain and skull tend to extend perpendicular to the fused suture. Thus, craniosynostosis produces a range of abnormal head shapes depending on the location of the prematurely fused suture (see Figure 2) (Bronfin 2001; Ridgway and Weiner 2004).

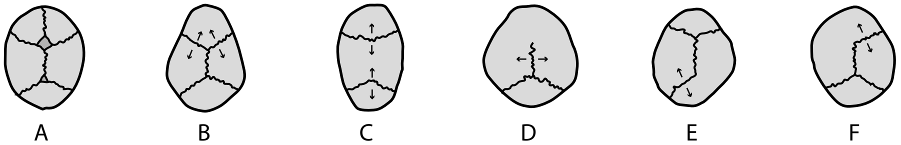

Figure 2 **An overview of the head shapes produced by craniosynostosis. A) normal, B) Trigonocephaly, C) Scaphocephaly, D) Brachycephaly, E) Posterior Plagiocephaly, F) Anterior Plagiocephaly.**

Deformations

Cranial deformations are a relatively common natural occurrence, with up to a third of newborns affected to some degree. In contrast to the previously mentioned malformations, the results of cranial deformation are typically mild and reversible. These cranial deformations can be grouped under the terms non-synostotic deformational or positional plagiocephaly.[2] The term plagiocephaly – derived from Greek and meaning bent or twisted head – refers to 'an asymmetrical, flattened deformity of the skull that can occur anteriorly or posteriorly' (Robinson and Proctor 2009:284). The resulting head shape is dependent on the location of mechanical pressure. Deformational brachycephaly refers to a shortening and widening of the cranial shape, in combination with a symmetrical flattening at the back of the skull. Deformational dolichocephaly or scaphocephaly results in a long and narrow head combined with facial asymmetries. The most common form of cranial deformation is referred to as occipital or posterior plagiocephaly and involves a flattening of both the occipital and forehead, resulting in a classic parallelogram shape (Littlefield et al. 2005; Ridgway and Weiner 2004; Robinson and Proctor 2009). A rare case of non-synostotic plagiocephaly is anterior plagiocephaly, where a prone sleeping position causes unilateral frontal flattening (Robinson and Proctor 2009).

The external forces that create non-synostotic deformational plagiocephaly can occur pre- and post-natally. Perinatal moulding is a common cause of cranial deformation, with approximately one in three infants affected. However, the results are generally mild and will subside within hours to weeks of birth without any medical mediation

2 The term plagiocephaly is also used to refer to the asymmetric head shapes produced by unilateral lambdoid or coronal synostosis. However, in this dissertation deformational or postional plagiocephaly refers solely to those deformations created by extrinsic forces.

(Bronfin 2001; Ridgway and Weiner 2004). Accordingly, infants should only be assessed for cranial deformation or malformation of a more permanent nature from six weeks of age onwards (Slate et al. 1993). Moulding occurs as a result of foetal head constraint, which is more common in first pregnancies, larger infants, cephalopelvic disproportion, a deficiency of amniotic fluid, multiple births, prolonged labour, *caput succedaneum*[3], and *cephalohematoma*[4] (Bronfin 2001:193). Babies in breech position generally have craniofacial and limb deformities due to the irregular in utero position. The skull becomes long and narrow, features a marked occipital shelf, overlapping lambdoid sutures and occasionally an indentation below the ears. Furthermore, babies born in breech position are more likely to develop torticollis, which is a causal factor in the development of non-synostotic plagiocephaly.

Figure 3 **Infant in a traditional Nez Perce cradleboard. Photograph by Edward S. Curtis (1911).**

Throughout early infancy, mechanical forces imposed on an infant's skull can create an asymmetric skull shape. The two most common factors in creating occipital or posterior plagiocephaly is a preferential supine sleeping position and a restriction of the movement of the infant's head. Since the promotion of a supine sleeping position for infants with the introduction of the American 'Back to Sleep' campaign[5] in the early nineties, an increase in this type of plagiocephaly has been detected (Bronfin 2001; Littlefield et al. 2005; Ridgway and Weiner 2004; Robinson and Proctor 2009). Other factors include prolonged time in car seats or baby swings. Likewise, this type of unintentional cranial deformation can also be observed among prehistoric populations using cradle boards or cradle constructions, an example of which can be seen in Figure 3, which restricted the movement of the infant (Littlefield et al. 2005).

3 *Caput succedaneum* 'is due to edema of the skin and subcutaneous tissues of the scalp resulting in a 'conehead' appearance, which normally resolves in less than 6 days' (Bronfin 2001:193).

4 *Cephalohematoma* is defined as 'a traumatic subperiosteal hemorrhage that does not cross a suture line. This deformity is initially soft and, with time, becomes firm and calcifies; it generally requires up to 4 months to resolve entirely' (Bronfin 2001:193-194).

5 This campaign was introduced by the American Academy of Pediatrics to reduce the occurrence of Sudden Infant Death Syndrome (SIDS) (Littlefield et al. 2005). Similar programs are in effect in most of the Western world (Carpenter et al. 2004).

Restriction in head movement can also be caused by medical conditions, including scoliosis and torticollis. Torticollis, also known as wry neck, involves an abnormal tilt of the head to one side and a rotation of the head in the opposite direction (Bronfin 2001; Cheng and Au 1994). This condition is usually due to strain on the neck during problematic deliveries or abnormalities of the cervical spine (Bronfin 2001). The posteriorly tilted side of the occipital will become flattened, since the child will tend to sleep on this side.

2.3 INTENTIONAL CRANIAL MODIFICATION

The practice of intentional cranial modification can be considered a cranial deformation from a medical point of view, as the altered head shapes are the result of mechanical forces on an otherwise normally developing skull. However, the premeditation of the human agent responsible for the extrinsic pressure on the skull clearly sets it apart from the naturally occurring deformations. Hence, intentional cranial modification warrants a separate discussion.

Terminology

Before turning to the practice of head shaping in all its diversity, a brief note on the terminology used in this dissertation is necessary. The term cranial deformation was often employed in the past to refer to such customs and this is technically correct when deformation is defined as 'an alteration of a body part that is developing normally until a mechanical force is applied' (Bronfin 2001:193). However, from an anthropological point of view the term leaves much to be desired. The word has clear negative connotations in the English language that are in direct opposition to the way in which the custom is viewed by its practitioners. Such derogatory terminology may in part be based on early Western prejudices against 'the Other' and such a Eurocentric perspective does not aid in detangling the complex social and cultural dynamics of the custom (Geller 2004, 2006). This thesis therefore opts to use more neutral terminology such as cranial modification, head shaping, or variations thereof.

The term intentional cranial modification is not universally accepted, as distinguishing between intentional and unintentional types of modification in the archaeological record can be problematic. Although the altered head shapes produced as unintentional side effects of child rearing practices generally consist of occipital flattening with a high degree of asymmetry, such asymmetry may also be seen among intentionally produced cranial shapes. An example of the difficulty associated with establishing intentionality in the past is the use of cradleboards among a wide variety of North American Amerindian groups. Cradleboards are generally considered to produce occipital flattening as a mere side-effect. However, certain groups, for example the Chinookan people of the Pacific Northwest coast, adapted the construction of the cradleboards with the aim to create a different cranial shape, thus moving cradleboards into the domain of intentional modifications (Dingwall 1931). Even without such additions in construction, the resulting occipital flattening produced by the cradleboard may be purposefully sought after. Among the Osage, the flattened occipital created by the cradle was considered an important marker of ethnic identity (Logan et al. 2003). Clearly, deducing this type of human behaviour in the past would be very difficult based solely on archaeological remains.

These difficulties have led some researchers to prefer the term artificial cranial modification, as an overarching term which incorporates all intentional and unintentional alterations of the human skull for which human agents are responsible. This research acknowledges the difficulty of determining intentionality behind past human actions, and particularly without the benefit of written sources, but the distinction is crucial when it comes to discussing social motivations behind altered head shapes. Clearly, unintentional modifications will lack the underlying social associations which are exactly what this study hopes to discuss in the Caribbean communities under investigation. Throughout this dissertation, it will be demonstrated that the cranial shapes found in the indigenous societies of the Caribbean are predominantly the result of intentional cranial modification practices and represent an important premeditated social choice.

Classifications

Since the first recorded typology of cranial modification was created by Gosse in 1855, a wide variety of classification systems have been proposed. This is partially due to differences in the criteria selected as the basis for the typologies: the shape of the skull, the type of modification device, the geographic distribution of different head shapes, or even ethnic or community names (Dingwall 1931). Numerous systems were created, but three stood the test of time and are still in common use: Hrdlička (1919, 1920), Imbelloni (1930), and Neumann (1942). The use of different typologies and terminology can complicate understanding of head shaping and hinder comparisons between investigations using different systems. Therefore, these three systems will be reviewed here and the parallels and correlations among the classifications will be shown, including the terminology chosen for this study.

Hrdlička

Hrdlička (1919) discusses all types of cranial deformations, dividing them into pathological, posthumous, and artificial categories. The pathological category consists of several variations of craniosynostosis and plagiocephaly. Hrdlička uses the term posthumous deformation to refer to any alteration of the skull shape caused by taphonomic processes, which can be accompanied by cranial warping or fractures. Finally, the term artificial deformation is used to group all alterations to the human skull as a result of cultural customs. Hrdlička further subdivides this category into non-intentional and intentional, with the unintentional modifications occurring as a side-effect of other child rearing practices as previously discussed (i.e. positional plagiocephaly).

Hrdlička subdivided intentional cranial modification into three main types: fronto-occipital, circumferential, and occipital modification. Fronto-occipital modification is defined as a flattening of the front and back of the skull accompanied by compensatory parietal bulging, the presence of a post-bregmatic depression, and a potential depression along the posterior part of the sagittal suture. The fronto-occipital compression creates a shortening and broadening of the cranial vault (Hrdlička 1919:191). Circumferential modification is typified by an annular depression along the frontal, temporal, inferior part of the parietals, and the lower section of the occipital. Compensatory growth of the skull takes place at the superior parts of the parietals and occipital, creating a narrow but long skull shape (Hrdlička 1919:191). Occipital modifications are characterised by a flattened occipital region. Hrdlička described this type as very similar to deformational plagiocephaly but generally more marked in appearance. Like fronto-occipital modifications, the skull becomes broader and shorter (Hrdlička 1919:191).

Hrdlička states that each of these main types may be subject to a number of variations, which relate to the different local modification devices. He does not, however, clarify what these varieties might be (Hrdlička 1919:191).

Imbelloni

The classification system devised by Imbelloni (1930) consists of two main types, tabular and annular modification. These can be subdivided into two subtypes or variations, oblique and erect, depending on the exact construction of the modification device and the resulting compensatory growth direction of the skull.

Tabular modification is a result of pressure on the front and back of the skull and leads to a shortening and broadening of the cranial vault (Dembo and Imbelloni 1938:255). The oblique variant is defined by a flattened plane on the occipital roughly parallel to the frontal flattening, whereas the erect variant shows an upright flattening of the back of the skull.

Annular modification is created by bandages wrapped tightly around the skull, causing a circumferential flattening and consequently a longer and narrower cranial vault (Dembo and Imbelloni 1938:255). Again, tabular and oblique varieties of this shape exist depending on the placement of the bandages.

Neumann

Neumann, building on the work of Hrdlička, Stewart and other scholars, created a classification of six types of altered skull shapes, which includes several variations on Hrdlička's main types. Like Hrdlička, Neumann's classification is based on the altered regions of the cranium and uses anatomical terminology (Neumann 1942).

The first type is obelionic deformation, previously described by Stewart (1939). The flattening takes place between bregma and lambda, at an angle of about 30-40 degrees with the ear-eye plane. Cranial growth is balanced by an expansion of the cranial vault at the anterior sections of the parietal and temporal bones (Neumann 1942). The second type is simple occipital deformation, a flattening of the occipital bone at a right angle to the ear-eye plane. The resulting skull shape is frequently asymmetric and tends to be unintentional, i.e. a result of cradle boarding (Neumann 1942). A variation of this shape is referred to as lambdoid deformation, in which the flattened plane is at an angle of 50-60 degrees to the ear-eye plane. This seems to be a shape sporadically encountered among certain societies in the south-eastern United States (Neumann 1942).

Bifronto-occipital modification is created by a bilateral flattening of the frontal bone and vertical flattening of the occipital. This produces a narrow frontal bone and is found in the north-eastern and midwestern United States (Neumann 1942). Fronto-verticoöccipital is typified by frontal and vertical occipital flattening. This type is created by boards tied to the front and back of the skull, where the occipital board can consist of cradleboard or a loose board. The compensation of growth takes place in a superior direction (Neumann 1942). Fronto-parieto-occipital modification, first described by Stewart, has three planes of flattening at right angles to each other. Since cranial growth is restricted in a superior direction, the skull expands laterally, in contrast to the fronto-verticoöccipital type (Neumann 1942). The final type in Neumann's typology is parallelo-fronto-occipital modification, in which the planes of flattening at the front and the back of the skull are roughly parallel. Skull growth is redirected in a lateral fashion, creating a broadening of the cranial vault (Neumann 1942).

Neumann did not include circumferential modification in his typology, despite referring to it in his article as annular modification (Neumann 1942). Although Neumann fails to provide an accurate description of the way in which this type is produced, he does mention that compensatory growth takes place in a superior-posterior direction (Neumann 1942). In all, Neumann succeeded in clarifying and enhancing the classification provided by Hrdlička. However, some of his types represent very local variations of intentional cranial modification which may have limited use in other geographical areas.

Comparing Classifications

Despite the different terminologies used in these systems, there are clear correlations between the main categories. In fact, the two main types created by Hrdlička and Imbelloni are identical in all but name, as can be seen in Table 1. These typologies are applied in different parts of the world, with the system proposed by Hrdlička widely used by the Anglophone scholarly community whereas Imbelloni's classification is widespread among Latin American scholars. The compatibility between the systems is advantageous, as it allows for cross-cultural comparisons between different regions.

This study has opted to use the nomenclature from the system proposed by Hrdlička with the added differentiation in the direction of occipital flattening. A category for frontal flattening was also added. A full description of this system and the justification for this choice can be found in the description of the methodology in Chapter 5, but it has been reproduced here as this is the terminology that will be used throughout the rest of the study for ease of comparison between different investigations into head shaping practices.

Table 1 **A comparison of the three main classification systems and the nomenclature used in the current study, demonstrating the high degree of overlap between the systems. * Annular is not technically a part of the division of cranial shapes by Neumann (1942) as it does not occur within his sample, but he does mention the term elsewhere in his article.**

Hrdlička	Imbelloni	Neumann	Current Study
Fronto-Occipital	Tabular Oblique	Parallelo-Fronto-Occipital	Fronto-Occipital Parallel
Fronto-Occipital	Tabular Erect	Fronto-Verticoöccipital	Fronto-Occipital Vertical
Circumferential	Annular	Annular*	Circumferential
Occipital		Occipital	Occipital Flattening
		Bifronto-Occipital	
		Fronto-Parieto-Occipital	
		Lambdoid	
			Frontal Flattening

Means of Modification

There is an important correlation between the altered head shapes and the modification devices that can be used to create intentional cranial modification. The location of external pressure determines the direction of compensatory growth and thus the resulting shape of the skull (Hrdlička 1920; Dembo and Imbelloni 1938). Hence, an analysis of skull shapes encountered in an archaeological context can yield important information on the type of device used by the society in question. Furthermore, differences among skulls within a population may point to minor or major variations in the construction of the modification device and thus different communities of practice (Hoshower et al. 1995; Tiesler 2012).

Besides the variation in altered head shapes, the degree of cranial modification ranges from very mild alterations to extreme changes to the skull shape. This fluctuation in degree can be attributed to several factors: the age of the subject when the practice is commenced, the length of time during which pressure is exerted, the amount of pressure applied, and the degree of flexibility of the materials used in the construction of the modification device (Littlefield et al. 2005; Oetteking 1930; Tiesler 2010).

Several methods can be used to exert pressure on the infant skull and intentionally alter its shape. In most cases, the practice seems to be executed by a female: the mother, a midwife or another female family member (Dingwall 1931; FitzSimmons et al. 1998; Tiesler 2010, 2011, 2012). Knowledge on the practice is held and passed on by women, while men tend to have little awareness of the custom (FitzSimmons et al. 1998).

Moulding or massaging the infant's head is a common element of child care practices, both in ethnographic case studies (Dingwall 1931) and modern populations (FitzSimmons et al. 1998; Herskovits 1964). The moulding of the head is occasionally accompanied by the use of oils or the massaging of other body parts (Dingwall 1931; FitzSimmons et al. 1998; Hatt 1915). The resulting cranial alterations are very mild and would be extremely difficult to detect in the archaeological record without additional knowledge of child-rearing practices (FitzSimmons et al. 1998:90). In several cases, the use of tight caps or coverings is reported to maintain or enhance the desired head shape (FitzSimmons et al. 1998; Hatt 1915). The entire process, with or without the additional use of constricting head coverings, takes place from birth until approximately one year of age, after which the resulting shape is fixed.

Head coverings may also be used as the sole modification device. These coverings can take the form of caps, hats, or ribbons and are often part of the traditional infant costume (Barge 1912; Delisle 1902; Dingwall 1931). These restrictive coverings can produce mild or marked modifications of the skull, depending on the tightness of the headgear and the location of exerted pressure. The resulting cranial modification can be seen as intentional or unintentional, since in milder cases it can be difficult to judge the practitioner's objectives.

Textiles, in the form of bandages or cords, may also be wrapped tightly around the skull in a circular fashion, resulting in the circumferential type of modification (Blackwood and Danby 1955; Dembo and Imbelloni 1938; Flower 1898). Animal hair, animal skin, bark, kelp, and other natural materials may also be used (Dingwall 1931; Oetteking 1930). The exact location of the bandages may create varieties of circumferential modification, and the amount of pressure and flexibility of the chosen material can create differential degrees of modification ranging from mild to marked (Dembo and Imbelloni 1938; Hrdlička 1919).

The use of firm tablets to modify the shape of the skull has an almost global spread (Dembo and Imbelloni 1938; Dingwall 1931). However, there are a multitude of ways in which these devices are constructed (Allison et al. 1981; Dembo and Imbelloni 1938). The board is usually made of wood, but can be substituted by other rigid materials or pads filled with clay, sand, or other natural materials. One or multiple boards may be used, with the location of each board determining the resulting cranial shape. A common construction uses two boards, located at the front and back, which are tied together by textiles. Another variant uses a board at the front of the skull held in place by a band around the occipital. The basic design of a cradleboard may also be altered to include a tablet or pad at the front of the skull (Dembo and Imbelloni 1938; Dingwall 1931; Mason 1889). All variations create fronto-occipital modification, a broadening and shortening of the skull with flattened areas in the exact location of the boards. In rare cases, parietal flattening is achieved by a device consisting of two boards at the sides of the skull (Dingwall 1931; Neumann 1942).

The cradle in which infants spend the first part of their lives can also cause alterations to their cranial shape. Flattening of the occiput can take place if the infant's head rests on a firm surface in the same position for some time. This was the case with infants from many Amerindian groups who were bound to cradleboards, that simultaneously served as a resting place for the infant and a transportation device (Mason 1889:161). However, such unintentional modifications may result from any situation in which the movements of the infant are restricted and the head rests on a hard surface, for example swaddling practices in post-medieval Europe (Dingwall 1931) or prolonged use of modern car seats (Tubbs et al. 2006). The resulting occipital flattening, which is often asymmetrical in nature, may be unintentional and simply a side-effect of child rearing practices or the cradle's construction. However, certain cradle designs show deliberate attachments aimed at creating an altered head shape (Dingwall 1931; Mason 1889).

Consequences of Cranial Modification

It is readily apparent that head shaping practices will have an impact on cranial shape and many studies have focussed on these effects of cranial modification on the human skull, both in general and in relation to particular types of modification. These will be presented following the system of cranial shapes selected for this study. The integrated nature of cranial growth and development implies that there may be additional changes to the skull resulting from the human influence on the natural cranial shape. The varying results of studies into the relationship between cranial modification and cranial non-metric traits will be presented, followed by a discussion of potential negative side-effects reported in ethnohistorical and ethnographic sources.

Cranial Morphology

The changes to the shape of the cranial vault created by head shaping are readily discernible through visual inspection and as a result, vault alterations are often used as a basis for descriptions. However, changes to the base and facial regions of the skull have been subject to a substantial debate since they were first recorded at the beginning of the 20th century. Part of the inconsistencies reported to date may stem from underlying genetic differences between populations or methods used to gather data. Here, a brief overview will be given of the most reliable studies using the classification system selected for this study.

The pressure placed on the front and back of the skull in fronto-occipital modification results in a compensatory reduction in cranial length, increased cranial breath, and a broadening and flattening of the cranial base (Cheverud et al. 1992; Dembo and Imbelloni 1938; Hrdlička 1919; Oetteking 1930). Facial changes have also been reported for fronto-occipital modification, although there is some variation between different studies. Anton's (1989) study of Peruvian crania showed that fronto-occipital modification produced significant differences in upper facial height, bizygomatic breath, interorbital breath, pyriform aperture breath, and the upper facial index. Cheverud and colleagues (1992) concluded that fronto-occipital modification resulted in a shorter and wider face, mainly as a response to the changes in the cranial base and vault, and a posterior and inferior shift of the orbital rim. Similar facial differences in relation to fronto-occipital modification, increased breath and height measurements, were found by Rhode and Arriaza (2006) and Manríquez and colleagues (2006).

However, Cheverud et al. (1992) also noticed significant differences between the two populations with fronto-occipital modification used in their study, which may result from different population genetics or variation in the manner in which fronto-occipital modification was achieved. Intriguingly, a study using 3D morphometric analysis of crania by Ross and Ubelaker (2009) showed no significant differences in the position of the facial landmarks in crania with fronto-occipital modification. This may be due to the elimination of individual size differences in this new methodology.

Circumferential modification is achieved by a tight wrapping of the skull. This lateral restriction of cranial growth results in a compensatory longitudinal development of the vault and base (Dembo and Imbelloni 1938; Hrdlička 1919; Kohn et al. 1993; Oetteking 1930). Among a population from Ancon in Peru, this type of cranial modification caused a reduction of the upper facial index, palatal breath, and palatal length as well as an increased orbital height, orbital index, and palatal index (Anton 1989). Blackwood and Danby (1955), Brown (1981), and Rhode and Arriaza (2006) report similar changes. Kohn and colleagues (1993) report an increase in antero-posterior facial growth and a decrease in antero-lateral to postero-medial dimensions. However, Frieß and Baylac (2003) report an increased anterior and interior projection of the face, but consider the relative dimensions of the face to be unchanged. Furthermore, a study by Kohn et al. (1993) shows differential facial involvement between the Kwakwaka'wakw and Nuu-chah-nulth in their sample, despite both being populations from the Pacific Northwest Coast.

Frontal flattening is created by direct pressure on the frontal bone and leaves a corresponding plane of flattening. Occasionally, the board used in this procedure is held in place by ties at the back of the head. In those cases, very mild occipital changes may be observed. Most investigations into the effects of cranial modification on morphology have focussed on the differences between the fronto-occipital and circumferential types, as these are both more common and more marked in degree. Frontal flattening may have an impact on cranial morphology similar to that reported for fronto-occipital modification, but it is likely to be far less marked.

Flattening of the occipital can result from the application of a hard board to the back of the head, the use of a cradleboard, or resting on a hard surface for a prolonged period of time (Kohn et al. 1995; Mason 1889; Tubbs et al. 2006). A little more investigation has been done into the effects of occipital flattening. The practice of cradleboarding did not impact the cranial base in the study by Kohn and colleagues (1995). Statistically significant differences were observed in upper and lower facial height in a prehistoric Hawaiian sample with occipital flattening (Schendel et al. 1980). However, a study of the Lebanese practice of cradleboarding produced no facial differences (Ewing 1950). If the flattening is asymmetrical, compensatory changes may occur such as contralateral occipital bossing and a forward displacement of the ipsilateral ear (Ridgway and Weiner 2004).

Cranial Non-metric Traits

Investigations have also focused on the potential influence of cranial modification on non-metric traits. Non-metric or discrete traits are 'morphological variants of anatomy' (Saunders and Rainey 2007:533) that can be found in any human tissue. Osteologists have described several hundred of these skeletal and dental variations, which are generally non-pathological in nature (Hauser and De Stefano 1989; Saunders and Rainey 2007). Initial investigations pointed to a high degree of genetic influence in the development of these variations (Berry and Berry 1967), but later studies demonstrated that these traits in fact represent the phenotype of an individual and may be influenced by physiological (i.e. sex and age) and environmental (i.e. activity and pathology) factors (Hauser and De Stefano 1989; Saunders and Rainey 2007). As was the case with the changes to cranial morphology, different investigations have found divergent results. Still, a general overview of the most important differences and the potential to use these in the visual determination of cranial modification status will be presented here.

Konigsberg and colleagues (1993) investigated the correlation between three different types of cranial modification (circumferential, fronto-occipital, and lambdoidal flattening) and 39 non-metric traits. Their results show that cranial modification only impacts a minority of traits.[6] If we exclude the effects on wormian bones, which will be discussed below, only two traits are affected. Konigsberg et al. (1993) conclude that the overall impact of modification on non-metrics is trivial. Interestingly, their results do show that the traits and locations of the skull most impacted by modification are dependent on the type of modification and the points at which most pressure is exerted on the cranium in the early years of life. These conclusions are supported by a recent study of Argentinian material by Del Papa and Perez (2007), who suggest that the traits most impacted will be those that develop postnatally and near the cranial regions which endure the greatest pressure and shape alterations during the modification process.

An examination of lambdoid sutural complexity in a small sample of southwest Native American crania shows an apparent increase in the complexity of the upper half of the lambdoid suture (Gotllieb 1978). Gottlieb proposes this is a direct result of increased pressure on the suture, based on the work by Moss (1958), which shows a relation between interdigitation of sutures and external forces. A later study by Anton and colleagues (1992) showed a rather limited increased sutural complexity

6 'Specifically, in the Hopi, deformation acts to decrease the relative frequency of left masto-occipital ossicles, and increases the relative frequency of the right foramen spinusom open, right foramen of Huschke, and sagittal ossicles. Among the Nootka, deformation increases the relative frequency of left and right coronal ossicles, while for Ancon, deformation acts to increase the relative frequency of sagittal ossicles. Among the Kwakiutl, deformation decreases the relative frequency of left epipteric bones, while increasing the relative frequency of the right parietal notch bone, right masto-occipital ossicles, and left and right coronal ossicles.' (Konigsberg et al. 1993:39-40).

in the coronally oriented sutures associated with circumferential modification. They suggested a variety of factors might limit the effect of modification on sutural interdigitation, although their evidence does support a link between head shaping and wormian bones.

Others have argued that the pressure exerted on the cranial sutures during the modification process may lead to premature closure of a suture, a condition also known as craniosynostosis. In a discussion on Andean cranial modification practices, Allison et al. (1981) observe several cases of premature closure of the sagittal or coronal suture in modifications which produce a high vault. However, they do not give a clear number of cases and produce an estimate that this occurs in 5 to 10 percent of cases without providing the actual prevalence in their sample. Similarly, Posnansky (1896, in Guillen 1992) reports a single case of premature suture closure in relation to annular modification without indicating the affected suture and extrapolates that this must be related to extreme modifications. These reports have been rather incidental, simply reporting on one or a handful of cases in a sample.

Gerszten (1993) observed earlier suture closure as well as a different pattern of suture closure in a number of populations from Northern Chile. However, the age of individuals was established based on dental wear patterns. With a sample spanning from 6000 BC to AD 1600, the use of dental wear patterns for ageing is extremely problematic due to potential shifts in dietary practices as well as food preparation techniques. Thus, it is difficult to assess the reliability of age assessment in the sample, a vital component for discussing whether sutures have indeed fused prematurely. White (1996) specifically studied the relation between premature sagittal suture closure and modification in the Lamanai site in Belize. This study reports a substantial difference in the prevalence of sagittal synostosis between the modified and normal subset of the sample. White hypothesises that this may result from deformations of the cranial base as a result of intentional modification practices or from extrinsic forces placed on the sagittal suture during key moments in the development of the skull (White 1996). However, the evidence for differential suture closure due to head shaping is still very tentative and some authors do not observe different rates of sutural closure (Blackwood and Danby 1955). More research should be executed, similar to White's work on carefully selected samples from different populations, before conclusions can be drawn.

Wormian Bones

Wormian bones - also referred to as supernumerary bones, sutural bones, and ossicles – are isolated bones of variable size and shape that form from independent ossification centres within the cranial sutures and fontanelles (El-Najjar and Dawson 1977; O'Loughlin 2004). The aetiology and developmental trajectory of these supernumerary bones have been a tropic of scholarly debate for over a century, ever since Dorsey (1897) proposed a link between the presence of wormian bones and the pressure exerted by cranial modification. Since then, numerous studies have attempted to clarify the origin and development of wormian bones with results ranging from complete genetic control (Berry and Berry 1967; Finkel 1976; Torgersen 1951; Wilczak and Ousley 2009) to environmental stress (Bennett 1965; Ossenberg 1970). Recently, researchers have favoured a hypothesis which suggests wormian bones are epigenetic in nature: their presence is determined genetically yet environmental factors can exert an influence on the frequency per individual (Anton et al. 1992; Del Papa and Perez 2007; El-Najjar and Dawson 1977; Konigsberg et al. 1993; O'Loughlin 2004; Sanchez-Lara et al. 2007; van Arsdale and Clark 2012; Wilczak and Ousley 2009; White 1996).

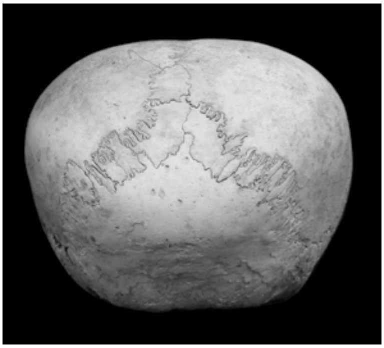

Figure 4 **Multiple wormian bones visible along the sagittal and lambdoidal sutures in the occipital view of individual LGC443, catalogue No. 349443, from the Department of Anthropology, Smithsonian Institution.**

However, these studies do not agree on the degree of influence created by cranial deformations and modifications. These disparities are due to several limiting methodological factors that should be taken into account when undertaking these types of studies and comparing results: using sample sets compiled of biologically different populations, not accounting for differences in modification type, and variations in the degree of cranial modification and thus the amount of pressure present.

Hanihara and Ishida (2001) have shown significant inherent differences in the frequencies of four types of wormian bones[7] between populations. This substantial interregional variation can skew the results of studies that group populations from different biological and geographical backgrounds, such as those by O'Loughlin (2004), Konigsberg et al. (1993), and Sanchez-Lara et al. (2007). However, such a mixed dataset can be employed to investigate whether different types of modification – and thus different points of pressure on the skull – will have a distinctive result on occurrence and frequency of wormian bones. The effect of localised pressure on specific types of supernumerary ossicles was shown by both O'Loughlin (2004) and Konigsberg and colleagues (1993).

7 Lamdoidal wormian bones, parietal notch bones, asterionic bones and bones in the occipito-mastoid suture (Hanihara and Ishida 2001).

Despite the small inconsistencies between the different studies, most of which are due to the methodological issues discussed previously, the overarching conclusion would have to be that wormian bones are indeed epigenetic in nature. Supernumerary ossicles are partially hereditary, explaining their presence in normal crania throughout the world and the varying degrees in which they are encountered. However, it seems that environmental influences, such as external pressure on the skull from a modification device, can have a moderate proximal effect on these traits (O'Loughlin 2004; Del Perez and Papa 2007; Saunders and Rainey 2007; van Arsdale and Clark 2012).

Post-bregmatic depression

One of the earliest references to a potential correlation between a post-bregmatic depression and cranial modification can be found in Hrdlička's Anthropometry (1920) and Oetteking's Account of the Jesup North Pacific Expedition (1930). Hrdlička (1920:48) discusses the presence of a depression 'along and just posterior to the coronal suture' in both fronto-occipital and circumferential modifications. Oetteking (1930) mentions that this transverse groove, just behind the coronal suture, is found occasionally in crania with fronto-occipital and circumferential types of modification and is produced by pressure on the frontal bone during the modification process. Goldstein (1940:313) refers to a 'saddle-like depression' which 'often occurs just back of bregma' and posits that this groove is due to simultaneous compression of the front and back of the skull.

Figure 5 **Post-bregmatic depression visible in the lateral view of individual DCAJ025, 1895 4038, from Limestone Cave, Jamaica, Duckworth Laboratory, LCHES, Cambridge.**

Post-bregmatic grooves or depressions have been identified in several other studies of intentional cranial modification (Anton and Weinstein 1999; Brown 1981; Clark et al. 2007; Ricci et al. 2008; Tiesler 2012; van Duijvenbode 2010). Although the trait is seen more frequently in the modified subset of the sample, it is not universally present in modified crania. Tiesler (2012) hypothesises that these grooves represent the redirection of cranial growth after the disappearance of the fontanelles and demonstrates that the degree of expression of the post-bregmatic depression is related directly to the severity of the modification and the amount of the frontal bone which is subjected to flattening.

Despite the evidence suggesting post-bregmatic depressions are a result of cranial modification, these grooves are also encountered as a non-metric trait in normal crania. In fact, the trait is often used in the forensic assessment of ancestry, as individuals of

African descent are more likely to have a slight concavity of the area behind bregma (Byers 2008; Gill 1998; Rhine 1990; cf. Hefner et al. 2012). More research is required into the origin and development of this trait, which similar to wormian bones, may be epigenetic in nature.

Sagittal depression

Another depression found in association with head shaping is a groove along the posterior section(s) of the sagittal suture (Dembo and Imbelloni 1938; Hrdlička 1920; Tiesler 2012). Crania with this indentation are often referred to as bilobed (Hrdlička 1920:48; Dembo and Imbelloni 1938:271), as the depression separates the two parietal lobes and creates a heart-shaped form in the superior view.

There is some debate in the literature on the nature of the sagittal depression. Dembo and Imbelloni (1938) consider it a direct result of pressure by an overlying bandage, while Hrdlička (1920) suggests it is an indirect consequence of the compression of the cranium, similar to the aetiology of the post-bregmatic depression. Tiesler (2012) hypothesises that both explanations may be valid, as depressions along the sagittal suture may result from direct pressure produced by a part of the modification device or as a result of the general compression of the skull. Evidently, more research is needed to determine the precise cause of these sagittal grooves and the resulting bilobed appearance of the skull in the superior view.

Sagittal keeling

There is only anecdotal evidence of the relation between cranial modification practices and metopic or sagittal keeling, bulging on the outer cranial vault located along the respective sutures. A study by Anton and Weinstein (1999) has shown slightly higher levels of sagittal keeling associated with fronto-occipital modification in a mixed sample from South America. Circumferential modification was associated with higher frequencies of metopic keeling yet lower frequencies of sagittal keeling. So far, no other studies have confirmed this correlation and it should be noted that the South American sample is composed from populations from four different regions (i.e. Bolivia, Chile, Peru, and Argentina) and an unknown number of sites. Hence, the biological distance between these populations is unknown and their grouping into a single sample can be questioned. Furthermore, the study does not separate vertical and parallel subtypes of modification which may further confuse the results.

Lesions

One of the first associations between cranial lesions and head shaping was made by Broca in the 19th century (Broca in Topinard 1879). Broca suggested that the pressure exerted on the skull during the modification process could lead to inflammation of the bone. A report by Dingwall on the use of bandages to create circumferential modification in 19th century France includes a description of infected and festering ulcers (Dingwall 1931). Reports of periosteal lesions, invariably on the occipital, have been reported by several authors in various Peruvian individuals and populations (Allison et al. 1981; Guillen 1992; Stewart 1976; Weiss 1932, 1958), a population from New Mexico (Holliday 1993), and a number of individuals from Northern Chile (Gerszten 1993).

Stewart (1976) suggests the pressure of the modification device impedes the circulation of blood within the growing occipital bone in early childhood, resulting in necrosis of the tissue and the potential development of lesions on the bone at the point of most pressure. Furthermore, these lesions are almost always associated with fronto-occipital vertical modification or cradleboarding practices (Stewart 1976; Holliday 1993), since these types of modification would produce the highest pressure on the supra-inion region of the skull.

However, Stewart's study also found these lesions, which he refers to as supra-inion depressions, in skulls without cranial modification, albeit in lower percentages than in the populations practicing head shaping. This lead him to conclude that 'the presence of a type of deformation in which the deforming pressure was exerted at the most prominent part of the occiput enhances a natural tendency towards the formation of a depression just above inion' (Stewart 1976:426). Anton and Weinstein (1999) have shown a high frequency of the trait in a non-modified population from Australia, suggesting that there may indeed be an underlying genetic aetiology to the trait which varies between modern human populations.

Potential Adverse Secondary Effects

Since the earliest descriptions of skulls with cranial modification in popular and academic writing, a debate has raged about the potential negative side effects of such alterations, including diminished intelligence, pain, and even death. The evidence for such adverse secondary effects will be discussed here.

Some scientists believed such remodelling of the brain case and by extension of the brain itself must result in serious intellectual consequences for the individual in question (Broca 1875; Gosse 1855; Posnansky 1924; Wyman 1881-1882). However, others were convinced that cranial modification would not impair the function of the brain (Dingwall 1931; Oetteking 1930; Rogers 1975; Wells 1964). Studies have shown that head shaping forces the human brain to adapt its shape under the influence of the pressure exerted by the modification device, but that the intrinsic rate of growth remains the same (Moss 1958). Cranial capacity and brain volume are similar in modified and normal skulls, suggesting the normal function of the brain is not significantly impacted

(Gerszten 1993; Moss 1958). Overall, the argument has been made that any practice with gross negative impact on cognitive function would not have been continued (Gerszten and Gerszten 1995; Lekovic et al. 2007).

The absence of substantial impact on mental capability is supported by a variety of ethnographic accounts that do not report any negative impacts on the intelligence of populations with modified crania in comparison to their peers (Flower 1898; Lewis et al. 1843; Morton and Combe 1839; Scouler 1829). An interesting example is the following description provided by Townsend, who despite his rather obvious negative attitude towards the altered head shapes encountered during his travels in the American northwest, does not appear to have been biased in his description of the mental capacity:

> 'The appearance produced by this unnatural operation is almost hideous, and one would suppose that the intellect would be materially affected by it. This, however, does not appear to be the case, as I have never seen (with a single exception, the Kayouse) a race of people who appeared more shrewd and intelligent' (Townsend 1839:175).

A potential connection between cranial modification and apoplexy (stroke) is infrequently mentioned (Scouler 1829; Rogers 1975) but this hypothesis has never been proven (Dingwall 1931:181). The same applies to the potential for cranial modification to cause epileptic fits (Dingwall 1931:50).

Another long-lasting debate has raged on the topic of infant suffering during the modification process. Certain sources report children appear to be in pain when undergoing these modifications, with a mention of continual nose bleeds under pressure and the frequent reporting of a bulging appearance of the eyes (Breton 1999 [1665]; Dingwall 1931; Flower 1898; LeBlond 1813; Scouler 1829). This latter feature is described in a colourful fashion by Cox: 'The appearance of the infant, however, while in this state of compression, is frightful, and its little black eyes, forced out by the tightness of the bandages, resembled those of a mouse choked in a trap' (Cox 1831:302). On the contrary, others describe children as calm and not distressed (Blackwood and Danby 1955) and apparently not in any pain (Flower 1898; Mayntzhusen in Dingwall 1931:203; Meares 1790). These discrepancies on the issue of suffering may stem from different modification procedures: the location and degree of pressure may be important. Unfortunately, this disagreement cannot be solved based on the original sources and must remain an uncertain factor.

It is of some importance, however, as chroniclers have reported that the suffering may in some cases have been extreme enough to cause death. Father Cobo, in his discussion of Peruvian modification practices, mentions 'he knew of one child who died from the pain caused by the operation and doubtless there were others also who suffered a similar fate' (in Dingwall 1931:214). This remark was repeated by Diez de San Miguel in regards to the practice in Peru (in Guillen 1992) and Bishop Diego de Landa in his description of head shaping among the Maya (Dingwall 1931:153). Similar assertions of cranial modification as the cause of death have been made by Guillen and colleagues (in Boston 2012:111) for two individuals and Mendonça de Souza and colleagues (2008) for a Peruvian mummified infant. Such anecdotal evidence has been used to propose death as a serious side-effect of cranial modification.

Attempts have been made to investigate whether cranial modification does in fact result in higher infant mortality rates, despite the inherent issue of the osteological paradox (Wood et al. 1992) and the problems of establishing cause of death through the analysis of archaeological human remains (Sauer 1998; Waldron 2001). The vast majority of fatal afflictions, be it disease or trauma, do not leave evidence behind on the skeleton. As Waldron puts it in his discussion on palaeopathology:

> 'Skeletal diseases are uncommon, as most diseases affect the soft tissues: this is certainly the case for the killing diseases. Thus, it is generally impossible for palaeopathologists to determine the cause of death of those they examine' (Waldron 2009:1).

Additionally, even active skeletal lesions present in an individual at the time of death cannot simply be assumed to be the causative agent, as other factors or complications that leave no skeletal traces could also be involved. Therefore, physical anthropologists are often hesitant to declare a cause of death for an individual apart from those rare cases where the nature of the trauma is clearly fatal (e.g. a gunshot wound to the head). In addition to these important issues, which complicate a meaningful assessment of the relationship between mortality and cranial modification, other factors have further complicated previous investigations.

Boston's (2012) study is one of the major investigations looking at the relationship between mortality and cranial modification beyond the level of anecdotal evidence. The study concludes that the practice of head shaping leads to increased morbidity and mortality in populations, using a pooled sample from Chile spanning almost 9,000 years. Although such pooling is a statistical necessity in most osteological investigations, it means that significant cultural and environmental changes that could affect disease and mortality rates in these populations cannot be accounted for. Furthermore, the fact that postcranial remains were apparently not available for analysis means that a full osteological and pathological assessment of the individuals could not be conducted and a significant amount of data necessary for the proper diagnosis of age, sex, and pathological conditions is missing. Thus, a proper investigation of all factors, specifically disease and trauma, contributing to population mortality was not possible. Overall, these factors make the sample inappropriate for the analysis as executed and call into question some of the conclusions.

This does not mean that extreme compression of the skull may not have occasionally resulted in the death of an infant undergoing cranial modification. However, incidental fatal consequences are a far cry from structural health risks and increased mortality of infants in societies which practiced head shaping. As of yet, no compelling evidence for the latter has been found. In fact, considering the enormous amount of adult modified crania found in skeletal collections across the globe representing individuals that survived the practice into adulthood, death as a result of cranial modification should probably be considered a highly unusual and atypical outcome.

A Question of Motivation

Human cranial development can be altered by numerous factors, including genetic and environmental influences, resulting in a variety of different cranial shapes. The role of humans as intentional agents in this process has been highlighted throughout this chapter and illustrated with several examples that hint at the wide temporal and geographical distribution of such head shaping practices. The social and cultural dimensions of intentional cranial modification, including the intriguing question of motivations, will be explored further in the discussion of the social skull.