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BIOARCHAEOLOGICAL EVIDENCE FOR THE HEALTH STATUS OF A LATE BRONZE AGE AND EARLY IRON AGE BAKHERI CHALA POPULATION (ARMENIA)

ABSTRACT: Thirty-two skeletons from burial ground Bakheri chala were analysed macroscopically and X-ray for pathological conditions such as trepanation, traumatic injuries, infectious disease and dental pathology. This study has shown that average age at death was relatively high. Trepanation with rectangular sawing for the first time found in the Armenia at two individuals. Trauma to the skull was common, which suggests a high level of inter-personal violence. We here report a case of decapitation. Bakheri chala site showed a high frequency of auditory exostosis. The dental pathology conditions of this population were numerous. Agriculture introduced people to carbohydrates, or sugars, which affect the teeth and cause dental caries. The staple diet of ancient population from Shnogh river consisted of wine, bread, vegetables, and fruits. Males do show a slightly higher rate of wear than females possibly suggesting a greater proportion of bread in the diet of males.

KEY WORDS: Armenia – Late Bronze Age – Early Iron Age – Trepanation – Cranial trauma – Dental pathology

INTRODUCTION

Bioarchaeology, or the study of archaeological human remains, will make substantial contributions to our understanding of human adaptation and the biological history of the population Armenia in Late Bronze Age and Early Iron Age. Physiological disruption resulting from poor environmental circumstances is paramount to the study of health and the adaptive success of past human populations. In bioarchaeology, adaptation is thought of as a process of adjustment to environmental constraints (Goodman, Armelagos 1984, Goodman *et al.* 1988). The most prominent obstacle to human adaptation is stress. Stress can be defined as a biobehavioral response to environmental conditions (Goodman, Armelagos 1984, Goodman *et al.* 1988). An ultimate goal of paleopathology is to understand how past human cultures may have caused or

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responded to stress (Goodman *et al.* 1984). The purpose of this thesis is to better understand the health and adaptive success of the individuals interred in the burial group at the Bakheri chala site. Emphasis will be placed on indicators of health derived from skeletal and dental lesions, although the skeletal remains are in a general poor state of preservation. These events, including trauma, trepanation and disease, can provide valuable information about the health of past peoples and populations.

Infectious disease

The analysis of skeletal lesions resulting from infectious disease on prehistoric human skeletal material offers the bioarchaeologist an insight into the interplay between disease, diet, ecology, social structure, settlement pattern, plant and animal domestication, warfare, sanitation level, immunological resistance, and psychological stress (Kelley 1989, Larsen 1997). Ortner and Putschar (1985) claim that infectious disease are the single greatest threat to life of prehistoric infants and children. But this does not mean that adults are immune. Of people surviving to adulthood, many will die of infectious disease, whether it be direct or indirect (Ortner, Putschar 1985). There are a host of biological and environmental factors that influence the prevalence of infectious lesions found in prehistoric skeletal samples. When an individual is infected by an organism, there are three ways in which a bone can become involved. First, the infection can spread from its primary source to skeletal elements via the blood stream. Second, an injury (such as a penetrating wound) can leave a bone open to direct infection. Third, a localized soft tissue infection can be so severe that it spreads to the underlying bone (Aufderheide, Rodriguez-Martin 1998).

Brain abscesses commonly occur when bacteria or fungi infect part of the brain. Swelling and inflammation develop in response to this infection. The most common source of the infection is a lung infection (Walker *et al.* 2004). Germs may also travel from a nearby infected area (for example, an ear infection). The cranial lesions have a round lytic focus, with or without a central sequestrum, and ultimately result in the complete perforation of the inner and outer cranial tables. Mastoiditis is an inflammation of the mastoid process, is usually caused by a middle ear infection (acute otitis media), is the most common disease in children in general (McKenzie, Brothwell 1967, Loveland *et al.* 1990, Berman 1995, Leskinen, Jero 2005, Benito, Gorricho 2007, Anderson, Adam 2009, Flohr, Schultz 2009a, b, Thorne *et al.* 2009). Otitis media may be caused by a variety of bacteria, but infections caused by Streptococcus pneumoniae, and Haemophilus influenza are the most common (Aufderheide 2003, Lewis 2007). This condition can cause earaches, headaches, swelling and fever. Acute mastoiditis may develop into necrosis and demineralization of the normal mastoid air cells, osteitis of the mastoid bone, and general damage of the mastoid air cells (Anderson, Adam 2009).

Tuberculosis it is a chronic infectious disease caused by one of the microorganisms of the group Mycobacterium. Transmission of the tuberculous bacterium can occur through the respiratory system, via infected droplets and/or sputum, or the gastrointestinal system, from contaminated milk or meat products (Aufderheide, Rodriguez-Martin 1998, Roberts, Buikstra 2003, Ortner 2003, Roberts, Manchester 2005). If the host's immune response is not strong, the tuberculous bacteria primarily spread throughout the host's body through the blood stream (Aufderheide, Rodriguez-Martin 1998, Mays *et al.* 2002, Roberts, Buikstra 2003, Ortner 2003). Pulmonary and intestinal infections cause primary foci in the lungs and intestinal wall respectively, with potential subsequent spread to neighbouring lymph nodes (Roberts, Buikstra 2003, Waldron 2009). Given that tuberculosis is characterized by lytic lesions and is known to affect the sternum to some degree, the presence of pronounced lattice-like porosity on the posterior surface of the manubrium could have potential associations with tuberculosis. Roberts and Buikstra (2003) list the possible differential diagnosis including brucellosis, congenital wedging of the spine, fractures, fungal infection, osteomyelitis, osteoporosis, Paget's disease, sarcoidosis, Scheuermann's disease, Schmorl's nodes, septic arthritis, tumors, and typhoid.

Roberts and Buikstra (2003) report a frequency of sternal involvement of 3.9% from a study consisting of 160 individuals with tuberculosis as a known cause of death. Ortner (2003) reports a frequency of 1.2% from a study conducted by Alfer (1892) on a sample of 1752 individuals. Finally, Kelley and El-Najjar (1980) report that 15.4% of 26 individuals in the Hamann-Todd collection exhibiting tuberculosis had sternal involvement.

Trauma and trepanation

A very important portion of trauma analysis is determining when an injury occurred in relation to the death of the individual. Traditionally, the timing of

traumatic episodes has been divided into three categories: antemortem, perimortem, and postmortem (Galloway *et al.* 1999, Nafte 2000). Traumatic injuries are frequently encountered pathologies in archeological samples (Ortner, Putschar 1985). Most cases of trauma are the result of "violent encounters with environmental hazards" and "inter- and intraspecies" conflicts (Merbs 1989). The type of trauma can give an idea as to the kind of injury that caused it (Mays 1998); therefore, the study of traumatic injury can provide information about the economy, environment, occupation, and level of violence in a given population (Merbs 1989).

Various explanations for the physical act of decapitation in different groups from distinct periods have been put forward (Bridges *et al.* 2000, Milner *et al.* 1991, Smith 2003, 2008). Various researchers have outlined and refined these parameters which include: trophy-taking activities including decapitation, scalping, and removal of limbs or other body parts taken away by the attacker(s). Damage to the upper cervical vertebrae (and also C7 or T1 in some instances), mastoid processes, occipital regions, the posterior parts of mandibles and first ribs have been considered as good markers (Aufderheide, Rodríguez-Martín 1998, Anderson 2001, Ardagna *et al.* 2005, Buckberry, Hadley 2007, Saponetti *et al.* 2008, Steadman 2008). Even if no evidence has been left on the bones, some aspects of the burial context can be indicative of decapitation such as the absence of a head (although bones can eventually be destroyed or lost through post-depositional processes such as intrusive burials, animal activities, and environmental conditions) (Okumura, Eggers 2008), the presence of a head without other postcranial elements (Nagaoka, Abe 2007) or the placement of a head in a non-anatomical position (Boylston *et al.* 2000).

Trepanation is perhaps the oldest form of neurosurgery (Glory, Roberts, 1947, Dastugue 1962, 1973, Crubézy *et al.* 2001). The history of trepanation is partially known through examples from all over the world, which have been discussed in numerous studies (Nemeskéri *et al.* 1965, Rokhlin 1965, Derums 1979, Gokhman 1989, Mays 2006, Holck 2008, Rubini 2008, Mountrakis *et al.* 2011, Han, Chen 2007, Aufderheide, Rodriguez-Martin 1998, Ferembach 1970, 1984, Zias, Pomeranz 1992, Hershkovitz 1987, Güleç 1995, Erdal, Erdal 2011). The reasons for trepanation in prehistoric to present times, among different peoples and cultures, are multiple. Hippocrates, as many other scholars (Bennike 1985, Crump 1901, Derums 1979, Jorgensen 1988, Ruisinger 2003, Khudaverdyan 2010) after him, believed trepanation was done for the relief of skull pressure on the brain, and was probably related to cranial trauma (Açıkkol *et al.* 2009) and/or to facilitate the exit of evil spirits (Lisowski 1967, Ortner, Putschar 1985). The trepanation was performed to somehow treat or relieve the symptoms of disease. These diseases include, but are not limited to, mastoiditis, scurvy, ear infection, meningiomas, hydrocephaly, brain tumors, headaches, and seizures (Oakley *et al.* 1959, McKinley 1992, Smrčka *et al.* 2003). Trepanation is caused by the intentional use of a sharp instrument for the removal of part of the skull vault, generally with out damaging the underlying meninges and brain.

Benign neoplasm

Benign neoplasms include osteomas, a small bony growth that peaks in frequency during the fourth and fifth decades of life. They often appear as a small bump or "button" on the outer surface of a bone. These slow forming lesions are usually found on the outside table of bone, and very often affect the skull (Aufderheide, Rodriguez-Martin 1998). The exact etiology of the disorder is unknown (Kennedy 1986, Manzi *et al.* 1991). However, it has been linked to repeated exposure to cold water (Kennedy 1986, Manzi *et al.* 1991, Velasco-Vazquez *et al.* 2000). Other hypothesized causes of auditory exostoses include chronic infection or inflammation, genetics, and mastication stress (see Aufderheide, Rodriguez-Martin 1998).

Hematopoietic diseases

Cribra orbitalia and porotic hyperostosis. There are two types of porotic hyperostosis: 1) porotic hyperostosis of the skull vault and 2) porotic hyperostosis of the orbital roofs, known as cribra orbitalia. The behavior of these indicators in the skeletal sample allows us to evaluate nutrition and health condition in these individuals, as it permits us to approach the disorders related to nutritional deficiencies, such as that of iron that leads to anemia (Aufderheide, Rodriguez-Martin 1998, Larsen 1997). With acquired iron-deficiency, which often results from chronic infection or excessive blood loss caused by gastrointestinal parasites (Lovell 1997). As reviewed by Cohen and Armelagos (1984) iron deficiency anemia is thought to be more common among agricultural populations than hunter-gatherers.

Dental pathologies

Many dental diseases are the result of the diet of the individual, other defects can be the result of childhood stress

or infections. Therefore, teeth are vitally important to the study of the skeletal remains of past peoples. Hypoplasia of dental enamel; from the pathological perspective, this indicator is due to a period of non-specific metabolic stress, caused by the lack of nutriments in a deficient alimentation or by infectious diseases, as well as parasitic ones that affect the normal absorption of nutriments, giving as a result insufficiency in the thickness of the enamel due to the interrupttion of amelogenesis or the formation of the enamel layer which covers the teeth (Larsen 1997). There are and et al. causes of enamel hypoplasias. Among these are poor trauma, exposure to toxins, and genetic deformities (Schultz *et al.* 1998). Macroscopic analysis can provide a lasting and retrospective record of stress during childhood, from birth to about 13 years of age (Lukacs 1989).

Dental caries causes the demineralization and dissolution of dental tissues, caused by an acid-producing bacterium called Streptococcus Mutans, which is produced in the dental plaque on the teeth surface (Aufderheide, Rodriguez-Martin 1998). Dental calculus is defined as the mineralization of bacterial plaque (Brothwell 1981: 159). Dental calculus is mineralised plaque that has accumulated on the enamel surfaces of teeth as the result of poor hygiene and diet (Hillson 1996). Plaque buildup can occur in diets with heavy carbohydrate consumption (Hillson 1996), although protein may increase oral alkalinity, thereby promoting calculus mineralisation. Attrition or teeth wear: a pattern of behavior in relation to the sort of alimentation or an occupational activity as for the use of dentition can be observed (Lagunas, Hernández 2000). Antemortem tooth loss (AMTL) is characterised by remodelling of the alveolar bone that leads to the obliteration of the tooth sockets.

FIGURE 1. Bakherii chala burials.

Determining the etiology of AMTL is difficult as evidence may have been lost, especially in instances of carious teeth (Hartnady, Rose 1991). However, the close association between periodontal disease, dental caries, and AMTL is well established, especially in archaeological populations (Larsen 1997). The prevalence of AMTL contributes to the overall picture of oral health in a population. Abscesses might be caused by a fast wear that provokes a diminution of dentine to fill the pulp, or are also the result of progressive caries which generate a dental infection frequently originating these abscesses; they are macroscopically observed in the maxillary and in the mandible (Lewis *et al.* 1986, Herrera *et al.* 2000). The purpose of this paper was to provide an overview of some of the common and unusual pathologies that have been recorded on the Bakheri chala skeletal collection.

MATERIALS AND METHODS

Excavations at Lori region began in 2009 by S. Hobosyan and are still in progress. Archaeological excavations were done near the villages of Shnogh and Teghut, Lori District of the Republic of Armenia. The large area of between villages Shnogh and Tekhut was divided into 8 archaeological zones. Due to good climatic and geographic conditions, the basin of the Shnogh river, where the Dukanadzor mining district is situated, had been inhabited since the Stone Age. On the area of nearly 1500ha there are tens of settlements and cemeteries dealing especially with the period from the Bronze Age to medieval times (Hobossyan 2011). The present paper discusses human remains uncovered at Bakherii chala. Only burials dated to the Late Bronze Age and Early Iron Age are included in this analysis. All analysed individuals were buried in a flexed position, in graves in the shape of a stone coffin (*Figure 1*).

All of the burials appear to have been primary interments, typical of the Late Bronze Age and Early Iron Age (c. 13st–12rd c. BCE), and oriented in an east-west direction. The burials display a range of mortuary practices including flexed, and semi-flexed burials. Most of the skeletons were accompanied by large numbers of pottery vessels, bangles, and beads, semi-precious stones.

In the Late Bronze and Early Iron Ages, Lori District was home to a number of established sedentary farming communities. The people dwelt in open settlements consisting of round or rectangular huts with clay walls. Sedentary group lived in this village, whose subsistence system was based on agriculture and the exploitation terrestrial resources, adequate for the relatively small populations. The primary food resource for communities was a variety of grain crops, which would have been grown in agricultural fields watered by man-made irrigation canals. They raised domestic animals-cattle, sheep, goats, and pigs; they harnessed oxen to carts. Mining and metallurgy quickly developed along with animal husbandry and agriculture. The beginning in the second half of the 3nd millennium BC, the copper mine deposits of Lori District began to be exploited.

The size of the sample, state of preservation of the skeletons, and the available archaeological data had to be adequate for the article (see *Table 1*). However, in most cases, integrity of the bones was bad preservation. The excavations of Bakheri chala cemetery produced a minimum number (MNI) of 32 skeletons: 14 males and 9 females, three individuals is not defined sexual identity. Five children (2–9 years) and one adolescent were the only subadults present in the sample (*Table 1*). It is hypothesized that the under-representation of infants and children is due to a variety of factors including preservation issues and differential placement of infant burials elsewhere. The deliberate separation of infants and young children from the group seems somewhat common in other regions

TABLE 1. Number of individuals from Bakheri chala site.

Sex	Age categories						
	0–10	11–19	20–29	30–39	40–49	50±	Total
male		1	5	1	4	3	14
female			4	3	1	1	9
undet.	5	1	1	2			9

Armenia (Khudaverdyan 2009). Data are subjected to the paleodemographic analysis (D. Bogotenkov statistical package (Institute of Archaeology, Moscow). The method by Acsádi and Nemeskéri (1970) and are one of the predominant tools used in early paleodemographic research. Demographic profiles must be estimated directly from the distributions of age indicator data themselves. These death structures serve as indicators of overall life expectancy.

The age-at-death and sex of adults were assessed through the use of multiple indicators: morphological features of the pelvis and cranium were used for the determination of sex (Phenice 1969, Alekseev, Debets 1964, Buikstra, Ubelaker 1994); a combination of pubic symphysis (Gilbert, McKern 1973, Katz, Suchey 1986, Meindl *et al.* 1985), auricular surface changes (Lovejoy *et al.* 1985), degree of epiphyseal union (Buikstra, Ubelaker 1994), and cranial suture closure (Meindl *et al.* 1985) were used for adult age estimation. For subadults, dental development and eruption, long bone length, and the appearance of ossification centres and epiphyseal fusion were used (Moorrees *et al.* 1963a, b, Ubelaker 1989, Buikstra, Ubelaker 1994).

Skeletons from the samples was subjected to a careful macroscopic and X-ray investigation for pathological lesions. Observable in archaeological material are types of trauma (Ortner, Putschar 1985) and trepanation (Aufderheide, Rodriguez-Martin 1998) that leave a mark on the skeleton. Recording follows Roberts (2000), summarised below. 1. Note the bone and side affected (if applicable). 2. Identify location using standard anatomical terms. 3. Note the state of healing (healed, healing, unhealed), the size and type of bone. 4. Record evidence of infection on the fractured bone (or any closely associated bones), together with the proximity to the fracture site. 5. Note evidence of pre-existing pathology, which may be related to the fracture and trepanation. Cases with clear postmortem breakage were excluded.

Brain abscess is a dynamic focal form of intracranial suppuration and a serious life-threatening emergency (Nathoo *et al.* 2011). They begin as a localized area of cerebritis and develop into an encapsulated collection of pustular materials presenting as a mass-like lesion, similar to the abscess in other sites (Wiwanitkit, Wiwanitkit 2012). The maturity of the abscess is indicated by the rim, which is formed probably by the collagen and inflammation due to free radicals and microhemorrhages in the abscess wall. Flohr and Schultz (2009a) describe the osseous changes in mastoiditis as characterized by related proliferation and resorption which result in enlarged cells and in spicular bone formation (remnants of former septa between the pneumatized cells). The osseous proliferations can be plate-like and spicular, with thickened or even bases, rough or smooth surfaces, and fine net-like bone formations that are very brittle and fragile (Flohr, Schultz 2009a, b). The formation of new bone indicates chronic mastoiditis (Flohr, Schultz 2009b).

Tuberculosis is characterized by lytic lesions and is known to affect the sternum to some degree, the presence of pronounced lattice-like porosity on the posterior surface of the manubrium could have potential associations with tuberculosis. Tuberculosis affects and the vertebral body, specifically the anterior portion of the centrum. The loss of trabecular bone causes the vertebral body to collapse, and a small wedge of what remains of the vertebral body is present.

Neoplastic disorders were categorized as benign. Each lesion was recorded in terms of its location and amount of involvement.

The orbital roof is examined macroscopically for evidence of pathological change. Each orbital roof is recorded as a single unit with cribra orbitalia noted as present, absent or unobservable. Lesions are recorded following the grading system defined by Stuart-Macadam (1991) (types 1–5).

Diagnosis of hypoplastic defects refers to Hillson (1996) for description of linear and pit-shaped interruption in the enamel formation. Enamel hypoplasia is recorded on individual tooth level. Dental caries is defined as destruction of the enamel, dentine and cement (resulting from acid production by bacteria in dental plaque) manifesting as a cavity in the crown or root surface (Hillson 1996). Caries is recorded at individual tooth level noting the position and severity of the largest carious lesion visible. Calculus is noted where mineralized plaque can be seen adhering to the tooth surface (Hillson 1996). Calculus is recorded on an individual tooth level stating the location and severity of the formation. Severity of the lesion was scored as small (pinprick to 1 mm), medium (>1mm to ¼ of the tooth crown), large (>¼ of the tooth crown, surface of origin cannot be assigned), or complete (complete or near complete obliteration of the crown) (Buikstra, Ubelaker 1994). Dental wear of the functional chewing surface depends on the hardness of food consumed and on whether the teeth are used as tools. Molar dental wear was recorded using Scott's scale (1979), while incisor, canine, and premolar wear was scored after Smith (1984). AMTL was assessed

based on evidence of resorption of alveolar bone around a tooth socket. If remodelling was evident, and the socket was partially (>2mm) or fully filled in, then a tooth was considered to have been lost antemortem. Sockets that were open and smooth, with no evidence of remodelling, were recorded as having lost teeth postmortem (Brothwell 1981: 155). Abscesses can be caused by various factors, such as pulp necrosis, periodontal infection and trauma. In the present study, abscesses were recorded if any trace of infection occurred in the alveolus around the tooth root.

RESULTS

In Bakheri chala site, there are two cases of surgical trephination. The only other method of trepanation observed was rectangular incised grooving (also called crosscut sawing or linear cutting). Particular features produced by the method of trepanation (such as linear grooves around the site of the hole) may be macroscopically and X-ray evident on the calvarium and contribute to the evidence supporting the identification of trepanation. This is a cutting technique in which four straight incisions are made, intersecting at right angles and the in-between fragment is removed (Lisowski 1967, Buikstra, Ubelaker 1994, Verano 2003). One case of peri-operative intervention comes burial 22. Within the burial 22 were recovered a lot of household goods. Skeleton of the child was at the center of burial. Skull of an 8 to 10 year-old child that showed evidence of trepanation, mastoiditis and brain abscess.

The most interesting feature of this particular skull constituted the presence of an opening (*Figure 2a*) at the region sagittal suture (left parietal bone), which was considered to be a clear case of trephination. That is, a deliberate and antemortem operation in the aim of removing part of the flat bones of the skull for the treatment of the child. Around the hole, deep grooves remained as evidence of the sawing method for the incisions, which left cutmarks along the margins of the perforation. Dimensions 2×15×2?×15?mm at the external part. However, except from the opening at the left parietal bone, the examination of the skull also gave interesting data on the second trepanation (*Figure 2b*). Thus, in the left parietal bone the presence of a second opening B of the skull (near of the temporal bone). Opening B has a diameter of 16×9×16?×9?mm and a morphology same as that of the initial opening A. Around the trepanation margin of bone, cutmarks remained as evidence of the sawing method used. These

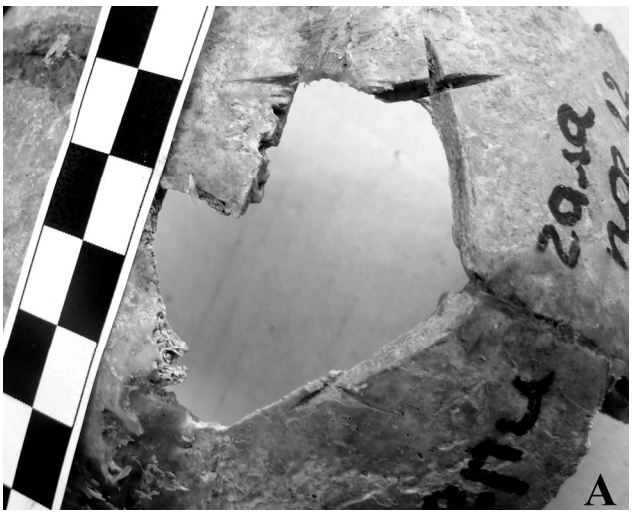

FIGURE 2a. Cranial trepanation (no1). Bakheri chala, burial No. 22.

FIGURE 2b. Second cranial trepanation. Bakheri chala, burial No. 22.

FIGURE 3. Mastoiditis on the endocranial surface of the left mastoid as small rounded lesions with a regular margin. Bakheri chala, burial No. 22.

cutmarks did not show signs of healing such as remodeling or reactive bone, leading to the conclusion that the child did not survive the trepanation procedure.

The paleopathologies (burial No. 22, child 8–10years) noted include porotic hyperostosis, brain abscess and mastoiditis. The porotic hyperostosis fixed the in pterional region of the skull. The child shows evidence of a brain abscess that is consistent with a diagnosis of tuberculosis (Walker *et al.* 2004). The infection has produced a smooth walled cloaca with the appearance of an accessory foramen that passes through the occipital bone. This same individual also has bilateral mastoiditis (*Figure 3*). Internally, there is pitting of the middle ear cavity with exposure of the mastoid air cells. Mastoiditis may have been related to the tuberculous infection.

Individual from burial 18 is a male, 40 to 49 years old. The body was in a primary posture, flexed, in an East-West orientation and left lateral position. The trepanation is located on the right parietal bone and the hole measures 23.7×18.5×9.5×8.2? mm. Around the trepanation margin of bone, cutmarks remained as evidence of the sawing method used. The hole is characterized by an irregular quadrilateral perimeter which is clearly visible (*Figures 4a, b*). The trepanation is incomplete suggesting that the individual died during surgery.

The paleopathologies (burial 18, male 40–49 years) noted include enamel hypoplasia (I_1, I_2, C, P^1, P^2) and tuberculosis. One of the lesions reported was on the

FIGURE 4a. Cranial trepanation. Bakheri chala, burial No. 18.

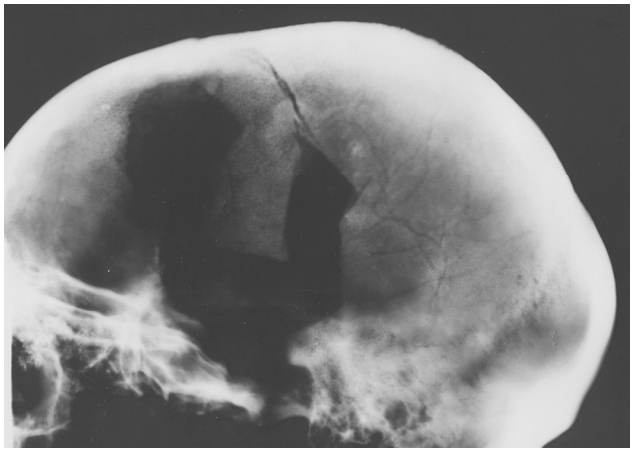

FIGURE 4b. X-ray of cranial trepanation. Bakheri chala, burial No. 18.

internal (posterior) surface of the manubrium, which had a latticework appearance (*Figure 5*), the other – thoracic vertebrae.

Special attention was given to traumatic lesions which may be associated with violence. Skull from burial 9 was located in a non-anatomical position. Skull belongs to an adult male of approximately 40 to 55 years of age at death. Evidence of decapitation clearly observed: damage to the mastoid processes, occipital regions (straight perimortem fracture to the left occipital bone), the posterior parts of mandibles (*Figure 6*). Such kind of injuries have only one definition (beheading at the person who is in vertical situation) (Manchester 1983). The blow was struck behind, obviously, by the right-handed person. Based on the well-defined sharp edges, polished cut surface, and macroscopically visible parallel striations perpendicular to the kerf floor, the injury was inflicted by a sharp bladed object, most likely a sword.

The present study showed that the cranial trauma rate among ancient Armenia from the Bakheri chala was 15.63 %, which is considered high. All of lesions were observed on the parietal bone: 2 in males, 1 – in female. The parietal lesions tended to be left-sided, which may indicate that the injuries resulted from face to face assault by right-handed attackers (Atta 1999). Two individuals (burials 28, 10) exhibit blunt traumas with complete bone remodeling in the skulls. An adult male (burial 28) and young female (burial 10) present a depression in the parietal bone while the other male young (burial 8) present a depressed fracture on the parietal bone. Blunt trauma in the skull is determined

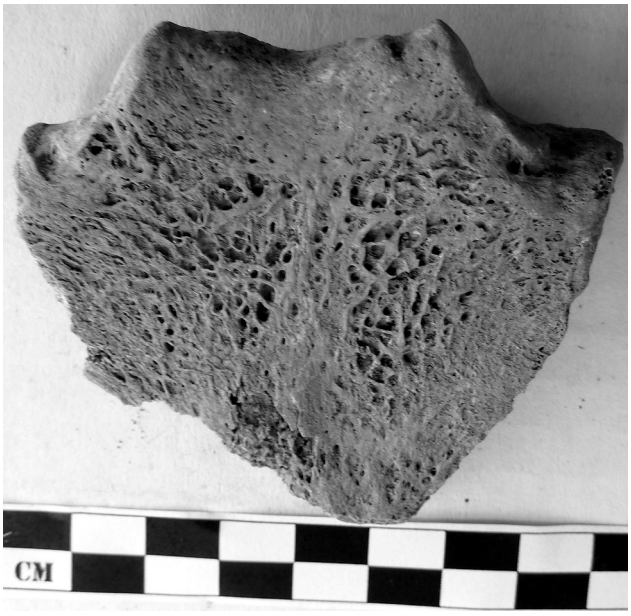

FIGURE 5. Tuberculosis of sternum. Bakheri chala, burial No. 18.

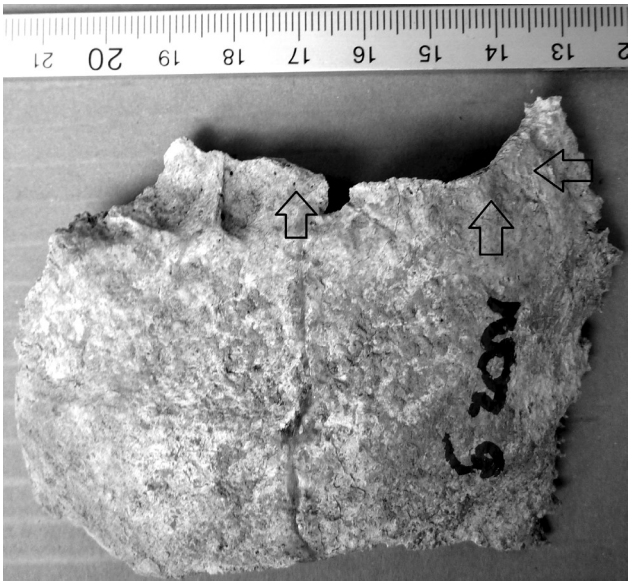

FIGURE 6. Decapitation. Bakheri chala, burial No. 9.

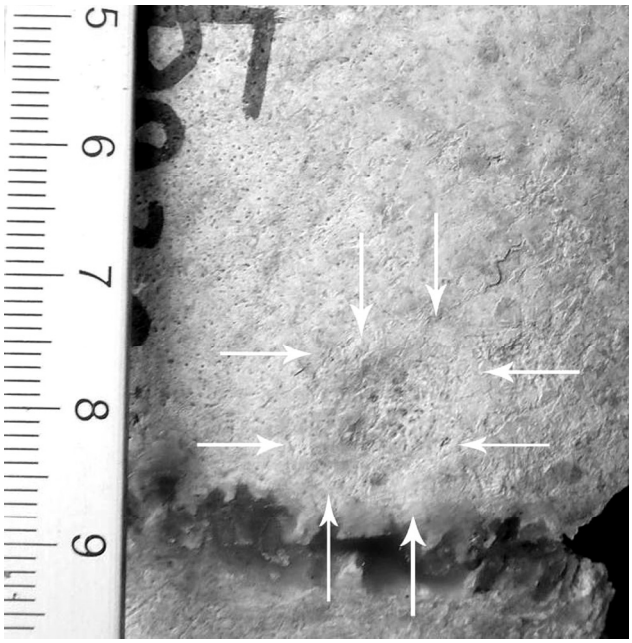

FIGURE 7. Healed depressed trauma on the left parietal bone (13×8 mm). Bakheri chala, burial No. 10, female, young adult (20–25years).

whenever the fractures manifested a clear external border with radiating and concentric reticulations. The entire area afflicted appears depressed.

Figure 7 show depressed trauma at left parietal bone (burial 10). Depressed trauma could have resulted from blunt force. The left side of the skull vault there is small (13mm × 8 mm), superficial, oval-shaped lesion. This lesion had puckered bevelled edges indicating that some healing had occurred. Young male (20 to 25-year) skeleton present a perforation fracture (burial 8) in the right parietal of the skull. Holes, oval-shaped lesion are present. The wound was fatal. The damage caused to the skull by pointed objects.

Skeletal material from burial 15 was well preserved allowing morphological determinations of age and sex.

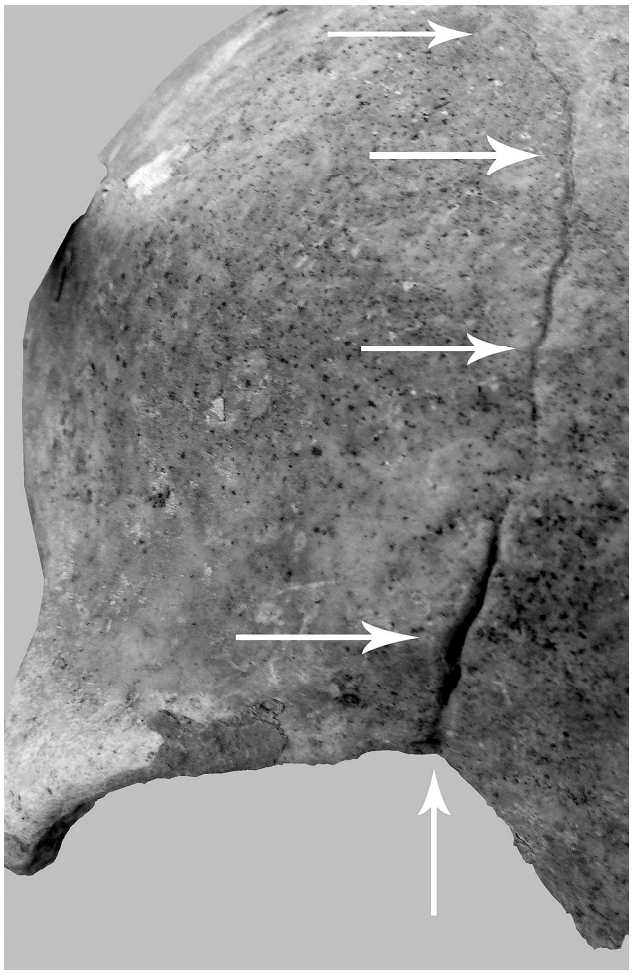

FIGURE 8. Healed fracture on the frontal bone, supraorbital foramen and inside the orbit. Bakheri chala, burial No. 15, male, young adult (18 to 23-year).

The individual was assessed to be approximately 18 to 23 years old at death and cranial and pelvic examination, based on well established criteria, indicated that he was clearly male. The most distinctive pathological signs of major trauma exhibited by individual from burial 15 were the extensive fracture seen on the frontal bone (*Figure 8*). The changes suggest a fracture the frontal bone and supraorbital foramen (distance 59mm) и inside the orbit (distance 11mm), possibly accidental. This fracture is usually the result of an indirect force, such as a fall, where the force of impact is transmitted up the bone to produce an oblique fracture line. The lesion was well healed indicating long survival after the injury i.e. the trauma was not lethal. Only a fractured bone near the orbital edge do not united.

One male (burial 15) has a 5 small 'button' osteomas present on the skull, located on the frontal bone and one female (burial 4) has a 'button' osteoma (7mm×5mm) present on the frontal bone. Bakheri chala site showed a high frequency of auditory exostosis (51.73%, 15/29). Two individuals (burials 19 and 18) have tuberculosis present, located on the sternum and vertebrae.

The Bakheri chala site show a high frequency of cribra orbitalia (83.34%, 15/18; 9 male, 5 female) and small frequency of porotic hyperostosis (24.14%, 7/29, 4 male, 3 female). The high frequencies of mastoiditis have been found among individuals Bakheri chala (40.91%, 9/22: 4 male, 3 female, 2 children). The destruction of the mastoid wall and mastoid cells suggests that most cases of mastoiditis were probably acute.

FIGURE 9. Apical abscess. Bakheri chala, burial No. 25, female, young adult (30 to 39-year).

TABLE 2. Dental pathology (affected/observed teeth).

Pathology	Sex	Position	I1	I2	C	P1	P2	M1	M2	M3
	♂	Maxilla							1 (10)	2 (9)
Caries	♀					1 (6)	2 (8)	1 (9)	1 (8)	1 (6)
	♂	Mandible								1 (8)
	♀					1 (10)			1 (9)	
	♂	Maxilla	3 (11)	4 (11)	6 (11)	6 (11)	6 (11)	1 (11)	3 (10)	
Enamel	♀			2 (7)	2 (7)	2 (6)	5 (8)	2 (8)	1 (8)	1 (6)
hypoplasia	♂	Mandible	3 (10)	3 (10)	8 (10)	5 (10)	3 (9)	1 (8)		1 (8)
	♀		1 (9)	1 (9)	1 (9)	4 (10)	2 (9)	1 (9)		
	♂	Maxilla	1 (11)	1 (11)	2 (11)	1 (11)	2 (11)	2 (11)		
Calculus	♀			1 (7)					1 (8)	
	♂	Mandible	3 (10)	3 (10)	3 (10)	2 (10)	2 (9)	1 (8)	1 (8)	1 (8)
	♀		2 (9)	2 (9)			1 (9)	1 (9)	1 (9)	
	♂	Maxilla		2 (11)	1 (11)	1 (11)	1 (11)	1 (11)		
Tooth Wear	♀					1 (6)	1 (8)	1 (8)		
	♂	Mandible			1 (10)			1 (8)	1 (8)	1 (8)
	♀							1 (9)		
	♂	Maxilla		1 (11)	1 (11)					
Absesses	♀				1 (8)	1 (8)	1 (8)		1 (8)	
	♂	Mandible			1 (10)	1 (10)				
	♀							1 (9)		
	♂	Maxilla						1 (11)	2 (10)	3 (9)
Antemortem tooth	♀		1 (7)			1 (6)				2 (6)
loss	♂	Mandible					1 (9)			1 (8)
	♀						1 (9)		1 (9)	1 (8)

The frequencies of various types of dental disease are presented in Table 2. The data refer to right and left teeth taken together. The highest frequencies of caries have been found among individuals Bakheri chala (24%). Absesses (*Figure 9*) are another indicator of infection and sanitary conditions. The enhanced frequencies of abscesses have been found in group (30%). The frequency for enamel hypoplasia exhibited by skeletal sample (60.0%, 18/30: male site 78.58%, 11/14; female site 62.5%, 5/8; individuals is not defined sexual identity 33.34%, 1/3) is high. The most severely affected teeth were the premolars, canines. Extreme wear to the level of the dental root is present on 40% of the male (6/15) and 37.5% of the female (3/8). The Bakheri chala site show a high frequency of dental calculus (40%; 7 male, 2 female, 1 adolescent). The most severely affected teeth were the incisors, molars. The overall frequency of AMTL in the dentitions, sexes combined, is 32%. Maxillary teeth were more often affected than the mandibular dentition.

DISCUSSION AND CONCLUSION

This skeletal collection is unique in that it provides a sample from a Late Bronze Age and Early Iron Age Armenia population. Uneven sex ratios, in terms of more males to females, have been reported at Bakheri chala. The unbalanced sex ratios at site may be the result of factors that have nothing to do with differential treatment of the sexes after death. Poor skeletal preservation, especially at Bakheri chala, may have skewed paleodemographic assessments. One vexing paleodemographic problem that is found in the entire Bakheri chala sample is the paucity of subadults (birth to 20 years of age). Subadults make up only 18.75% of the sample (see *Table 1*). This dearth of young individuals is mirrored at other sites in the region (see Khudaverdyan 2014). There are several lines of speculation that can be explored in order to explain this situation. One possibility is that most of the young individuals in the population were surviving to adulthood. Nutrition was good, diseases were few, and the amount of physiological stress facing the youngsters was slight. This should translate into an excellent state of health not only for the children, but for the population at large. Another possibility for the lack of subadult skeletons is the taphonomic process. The soil type of the Bakheri chala site is not conducive to good skeletal preservation. Of the two possibilities discussed to explain the low numbers of subadult skeletal elements, this is probably the most likely

answer. Only 9.4% of the individuals in group were assessed as old adults. The only one old adult in the group were females. This dichotomy has implications concerning the health and adaptation of the Late Bronze Age and Early Iron Age. Life expectancy at birth is about 29.7 years. Estimated life expectancies are high and for the males (36.1years), and for the females (33.1years). Life expectancy at birth in group Landjik (Early Bronze Age) is about 24.5 years, in group Black Fortress (Late Bronze Age and Early Iron Age), is about 31.4 years (Khudaverdyan 2014). This study has also shown that average age at death was high. These mortality rates should be viewed cautiously.

A study of trephinations from skulls found in archaeological site, indicates that a they had some form of cranial pathology - such as mastoiditis, brain abscess (that would have caused both pain and swelling) and tuberculosis. This provides further support for the suggestion that trephination was primarily for therapeutic reasons. The trepanation was performed to somehow treat or relieve the symptoms of disease. Oakley *et al.* (1959) reported an ancient trepanned skull from Jericho that showed signs of mastoiditis. They argued that an infection of the mastoid process of the temporal bone could be the reason for the trepanation. The authors also note a perforation of the external auditory meatus (external ear canal) of the same skull from Jericho. This is the only clue as to why this trepanation was performed; there is no other sign of disease on the skull. This condition can cause earaches, headaches, swelling and fever, these symptoms apparently did prompt surgical intervention.

Tayles and Buckley (2004) proposed that pronounced porosity in the form of web-like pores on the manubrium might be the result of an inflammatory process of associated blood vessels, which can be caused by a multitude of conditions. Kelley (1979) reported on a case from the Hamann-Todd collection in which an individual had an aneurysm of the ascending aorta associated with severe bone destruction on the posterior surface of the manubrium. Tayles and Buckley (2004) stated that the porosity seen on the posterior surface of the manubrium (individual B107) was likely the result of increased vascularity due to chronic inflammation of blood vessels since branches from the internal thoracic artery supplies the manubrium with blood via numerous foramina on the posterior surface. Differential diagnoses listed by Mann and Tuamsuk (2005) included: thalassemia, Gaucher's disease, hemangioma/lymphagioma, multiple myeloma, chronic leukemia, lymphoma, Hodgkins disease, and metastatic carcinoma. Mann and Tuamsuk (2013) referred to a study conducted by Lagia *et al.* (2007) that reported on the skeleton of a 14-year-old female from a skeletal collection at the University of Athens that presented a similar lesion pattern and morphology; the individual was believed to have had thalassemia. The 40–50 year male from Bakheri chala, in addition to a trepanations on the left parietal bone, had inflammation (possibly tuberculosis). One of the lesions reported was on the internal (posterior) surface of the manubrium, which had a latticework appearance, the other – thoracic vertebrae. Given that tuberculosis is known to affect the sternum and thoracic vertebrae could have potential associations with tuberculosis.

The examples of the rectangular sawing technique were encountered in the Bronze Age as well; its typical examples were represented by 3 individuals from Anatolia (İkiztepe, Çavlum) (Erdal 2005, Erdal, Erdal 2011) and one – from Azerbaijan (Dashkesan region) (Kirichenko 2007).

The symbolic case requires most attention. In the cases from Bakheri chala (made with the scraping technique) incomplete trepanation was present. Only the external table and the diploe were perforated and when the internal table was reached the process was stopped. Similar examples of this application were also encountered in different places of the world such as Anatolia, India, France, Spain, Bulgaria, Russia, Ukraine, Portugal, England, Norway (Jordanov *et al.* 1988, Campillo 1993, Sankhyan, Weber 2001, Bennike 2003, Holck 2008). Why the trepanation was not completed is merely a subject of speculation (Holck 2008).

Head injuries have been a feature of all human societies and one of the few experiences that cannot be hidden from archaeology, since the skull is easily damaged, and fractures, punctures, dents and gashes are found on skulls.The present study showed that the cranial trauma rate among ancient Armenia from the Bakheri chala was 15.63%. Depressed fracture could have resulted from blunt force and blade injury could have resulted from edged weapons.

Some of the recorded traumas in sample resulted from accidents (burial 15). Falls from heights, such as ladders or roofs, may occur and like the present day, they were likely due to the carelessness of those on the ladder. It is also possible that such pathologies may have occurred as a result of a horse-riding accident, and considering the time-frame this would be a more likely scenario.

Special attention was given to traumatic lesions which may be associated with violence. Skull belong to an adult male of approximately 40 to 55 years of age at death from burial 9, was evidence of decapitation. The blow was struck behind, obviously, by the right-handed person. Decapitation is one of the common forms of sacrifice in Bronze Age and Early period. At Armenia, widespread damage typically occurs on the structures of the base of the skull, including the edge of the foramen magnum, the mastoid process, the inferior surface of the occipital, and the posterior angles of the mandible. The as a means of murder or execution; it may be accomplished, for example, with an axe, sword, or by other means.

Bakheri chala site showed a high frequency of auditory exostosis (51.73%). The exostoses, although allowing lateral open passages toward the tympanic membrane had grown to full occlusion intra vitam, indicative of cumulative osteoblastic responses to prolonged exposure and irritation to external stimuli /causative agents. The presence of auditory exostosis has been related with a specific activity: individuals diving in cold water. Ecological conditions of the Bakheri chala population, close to the river, were suitable for exploiting. It is probable that one of the work activities was diving. The frequency of auditory exostosis supports this hypothesis. Cases of benign neoplasms observed in group should be viewed as non-life threatening disorders. Osteomas are uncommon (2 cases) findings on the Bakheri chala and should be looked at as having little to no effect on health or adaptation.

These results have indicated a population under stress. Through this research, the expected findings are that adults will have higher prevalence of cribra orbitalia. Total frequency of cribra orbitalia in Bakheri chalar (83.34%) is somewhat higher than the frequencies recorded in most of the skeletal samples from the territory of the Armenia (Khudaverdyan 2010, 2011, 2012). The adults in the sample of Bakheri chala display healed cribra orbitalia. Porotic hyperostosis was only seen in 7 cases. The presence of porotic hyperostosis and especially cribra orbitalia is a great indicator to determine the health and nutritional status of past populations (Facchini *et al.* 2004). Due to a diet consisting of milled cereal grains and cow milk, individuals from Bakheri chala were susceptible to illnesses. Furthermore, they were exposed to infectious agents. Additionally, children can be affected by diarrheal infections when they stop feeding on sterile breast milk and begin ingesting food and water that may be contaminated by microorganisms (Facchini *et al.* 2004).

Cribra orbitalia may be also associated with dental enamel hypoplasia which also indicates stress periods in life. Lovell and White (1999) point out that the presence of hypoplasia in the deciduous dentition often reflects maternal and neonatal hypocalcemia, while hypoplasia in the permanent dentition reflects nutritional and infectious stresses that are commonly associated with the process of weaning. Enamel hypoplasias occurred in a high frequency in dental samples in Bakheri chala group. Of all the individuals excavated, 60% had one or more teeth affected by dental enamel hypoplasia. Dental enamel hypoplasia have higher frequencies in males in Bakheri chala. This suggests that the Late Bronze Age and Early Iron Age was a time of greater nutritional stress. The archeological record indicates that population increased in the Late Bronze, which would have meant greater competition for resources.

The skeletal material from Bakheri chala shows higher frequencies of dental caries (24%). The majority of carious lesions were on occlusal surfaces, indicating the consumption of refined carbohydrates as they are sticky and are easily trapped in grooves of the enamel surface. Caries occurs in higher frequencies in agricultural societies (Larsen 1997). Agriculture introduced people to carbohydrates, or sugars, which affect the teeth and cause dental caries. The staple diet of ancient population from Shnogh river consisted of wine, bread, vegetables, and fruits (Hobosyan 2011). Within the adult population (25 individuals) only 6 carious lesions led to abscess. The remaining 3 abscesses resulted from attrition. When the primary dentin is exposed, as through attrition, secondary reparative dentin forms. If the primary dentin exposure is slow enough, the secondary reparative dentin is sufficient to protect the pulp cavity from exposure (Kuttler 1959).

The severe dental wear is the result of the bread baking for which the grain needed to be grinded, a process in which sand was incorporated into finished bread molds. The sand caused extensive dental abrasion (Larsen 1997, Aufderheide, Rodriguez-Martin 1998). Males do show a slightly higher rate of wear (40%) than females (37.5%) possibly suggesting a greater proportion of bread in the diet of males. Wear on all individuals regardless of age or sex appears to be flat or nearly flat. Although wear angles were not compared quantitatively here, they are mentioned because this pattern is somewhat unusual. In mandibular molars,

buccal cusps typically wear at a greater rate than lingual cusps and vice versa for maxillary molars, due to tooth-to-tooth contact allowed by a soft diet (Hillson 1996). The flatter plane of wear is seen almost exclusively among groups due to consumption of fibrous plant material, which spreads uniformly over the tooth surface during mastication (Smith 1984).

Calculus was recorded on the teeth of 10/25 individuals in Bakheri chala sample. The presence of calculus can result in protection against caries as the tooth surface is covered with hard concretions making it less susceptible to infection (Hillson 1996). Plaque buildup can occur in diets with heavy carbohydrate consumption (Hillson 1996), although protein may increase oral alkalinity, thereby promoting calculus mineralization.

Antemortem tooth loss was a not frequent finding (32%) in the dentitions at Bakheri chala. The loss of teeth before death can be attributed to several causes indicative of pathological processes including periodontal disease, carious lesions, and alveolar defects. The rate of loss, however, may not be entirely representative of an oral pathological condition. Furthermore, AMTL is age-progressive, as rates of tooth loss increase with age.

Although the sample size was small, bioarchaeological data from the studied historical population of Bakheri chala are useful in understanding the life ways of the ancient Armenian population.

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