Resorption of the alveolar region in Facies leprosy: a paleoanthropological and paleopathological analysis (Aragatsavan, Armenia) *

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Abstract

During recent excavations in Aragatsavan (Armenia), a fairly complete skeleton of a individual unearthed. The individual was identified as adolescent male with mesocrany skull form, and an estimated stature of 159 cm. Unintentional tumpline and cradle deformations were found in individual. Skull bones exhibited signs of healed trauma, small blunt force lesions on the frontal and parietal bones. The goal of this study was to detect Mycobacterium leprae (M. leprae) in archaeological human skeletal remain. Resorption of the alveolar bone in the anterior maxilla was in individual with lepromatous leprosy in Aragatsavan. The skull also showed the premature closure of the sagittal suture. This individual experienced multiple bouts of starvation or malnutrition due to serious disease (lines enamel hypoplasia). The analysis also revealed bowing of the hips, osteoarthritis and periostitis. These data are interpreted to mean that resorption of bone inferior (alveolar bone) and other paleopathologies appears in individual occur independently.

Keywords: Armenia; Aragatsavan; Leprosy; Supernumerary Teeth; Sagittal Craniosynostosis; Linear Enamel Hypoplasia; Calculus; Periostitis; Osteoarthritis

** Authors are responsible for language correctness and content.*

Introduction

Infectious diseases were the single greatest threat to life of prehistoric infants and children (1). 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 (1). Pathogenicity of the agent, route of transmission, nature and strength of host response, age, sex, genetic predisposition, nutritional status (there is a relationship between quality of diet and infection), occupation, trade and contact, climate, population density, economy, sanitation, quality of housing, and many more factors must be considered when interpreting the evidence for infectious disease in the past. Human remains are the primary evidence for study of diseases and health in the past. In antiquity the infections evident in the skeletal record were more often caused by bacteria rather than viruses, as the latter would have been more rapidly overcome (or proved fatal), leaving no bone change (2, 3).

Figure 1 Available skeletal elements

The infections most commonly reported and analysed in the paleopathological literature arc the non-specific infectios affecting the periosteum (periostitis), cortex (osteitis) and medullary cavity (osteomyelitis) of bonc. These changes, however, can also be seen as manifestations ofa specific infection (but in a specific distribution pattern), or be focused on a particular part of the body. Leprosy, tuberculosis and treponemal disease are those specific infections reported most frequently (3, 4). However, focal non-specific infections in the sinuses (maxillary sinusitis), meninges (meningitis), ears (mastoiditis, otitis media), and lungs (affecting ribs) have seen increasing interest in biological anthropology in recent years, particularly in Armenia (2). As the primary focus of the present research was the investigation of the resorption of bone in the nasal spine with lepromatous leprosy in the individual from Aragatsavan site. Aragatsavan formerly known as Alagyoz, is a major village in the western part of the Aragatsotn Province of Armenia. The resorption of alveolar bone in leprosy is believed to be mediated by osteoclasts (5) independent of periodontal disease (6), directly related to the length of untreated disease (7) and, by inference, to the presence of the leprosy bacillus.

Materials and methods

Aragatsavan site was excavated in the 2018 by archaeologists Mariam Shakhmuradyan, Sona Manukyan, Benik Vardanyan (Institute of Archaeology and Ethnography, National Academy of Science of Armenia) and Levon Mkrtchyan. Excavations were carried out in one of the ‘desert kites’ of the site, along with nearby settlement and necropolis. There is no yet evidence for the dating of ‘desert kite’ and necropolis, while the settlement is preliminary dated to the Middle Bronze age (Based on the typology of pottery, the settlement preliminary dates to the second phase of the Middle Bronze Age (Trialeti-Vanadzor culture, 2300/2200 – 1800/1700 BC), which might be proved by the upcoming C14 analysis. However, the excavation was not reached to virgin soil and the final stratigraphy will be revealed by further excavations.) The tomb №2 revealed the fully preserved sceleton, without any archaeological materials.

The skeleton was analysed in detail, assessing for preservation and completeness (Figure 1), as well as determining age-at-death and sex of the individual. Sex and age at death of the individual were determined according to standard osteological methods. Morphological features of the pelvis and cranium were used for the sex assessment (8, 9). The estimation of age is based on the analyzing the development of their teeth and bones (pubic symphysis (10, 11, 12), auricular surface changes (12), degree of epiphyseal union (9), and cranial suture closure (13).

Measurements were taken as outlined in Alekseev (14, 15). The results are shown in Table 1. Next, a series of standard measurements are taken of the bones and teeth, and the presence and absence of "non-metric traits" (16, 17, 18). Maximum bucco-lingual and maximum mesiodistal diameters were measured for each tooth in the dental arcade, following Zubov (18). The thirty-two traits were observed using ASUDAS (Table 3). The bone is measured on an osteometric board, and stature is then calculated using a regression formula developed upon individuals of known stature (19, 15). Musculoskeletal stress markers have been widely used by bioarchaeologists indicators of physical activity (Table 6). These stress markers occur at the sites of the attachment of soft tissues (muscle, tendon, ligament, fascia and menisci) to bone. In addition, the skull and the postcranial skeleton were examined macroscopically to investigate any pathological changes.

Facies leprosa, a term used to describe sorption of bone in the facial region of individuals with leprosy, was first introduced by Moller-Christensen and colleagues (20-23) in a series of reports on the skeletal remains of medieval populations with leprosy in Danish cemeteries. These studies have shown that resorption of the alveolar process in the maxilla is a characteristic manifestation of leprosy. His descriptions form the basis of diagnosis in paleopathology but have been further developed, particularly by Johs Andersen and Keith Manchester (24-26). All skeletal elements and fragments were examined visually and with the aid of a 10x hand lens for macroscopic evidence of pathological lesions.

Figure 2 Cranium: anterior view, superior view, left lateral view

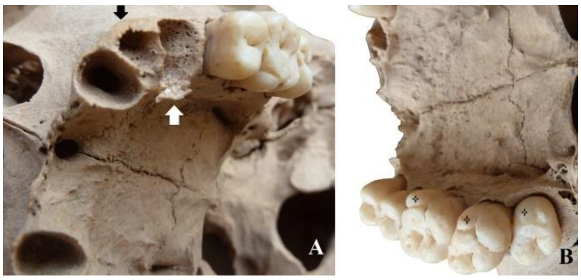

Figure 3 A: a place small conical tooth between the permanent maxillary left canine and first premolar (black arrow), injury alveolus of the first premolar (white arrow); B: Carabelli's trait is expressed on the lingual surface of the mesiolingual cusp (the protocone, or cusp 1). It occurs on maxillary molars: first permanent molar, second permanent molar and third permanent molar.

Results

The skeleton was fairly complete and well preserved (Figures 1-2). The shape of the pelvis indicated that the skeleton was a male. Observations of the pelvis, teeth, and skull sutures suggested he had been between 14 and 17 years old (adolescent) at death.

Figure 4 Radial fossa on the distal end of the humerus

Cranio-Facial Morphology

The form of the neurocranium, in norma verticalis, is sfinoid. The cranial index was 78.09, which placed it in the mesocrany range, a weakly developed glabella. The face is narrow and not high. The general facial angle is ortognathic. In horizontal plane, face is well-profiled at the top level. The orbits are average in height and average in width. Piriform aperture very small in height and small in width. All principal dimensions of the mandible and the ramus angle are small and medium in adolescent.

The skeletal and dental variations are considered in kinship studies, which allow for socio-political understanding of population structures and can shed light on post-marital residence as well as other demographic processes (27, 28).

Non-metric traits

The analysis revealed the following cranial traits (Table 2): anterior ethmoidal foramen, foramina zygomaticofacialia, os zygomaticum bipartitum, inferior squamosal foramen, stenocrotaphia, processus frontalis squamae temporalis, processus temporalis ossis frontalis, os wormii suturae squamosum, os postsquamosum, foramina parietalia, os wormii suturae lambdoidea, torus occipitalis, foramina mastoidea (outside the seam), sutura palatina transversa (П-shaped), sutura incisive, condylus occipitalis bipartitum, processus paramastoideus, canalis condyloideus, foramina mentalia.

Dental morphology

Examination revealed absence 11 and 21, while rest of the permanent dentition were completely erupted except third molars (partially erupted). Observed in the individual a small conical tooth (mesiodens) between the permanent maxillary left canine and first premolar. The mesiodens usually presents a peg- or cone-shaped crown with a single root (the tooth was lost, Figure 3A). Supernumerary tooth led to injury to the alveolus left first premolar (Figure 3, A: white arrow).

Though there is no significant sex distribution in primary supernumerary teeth, males are affected approximately twice than females in the permanent dentition (29, 30). Supernumerary teeth show strong association with developmental disorders such as cleft lip and palate, cleidocranial dysostosis, Gardener syndrome and less commonly with Ehlers-Danlos syndrome, chondroectodermal dysplasia, Fabry Anderson's syndrome, incontinentia pigmenti and tricho rhino-phalangeal syndrome (31, 32).

All 24 of the tooth dimensions were surveyed (Table 3), analysis demonstrated slight differences (asymmetry) of between the right and left. The teeth in individual from Aragatsavan have smaller crown indices.

Non-metric traits

In general, the morphology of the dental system allows to regard the individual from Aragatsavan as belonging to the western odontological stem. Information about the southern gracile dental types can be found in Zubov (33). The southern gracile type has low percentages of Carabelli's cusp UM1, somewhat increased distal trigonid crest LM1, four-cusped LM1, four-cusped LM2 and low variant 2 med II LM1 (34). Trait presence is in Table 4. Traits was found in 17 traits of upper dentition only: mesial accessory cusps (UP1, UP2), distal accessory cusps (UP1), double roots (UP1, UP2), metacone (UM1,UM2, UM3), hipocone (UM1, UM2, UM3), Carabelly trait (UM1, UM2, UM3) (Figure 3, B), enamel extension (UM1, UM2, UM3). Traits was found in 9 traits of lower dentition only: lingual cusp (LP3, LP4), multiple cusps (LP3), 5-cusped M1 (LM1), 4-cusped M2 (LM2), deflecting wrinkle (LM1), protostylid (LM1).

Upper and Lower Limb

Basic of limb bone measurements the individual from Aragatsavan are listed in Table 5. Body proportions analysis was performed on several skeletal parameters: length of the main long bones (humerus, radius, femur, and tibia). The peculiar feature of the adolescent is that his legs are relatively long compared to his arms, as indicated by the low values of the three indices - intermembral (69.7), humero-femoral (73.1), and radio-tibial (65.6). The tibio-femoral index were found to be higher, exceeding 81.73. The adolescent was between 156.5 cm and 161.6 cm tall (see Table 5), with a mean of 159.1cm.

Figure 5 Cranial lesions associated with leprosy, including resorption of the alveolar region and anterior nasal spine resulting in antemortem tooth loss.

Musculoskeletal stress

On the right humerus, a gross porosity area is visible at the insertion of the muscle supraspinatus indicating a stress on the shoulder; the clavicle of the same side shows an accessory facet on its inferior face medially, due to the anomalous contact with the first rib, perhaps in carrying heavy loads. A deep radial fossa on the distal end of the humerus (Figure 4) could result from the habit of carrying loads in a bag slung over the shoulder and held in place with the hand. The arm is tightly flexed at the elbow so that the head of the radius impacts above the distal epiphysis of the humerus (35). The weak traits that characterize habitual horse-riders were observed in femora (Table 6).

Cleft of the upper jaw.

The cranium (Figure 5) shows the classic lesions of leprosy (36, 22, 20, 3). The edges of the hard palate have been resorbed. The area of reaction extending to the alveolar bone of the premaxilla and anterior maxilla. The bone has been destroyed with loss of right and left incisors.

A lump protruding from either the midline, into the nasal passage, may indicate if are dealing with nose infection (rhinitis). This inflammatory condition has many causes, some of which may co-exist. 1). Hayfever (Allergic rhinitis). There is usually a clear history of provocation due to dust, animals or pollen. Some kinds of food can provoke allergic rhinitis. 2). Hyperactivity in the nose. The hyperactivity may be triggered by smells, emotions, temperature changes, foods etc. It is important to note that, this condition can co-exist with hayfever. 3). Septum problems. Normal nasal function depends on smooth, laminar air flow through the airways. Disrupted anatomy makes this air flow turbulent, causing local mucosal trauma, drying and inflammation.

Sagittal craniosynostosis

Congenital malformations observed in paleopathology is largely underestimated; in fact, although congenital defects have been reported in ancient human remains (37, 38), it is still impossible to determine the range and incidence of congenital diseases in past populations. The skull of Aragatsavan showed the premature closure of the sagittal suture (Figure 6). Sagittal suture synostosis is the most common type of single suture synostosis and predominantly affects males. In sagittal synostosis the sagittal suture is closed, meaning the suture permanently changes to bone and the parietal bones are fused together as one big skull bone. There is a low risk of abnormal brain growth and development. The aetiology of non-syndromic craniosynostoses seems multifactorial. However, recent molecular genetic studies have demonstrated that most of these disorders or syndromes have mutations in the fibroblast growth factor receptor genes (39, 40).

Figure 6 Sagittal craniosynostosis

Tumpline and cradle deformations of skull
Unintentional tumpline (Figure 7) and cradle (Figure 8) deformations were found in individual from Aragatsavan. Skulls with post-coronal depression, classified as tumpline deformation and positioned on both parietals slightly posterior to the coronal suture. Average length of horizontal grooving - 85 mm, width - 28 mm. Figure 8 shows depression immediately above the lambda affecting the mid-sagittal contour. The flattened area is roughly circular with bilateral dimensions roughly equal. This flattening is a cradle deformation that could have been affected by the infant lying on the back with the head resting on the occiput.

Trauma
The present study showed that the three cranial traumas were observed on the parietal and frontal bones. These injuries were most likely caused by multiple blows with a blunt instrument (Figure 8).

Dental pathology
Enamel hypoplasia appears linearly on the enamel surface (I1, I2, C, M1, M2) (Figure 9). Calculus was recorded on the upper molars on the buccal surface and lower incisors on the lingual surface and buccal surface.

Skeletal changes in lower limb bones
Apart for these changes, the individual exhibits bowing of the hips (Figure 10). This condition may be interpreted as either residual rickets. Periosteal bone reactions were observed in several different bones (Figure 11). Other related diseases that may be seen in a skeleton include osteoarthritis (Figure 11). As osteoarthritis progresses continued articular attrition causes subchondral sclerosis or a thickening of the bone (41) as well as subchondral cysts which manifest osteologically as porosity (42). Porosity is manifested on the articular surface of the joint by the discontinuity of subchondral bone (42). As suggested by Merbs (43), porosity is reflective of sclerotic osteogenic reaction which occurs during osteoarthritis pathogenesis. Vascularity is lost in the bone causin the marrow to become fibrous which subsequently penetrates the subchondral bone.

Discussion and conclusion
We have looked at a number of pathological conditions in a skeleton 1 from the Aragatsavan site. A range of skeletal lesions may develop during childhood, as a result of blood-borne diseases, non-specific stress and infection, metabolic disease and trauma. Our results indicate that tumpline and cradle deformations were detected at the individual. The occipital modification and tumpline deformation is most likely unintentionals. Through the ages, prehistoric and even some contemporary civilizations have practiced various forms of unintentional and intentional cranial deformation. Tumpline deformations may be informative about day-to-day practices, but their morphological imprints on the neurocranium hardly indicate any voluntary choices taken by their practitioners. It could be a fortuitous byproduct of occupational activities, like carrying heavy loads during childhood (Figure 6). Post-coronal depression, defined as "a…depression located slightly posterior to the coronal suture on both parietals" (38, p. 52). Molleson (35) and Khudaverdyan (36) believe that horizontal grooving may result from activities, such as carrying loads with a band across the parietal bones. Cradle deformation (Figure 8) is heavily influenced by infant sleep position, and constant supine positioning is a frequent cause of deformation during infancy. When an infant remains in a persistently supine position without the developmental benefits of the head turning from side to side during recurrent periods of tummy-time, the occiput becomes progressively flattened through the impact of gravity and persistent occipital mechanical pressure (44).
The analysis revealed sagittal craniosynostosis. Sagittal craniosynostosis remains the most common type of synostosis. It would result from a mesenchymal disorder involving the intramembranous ossification of the sagittal suture and leading to its early fusion (45). No specific data on the etiologic factors are currently available.
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 frontal and parietal lesions tended to be left-sided, which may indicate that the injuries resulted from face to face assault by right-handed attackers (46). Depressed fractures could have resulted from blunt force.
Dental pathology observed in prehistoric human remains contributes valuable information for deducing data from past lifestyles, including diets, which further indicate their living environments, cultural development and types of

economy. The several lines enamel hypoplasia can be seen in an individual (Figure 9), it can be speculated that this individual experienced multiple bouts of starvation or malnutrition due to serious disease. Some authors defend that calculus deposition may be mainly related to consumption of protein-rich food, as fish or meat (47), whereas others have found that diets rich in carbohydrates may promote calculus deposition (48).

The analysis also revealed bowing of the hips, osteoarthritis and periostitis. A lack of vitamin D can result in bending deformities of the long bones, deformation of the ribcage, and porosity and deformation of the skull. In subadults this condition is called rickets; in adults osteomalacia. Both diseases are classified as metabolic bone disease, because they are the result of a metabolic malfunction and the symptoms are visible on the skeleton. The factors responsible for the rickets are generally included poor diet and activities related to sunlight exposure, such as narrow architecture, air pollution and occlusive clothing. Periosteal lesions is a proliferative skeletal lesion that occurs in response to stimuli that tear, stretch, compress or otherwise traumatize the periosteum, and as a result of local or systemic infection or inflammation associated with a variety of factors (49, 4). Though typically viewed by bioarchaeologists as a marker of traumatic injury or an infection, periosteal new bone formation can occur as a result of a nutritional imbalance (50, 51); for example, localized hemorrhages resulting from vitamin C deficiency can lead to the proliferation of new bone (52). Many researchers have used the prevalence and distribution of osteoarthritis to interpret levels of biomechanical stress in individuals incurred through the hardships of work and life within their culture. Osteoarthritis was found on femur, tibia, fibula, while osteophytosis was found on vertebral. Periosteal lesions are also associated with neoplastic, metabolic, congenital, and genetic diseases (53). In a skeleton from Aragatsavan there is an initial atrophia of the alveolar bone. What is the reason is this pathology? Similar lesions can occur in tertiary syphilis and in lupus vulgaris (1). Syphilis was a very frequent reason for palatonasal destruction on skulls, where the affliction was caused by gumma spreading from soft facial tissues to the skeleton. The destruction process could perforate the hard palate and descend to the alveolar processes of upper jaws. Nasal bones might also be deformed (saddleback nose). Traces of the healing process or possible other syphilitic symptoms at the skeleton as described by Hackett (54) are also significant for a differential diagnostic. Some facial bone changes may also be seen in neoplastic disease, leishmaniasis, and tuberculosis (55). The palatonasal destruction can be also caused by a tumour. Malign tumours originating in adjacent soft tissues may destroy bones by osteoclastic reabsorption at their invasive growth. The developed lytic niduses are of irregular, even bizarrely shaped, their contours are mostly sharp. The absence of erosions on the cranial vault (23) strongly favour a diagnosis of leprosy. The loss of anterior teeth can also be the result of a cultural norm, for example in places where teeth are deliberately extracted or lost due to dental disease (56). However we believe, leprosy - a probable cause of disease in a young person.

Hansen's disease, or as it is more commonly known as leprosy, is a chronic infectious disease caused by Mycobacterium Leprae which attacks the skin, mucous membranes and peripheral nerves, resulting in destructive skeletal manifestations (57). Leprosy occurs in a variety of forms, causing diverse responses depending on an individual's immunity, with lepromatous leprosy being the most severe and tuberculoid leprosy being the least (37).The facial bones (and developing incisors) are believed to be affected by leprosy because the bacillus is inhaled directly into the respiratory tract, impacting the integrity of the nasal and maxillary bones and the development of teeth in non-adults. The evidence for leprosy observed in skeleton is most often the result of chronicity (a person has to have had the infection for some time). Leprosy is generally characterized by multiple skin lesions and nodules, damage to the nervous system, thickening of the brow ridge, a collapsed nasal area, the loss of the anterior dentition and the resorption of the limb extremities (3, 4, 58, 59). Bone resorption associated with leprosy is the direct result of nerve damage and circulatory obstruction, causing progressive sensory and motor loss, which can then give way to ulceration and secondary infection of the overlying dermal and muscular tissues (3, 37). In the cranial skeleton, rhinomaxillary syndrome is the combination of several destructive proliferative lesions, which include loss of the anterior nasal spine, endonasal inflammation and recession of the alveolar process, resulting in the loss of the anterior dentition (60, 3). The maxillary sinuses have to be inflamed in people with leprosy (61).

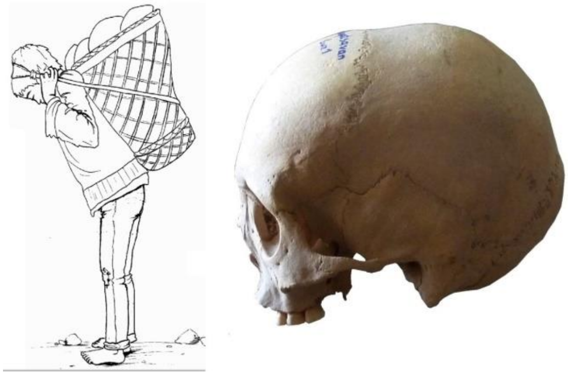

Figure 7 Post-coronal depression

Figure 8 Cradle deformation, healed depressed trauma on the right parietal bone, frontal bone

Figure 9 Dental pathologies: linear enamel hypoplasia, calculus

Figure 10 Bowing of the hips.

Figure 11 Osteoarthritis, periostitis

Leprosy is associated with poverty and poor access to health care, all relevant for people with leprosy who lived in the past. This unfortunate individual from Aragatsavan lived in marginal conditions. The adolescent had suffered from malnutrition and disease. There is very little evidence of leprosy in people who had not reached adulthood before they died, although skeletons of non-adults have been located in the Turkey, Italy, Czech Republic, Hungary, Sweden, and the UK. Some examples in this age group include adolescent skeletons at a post-1066 AD site in Scarborough (East Yorkshire, England) (62) and at a 13th–14th century AD site at Deerness, in the Orkney Islands, Scotland (63).
Monot et al.'s research (64, 65) which is mainly based on modern leprosy data, has indicated that leprosy originated in the near East or Africa around 100,000 years ago, spreading east and west along migration routes. The evidence of leprosy in Armenia probably dates from around the 3rd–2nd millennium BC to the 4th century AD (66, 67). One individual from Karmir (Early Iron Age) has nasopharyngeal lesions, including significant remodeling of the nasal aperture margins. And 6 individuals from Lchashen have nasopharyngeal lesions characteristic of leprosy (Late Bronze Age and Early Iron Age). The osteoarchaeological Vardbakh sample reveale traces of the two cases with nasal periostitis (1st century BC–3rd century AD). Some of the earliest skeletal evidence of leprosy comes from Iran (6200–5700 BC), Turkey (2700–2300 BC), Sudan (2300 BC), India (2000 BC), suggesting early foci of the disease (55). However, it is clearly evident that the migration of people in the past made a major contribution to leprosy's dissemination over the years, although more data are needed to fill gaps in our knowledge (68, 69). Living conditions, diet, and work, for example, all potentially impacted whether a person was more susceptible to contracting leprosy. Genetic factors may also be an important influence on the degree of susceptibility.

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1	Maximum cranial length (g-op)	178
8	Maximum cranial breadth (eu-eu)	139
9	Minimum frontal breadth (ft-ft)	96.8
10	Maximal frontal breadth	122
12	Occipital breadth	114
29	Frontal chord (n-b)	103.2
30	Parietal chord (b-l)	117
31	Occipital chord (l-o)	89
43	Upper facial breadth (fmt-fmt)	83?
45	Bizygomatic breadth (zy-zy)	129
48	Upper facial height	62.5?
46	Mid-facial breadth	90
60	Maxillary alveolar length (incision-alv)	41.5
61	Maxillo-alveolar breadth (ecm-ecm)	59.9
62	Palatal length (st-o)	36.8?
63	Palatal breadth between the second molars (enm-enm)	31.7
55	Nasal height (n-ns)	44.3
54	Nasal breadth (al-al)	23
51	Orbital breadth (d-ec)	42
51a	Orbital breadth (ect-d)	38
52	Orbital height bicondylar width	34
DC	Dacryal chord	24.8
DS	Dacryal subtense	12
SC (57)	Simotic chord	9
SS	Simotic subtense	3.8
MC	Maxillo-frontal chord	19
MS	Maxillo-frontal subtense	6.7
32	Frontal pronfile angle (n-m)	84
	Frontal pronfile angle (g-m)	82.5
72	Total facial angle	100
73	Mid-facial angle	102
74	Alveolar angle	103
75	Nasal inclination angle	92
75 (1)	Nasal protrusion angle	8
77	Naso-malar angle (fmo-n-fmo)	136
Zm`	Zigo-maxillary angle (zm`-ss-zm`)	141
8:1	Cranial index	78.09
9:8	Fronto-transverse index	69.65
48:45	Upper facial index	48.45
54:55	Nasal index	51.92
52:51	Orbital index (mf)	80.96
52:51a	Orbital index (d)	89.48
63:62	Palatal index	86.15
DS:DC	Dacryal index	48.39
SS:SC	Simotic index	42.23

Table 1. Measurements of the male skull from Aragatsavan

	Traits	right	left
1	Sutura frontalis	-	
2	Foramina supraorbitalia	-	-
3	Foramina frontalia	-	-
4	Anterior ethmoidal foramen	+	+
5	Cribra orbitalia	-	-
6	Spina trochlearis	-	-
7	Foramina infraorbitalia	-	-
8	Foramina zygomaticofacialia	+	+
9	Os zygomaticum bipartitum tripartitum	+	+
10	Inferior squamosal foramen	+	-
11	Spina processus frontalis ossis zugomatici *straight* *outgrowth*	 +	 +
12	Stenocrotaphia X-shaped	 +	 +

13	Processus frontalis squamae temporalis	+	+
14	Processus temporalis ossis frontalis	+	-
15	Os epiptericum	-	
16	Os Wormii suturae squamosum	+	+
17	Os postsquamosum	+	-
18	Os parietale bipartitum	-	-
19	Os Wormii suturae coronalis	-	
20	Os bregmaticum	-	
21	Os Wormii suturae sagittalis	-	
22	Foramina parietalia	+	-
23	Os Incae completus	-	
24	Os triquetrum	-	
25	Os quadratum	-	
26	Os apicis lambdae	-	
27	Os interparietale s. sagittalis	-	
28	Propcessus interparietalis	-	
29	Os Wormii suturae lambdoidea	+	-
30	Sutura mendoza	-	-
31	Os asterion	-	-
32	Torus occipitalis (0-3)	1	
33	Os Wormii sut. occipitomastoideum	-	-
34	Foramina mastoidea		
	on the seam	-	-
	outside the seam	+	+
35	Torus palatinus (0-3)	0	
36	Sutura palatina transversa		
	winding	+	
37	Sutura incisiva	+	
38	Foramen pterygospinosum	-	-
39	Canalis craniopharyngeus	-	
40	Foramina spinosum (absence)	-	-
41	Condylus occipitalis bipartitum	+	-
42	Processus paramastoideus	+	+
43	Manifestatio vertebrae occipitalis	-	
44	Tuberculum praecondylare	-	
45	Canalis condyloideus	+	+
46	Foramina mentalia	+	+
47	Torus mandibularis (0-3)	-	-
48	Sulcus mylohyoideus	-	-
49	Foramina mandibularia	-	-

Table 2. Non-metric cranial traits individual from Aragatsavan

	Maxilla		**Mandible**	
	VLcor			
	right	left	right	left
I1	-	-	5.5	5
I2	-	-	4.5	4.5
C	-	-	6.2?	6
P1	8.6	-	7.5	7.8
P2	8.5	8.5	7.8	7.9
M1	11.2	11.1	9.6	9.6
M2	10.7	10.7	9.6	9.7
M3	10.5	-	8.8	-
	MDcor			
I1	-	-	5.6	5.2
I2	-	-	5.8	5.8
C	-	-		6.3
P1	6.6	-	6.6	7.1
P2	6.3	6.6	6.4	6.8
M1	9.5	9.9	11.2	11.6
M2	8.7	9.2	10.2	10.8
M3	7.5	-	10.5?	-
	Hcor			
M1	7.1	7.2	7.1	7.1
M2	6.5	6.5	7.5	7.4

M3	5			
	MDcol			
M1	7.8	7.2	9.2	9.7
M2	6.2	6.8	8	8
M3	5.2	-	-	-
	MD × VL			
M1	106.4	109.89	107.52	111.36
M2	93.09	98.44	97.92	104.76
M3	78.75	-	92.4	-
	Icor (VL / MD) × 100			
M1	117.895	112.13	85.72	82.76
M2	122.99	116.31	94.12	89.82
M3	140.0	-	83.81	-
	mcor MD + VL / 2			
M1	10.35	10.5	10.4	10.6
M2	9.7	9.95	9.9	10.25
M3	9	-	9.65	-

Table 3. Dental features individual from Aragatsavan

Traits	Right	Left
Maxilla		
Mesial accessory cusps UP1	+	
Mesial accessory cusps UP2	+	+
Distal accessory cusps UP1	+	
Distal accessory cusps UP2	0	0
Tricusped premolars UP1	0	
Tricusped premolars UP2	0	0
Distosagittal ridge UP1	0	
De Terra's tubercle UP1	0	
Double roots UP1	+	+
Double roots UP2	+	0
Odontome UP1	0	0
Odontome UP2	0	0
Metacone M1	+	+
Metacone M2	+	+
Metacone M3	+	+
Hypocone M1	4	4
Hypocone M2	3.5	3.5
Hypocone M3	1	
Carabelly trait grade 0, M1		0
Carabelly trait grade 2-7, M1	+	+
Carabelly trait grade 0, M2		+
Carabelly trait grade 2-7, M2	+	0
Carabelly trait grade 0, M3		
Carabelly trait grade 2-7, M3	+	
C5 (hypoconule) M1	0	0
C5 (hypoconule) M2	0	0
C5 (hypoconule) M3	0	0
C6 M1	0	0
C6 M2	0	
C6 M3	0	
Parastyle M1	0	0
Parastyle M2	0	0
Parastyle M3	0	
Anterior fovea	0	0
Posterior fovea	0	0
Enamel extension M1	+	+
Enamel extension M2	+	+
Enamel extension M3	+	
Mandible		
Shoveling LI1	0	0
Shoveling LI2	0	0

Distal accessory ridge LC		0
Lingual cusp LP3	+	+
Lingual cusp LP4	+	+
Multiple cusps LP3	+	+
Multiple cusps LP4	0	0
Odontome LP3	0	0
Odontome LP4	0	0
Hypoconulid (Cusp 5) M1	0	0
Hypoconulid (Cusp 5) M2	0	0
Entoconulid (Cusp 6) M1	0	0
Entoconulid (Cusp 6) M2	0	0
6-cusped M1	0	0
5-cusped M1	+	+
4-cusped M1	0	0
6-cusped M2	0	0
5-cusped M2	0	0
4-cusped M2	+	+
YM1	0	0
XM1	+	+
+M1	0	0
YM2	+	+
XM2	0	0
+ M2	0	0
Tami (Cusp 7) M1	0	0
Tami (Cusp 7) M2	0	0
Deflecting wrinkle M1	+	0
Deflecting wrinkle M2	0	0
Epicristid	0	0
Protostylid	+	0
Protostylid pit	0	0

Table 4. Dental non-metric trait.

Traits	Right	Left
	Humerus	
1. Maximal length	289	288
2. Total length	283	281
3. Upper epiphysis breadth	47?	45
5. Maximal midshaft breadth	18	16,8
6. Minimal midshaft breadth	15.8	15.1
7. Minimal shaft circumference	52	48
7a. Midshaft circumference	54	50
6 : 5. Cross-section index	87.78	89.89
7 : 1. Robusticity index	17.994	16.67
	Radius	
1. Maximal length	210	213
2. Physiological length	199	201
4. Cross-section diameter	13.5	12.8
5. Sagittal shaft diameter	10.5	9.9
3. Minimal shaft circumference	34	35
5 : 4. Cross-section index	77.78	77.35
3 : 2. Robusticity index	17.09	17.42
	Ulna	
1. Maximal length	-	230
2. Physiological length	-	200
11. Sagittal diameter	11	10.5
12. Transverse diameter	15	14.8
13. Upper transverse diameter	17	17
14. Upper sagittal diameter	21	21
3. Minimal shaft circumference	20	20
3 : 2. Robusticity index	-	10.0
11 : 12. Cross-section index	73.34	70.95
13 : 14. Platyleny index	80.96	80.96
	Femur	
1. Maximal length	399	400

2. Natural length	394	396
21. Condylar breadth	74?	75
6. Sagittal diameter of midshaft	23.8	23.9
7. Transverse midshaft diameter	24	23.2
9. Upper transverse shaft diameter	28.3	30.5
10. Upper sagittal shaft diametere	19.4	19.3
8. Midshaft circumference	72.3	73
8 : 2. Robusticity index	18.36	18.44
6 : 7. Pilastry index	99.17	103.02
10 : 9. Platymery index	68.56	63.28
Tibia		
1. Full length	322	323
2. Condylo-talar length	300.5	301
1a. Maximal length	327	327
5. Upper epiphysis breadth	71.7	68.8?
6. Lower epiphysis breadth	43	45
8. Sagittal diameter at midshaft level	24	23
8a. Sagittal diameter at the nutrient foramen level	29.9	26
9. Transverse diameter at midshaft level	19	19
9a. Transverse diameter at the nutrient foramen level	21.2	20.2
10. Midshaft circumference	70	68
10b. Minimal shaft circumference	66	65
9a : 8a. Cross-section index	70.91	77.693
10b : 1. Robusticity index	20.497	20.13
Skeletal proportions		
Intermembral index (H1 + R1) : (F2 + T1)	69.693	69.69
Tibio-femoral index (T1 : F2)	81.73	81.57
Brachial index (R1 : H1)	72.67	73.959
Humero-femoral index (H1 : F2)	73.36	72.73
Radio-tibial index (R1 : T1)	65.22	65.95
Body length		
After K. Pearson & A. Lee	161.48	161.69
M. Trotter & G. Gleser (standard error ±3.72)	156.38	156.61
Average	158.93	159.15

Table 5. Postcranial measurements of a skeleton.

	Aragatsavan		
	Right	Left	Right and left in total
Humerus			
Crista tuberculi minoris, crista tuberculi majoris	2	1.5	1.75
Tuberositas deltoidea	1	1	1
Tuberculum majus, tuberculum minus	1	1	1
Margi lateralis, medialis et anterior Epicondili lateralis et medialis	1.5	1	1.25
In total	1.38	1.13	1.25
Radius			
Tuberositas radii	1.5	1	1.25
Margo unterossea	2	1.5	1.75
Furrows for extensor tendons	1	1	1
Processus styloideus	2	2	2
In total	1.63	1.38	1.5
Ulna			
Margo interossea, margo posterior	2	1,5	1.75
Crista musculi supinatoris	1	1	1
Tuberositas ulnae	2	1	1.5
In total	1.67	1.17	1.42
Femur			
Trochanter major	1	1	1
Trochanter minor	1	1	1
Tuberositas glutea	2	2	2
Linea aspera	1.5	1.5	1.5
Epicondili	1	1	1
In total	1.3	1.3	1.3

Tibia			
Tuberositas tibiae	1	-	1
Margo anterior, margo interossea	2	2	2
Linea m. solei, m. soleus	2	2	2
Furrows for extensor tendons	1	1	1
In total	1.5	1.67	1.5
Fibula			
Edge development	2	2	2

Table 6. The recording system for musculoskeletal stress