# Touching the surface: Biological, behavioural, and emotional aspects of plagiocephaly at Harappa

By: Gwen Robbins Schug

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## Abstract:

In biology, the maternal–fetal interface refers specifically to the hemochorial, immunological, and hormonal relations between mother and offspring in placental mammals. Anthropologists broaden the definition to include sociocultural and behavioral aspects of the developmental environment, maternal-fetal relations, and identity construction. This chapter describes the differential diagnosis and a social bioarcheology interpretation of crania from two children, approximately 5 years old at death, interred in an ossuary (Area G) at the prehistoric city of Harappa, Pakistan (2000–1900 BCE). Both children were affected by variation in cranial shape known as plagiocephaly; viewed from above, the crania are asymmetrically distorted by flattening on one side of the frontal or occipital region. This striking variation in shape results when cartilaginous sutures that typically separate the bones of the cranial vault fail to form or prematurely close. Plagiocephaly can also be deformational. This chapter describes a biomedical method to tease apart intrauterine and postnatal causes of plagiocephaly—genetics, epigenetic factors, intrauterine constraints, plural birth, prolonged vertex molding, postnatal sleeping posture, supine positioning, and/or conditions that limit movement in young infants and children, such as torticollis—and the likely cognitive effects of the condition. The chapter then describes biocultural interpretations of these two individuals using a theoretical approach rooted in an archeology of emotion to explore social identity, motherhood, and the emotional response to plagiocephaly at Harappa.

**Keywords:** Bioarcheology | Archaeology | Emotion | Palaeopathology | Congenital | Plagiocephaly | Harappa | Indus civilisation | Childhood | Maternal–infant nexus

## Article:

### Introduction

Philosophers have long explored the connection between perception, sensation, emotion, memory, and time. Sensation (e.g., seeing, hearing, etc.) and sensory modalities (e.g., sense of pain, heat, and movement, etc.) are the basis for human interactions with the world and each other. If archeologists can identify a material signature of sensation and emotion in the past, we can imagine how these processes drive the constitution of daily existence and social life (Fleisher & Norman 2016; Harris & Sørensen 2010; Kus 1992; Meskell 1998; Stutz 2003; Tarlow 1999; Tarlow 2000; Tarlow 2012). Bioarchaeologists have thus begun to consider aspects of human sensation and experiences through research on embodiment, violence, disease, deviant burials, disability, and care (Boutin 2016; Gowland & Knüsel 2006; Sofaer 2006; Spence et al. 2014; Tilley 2015), but emotion is still largely under-theorised in our narratives. In part, this is because of a potential pitfall with the archaeology of emotion. Empathy as an approach to archaeology has significant limitations and risks ethnocentric projections of essentialised feelings and perspectives on the "other." However, it may be possible for archaeologists to recognise some aspects of emotional and perceptual experiences that underlie our interactions with the material and social world (e.g., Fleisher & Norman 2016) if we remain conscious about the ways in which perception and specific emotions are deeply historically and culturally situated.

Emotion is a term that spans a variety of disciplinary definitions and the meaning of this term varies from a focus on emotion as a mental state, neurological function, chemical transaction, hormonal condition, bodily agitation, evolutionary adaptation, linguistic phenomenon, constructed social experience, or a form of cultural knowledge, or even tradition (Tarlow 2012). Emotions transcend philosophical distinctions between "mind" and "body" (Damasio 1999). They lack essential properties of matter but they have measurable, morphological consequences on both the form and function of bodies (and parts of bodies) as we perceive, understand, and communicate emotional information (Hamann et al. 1996; Ratcliffe 2008; Rosaldo 1994; Winkielman et al. 2016). Emotional experiences are cross-culturally variable but they are also embodied (Barsalou et al. 2003; De Gelder et al. 2004; De Gelder 2006; Desjarlais 1992; Kus 2010; Yu 2002). Ultimately, emotion drives social change (Fleisher & Norman 2016), and a local, contextual consideration of embodied emotional experiences could provide a critical tool for examining human relations and power in the past (Tarlow 2012).

This chapter has a few related goals. First, I provide an analytical approach to two individuals with plagiocephaly from Harappa. Using a differential diagnosis approach based on clinical literature, I make some inferences about the biocultural experience of these children, in utero and as infants. Then, I use these data as an opening by which to explore motherhood, a human condition not often made visible in archaeology, as well as to investigate maternal-fetal relations and emotions surrounding the violent death of the child. My intention is not to essentialise human emotion nor to make assumptions about specific emotional experiences or their meaning (Harris & Sørensen 2010), but rather to respect the idea that emotion is the root of meaning and it is what fixes memorability in both violent events and in ritual practice (Jones 2007; Stutz 2003).

## The Archeological Context of Area G at Harappa and Plagiocephaly in Two Immature Crania

Harappa


**Figure 13.1.** Map of Harappa and other Indus sites

The Indus Civilisation encompasses more than 2500 sites—large urban centres, villages, hamlets, and small occupational sites—across more than a million square kilometers of territory (Fig. 13.1). This Civilization coalesced relatively rapidly after 2600 BCE as migrants from villages across the hinterlands of South Asia and traders from places as far away as Mesopotamia and the Arabian Peninsula, immigrated to Indus cities (Kenoyer et al. 2013; Valentine 2016). Although many of the largest cities were built on sterile soil, by the late Mature Period (c. 2200–2000 BCE), tens of thousands of people populated these urban centres. These settlements were laid out in a highly organised grid with consistent features of settlement planning across the territory. These cities often consisted of a high-walled administrative area and a lower town for residences; cemeteries were generally located away from the city, in low-lying areas or along riverbanks. Indus people created a uniform sanitation and water management system with public

water works, neighbourhood well access, residential indoor toilets, open and closed sewer systems that rival contemporary planned communities; standardised brick sizes, weights, measures, and script were used for exchange across the territory and beyond (Shinde 2016). The Civilisation built a powerful intercontinental exchange network, based on some perishables as well as beads, including the inscribed carnelian form that became ubiquitous in the Bronze Age settlements of the Old World (Kenoyer 1997).

Circa 2000–1900 BCE, after centuries of environmental, political, economic, and biocultural change, Indus people went through a reorganisation of the human population on a scale that many refer to as a civilisational collapse (Wright 2010). Settlement planning took a more haphazard turn in the Localisation Era, as building materials were scavenged from mature period structures, new bricks did not follow standard specifications, and houses were constructed within the lanes themselves (Kenoyer 2005). Trash and carcasses of dead animals accumulated in the residential areas. By 1700 BCE, the population of settlements in the Indus Valley was decimated; people moved south and east, largely abandoning not only the settlements but also their traditions, styles, and even the script used in Indus Civilisation sites. It is currently unclear why the Indus Civilisation ended. At least some of this abandonment can be attributed to climate change, or the role climate and culture played in the disruption of exchange networks in Syria and around the Arabian Sea (Giosan et al. 2012; Frahm & Feinberg 2012; Ponton et al. 2012; Robbins Schug et al. 2018). What is clear is that historical, sociocultural, political, and economic forces all played a role in individual and collective decisions to leave the city.

At the height of the urban period at Harappa, there was comparatively little evidence of physiological stress observable in the human skeletal material, but as the Civilisation comes to an end, we find that females and individuals buried in marginal areas of the site are more likely to have suffered from trauma, infection, and infectious diseases. The human skeletal material from the urban period cemetery (R-37) appears relatively healthy (Lovell 2014a,b; Lovell 2016; Robbins Schug et al. 2012; Robbins Schug et al. 2013; Robbins Schug 2016). There is very little evidence of traumatic injury (4% of individuals) and only a small proportion of individuals demonstrate signs of congenital, infectious, or degenerative pathology. In contrast, high rates of traumatic injuries, infection, and infectious disease characterised the skeletal assemblages from the posturban ossuary (Area G, c. 2000 BCE) and the Localisation Era cemetery (H, 1900–1700 BCE) (Robbins Schug et al. 2012; Robbins Schug et al. 2013). Interpersonal violence and infectious diseases—well known for their association with urbanism, social inequality, and poor living conditions (Roberts 2011; Roberts & Buikstra 2003)—increasingly affected female skeletons and people who were excluded from the city cemeteries.

The circulation of material wealth at Harappa, including differences in mortuary objects, suggests social inequality was always part of the Harappan experience (Kenoyer 1991; Kenoyer 1992; Kenoyer 2008; Robbins Schug 2017). These differences in mortuary treatment may demonstrate aspects of community membership (Robbins Schug 2017; Robbins Schug et al. 2012, 2013), natal geography (Valentine 2016), or occupational specialisation (Kenoyer et al. 2013). Social differentiation along axes of gender and community membership have been previously suggested in the interpretation of apparent sex-based and mortuary differences in the risk for violence (Lovell 2014a; Robbins Schug et al. 2012), nutritional insufficiency (Robbins

Schug & Blevins 2016), and dental developmental disturbances—enamel defects are much more common among females in the urban cemetery R-37 (Lukacs 1992).

## Area G and the Mortuary Context

Area G is a secondary burial deposit located in a low-lying field southeast of the city wall. The precise nature of this deposit is unclear. It was excavated last in 1928–29 by MS Vats, who was interested in understanding people who lived "outside the gate," whom he predicted would have been the non-elite people or those who might not be full members of Harappan society (Vats 1940). He excavated a 140-foot trench through what he defined as the core of this area. The excavation of this trench, which ran north to south, revealed a well at the far southern end. At the northern end were found some "poorly constructed" architectural remains, ceramics, terracotta figures, cylindrical and unicorn seals, and 1.3–1.5 meters below the surface, he found a collection of human and animal bones.

The piles of human bones in Area G consisted of 20 isolated crania, 3 mandibles, 2 partial vertebral columns, a scapula, and a collection of long bones. There was also a bovine cranium and a canine vertebral column in a scatter at the northern end of the deposit and one intact human burial (G289) located in the southeast corner of the excavated area. That individual was in a prone position, with the body oriented northwest to southeast, the head placed at shoulder-level, south of the upper body (Vats 1940; Robbins Schug et al. 2018). The rest of the human crania were in four distinct piles and these remains were described as "disarticulated" and "disorderly" (Gupta et al. 1962: 2). In all, a minimum number of 23 people were interred here (12 adults and 9 subadults).

When compared to the excavated areas of cemetery R-37 and H, the remains in Area G appear to represent a kind of deviant burial. These individuals were not interred in individual or collective graves, in a supine extended or flexed posture as we find in cemetery R-37. They were not interred in mortuary jars like those buried in cemetery H. Instead, there was variety in the mortuary treatment provided for these remains. G.289 was interred as a whole body, but with the head lying next to the rest of the skeleton. The majority of individuals, however, consisted of an isolated cranium and disassociated fragments of other body parts from these and other individuals. The presence of partly articulated leg bones, vertebral columns, and partial feet suggests that at least the initial part of the decomposition process occurred elsewhere. There was no sign of burning or charring on any of the remains, suggesting that these are not incompletely cremated individuals. The presence of other animals with the human remains is interesting in that the faunal remains are also isolated segments and not whole animals. This skeletal collection in Area G show a high prevalence of individuals affected by either tuberculosis or leprosy (Robbins Schug et al. 2013), interpersonal violence (Robbins Schug et al. 2012), and in the two cases described below, plagiocephaly.

### GIIIS1

This cranium was excavated in 1928–1929 and was depicted in the monograph of the skeletal collection (Gupta et al. 1962). The present author examined the material in 2011. The craniofacial skeleton and the cranial base are complete except for postmortem damage along the

right occipital and right temporal along the region where the squamous suture would be expected. The left parietal is damaged along the sagittal suture and the superior half of the right parietal is missing. Although this cranium suffered postmortem damage, the remaining bones are well preserved. The maxillary dentition was largely lost postmortem but the right deciduous canine and first deciduous molar, and the left first and second deciduous molars are present. Age was estimated at 5 years for this individual based on the presence and formation stage of the right and left permanent first molar crowns in their respective crypts (Moorrees et al. 1963).

The cranium was reconstructed at the time of excavation or during a prior analysis, making it difficult to assess the region around the right lambdoidal suture. However, the mid-section is present, and the syndesmosis is not open. The endocranial surfaces could not be examined due to the reconstruction effort, some adhering soil, and the fragile conditions of the remains.

Despite the obscuration of the right lambdoidal suture from postmortem damage, the cranium had the following features that suggested unilateral lambdoidal synostosis as opposed to positional molding (see Figs. 13.2, 13.3 and 13.4 for descriptive diagrams): ipsilateral tilt to the cranial base, parallelogram shape from the posterior view, ipsilateral occipital flattening, contralateral occipito-parietal bulging, inferiorly shifted external auditory meatus on the right side, ipsilateral bulging mastoid, ipsilateral frontal flattening, or deficit, a trapezoid shape from the superior view, facial asymmetry, and contralateral occipital bossing. In Fig. 13.4, the fused lambdoid suture would be located just posterior to a traumatic injury to the right parietal (Robbins Schug et al. 2012). This injury is best described as an area of plastic deformation on the posterior part of the right parietal, superior to the squamous suture. The plastic deformation suggests that this occurred in the perimortem period. This inference is further supported by the presence of concentric fracture lines adjacent to the depression, inferior to the parietal eminence.

**Figure 13.2.** Anterior view of *GIS1* (left) *GIIIS1* (right) crania from Area G at Harappa

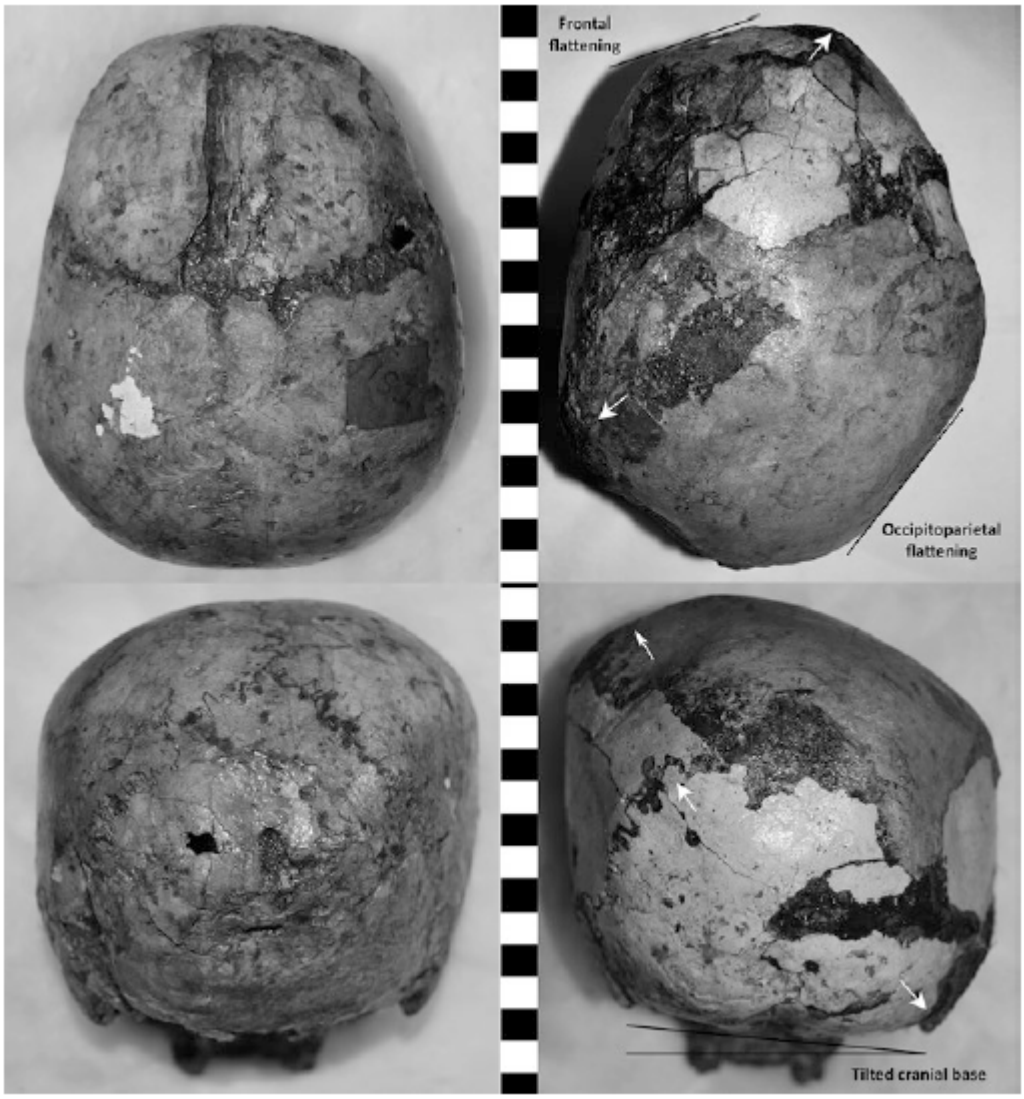


**Figure 13.3.** Superior (top row) and posterior (bottom row) views of *GIS1* (left) and *GIIIS1* (right) crania from Area G at Harappa

**Figure 13.4.** Right lateral view of *GIS1* (top) *GIIIS1* (bottom) crania from Area G at Harappa

GIS1

This cranium was relatively complete (Figs. 13.2, 13.3, and 13.4). There was postmortem damage to the left frontal in the supraorbital and orbital regions, the rhinomaxillary region of the maxilla, the left maxilla was also missing in the infraorbital region, and the left zygomatic was missing. On the right side of the cranium, the zygomatic arch is broken away, there is a circular hole (approximately 2 cm in diameter) in the squamous portion of the temporal, and there is a piece of bone missing from the posterior edge of the foramen magnum. This individual was not subjected to reconstruction prior to publication of the monograph (Gupta et al. 1962), but the skeletal remains were covered with PVA and surfaces are somewhat obscured by that coating.

The maxillary dentition was largely lost postmortem but the right and left deciduous first and second molars are present and erupted. Age was also estimated for this individual to be

approximately 5 years, based on the presence of the complete right and left permanent first molar crowns in their respective crypts (Moorrees et al. 1963).

The cranium is asymmetrical such that the right side of the vault is elevated, the right frontal and the left occipital is mildly flattened. The morphology of the cranium suggests GIS1 had deformational plagiocephaly. The lambdoid sutures are present and unfused, the right and left lambdoid sutures are symmetrical, the cranial base is not tilted, and there is no evidence of compensatory growth.

This individual also had two blunt force traumatic injuries that resulted from clubbing injuries at the mid-sagittal plane on the frontal bone and affecting the left lambdoid suture near the mastoid (Robbins Schug et al. 2012). A depression fracture (17 mm wide and 90 mm long) runs from bregma down to the frontal squama at the midline of the frontal. Oblique and concentric fracture lines at bregma meet the coronal suture bilaterally. A second injury (roughly 35 mm wide and 80 mm in length) is located on the left side of the skull along the lambdoid suture. Concentric fracture lines cross the posterior left parietal and the left side of the occipital. Oblique fracture lines extend from the superior margin of the depression across the parietal. The outer table is crushed near the mastoid process. Neither injury demonstrates evidence of healing (see Figs. 13.2, 13.3, and 13.4; Robbins Schug et al. 2012, 2013).

**Genetic and Cell Signaling Aspects of Synostotic Posterior Plagiocephaly**

This chapter is ultimately interested in the emotional and experiential aspects of the life and death of two individuals, who are represented only by their crania yet for whom biological circumstances align to suggest that they were twins. The inference that two immature crania represent twins is on the surface, a very bold claim but it is based on the genetic, epigenetic, and developmental processes that lead to an atypical cranial morphology and the presence of this condition in these two individuals, who were interred in a pile of crania in an ossuary. Thus, this chapter must also be concerned with the proximate biological processes surrounding the condition known as plagiocephaly. I describe the biological basis for this condition in detail here because it provides the logical basis for the claim that two crania from 5-year-old children who died c.3000 years ago might have been related and more so that they might have been twins. After constructing the biological argument, the chapter moves on to the perceptual, emotional, and social aspects of this condition in the past.

In the typically developing cranium, syndesmoses separate the primary centres of ossification for the cranial vault bones to allow for postnatal brain growth. Sutural agenesis and craniosynostosis are congenital conditions in which these syndesmoses either do not form in utero, or they fuse prematurely (Barnes 1994). The first description of this phenomenon was published in 1830 (Otto 1830), but Virchow was the first to create a classification system for these conditions and their resulting changes to craniofacial morphology (Cohen 2000; Persing et al. 1989). More recently, important distinctions have been made between syndromic and non-syndromic synostosis and unilateral versus bilateral manifestations. There are more than 150 different syndromes that can lead to craniosynostosis. This chapter focuses on unilateral, non-syndromic synostosis, its morphological, aetiological, and developmental correlates.

Craniosynostosis is relatively common among congenital defects, occurring in approximately 1 in 2500 live births today (Panigrahi 2011). Phenotypically speaking, it is heterogeneous—any of the vault sutures can be involved, it can occur unilaterally or bilaterally, a diverse array of cranial shapes can result, there are a large number of syndromes associated with it, and differing degrees of neurobehavioural and developmental consequences. The non-synostotic forms, affecting the sagittal, coronal, or lambdoidal suture on one side only, are seen in 0.4 out of 1000 live births (Panigrahi 2011).

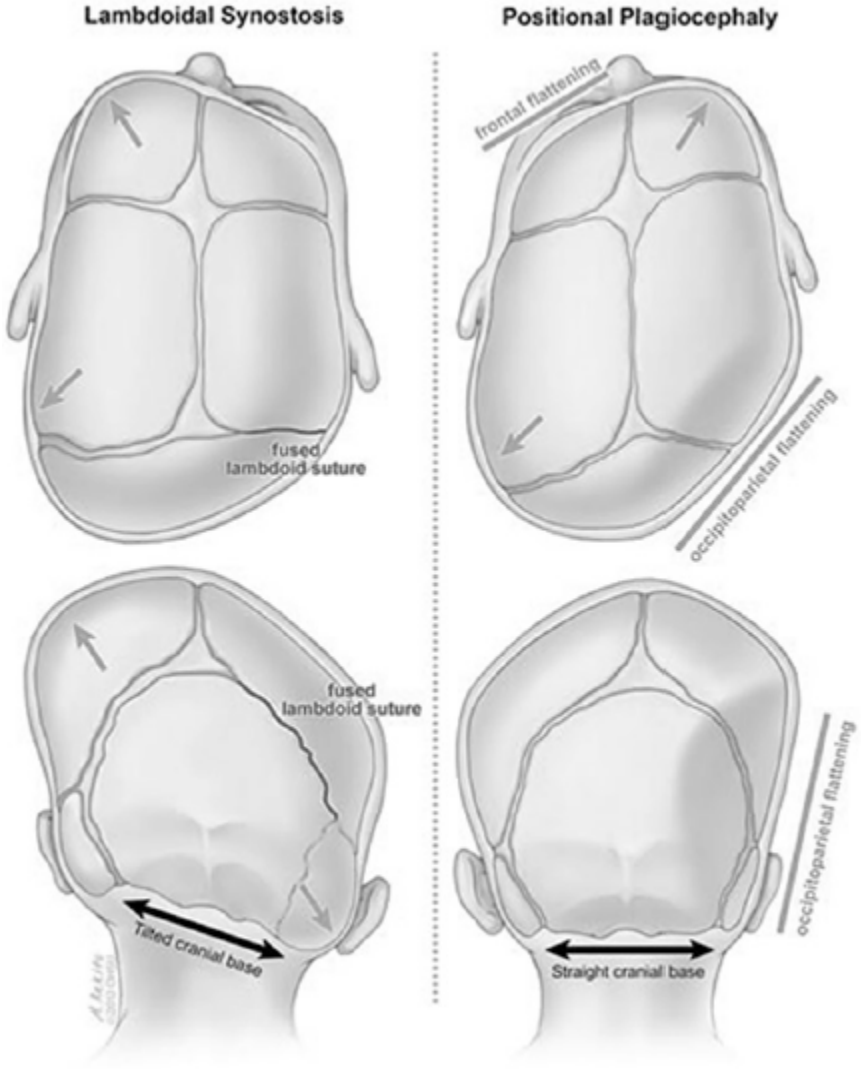


**Figure 13.5.** Gross morphological differences observed in plagiocephaly caused by unilateral lambdoidal synostosis as compared to deformational, or positional plagiocephaly

The term plagiocephaly specifically refers to a unilateral synostosis of the coronal or lambdoid suture, which results in a "lopsided" flattening of the cranium on the affected side (Fig. 13.5). The unilateral manifestation is thought to be non-syndromic, with the coronal suture accounting

for 25% of all cases and the lambdoid suture being the rarest form of non-syndromic craniostenosis of all (Garza & Khosla 2012; Komotar et al. 2006), accounting for only 1–3% of all craniosynostosis cases (Linz et al. 2015). Other types of craniosynostosis result in different cranial morphological changes and are more common. The most common form of sutural anomaly is sagittal stenosis, comprising 40–50% of all cases (Garza & Khosla 2012; Komotar et al. 2006). This type of midline stenosis results in a long, narrow cranial shape known a scaphocephaly, a condition that was reported in an adult female buried in the urban period cemetery (R-37) at Harappa (Kennedy et al. 1993).

The experience of craniosynostosis begins in the second gestational month when mesenchymal substrate condensations initiate intramembranous ossification of the squamous portions of the cranial vault (Scheuer & Black 2000: 43). Neural crest cells migrate to and differentiate at these condensations, which become the primary centres of ossification for the squamous portions of the frontal (6–7 weeks), parietal (7–8 weeks), squamous temporal (7–8 weeks), and occipital (8–10 weeks) bones. The mesenchymal regions between the primary centres of ossification, areas where the sutures will be located, remain undifferentiated.

At the same time, neural crest cells form the meningeal tissues and the *dura mater*, which attach to the endocranial surfaces of the ossifying vault bones. As cranial expansion occurs to accommodate brain growth, that pressure is counterbalanced by the contracting forces of the meningeal tissues (Opperman 2000). This tension may play a role in the development and maintenance of the syndesmoses, or cranial sutures (Richtsmeier & Flaherty 2013). The growth of the brain, osteogenesis of the cranial vault, formation and maintenance of cranial sutures are coordinated to a degree that would seem to suggest "direct signaling between cells of the two organs, coordinated response of tissue-specific cells to similar signals, the ability of cells of one tissue to indirectly respond to changes in the other, or a combination of these mechanisms" (Richtsmeier & Flaherty 2013: 2).

Genetic signaling pathways initiate, detect, up- and downregulate, and terminate cell signaling. In their review of this phenomenon, Richtsmeier and Flaherty (2013: 2) describe five gene families that strongly affect the most influential pathways involved in the development of the cranium (and other systems). They focus on the role of fibroblast growth factor (FGF) receptor and TGFβ receptor in regulating cell condensation, proliferation, differentiation, and preprogrammed death; Hedgehog (hh family) and its role in condensation and proliferation; Wnt (Frizzled), which regulates osteoclast differentiation, osteoblast proliferation, and mineralisation; and Notch, which is a pathway that can be involved in differentiation and inhibition of osteoblasts (Richtsmeier & Flaherty 2013).

Non-syndromic cranial dysmorphogenesis can result from mutation and/or developmental perturbations in these gene families, their local and global signaling networks. Gain-of-function mutations in the FGF and TGFβ receptors result in downregulation of noggin, an antagonist to bone morphogenetic proteins involved in suture formation (Warren et al. 2003). Noggin is involved in embryonic neural tube formation, somite, and skeleton patterning and in its typical expression, is postnatally involved in the maintenance of mesenchyme in patent cranial sutures (Warren et al. 2003). While mutation is one demonstrated pathway, positional restraint of the foetal head can also lead to craniosynostosis (Resnick 2002: 4504) through substantial

upregulation of TGF and FGFR2 pathways, as moderated by increased immune reactivity in cases of intrauterine head constraint (Hunenko et al. 2001). Thus, non-syndromic, unilateral craniosynostosis can result from both genetic and "epigenetic" processes in utero. Intrauterine environmental factors include: antenatal altitude, maternal smoking, and parental occupational hazards such as exposure to mutagenic chemicals (Komotar et al. 2006).

Foetal non-syndromic craniosynostosis can also result from intrauterine head constraint combined with either a mutation in the FGFR-2 pathway or upregulation in the TGF and FGFR2 pathways. Aside from genetic and epigenetic factors, similar anatomical phenotypes can result from prenatal positional molding due to twinning or multiple birth, intrauterine crowding, breech orientation, vertex molding just prior to birth, macrosomia, low birth weight, structural, or Müllerian, anomalies of the uterus, uterine or abdominal muscle tone anomalies, or oligohydramnios (Clarren & Smith 1977; Huang et al. 1996; Littlefield et al. 1999; Littlefield & Kelly 2004; Moss 1997; Rekate 1998).

**Differential Diagnosis of Synostotic and Deformational Plagiocephaly**

Both synostotic and deformational plagiocephaly are more common in twins. A recent study of 13,817 births, 2764 of which were cases of plagiocephaly, demonstrated a strong association (96.8%) between deformational plagiocephaly and twin birth (McKinney et al. 2009). Intrauterine constraint and multiple birth is also associated with more severe plagiocephaly (Oh et al. 2009). In one recent study, Littlefield and colleagues demonstrated right-side plagiocephaly in 60% of 55 multiple births (in a sample that was predominantly comprised of dizygotic twins). Of these infants, 7.2% (4/55) had craniosynostosis, possibly secondary to intrauterine constraint. The majority of cases could be explained as deformational plagiocephaly due to physical intrauterine constraint, which is responsible for a range of morphological differences referred to as "aberrant fetal molding" (Clarren & Smith 1977).

Based on the above observation of the association of plagiocephaly and twins, Littlefield and colleagues conducted a meta-analysis of the risk factors among multiple births at an Arizona hospital between the years of 1993 and 1996. Each of the 4 years considered, roughly 2–2.5% of births were multiple births and an average of 7.5% of these infants had deformational plagiocephaly (Littlefield et al. 1999). In a related study, Littlefield and colleagues found that for discordant and concordant pairs (where one or both twins are affected), the infant lower in the uterus is more likely to be affected; they are more likely to have a vertex presentation and to be affected by postnatal torticollis (Littlefield et al. 2002), defined as the persistent positioning of the head due to stiffness of the sternocleidomastoid muscle.

Strong associations have also been found between plagiocephaly, male sex, and low birth weight (1500–2499 g) (McKinney et al. 2009). Preterm birth (32–36 weeks gestational age) was also associated with higher risk for plagiocephaly but not extreme prematurity (<32 weeks). Infants with plagiocephaly were 4.5 times more likely to have been delivered first, a longer duration of vertex molding being implicated in the aetiology of the condition. Infants with plagiocephaly were also statistically more likely to have been injured at birth or to have other congenital anomalies, primarily torticollis, but cleft lip or palate and other craniofacial anomalies were statistically also more likely. Foetal macrosomia (boy weight above 8 pounds 13 ounces at birth),

oligohydramnios (deficient amniotic fluid), cephalopelvic disproportion (small birth canal relative to foetal cranium size), and birth asphyxia (lack of oxygen to foetal tissues during the birth) were also statistically significant.

Generally speaking, 90% of plagiocephaly cases that are due to postnatal torticollis or positional deformation resolve in the first 2–3 years of life (Staheli 2003: 110). Biological and behavioural factors that contribute to plagiocephaly in the postnatal life course include supine sleeping position, cervical or neurological defects, and torticollis. The "back to sleep" movement in the US has reduced the incidence of sudden infant death syndrome (SIDS) but has also led to an increase in the prevalence of positional plagiocephaly. In fact, 70% of infants with deformational plagiocephaly in the US were sleeping regularly in a supine posture and they were much more susceptible to torticollis (McKinney et al. 2009). These factors may be combined with prenatal risk factors, like multiple births, prematurity, or low birth weight, or postnatal factors like supine positioning of infants by their mothers (Littlefield et al. 1999).

**Cognitive and Developmental Consequences of Cranial Deformation**

In typically developing children, there is no clear association between slight phenotypic variations in brain shape (or size) and cognitive functioning. Clearly, the morphology of the brain is altered in more dramatic and lasting ways in cases of severe plagiocephaly and there can be a clinical association with cognitive and developmental consequences. One hypothesis concerning neurodevelopmental differences with plagiocephaly is that developmental delays, cognitive and behavioural differences result from displacement of the brain and increased intracranial pressure (Lekovic et al. 2004). Hydrocephaly and other alterations to intracranial volume have also been proposed to explain the increased risk for neurological differences in cases of plagiocephaly. However, alterations to the cranial form—changes to morphology, persistence of metopic suture, and thinning of cranial vault bones—may compensate such that the overall volume is not significantly different in affected versus unaffected individuals (Arnaud et al. 1995; Collett et al. 2012; Sgouros et al. 1999).

There is some uncertainty about the neurodevelopmental aspects of craniosynostosis because many clinical studies suffer from small sample sizes and a lack of sufficient control groups. However, research on the prevalence of cognitive impairment in children with premature synostosis has demonstrated that developmental delay is more likely in these children than in the rest of the population (Magge et al. 2002; Shipster et al. 2003). Some recent research, including a meta-analysis of 17 studies on neurobehavioral outcomes for children with craniosynostosis, suggested as much as a three to fivefold increase—a "modest but reliable" association—in speech and language learning ability and cognitive differences; one study suggested it could be up to six times higher compared to typically developing children (Shipster et al. 2003).

Becker and colleagues reported that for the lambdoid suture specifically, agenesis or premature synostosis is associated with neurobehavioural differences in 44% of children studied (Becker et al. 2005). Neurological deficits are thought to range between 35% and 50% of all cases of synostosis (Panigrahi 2011), but impairment is not strongly associated with the aetiology of the stenosis; the likelihood of cognitive and behavioural impairment was not statistically different between syndromic and non-syndromic stenosis (Becker et al. 2005). Positional plagiocephaly,

on the other hand, has only recently been associated with cognitive defects, having once been assumed to be a cosmetic issue only (Collett et al. 2012). While initial research suggests 30–50% of these children may also suffer from cognitive impairments, more research on larger study populations is required (Collett et al. 2012).

Because 25% of single births and 50% of twin births have an atypical cranial morphology at birth from "moulding" due to pressure on the cranium while it is in the birth canal, research has been conducted to discriminate pathological versus nonpathological aetiology based on morphological differences, aside from an examination of the sutures themselves (Huang et al. 1996; Komotar et al. 2006; Linz et al. 2015). When a suture fuses prematurely, growth is halted perpendicular to the stenosis and compensatory growth occurs perpendicular to the patent sutures (Cohen 2000). Positional plagiocephaly or deformational plagiocephaly can be discriminated from lambdoidal synostosis—even in the absence of clear evidence from the suture itself—based on the resulting head shape (Fig. 13.5). The following diagnostic key was developed from an examination of 375 infants (0–12 months of age) with non-syndromic plagiocephaly, performed using clinical examination and ultrasound (Linz et al. 2015). Of these infants, 269 had posterior plagiocephaly, 261 of positional, and 8 of craniosynostotic origin. The following diagnostic criteria are listed by order of most to least frequent traits.

- Positional plagiocephaly resulted in unilateral occipital flattening (100%), a normal shape from the posterior view (99%), contralateral occipital bossing (95%), anteriorly shifted external auditory meatus (93%), facial symmetry (92%), ipsilateral frontal bossing (89%), and a parallelogram shape from the superior view (89%).
- Posterior plagiocephaly due to unilateral fusion of the lambdoid suture results in ipsilateral occipital flattening (100%), contralateral occipito-parietal bulging (100%), inferiorly shifted external auditory meatus (100%), parallelogram shape from the posterior view (100%), ipsilateral bulging mastoid (75%), ipsilateral frontal flattening or deficit (63%), a trapezoid shape from the superior view (63%), facial asymmetry (63%), and contralateral occipital bossing (12.5%).

Another important feature for distinguishing the two aetiological pathways is the ipsilateral tilt of the skull base in posterior plagiocephaly due to craniosynostosis. The cranial base remains parallel to the ground in positional plagiocephaly, but an important diagnostic difference to posterior plagiocephaly is the angled cranial base (Huang et al. 1996). Additionally, the majority of infants with alterations to the vault from positional moulding will be expected to demonstrate a complete resolution by age 2 (Komotar et al. 2006); unilateral synostosis is expected to result in accentuated deformity over time (Linz et al. 2015).

## (Re)Constructing the Maternal-Infant Interface at Area G

Maternal and child identities and experiences are embodied in human skeletal remains. In many human communities, multiple births hold a special significance (Halcrow et al. 2012), but this aspect of identity is difficult to identify archaeologically, in the absence of genetic evidence (Marshall et al. 2011). Twinhood has been documented in bioarchaeology twice based on a burial with twins in utero (Owsley & Bradtmiller 1983) and a case of dystocia during the birth of twins (Lieverse et al. 2015). In other cases, possible twinhood has been suggested for perinatal

skeletons whose burials coincided, based on similarities in body size or other aspects of morphology, age-at-death, or mortuary treatment that has often included elements of the skeletons touching one another or being "intertwined" (e.g., Crespo et al. 2011; Flohr 2014; Halcrow et al. 2012). Halcrow et al. (2012) suggested the presence of relatively rare congenital anomalies could be used to infer twinhood as well but to my knowledge, this has only been suggested and remains unconfirmed in one previous case (Chamberlain 2001; Harrison et al. 1979; Hawass & Saleem 2011).

This chapter makes the claim that we can understand something about the maternal-fetal interface (biologically and behaviourally) from a set of archaeological crania. Given that posterior plagiocephaly is due to unilateral lambdoid craniosynostosis in *GIIIS1*, it is statistically likely that this individual had a genetic predisposition toward sutural agenesis, a mutation in the TGF or FGFR2 pathways. In the case of *GIS1*, the plagiocephaly was non-synostotic; thus, statistically speaking, it is likely that this individual was in vertex presentation early in the third trimester, that s/he went through prolonged vertex molding, perhaps developing postnatal torticollis as a result of this posture, and that postnatally, s/he spent considerable time on her back, with her head resting on the posterior left side. While the plagiocephaly resolved to some extent before she/he died at 5 years of age, s/he was left with some remaining deformity. Given the older age of this individual and the relative severity of the plagiocephaly, statistically, it is also likely that this individual shared with *GIIIS1* a genetic predisposition toward cranial moulding (i.e., it is even possible that these may have been monozygotic twins). Intrauterine head constraint for *GIS1* may have stimulated increased immune reactivity in utero, which resulted in substantial up-regulation of TGF and/or FGFR2 pathways (Hunenko et al. 2001).

Aside from the biological aspects described above, Western ways of knowing might predispose a bioarchaeologist toward thinking of these two individuals as disabled, particularly since greater than 40% of individuals with plagiocephaly are characterised today as developmentally delayed or neurologically impaired. In a practical and "common-sense" manner (in the Gramscian sense of that term), bioarchaeologists might try to attribute a requirement for care to these two individuals (Tilley 2015). Or we might ascribe meaning to their appearance based on the fact that today there is an aesthetic concern with remoulding the cranium in cases of deformational or synostotic plagiocephaly. However, there is no method to scientifically evaluate whether these individuals were regarded as deformed or disabled at Harappa. Clearly, they were corporeally different from their peers but the persistence to the age of 5 years of the deformational plagiocephaly in particular, suggests their mother and other caregivers did not successfully attempt to remould or otherwise correct the shape of their heads. These children were placed in this secondary burial context together and they both suffered traumatic injuries, facts which could be approached from the perspective of aesthetics, developmental disability and care, or neurodiversity. Here, I prefer to consider the evidence for plagiocephaly from the perspective of identity formation, which is always intersectional, contingent, and in this case, potentially was also constrained by the physical and structural violence experienced by these two individuals from Area G. Furthermore, I am interested in a phenomenological and emotional perspective, using an archaeology of emotion.

Crania in particular can communicate information about age, sex, gender, social status, familial and community membership, ethnicity, and other axes of identity (see Bonogofsky 2011, for

example). Phenomenologically speaking, we can infer some aspects of personhood, emotional experience, and even habitual behaviour from these remains. Although motherhood may often be archaeologically invisible, in this case, we can imagine there was a mother, pregnant with twins. The twins' craniofacial similarity to one another and their difference with others a spectacle from their emergence. When she gave birth, it is possible *GIS1* emerged first from the birth canal, its deformational plagiocephaly having been created by an early vertex presentation and intrauterine constraint. That infant was then followed by *GIIIS1*, whose similar phenotype was shaped by a genetic form of synostosis. One can also imagine their caretakers habitually laying these babies down on their backs, intentionally or not, reinforcing their morphological variance. It is particularly interesting to think of these individuals as twins who survived infancy as that would be the only archeological case known. One can imagine these two individuals growing up for 5 years at Harappa, their resemblance magnified and made more uncanny by shared difference.

As objects too, crania are powerful symbols and ritual tools that embody our subjectivity, personhood, consciousness, and power. Additional excavation in Area G is required for us to trace the specific meaning of the cranial remains interred there; however, using the excavation reports and photographs, it is possible to draw some basic inferences from the mortuary context. Apart from the city's two cemeteries (R-37 and H), 20 isolated crania were interred at Area G, along with one complete burial, scattered postcranial, and animal bones. This cache of crania in many ways appears to modern, Western eyes to represent an "interplay between violence and ritual" (Bonogofsky 2011: 13). The two children with plagiocephaly rested on top of one of four piles of crania, which may suggest that not only did they die in the context of a violent event, but also suggests that some form of display was central to the mortuary ritual that followed. These two crania provided powerful optics, they contained emotional power, and they had a charge—an emotional force—as ritual objects for at least some short period of time before they were buried. Their interment represented a departure from normative rituals and normative burial geography. This departure may have been affected to fix a memory of a person, a relationship, an event, or a social value (Harris 2006; Hamilakis 2014).

As was previously mentioned, a large proportion of the cranial remains cached at Area G provided evidence of infection, disease, and interpersonal violence (Robbins Schug et al. 2012, 2013; Lovell 2016). Because of its marginal location, combined with the significantly greater risk for violence and disease for individuals buried in this area, I have suggested this site could represent evidence for structural violence, or a lack of access to basic health and safety for a segment of Harappan society (Robbins Schug et al. 2012; Robbins Schug 2017). The risk for violence and infectious disease appears to have been structured along the fault lines of inequality that may have formed during rapid urbanisation in the Mature Period (Robbins Schug et al. 2012, 2013; Robbins Schug 2017). Both violence and infection appear to significantly increase during a period of heightened social anxiety as climate, economic, and ideological changes led to the civilisational collapse of the Indus Civilisation (1900–1700 BCE). For these reasons, Area G and later burial deposits, have come to represent a kind of bioarchaeological record of anxiety, biocultural stress, and social change (Robbins Schug 2016).

Although the nature of the evidence presented here does not permit certainty, it is likely that plagiocephaly resulted in both of these individuals from interactions between genetics, a constrained intrauterine environment, and maternal-fetal interactions and it is possible that these

congenital factors were shared as a result of multiple birth for these two 5-year-old crania buried in Area G at Harappa. These two children shared atypical cranial morphology and mortuary deviance, but it would obviously be helpful to test this hypothesis using molecular techniques in the future; unfortunately, ancient DNA is rarely preserved in the South Asian skeletal assemblages due to the extreme fluctuations in moisture, temperatures, and the soil conditions (Kumar et al. 2000; but see Walimbe 2007). Further analyses including 3D geometric morphometrics, odontometrics, and isotopic signatures should be conducted in future and may provide additional support to the analytical approach employed in the present chapter.

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