

The Anthropology of Infectious Diseases of Bronze Age and Early Iron Age from Armenia

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ABSTRACT This study reviews the evidence for the presence of specific infectious diseases in Armenian skeletal series of Bronze Age and Early Iron Age. Throughout human history, pathogens have been responsible for the majority of human deaths. Factors such as age, sex, and nutritional status can influence whether an individual contracts and develops a particular infection, while environmental conditions, such as climate, sanitation, pollution, and contact with others will affect the susceptibility of a population. The frequencies of such signs as osteomyelitis, periodontal disease, leprosy, abscesses, and so forth, testify that the people experienced a variety of forces and durations—

Ortner and Putschar (1981) claim that infectious diseases were the single greatest threat to life of prehistoric infants and children. But this does not mean that adults were immune. Of people surviving into adulthood, many will die of infectious disease, whether it be direct or indirect (Ortner and Putschar, 1981). There are a host of biological and environmental factors that influence the prevalence of infectious lesions found in prehistoric skeletal samples. Early hominid populations likely were too small and dispersed to support many of the acute communicable pathogens common to densely populated sedentary communities (Burnet, 1962), especially those for which humans are the only disease pool (Cockburn, 1971; Polgar, 1964). Pathogens such as smallpox, measles, and mumps were unlikely to afflict early hominid groups (Cockburn, 1967a). Viruses such as chickenpox and herpes simplex may survive in isolated family units, suggesting that they could have been sustained in early dispersed and nomadic groups. The shift to permanent settlements created larger aggregates of potential human hosts while increasing the frequency of interpersonal contact within and between communities, likely fostering the spread and evolution of more acute infections (Ewald, 1994). Accumulation of human waste would have created optimal conditions for dispersal of macroparasites and gastrointestinal infections. The appearance of domesticated animals such as goats, sheep, cattle, pigs, and fowl provided a novel reservoir for zoonoses (Cockburn, 1971). Tuberculosis, anthrax, Q fever, and brucellosis could have been readily transmitted

both internal and external—of stressful influences. Individuals from Sevan region may have had more chronic infections due to continued exposure to pathogens during their lives as well as traumatic injuries. Seven individuals had nasopharyngeal lesions consistent with a diagnosis of leprosy. Dental caries was less severe in the Sevan region, although dental abscesses (51 individuals) and antemortem tooth loss (87 individuals) were more prevalent. In contrast, periodontal disease (8/18 adults) and antemortem loss (8/18 adults) of the molars were more prevalent at the Shiraksky plain. Data focusing on climate influence, migratory, and cultural habits in the past are discussed. *Dental Anthropology* 2011;24(2):42-54.

through the products of domesticated animals such as milk, hair, and skin, as well as increased ambient dust (Polgar, 1964).

The analysis of skeletal lesions resulting from infectious disease on prehistoric human skeletal material offers the osteologist insights into the interplay among many considerations, such as disease, diet, ecology, social structure, warfare, settlement pattern, plant and animal domestication, sanitation level, immunological resistance, and psychological stress (Larsen, 1997). 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 by way of 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 and Rodriguez-Martin, 1998).

The basis of the present study are four skeletal collections from the the Sevan region of Armenia, plus two from the Shiraksky plain. Figure 1 shows the spatial perspective of these sites. The Armenian Highland—also

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Fig. 1. Map of the Republic of Armenia. Main sites are discussed in text.

known as the Armenian Upland, Armenian plateau, or simply Armenia (Hewsen, 1997) – is the central-most and highest of three land-locked plateaus that collectively form the northern sector of the Middle East (Hewsen, 1997). The Armenian plateau has been a crossroads linking the worlds of East and West (Martirosyan, 1964). The areas surrounding the Black Sea coast at certain stages of history became a center of interrelations of multiple cultures. Overland lines of contact existed between the Near East through the Armenian highlands and the Caucasus and on to the Balkans, and through Caucasus and the Balkans to the north Black Sea coast and in the return direction. The ethnic history of the region developed under the interaction of various groups since the early Bronze Age, among which the Indo-European played a leading role, those tribes having created one of the most advanced cultures of the then-contemporary world (Khudaverdyan, 2011a,b). Late Bronze Age and Early



Fig. 2. A burial from the Black Fortress (photo S. Ter-Markaryan).

Iron Age also mark the time of contact between Eurasians in this area (Khudaverdyan, 2011a,b). According to the archeological record (Kyshnareva, 1990), it was a time of expanding population. Trade networks expanded and social systems grew more complex. Increasing migration and trade between state-level societies in Eurasia led to the convergence of regional infectious disease pools.

The economy in Armenia was based on forms of mixed agriculture. Analysis of the faunal remains indicates that cattle and sheep and goat herds were managed for many purposes such as milk, wool, skin, meat, and other secondary products. At the Armenian necropolis in the Late Bronze Age among the usual graves with human skeletons there were burials of a horses and a chariot burial (Khudaverdyan, 2009, 2011b). The exploitation of wild animals continued as hares and wild birds have been found at sites in the region. The rites of single or multiple inhumations started in the Bronze to Early Iron Age and were located in settlements, in well-defined burial areas. Individuals' remains were accompanied by grave goods of metalwork (jewelery and weaponry), pottery, and joints of meat.

Little is known about the health status and epidemiological aspects of historic Armenia (Khudaverdyan, 2010), but the quality of life of the members of past societies can be assessed by analyzing their remains (Larsen, 1997). Together with osteometric study, pathological examination can provide useful information on the biological aspects of a skeletal series. Burial grounds from the Lanjik and Black Fortress are located in the Shiraksky plain. Archaeological and anthropological monuments are common from in two time periods: the first half of the IV-III millennium B.C. (Lanjik) and the beginning of II millennium B.C. (Black fortress). The Yerevan Medical University had an archive of paleopathological specimens from A. Sarafyana, which had been taken for the Khudaverdyan report (2005; Sarafyan and Khudaverdyan, 1999). This provides 17 adults from Sarykhan (*ca.* XI-IX/ VIII B.C.), 126 adults from Lchashen (II-I millennium B.C.), 4 adults from Karmir (*ca.* IX-VIII B.C.), and a sample of 28 individuals from Akynk (*ca.* XIII-XII B.C.). It is only recently that these skulls have been studied for evidence of disease.

MATERIALS AND METHODS

The human remains that were analyzed for this article were excavated by a Gyumri team under the directions of Levon Petrosyan and Stepan Ter-Markaryan (the sites of Landjik and the Black Fortress). This is a most important culture of Early Bronze Age in Armenian highlands called the Kura-Araxes Culture (Landjik burial). One mass burial from the Landjik site (end of the fourth millennium and beginning of the third millennium) has been excavated, and it contained remains of at least 10 individuals, together with rich archaeological grave goods (Petrosyan, 1996). Most of these skulls were in a good state of preservation (2

TABLE 1 Number of individuals included in the study

	Males	Females	Total
Lanjik	2	6	10
Black Fortress	2	8	13
Sarykhan	8	9	17
Lchashen	62	23	85
Akynk	16	12	28
Karmir	1	3	4

males, 5 females). Two children (2-9 years) and 1 juvenile between 13 and 19 years of age were the only non-adults present in the sample.

The site of Black Fortress is remarkable due to the archaeological presence of two time periods of ancient Armenian history (Late Bronze Age and Ancient period, dating from the 1st century B.C. to the 3rd century A.D.). Many sites are found here with a very large cemetery. The Black Fortress site (2nd millennium B.C.) is a regular cemetery (Fig. 2) has been excavated since 1993, and the excavations are still ongoing (Ter-Markaryan, 1991; Ter-Markaryan and Avagyan, 2000; Avagyan, 2003). This cemetery was located near the Aleksandrapol tower in the city Gyumri. All of the burials appear to have been typical Late Bronze Age interments, oriented in an east-west direction. Intentionally interred remains of small animals were common. The majority of animal remains recovered at Black Fortress were horned livestock and reptiles (especially turtle) (Avagyan, 2003). A total of 13 skeletons were exhumed from a burial that included 2 males, 8 females and 3 children (4-9 years).

An excavator disinterred skulls in the village of Sarykhan. Due to this information, a survey was conducted, which led to the beginning of an archaeological excavation. It was supervised by A. Piliposyan (Yerevan), and the excavations were developed in 1984. Group Sarykhan contained some 17 individuals. The distribution of sex is predominantly female (9 individuals: 24% of young adults (20-40 years), 18% of middle 11.8% of old adult). Of these, 8 were male (6% adolescent, 6% young adults, and 18% middle and 18% older adults) (sex and age from the unpublished data of A. Sarafyan) (Khudaverdyan, 2005).

The Lchashen site is a mass burial ($n \approx 500$) which includes at least 126 individuals of both sexes and all ages (Alekseev, 1974), accompanied with many stone and bone tools as well as ornamental objects. Many sites are found surrounding this large cemetery that was excavated in 1957-1967 (Mnacakanyan, Yerevan), and the excavations are ongoing. The distribution of sex is predominantly male (62 individuals), and 23 were females (Alekseev, 1974).

Group Karmir (archaeologist A. Piliposyan) contained 4 individuals. The distribution of sex is three female (middle adult) and one was male (old adult) (from the

unpublished data of A. Sarafyan) (Khudaverdyan, 2005). The Akynk includes at least 28 individuals (Kochar *et al.*, 1989).

The analysis uses traditional approaches for the assessment of the general physical characteristics of the age at death and sex in the samples. Age-at-death and sex were assessed through the use of multiple indicators. Morphological features of the pelvis and cranium were used for the determination of sex (Phenice, 1969; Buikstra and Ubelaker, 1994). A combination of pubic symphysis (Gilbert and McKern, 1973; Katz and Suchey, 1986; Meindl *et al.*, 1985), auricular surface changes (Lovejoy *et al.*, 1985), degree of epiphyseal union (Buikstra and Ubelaker, 1994), and cranial suture closure (Meindl and Lovejoy, 1985) were used for adult age estimation. For subadults, dental development and eruption, long bone length, and the appearance of ossification centers and epiphyseal fusion were used (Moorrees *et al.*, 1963a,b; Ubelaker, 1989; Buikstra and Ubelaker, 1994).

Dental inventory and recording of pathologies were collected using standards and forms found in Buikstra and Ubelaker (1994). Periodontal disease was assessed by measuring the amount of alveolar bone loss. Measurements were taken from the cemento-enamel junction to the surface of the alveolar bone. Only those measurements that exceeded 2 mm were recorded as evidence of periodontal disease (Tumer *et al.*, 1991). Caries were recorded based on the system devised by Moore and Corbett (1971, in Buikstra and Ubelaker, 1994:55). Dental caries were recorded for each tooth and surface affected. Care was exercised in order to avoid confusing legitimate caries with pulp exposure due to severe wear. Abscesses were recorded based on their presence and location. Buccal or labial lesions were differentiated from lingual perforations (see Buikstra and Ubelaker, 1994:55; Tumer *et al.*, 1991). Antemortem tooth loss (ATL) was based on evidence of resorption of alveolar bone around a tooth socket. If remodeling was evident and the socket was partially or fully filled in, then a tooth was considered to have been lost antemortem. Sockets that were open and smooth, with no evidence of remodeling, were recorded as postmortem loss (Tumer *et al.*, 1991). Enamel



Fig. 3. Osteomyelitis. Materials from excavation of burial ground Akynk (burial 11, ♂ 35-40 years).

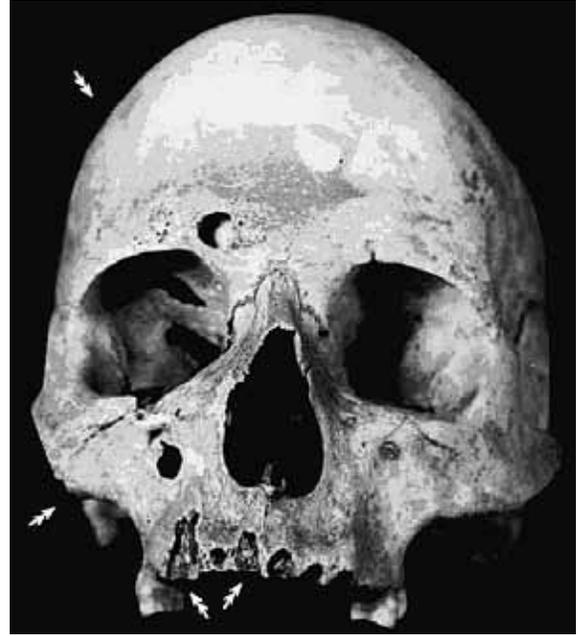


Fig. 4. Subacute osteomyelitis of the upper jaw; inflammation of an antrum of Highmore; facies leprosa. Materials from excavation of burial ground Lchashen (burial 52, ♀ 30-35 years old).

hypoplastic defects—a deficiency of enamel thickness, which is normally smooth, white, and translucent—were divided into linear, pit, and plane defect types (Hillson, 1996). To determine the effects of stress on the bone, special indicators can be used that allow one, with various degrees of accuracy, to speak of adaptive complexes within the populations (Goodman *et al.*, 1984; Goodman and Rose, 1990).

RESULTS AND DISCUSSION

Skeletal Indicators of Health: Infection

Osteomyelitis is a combination of inflammation of the bone (osteitis) and the bone marrow (myelitis) by pus producing bacteria (Aufderheide and Rodriguez-Martin, 1998). Severe osteomyelitis and osteitis are caused by the spread of *Staphylococcus* and *Streptococcus* microorganisms. Depending on the virulence of the microorganisms and/or host resistance, the reaction may be localized and acute or chronic and systematic (Goodman *et al.*, 1984). Ortner (2003) points out that other infectious agents, such as viruses, fungi, and multicelled parasites can also affect the bone marrow. The skeletal changes consist of bone destruction along with new bone formation (involucrum) and necrotic bone (sequestrum) (Aufderheide and Rodriguez-Martin, 1998). Another typical manifestation of osteomyelitis is the formation of cloacae (drainage canals) that may be present in many cases. Osteomyelitis does not only occur in an acute form, but also in a subacute as well as a chronic form that can reappear over a period of several years and, according

to Larsen (1997), it can be the response to systemic or localized stress. Death can occur if the infection spreads from the bone to the circulatory system and finally affects vital organs. If osteomyelitis heals, the bone becomes dense and becomes part of the normal cortical tissue and sclerotic scarring may occur (Larsen, 1997; Ortner, 2003). Aufderheide and Rodriguez-Martin (1998) discussed that acute osteomyelitis can result from infections due to compound fractures, injuries, or surgery, and it occurs most frequently in adults over 40 years of age.

Figure 3 shows a middle adult male approximately 40 years old in group Akyнк, diagnosed with severe osteitis and periodontal disease. This unfortunate individual had lesions on his entire skull. The cranium of exhibits lesions on the frontal and left temporal bones. The frontal contains 2 lesions ranging in size from <0.2 mm to 0.3 mm in length and sclerotic reaction. The left temporal contains 1 small indentation on the side of the occipital bone along with a sclerotic reaction.

In the woman (30-35 years old) from Lchashen (burial 7), acute hematogenous osteomyelitis of the frontal sinus is revealed along with dental abscesses (Fig. 4). Periapical abscesses can be fatal if the resulting infection spreads into the sinuses. Development of odontogenic osteomyelitis is visible in the region of upper right incisors, and the canine tooth was the source of a secondary defect of antrum of Highmore. The antritis was accompanied by an osteomyelitis and destruction of the forward wall of a sinus. The sharp antritis has been complicated by the distribution of inflammatory process on a trellised labyrinth of the frontal sinus. The margin of the main erosion was marked by a number of small distinctive subsions in the outer table, comprising groups of small pits having an apparent sclerotic margin clustered around a small region of intact outer table. Some of these subsions were present in isolation on other parts of the frontal bone (Fig. 4). The frontal bone is diploic with a marrow cavity capable of developing osteomyelitis. A typically fluctuant swelling



Fig. 6. Osteomyelitis. Materials from excavation of the burial ground Lchashen (burial 27, ♂ 30-35 years old).



Fig. 5. Osteomyelitis and facies leprosa. Materials from the excavation of burial ground Sarykhan (burial 11/2, ♂ 50-55 years old).



Fig. 7. Osteomyelitis in the temporomandibule joint and porotic hyperostosis on the skull. Materials from excavation of burial ground Lchashen (burial 7, ♂ 45-50 years old).

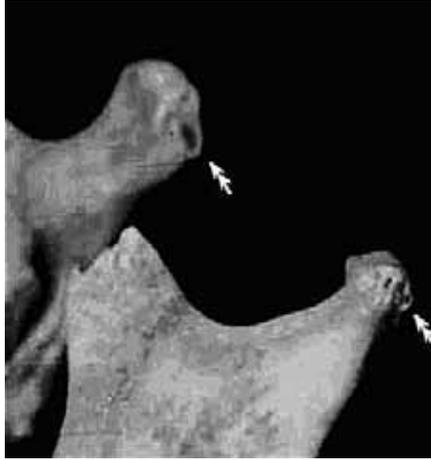


Fig. 8. Mandibular condyles with porous surface. Materials from excavation of the burial ground Lchashen (burial 62, ♂ 30-35 years old).



Fig. 9. Dental abscesses. Materials from excavation of burial ground of Akynk (burial 7/2, ♀ 40-45 years old).

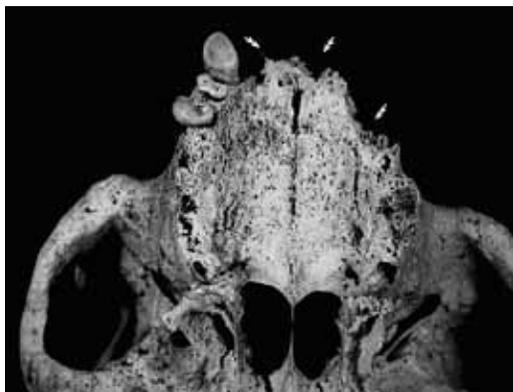


Fig. 10. Subacute osteomyelitis in the upper jaw. The adsorption is almost complete in numerous regions of the alveolus. Note the extreme pitting of the palatine bones and the extensive dental wear. Materials from excavation of the burial ground of Lchashen (burial 83, ♂ 50-55 years old).

over the forehead known as “Pott’s Puffy Tumor” after Sir Percival Pott who described the condition in 1760, results from frontal sinusitis and osteomyelitis eroding the anterior table of the frontal bone. The term Pott’s Puffy Tumor has been applied to any scalp swelling associated with frontal sinusitis. Some prefer to limit the term to the swelling overlying and area of osteomyelitis in a diploic bone and use the term “a ruptured frontal sinus” for those associated with frontal sinusitis (Thomas *et al.*, 1977). It is a serious life-threatening complication of frontal sinus infection. Pott’s Puffy tumor and its complications result from the unique anatomy of the frontal sinus. The sinus is separated from the frontal bone marrow by only 100 to 300 μm . The sinus mucosa, marrow cavity and frontal bone have a common venous drainage via valveless diploic veins (Breschet’s canals). Frontal sinus infection can thus invade the marrow cavity causing osteomyelitis and erode through the thin anterior and posterior table, producing subperiosteal and extradural abscess, respectively (Feder *et al.*, 1987; Lund, 1987).

Figure 5 shows a middle adult male approximately 50 years old in group Sarykhan (skull 2, burial 11), diagnosed with severe osteomyelitis and dental abscesses. The frontal bone contains 1 lesion about 2 cm in length with sclerotic reaction.

Chronic osteomyelitis occurs more frequently in the mandible than in the maxilla and is often associated with suppuration. It is usually diffuse and widespread (Lavis *et al.*, 2002; Eyrich *et al.*, 2003). Kazunori Yoshiura (Reinert *et al.*, 1999) classified mandibular osteomyelitis into four patterns, as lytic, sclerotic, mixed, and sequestrum patterns. Our case presented with the last pattern. Chronic osteomyelitis will result in deformity of the affected bone (Fig. 6). With an infection of the bone, the subsequent inflammatory response will elevate the overlying periosteum, leading to a loss of the nourishing vasculature, vascular thrombosis, and bone necrosis, and ending in formation of sequestrae. Figure 6 confirmed the presence of a deep sequestra. Although most cases of chronic osteomyelitis of the jaws result from dental origins, other sources of infection are possible (Eyrich *et al.*, 2003). It may also occur following penetrating trauma. Viral fevers (*e.g.*, measles), malaria, anemia, malnutrition may also contribute to the development of osteomyelitis. At Lchashen, 27 adults showed evidence of osteomyelitis in the mandible.

The inflammation of a mandible joint (Figs. 7-8) can arise as hematogen metastatic as a result of general infectious diseases such as scarlet fever, diphtheria, measles, dysentery, or typhus, and owing to contact distribution of an infection: an osteomyelitis of an ascending branch of the bottom jaw or a purulent otitis. The mandible joint of a skull (Lchashen: burials 7, 62, Figs. 7-8; Black Fortress: burial 9) expresses the presence of small sclerotic reactions.

Dental Abscesses

Abscesses of a tooth lead frequently to its exfoliation and cause a remodeling process that usually destroys the alveolus and reduces the size of the alveolar process at the site of the tooth loss (Ortner, 2003). Some researchers note that abscesses are caused by *Streptococcus milleri*, *Fusobacterium nucleatum*, or *Streptococcus mitis* (Lewis *et al.*, 1986). Abscesses can be instigated by various conditions, such as pulp necrosis, periodontal infection, or trauma. Periapical abscesses can be fatal if the resulting infection spreads into the sinuses (Fig. 4). Although periapical abscesses can occur on the roots of any tooth, Herrera *et al.* (2000) conclude that molars are most frequently affected with an occurrence of 69%. Most abscesses happen in patients that already suffer from periodontal disease (Herrera *et al.*, 2000). In Lchashen, 41 adults suffered from dental abscesses. Regarding the skeletons from Lanjik, three adults showed evidence of dental abscesses. At Sarykhan, seven adults showed evidence of dental abscesses, which was higher than in the Akyнк group (Fig. 9), where only one individual was affected. In the group from the Black Fortress, one adult suffered from dental abscesses (Khudaverdyan, 2009). Two out of four dentitions from Karmir showed evidence of dental abscesses.

Periodontal Disease

Periodontal disease is the inflammation of the soft tissues of the mouth, namely the gums, and/or the periodontal ligament, and alveolar bone (Levin, 2003). Retraction of the gums exposes the vulnerable root of the tooth to attack by acidic plaques, commonly resulting in caries, abscesses and antemortem tooth loss. Periodontal disease is caused by several irritants such as bacterial plaque that becomes calculus due to calcification of plaque, and living or dead microorganisms (Clarke, 1990; Aufderheide and Rodriguez-Martin, 1998; Ortner, 2003). Another cause of periodontal disease can be gingivitis, an inflammation of the surrounding soft tissues (Ortner, 2003). Gingivitis can be caused by penetrating foreign bodies, major

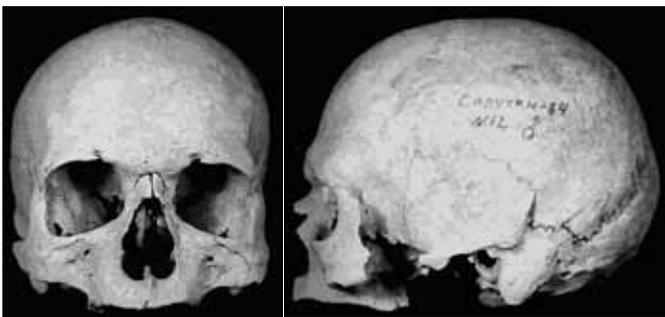


Fig. 11. Teeth lost during life. Materials are from an excavation of burial ground Sarykhan (burial 3/12, ♂ 60-65 years old).



Fig. 12. Dental caries and antemortem tooth loss. Materials from the excavation of the burial ground at Lchashen (burial 13, ♂ 30-35 years old).



Fig. 13. Example of dental caries. Materials from excavation of the burial ground of Black Fortress (burial 14, ♂ 25-30 years old).

local trauma, or, indirectly, the loss of interproximal contacts (Aufderheide and Rodriguez-Martin, 1998). In a progressive phase of periodontal disease, the roots of the teeth may be exposed and tooth loss may occur. It occurs interdentially and creates vertical defects between the root of the tooth and the alveolar bone. Most commonly, the posterior teeth, the second and the third molars, are affected (Clarke, 1990; Aufderheide and Rodriguez-Martin, 1998). Clarke (1990) and Larsen (1997) point out that if periodontal disease is unchecked and untreated, the bony support for the teeth diminishes and exfoliation can occur. Once a tooth is lost, the alveolus will be remodeled. Furthermore, Larsen (1997) lists the influencing factors,



Fig. 14. Facies leprosa: rhinomaxillary changes. Materials from the excavation of burial ground Karmir (burial 1, ♂ 50-55 years old).

such as bacteria, poor oral hygiene, malocclusion, nutritional status, pregnancy, and psychological stress.

There are four main types of periodontal disease, namely prepubertal, pubertal, rapidly progressive, and adult periodontitis (Hildebolt and Molnar, 1991). Of these four, only the last was observed in skeletons from Armenia. In the samples from Armenia, periodontal disease was present in 35 individuals. Periodontal disease was the most common dental pathology among the Landjik burials. A total of 4 out of 10 observable dentitions possessed some form of alveolar bone loss. On average there was greater bone loss on the mandible than the maxilla. The trend of periodontal disease in Lchashen (24 adults) was one of slightly greater involvement than that observed in the Black fortress group. Four out of 13 dentitions showed evidence of alveolar bone loss. At Sarykhan,



Fig. 15. Facies leprosa: rhinomaxillary changes. Materials from the excavation of burial ground Lchashen (burial 73, ♀ 50-55 years old).



Fig. 16. Multiple lesions of the skull. Materials from the excavation of the burial ground Lchashen (burial 31, ♂ 30-35 years old).

three adults showed evidence of periodontal disease. For the individuals from Karmir and Akyнк periodontal disease was not noted. Those teeth lost during life (Fig. 11) were not counted as periodontal disease because other conditions can also cause tooth loss, such as accidents or interpersonal violence.

Antemortem Tooth Loss

Antemortem tooth loss is characterized by the presence of abscess and/or remodeling of the alveolar bone obliterating the tooth sockets. Specific etiologies of antemortem tooth loss are problematic, as evidence may have been lost, especially in instances of carious teeth; however, the close association between periodontal



Fig. 17. Multiple lesions of the skull. Materials from excavation of the burial ground Lchashen (burial 79, ♂ 45-50 years old).

disease, dental caries, and antemortem tooth loss is well established, especially in archaeological series (Larsen, 1997). The prevalence of antemortem tooth loss contributes to the overall picture of oral health in a sample. For the group from Landik, antemortem tooth loss occurred in 4 adults. Also, four adults from the Black Fortress met the criteria for antemortem loss. At Lchashen, 72 adults showed evidence of antemortem tooth loss. Antemortem tooth loss were observed in 7 people from Sarykhan, 2 from Karmir, and 6 from Akynk.

Dental Caries

Tooth analysis plays an important role in anthropological research. Teeth are a rich “archive” that tell us about health and nutritional status, individuals and collective ancient and modern habits and life styles (Powell, 1985; Moggi Cecchi and Corruccini, 1993; Milner and Larsen, 1991). Dental caries is an infectious disease that destroys the tooth structure, the root and the crown (Brothwell *et al.*, 1967; Aufderheide and Rodriguez-Martin, 1998). Ortner (2003) mentions that caries are caused by acid-producing bacteria in dental plaque that initiate the destructive process. Larsen (1997) argues that caries do not refer to lesions in teeth resulting from the invasion of microorganisms, but that the disease is characterized by the focal demineralization of dental hard tissues by organic acids produced by bacterial fermentation of dietary carbohydrates, especially sugars. According to Larsen (1997), there are several modifying

factors for the development of dental caries: crown size and morphology, enamel defects, occlusal surface attrition, food texture, oral and plaque pH, speed of food consumption, some systemic diseases, age, child abuse, heredity, salivary composition and flow, nutrition, periodontal disease, enamel elemental composition, and the presence of fluoride and other geochemical factors. In Lchashen, 2 adults suffered from dental caries (Fig. 12). Caries were observed in 6 people from Landjik (3/8) and the Black Fortress (3/10; Fig. 13) (Khudavedyan, 2009). In individuals from Karmir, Akynk and Sarykhan there was no instance of dental caries.

Leprosy (Hansen’s Disease)

Leprosy is a chronic infectious disease caused by *Mycobacterium leprae* transmitted through contact with skin lesions or through inhalation of droplets containing the pathogen that are coughed or exhaled into the air by infected individuals (Roberts and Manchester, 2005). True leprosy is a chronic, debilitating, and disfiguring infection. This process can result in loss of fingers, toes, nasal tissue, or other body parts. Leprosy varies in expression from a mild, or tuberculoid, infection (also known as high-resistance leprosy) to the most severe infection, referred to as the lepromatous type (also known as low-resistance leprosy) (Andersen *et al.*, 1994; Ortner, 2003). Skeletal involvement can occur with any degree of infection, but it is most acute in the lepromatous form. However, the skeleton is not affected in most cases; only 5% of individuals with leprosy develop bony lesions (Ortner, 2003). Changes in the bones of the face can accompany lepromatous leprosy and are collectively known as the rhinomaxillary syndrome or ‘facies leprosa’ (Møller-



Fig. 18. Multiple lesions of the skull. Facies leprosa: rhinomaxillary changes. Material from the excavation of the burial ground Lchashen (burial 46, ♂ 20-25 years old)

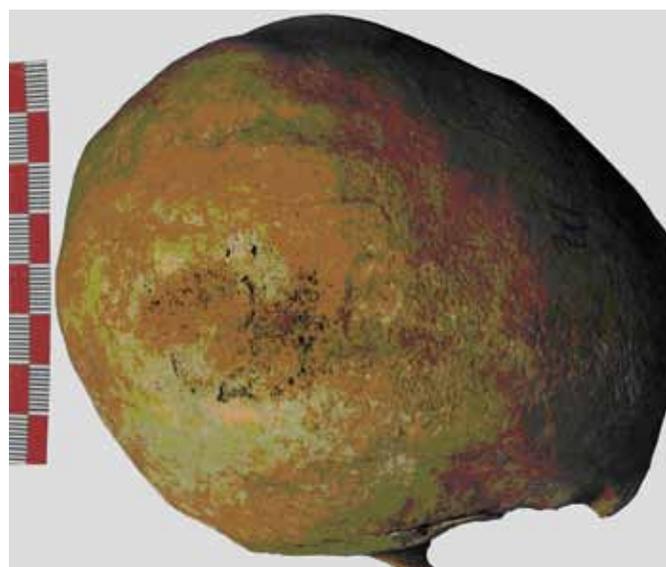


Fig. 19. Porotic hyperostosis. Material from the excavation of the burial ground the Black Fortress (burial 3/2, ♀ 45-50 years old).

Christensen *et al.*, 1952; Møller-Christensen, 1961, 1978; Andersen and Manchester, 1992).

Mycobacterium leprae prefers cooler areas of the body, leading to infection of mucosal tissues. Infection of the nasal area causes skeletal changes, such as loosening of the chondro-osseous junction at the bridge of the nose, which results in the characteristic 'saddle-nose' deformity. The nasal septum and hard palate are often perforated, and the anterior nasal spine, nasal aperture margins, and alveolar process of the maxillae are resorbed, the last of which leads to the loss of anterior maxillary teeth (Andersen and Manchester, 1992; Andersen *et al.*, 1994). There is evidence of leprosy in the adults, though one individual from Karmir (burial 1) has nasopharyngeal lesions, including significant remodeling of the nasal aperture margins (Fig. 14). And 6 individuals from Lchashen have nasopharyngeal lesions characteristic of leprosy (Figs. 15, 18).

Non-Specific Infections

Lesions on the cranial surface of the skull are indicators of non-specific infection or of trauma but they share similar difficulties with interpretation and identification in adults. Endocranial lesions can appear as 'worm-like' deposits of new bone, vascular depressions or 'hair-on-end' formations. This new bone is macroscopically identical to the 'woven' bone deposited during an infection or after trauma. The various appearances of endocranial lesions may indicate different aetiologies: meningitis, epidural haematomas, birth trauma, scurvy, venous drainage problems and tuberculosis, or syphilis (Virchow, 1896, in Hackett, 1976, p. 44) may cause inflammation or haemorrhage of the meningeal vessels (Schultz, 1993).

Individual 31 exhibits multiple lesions of the outer table of the parietal bones. On the right parietal bone there are several distinct lesions (Fig. 16), but two of these are particularly prominent. The surface is composed of smooth, cortical bone, suggesting a healed pathological process. The margins are rolled inwards towards the center of the lesion and fine grooves are present, compatible with the presence of small blood vessels. The inner table shows no evidence of pitting on the endocranial surface. Pathological changes observed in the cranial vault (burials 79, 46) include several focal cavitations that penetrate into the diploe but do not affect the inner table. There are also compact bone depressions with grooves (Figs. 17, 18). All these cranial vault injuries seem to be a reaction to an inflammatory process that affected the scalp and, consequently, the cortical cranial bone. Whether the inflammation was the result of blows, or local or systemic infections, cannot be determined.

Skeletal Indicators of Health: Systemic Stress

Anthropologists often consider porotic hyperostosis and cribra orbitalia as indicators of iron deficiency anemia,

although these markers may have other, less-common etiologies, such as hemolytic anemia and thalassemia (Stuart-Macadam, 1989, 1992a,b; Schultz, 1993, 2001). Iron is an important element found in blood, as it assists in oxygen transport to tissues throughout the body. Iron deficiency, which can have detrimental consequences, results from a number of factors, including malnutrition, parasitic infection, blood loss, and disease (Stuart-Macadam, 1989, 1992b). A deficiency in iron produces an associated increase of red blood cell production in the marrow cavities to compensate for the decreased level of oxygen available to tissues. The resulting expansion of the marrow cavities in thin, flat bones such as the cranial and orbital bone causes the external, compact bone to erode, creating a porous surface on the cranial vault (porotic hyperostosis; Figs. 7, 18) and in the eye orbits (cribra orbitalia) (Stuart-Macadam, 1987).

The mild forms of this stress indicator (cribra orbitalia) were observed in all age and sex cohorts in the Armenian samples. The overall frequency of cribra orbitalia in the Lchashen is 8.0%. The prevalence of cribra orbitalia is 28.6% from Sarykhan and 9.1% from Akyнк (Movsessian, 1990; Movsessian and Kotchar, 2001). Eight individuals out of 10 from Lanjik showed evidence of this marker. Seven individuals from the Black Fortress showed cribra orbitalia. It is also important to note that the temporal increase in prevalence of cribra orbitalia did not correspond to an increase in severity for groups from Lanjik and Black Fortress. In individuals from Karmir, cribra orbitalia was not revealed as a stress marker.

A middle-adult female approximately 50 years old in group Black Fortress (burial 3/2) was diagnosed with porotic hyperostosis (Fig. 18). The external surface of the neurocranium exhibits a two large and irregular areas, lesions that cover most of the parietal bones. Manifestations developed on the portions of each parietal bone between the temporal crest and the sagittal suture. In the cranium are several grouped irregular cavities, furrowed by grooves and surrounded by porotic bone. Also, 4 adults from the Lchashen exhibited porotic hyperostosis (Fig. 7)

Enamel hypoplasias are indicators of growth disruptions during dental development and are visible on teeth as areas of enamel deficiency. Most of these hypoplastic defects are oriented horizontally across the tooth, and multiple grooves reflect multiple stress episodes. Like porotic hyperostosis and cribra orbitalia, these stress markers are indicative of a childhood condition, as tooth formation is complete before adulthood. The etiological factors implicated in the occurrence of a growth disruption and resulting in a hypoplastic defect, include disease, malnutrition, trauma, and hereditary conditions (Goodman and Rose, 1990, 1991; Hillson, 1996, 2000; Roberts and Manchester, 2005). However, malnutrition and disease appear to be a far more common cause of these defects, because hereditary defects and localized trauma are relatively rare occurrences (Goodman and

Rose, 1990, 1991). The prevalence of hypoplasia from the Black Fortress sample is 62% (n = 13) and 50% (n = 10) from Landjik. Six individuals from Sarykha showed evidence of enamel hypoplasias.

CONCLUSION

The Sevan region and Shiraksky plain (Armenia) was not an ecologically favorable place for human populations. The results of this study further this notion, as there are a number of significant trends for various skeletal indicators of health and lifestyle that suggest the population in Armenian experienced stress and biological changes over time. The developing economy—the rudiments animal husbandry—promoted the occurrence and spread of infections among the ancient population of Armenia. Bad hygienic conditions and dirt should render infections of cumulative influence on skeleton morphology. Anthropological examination revealed that the inhabitants in these areas in Bronze Age and Early Iron Age were subject chiefly to osteomyelitis, facies leprosa, dental diseases such as caries, abscesses, and periodontal disease.

Osteomyelitis of the skull may follow infection of one of the cranial air sinuses or the middle ear, dental disease, or an open skull fracture. Three individuals have evidence of osteomyelitis on the frontal bone. The bony lesion is classically composed of a central sequestrum surrounded by a lytic zone, and then an area of sclerotic response with periosteal new bone peripherally on both inner and outer tables (the involucrum). Individuals from the Sevan region may have had more chronic infections due to continued exposure to pathogens throughout their lives as well as to traumatic injuries. The unsanitary living conditions, pollution of the water supply, and population density all likely contributed bacterial infections to the population. Seven individuals had nasopharyngeal lesions consistent with a diagnosis of leprosy.

Dental abscesses have an important role in infectious processes, as they are propitious for the development of the bacteria that cause infection, not only in the alveolar bone but also in the rest of the body. Dental caries were less severe at Sevan (2 individuals from Lchashen), although dental abscesses (51 individuals) and antemortem loss (87 individuals) were more prevalent. In contrast, periodontal disease (8/18 adults) and antemortem loss (8/18 adults) of the molars were more prevalent at Shiraksky, although the small sample size may be a factor. Despite the lack of significant trends in periapical lesions and dental caries, the patterns that emerge indicate that a dietary change took place. However, this change may be associated with food preparation techniques, rather than dietary components. Antemortem tooth loss may reflect a softer diet in which there was less abrasion and attrition.

It is especially interesting that the prevalence rates for cribra orbitalia are rather similar between the two groups from Shiraksky plain. The lack of any trend for porotic

hyperostosis and the presence of only the mild form of cribra orbitalia may be due to an overall milder form of anemia in the population. The higher prevalence of enamel hypoplasias may be due to a number of factors, including greater exposure to pathogens (other than parasites) or poorer nutrition (Goodman and Rose, 1990, 1991; Hillson, 2000). Poor nutrition in combination with exposure to infectious pathogens would have only heightened this problem, creating periodic episodes of growth arrest, leading to higher rates of enamel hypoplasias.

All these data can throw light on aspects of the conditions of the life of people during the Bronze Age and Early Iron Age in Armenia. The forms of infectious diseases illustrated in this article suggest perspectives that hold promise for future dental anthropological studies.

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