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Anomalies causing fatality in individual from Beniamin burial ground (Late Antiquity period), Shirak province, Armenia*

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Abstract

An individual whose skeleton was exhumed from tomb No. 2 at the Beniamin site showed healed trauma to the right midface, damage to the left frontal, parietal, temporal and occipital bones. We report of presence of osseous bridge on the left side of atlas, connecting posterior part of superior articular process to the posterior arch of atlas. Sulcus vertebrae for third part of vertebral artery over superior aspect of posterior arch of atlas, converted into foramen. This is a retrogressive and morphological phenomenon considered as Kimmerle anomaly. Double foramen transversarium were detected bilaterally in 2 cervical vertebrae (C5, C6). The course of vertebral artery may be distorted under such conditions. Many studies have reported an association between above anomalies (foramen arcuale, foramen transversarium) and neurological symptoms such as vertigo and migraine et all. It can be argued that woman entered a sedentary lifestyle. Her cause of death is likely to be related to severe trauma to the occipital bone during a fall.

Keywords: Armenia; Beniamin; Late Antiquity period; Kimmerle anomaly; trauma

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Introduction

One of the goals of bioarchaeologists/ paleopathologists in particular, is to understand how the lives of past people were affected by differential disease, diets, warfare and other aspects of everyday life (1-6). The existence of skeletal anomalies within a population can have broader implications than merely indicating the presence of disease. These lesions can have associations with risk of death for the individual and the final mortality distribution. Risk of death is defined as the likelihood of an individual, with specific pathological criteria, dying relative to other individuals. The question of this article is, do the same anomalies increase the risk of death from later related traumas experienced in adulthood?

The skull has a pinnacle importance in the vertebral column. Anomalies found around the foramen magnum may be of clinical significance as is closely related to vascular and nervous structures. The frequency of basilar processes, also known as mamillar or papillar processes, is reported to be 4%). The basilar processes are emisphere-shaped bone projections located at the front rim of the occipital foramen magnum. They occur most often as a continuation of the occipital condyle. Position of this tubercle may be related to traumatic medullary lesions of the occipito-vertebral region. Basilar processes show a surprisingly high degree of variance: they may be unilateral or bilateral or present as isolated and sphere-shaped bone elements. Large processes may fuse at the median line and are then called a false condylus tertius. Unlike the real condylus tertius, the false one has a sagittal directed canal. The basilar processes are formed from the hypochordal arch of the proatlas so that the medial part of the hypochordal arch vanishes, but both lateral parts persist (7).

The prebasioccipital arch is a bony, bulging arch at the front rim of the occipital foramen magnum. In extremely rare cases, it can be isolated and mounted on the dens axis in a manner resembling a Napoleon hat while articulating with the anterior atlantic arch and the front rim of the occipital foramen magnum. In the early embryonic precursory spine, each vertebral segment is accompanied by a blastema, called the hypochordal arch, which is located in front of the vertebral corpus (8). The hypochordal arch of C1 forms the anterior atlantic arch, while those of the other vertebrae recede. The prebasioccipital arch develops if the whole hypochordal arch of the proatlas persists and ossifies (9). The prebasioccipital arch is in a sense the combination of bilateral processus basilares and a condylus tertius. The highest degree of persistence will be reached if the prebasioccipital arch is established as an isolated bony arch. The osseus assimilation to the anterior margin of the foramen occipitale magnum again points out a regressive tendency.

Acervical vertebra can be distinguished from other vertebrae by the presence of a foramen transversarium in the transverse processes (10). Foramen transversarium is the special foramen located on the left and right transverse processes of the cervical vertebrae (C1 to C7) containing the vertebral vessels and sympathetic plexus. Each side of the vertebral artery originates from the subclavian artery before continuing onto the foramen transversarium of the 6th or 7th cervical vertebrae through the atlas to form the basilar artery on the brain stem. Variations of foramen transversarium could be associated with compression of vertebral vessels, resulting in blood flow disturbances, especially vertebrobasilar insufficiency (11-13). The foramen transversarium present on the transverse process of cervical vertebrae are known to transmit the vertebral artery, vertebral veins and sympathetic nerves (14). These foramina are known to exhibit variations with respect to the shape, size and sometimes are multiple or absent. Their etiology may be related to variations of the course of vertebral artery and is developmental (14). An accessory transverse foramen, posterior to and smaller than the primary foramen, may be found in the sixth vertebra, and less frequently in the adjacent vertebrae (12). Under such circumstances, the course of the vertebral artery may be distorted. The variations in number and size of foramina transversaria of cervical spine may be one of the causes for complaints like headache, migraine, and fainting attacks and are due to the compression of vertebral artery (15).

The skeletal indicators of trauma analyzed in this article include blunt force trauma. Bioarchaeologists/ paleopathologist differentiate between intentional and accidental trauma. Blunt force trauma to the skull is rarely accidental except in the case of standing falls that result in fractures of the vault. This trauma may result in depressed fractures in which the outer table is pushed inwards, or linear fractures that follow the path of least resistance across the skull (16-20). Blunt force trauma to the postcranial skeleton may be accidental as individuals may fall and fracture their limb bones. Fractures to the face

and/or cranium were considered to be intentional violence.

History of the Armenian Highlands

The Armenian Highlands has been an area of frequent military conflict, and its history was largely determined by external forces (21, 22).

The Antiquity period (1st century BC – 3rd century AD) of the Armenian people covers nine centuries from the 6th century BC to the 3rd century AD.

With the decline of the Achaemenid Empire, local state formations emerged in Armenia; these formally recognized the supremacy of the Seleucid kings until the close of the third century BC when they fell completely under Seleucid sovereignty. But in 189 BC, the kingdom of Great Armenia came into existence bearing the name of its founder Artashes I. Th is kingdom grew into a powerful and prosperous state under Tigranes the Great (95–96 BC) (21, 22, 23). Suffering defeat by Rome, Tigranes lost the lands he had conquered, but preserved its natural boundaries, and the social, economic and political life of the country continued to progress under Tigranes and his son and successor, Artavazdes II (55–34 BC). Urban construction gained substantial impetus under the Artashesid dynasty, and a number of cities sprang up, along Hellenistic lines. Renowned among them were the capital city of Artashat, founded by Artashes I, and Tigranakert, the city of Tigranes the Great, inhabited, according to the exaggerated figures of Greek authors (24), 300 thousand inhabitants. The Artashesid kingdom collapsed early in the 1st century AD as Rome, seeking to turn Armenia into a province of the Empire but facing resistance, contented itself with the nomination of puppets to the Armenian throne. Allied with the Parthians, the Armenians strove to resist the expansionist actions of Rome, but in the autumn of 58 the Roman troops conquered Armenia and captured its capital Artashat, but the allied forces of Armenia and Parthia, eventually defeated the Roman invasion and Nero acknowledged Tiridates, the brother of the Parthian king Vologes, as king of Armenia. Thus the kingdom of Armenian Arsacids came to power in Armenia; they fought a life and death battle to preserve the independence of the country and since Rome still clung to the idea of overrunning Armenia, and the Sassanian kings, who had mounted Iran's throne following the breakup of the Parthian kingdom in 226, also fought hard to conquer Armenia (23).

Armenia has been rich and independent at times, particularly under the dynasties of the Ervandids, the Artashesians, the Arshakunis, and the Bagratunis. At other times, when surrounded by powerful empires or invaded by militant peoples, Armenia found itself only autonomous, semi-autonomous, or completely under foreign dominion.

During the Late Antiquity period in the Armenian Highlands and in the Caucasus various ethno-cultural groups – Iranic nomads (Scythians, Sarmatians, Sauromatians, Saka) and locals are interacted. Their presence in this region perhaps goes back to the 8th century BC (22). The archaeologists believe that their presence can be attested through the occurrence of their distinctive weapons, their horse harness and objects decorated in the Scythian animal style (25, 26). It is generally accepted that in the 7th century BC the Scythians mounted their incursions into the Ancient Near East through the Caucasus. The Scythians domain reached from north of the Danube and east of the Carpathians across the fertile plains of eastern central Europe and southern Russia to the River Don. Although the Don formed their eastern boundary, beyond it lived other groups of nomadic peoples culturally similar to the Scythians. These included the Sarmatians (27), their immediate neighbors to the east. Beyond the Sarmatians lived the Massagetae, and beyond them the Saka. The Saka were Asian Scythians and were known as Sai to the Chinese.

Anthropological study of the skeleton provides an understanding of the individual as a functioning, living human being. The record of traumatic incidents imprinted upon a skeleton may contain a wealth of information about a lifetime of encounters with the environment and fellow humans. Here we report the pattern or injuries in a skeleton from Beniamin, a cemetery dated to the Late Antiquity period. Several traumatic events left their signs on the bones. And let's try to find out whether they are connected with violence or are the result of a fall. The investigation of trauma residues may provide information about the trauma cause, be it by accident or by human violence.

Materials and Methods

Beniamin is a village in the Akhuryan Municipality of the Shirak Province of Armenia (Figure 1a). Archaeological rescue excavations in Beniamin at burial 2 were conducted 19 July 2022 (archaeologists out by Hamazasp Khachatryan and Levon Agikyan) (Figure 1c).

An understanding of individual from Beniamin burial pattern is important for the analysis and

interpretation of the human remains. Differences in burial treatments were observed between individual from burial 2 and others buried individuals from the Beniamin burial ground. The individual (burial 2) in question was reburied in a stone box (size 1.10×1.30m), oriented on an east-west axis (Figure 1c). Secondary burial was the not norm during the Late Antiquity Period. Apart from human and animal bones, the grave also contained a ceramic vessel.

The skeleton was analysed in detail, assessing for preservation and completeness, as well as determining age-at-death and sex of the individual (Figure 1b). Morphological features of the pelvis and cranium were used for the sex assessment (28, 29). A combination of pubic symphysis (30-32), auricular surface changes (33), degree of epiphyseal union (29), and cranial suture closure (32) were used for adult age-at-death estimation.

The inferior aspect of basiocciput was examined for the occurance of precondylar tubercle which consisted of bony elevations ranging from ridges near the anterior end of occipital condyles to larger median or paramedian projections along the anterior margin of foramen magnum. Their location, size, shape and presence of facet was noted. The size was evaluated and ridges, spines and processes.

All the cervical vertebrae were examined macroscopically for the existence of the double foramen transversarium on both sides.

All bones were examined macroscopically for evidence of traumatic lesions. The location of fractures in areas of the skeleton was recorded using description combined with measurements from anatomical landmarks. The scoring protocol followed the descriptive terms outlined in Lovell (34). Antemortem trauma was distinguished from perimortem trauma by the appearance of new bone deposits, resulting in callus formation or beveled edges (35). Careful observation of the lesions (with 4× or 10× magnification) was applied for assessing the degree of healing.

The diagnostic criteria used for assessing characteristics of degenerative joint disease include marginal and surface osteophytes, porosity, and eburnation (36, 37).

Results

Skeletal material from burial 2 was well preserved allowing morphological determinations of age and sex (Figure 1b). The individual was assessed to be approximately 30 to 39 years old at death and cranial and pelvic examination, based on well established criteria, indicated that he was clearly female. The individual's estimated stature, 147.7cm, is similar to the small stature reported for other Late Antiquity Period populations (38).

The skull had complete prebasioccipital arch. Prebasioccipital arch was conical in shape and measured about 12 mm in length and 20.5 mm in width (Figure 2). It was situated at the anterior margin of foramen magnum in the midline. Prebasioccipital arch was not projecting into the foramen magnum. Both the occipital condyles were directed anteromedially and were constricted in the centre with the maximum length of 33 mm (right) and 27mm (left).

We report a variant of unilateral left arteriae vertebral canal in atlas, connecting posterior part of superior articular process to the posterior arch of atlas (Figure 3a). The resulting foramen contains the vertebral artery referred as arcuate foramen.

Out of 7 cervical vertebrae showed the accessory foramina only 2 vertebra (C5, C6). Ertebrae showed the foramen on both sides (Figure 3b). All the accessory foramina were observed in the lower vertebrae. The accessory foramina transversaria were smaller than the regular foramina in all cases.

The crack in the facial bone extends from the lower edge of the right eye socket (length crack of 23.2 mm) (Figure 4a). This type fracture is characterized by a dissociation of the maxilla, the nasal bones, and the nasal septum from the cranial skull and from the lateral midface. The fracture line extends from the nasofrontal suture via the fronto-maxillary suture through the lacrimal bone to the floor of the orbit. From there, it extends through the infraorbital margin viathe facial wall of the maxillary sinus to the zygomatico-alveolar crest.

Inspection of the fractures suggests perimortem injuries of the maxillary (length crack of 34.5mm), frontal (length crack of 64.5 mm), and occipital (length crack of 104 mm) bones (Figure 4a,c).

Individual had a healed fracture on the region of the frontal, temporal and parietal bones (dimensions 50mm×43.7mm) that originated in amassive depression fracture (Figure 4b). The inner table presents strong remodeling.

The left clavicle displayed a simple, well-healed, oblique fracture at its medial third (Figure 5a) and was notably shorter (120mm) than the unaffected right clavicle (132 mm). No documented infections at the individual.

The femur displayed a blunt trauma in the area of the right condyle (dimensions 32 × 12.5 mm) (Figure 5b). This can be seen from the smooth edges of the defect and patination of the feature.

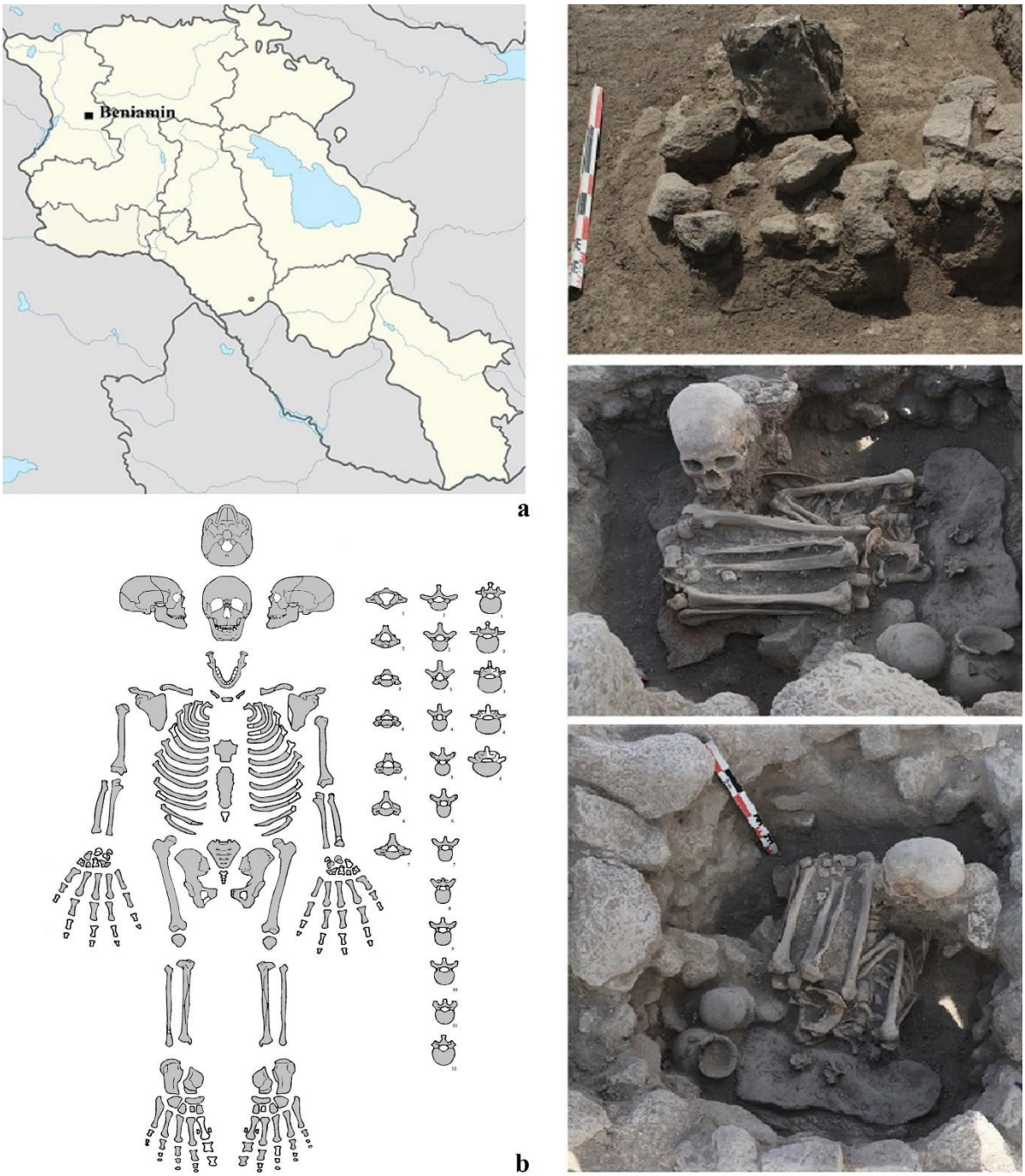


Figure 1. a) Map of Armenia showing the location of Beniamin, b) completeness of the human skeleton from Beniamin, c) picture of the burial discussed in the text (photographs of Armen Shakparonyan).

Figure 2. Skull showing tubercles at the anterior margin of foramen magnum.

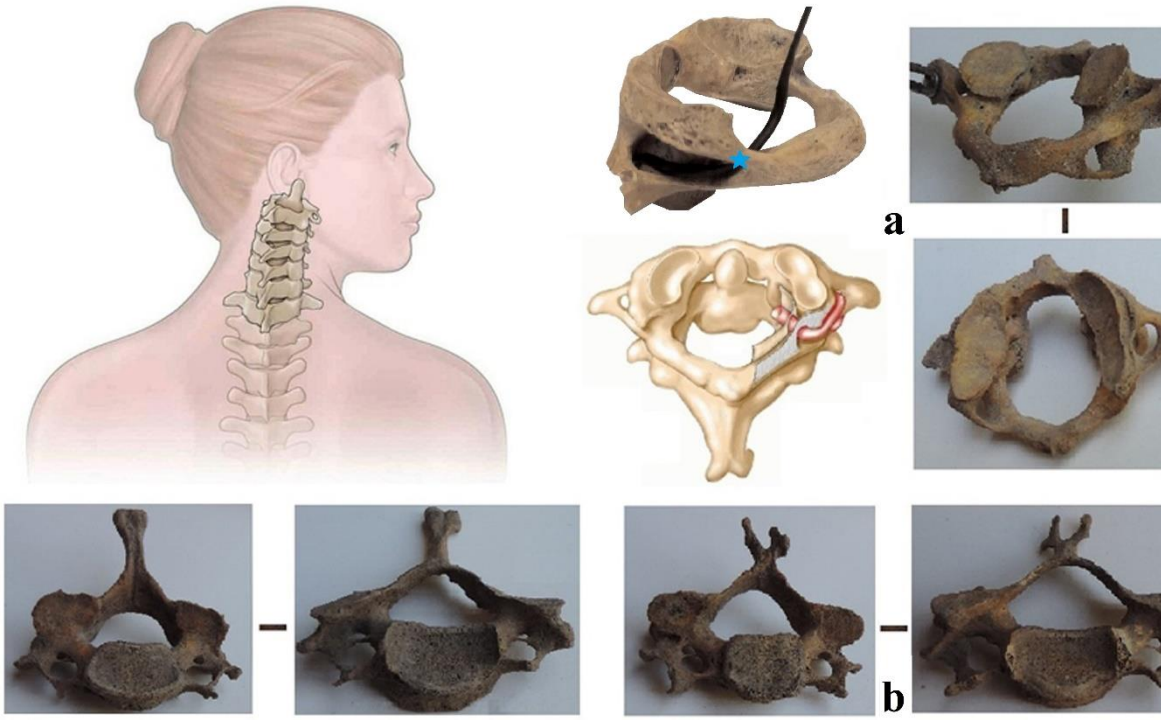
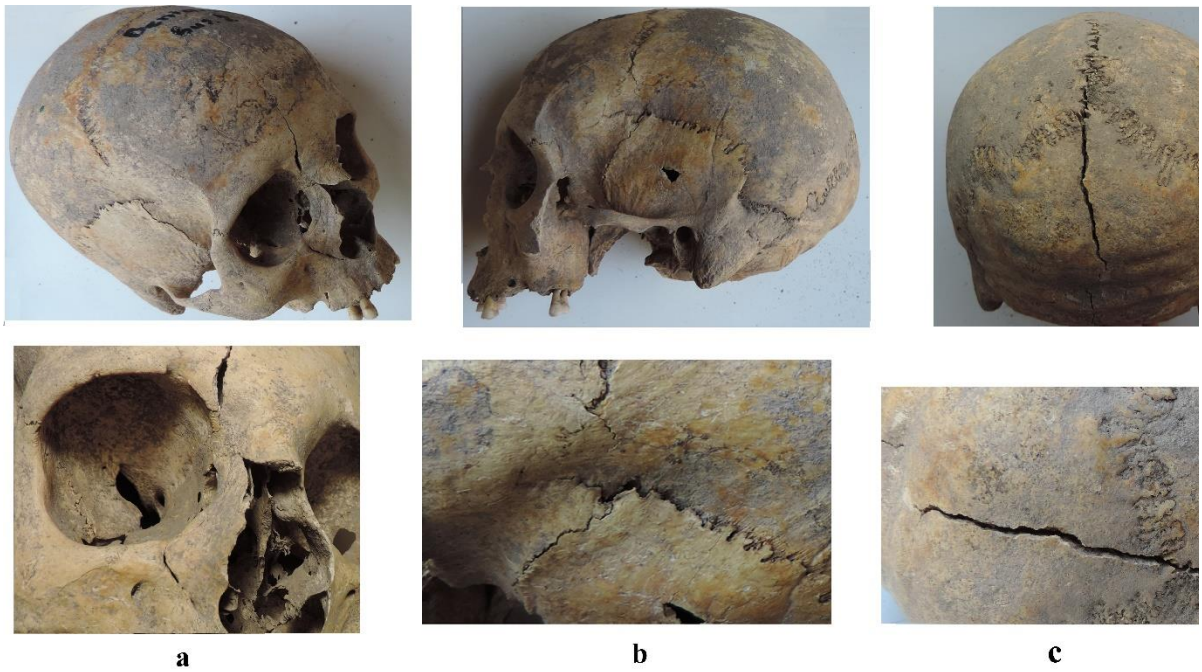


Figure 3. a) Foramen arcuale of atlas, b) accessory foramen transversarium on both sides of C5, C6 vertebrae.



a b c

Figure 4. a) Fracture of the midfacial, b) Fracture of the frontal, temporal and parietal bones, c) perimortem injuries occipital bone.

Figure 5. a) Fracture of the left clavicle, b) Fracture of the right condyle.

Figure 6. Bulla ethmoidalis and nasal septum deviation.

Figure 7. Facets on the portion of the lower leg bone.

Figure 8. The Schmorl's node on the thoracic and lumbar vertebrae of individual.

There also appears to have been some healing to the area as the edges are slightly smooth rather than sharp.
Changes within the nasal are observed. In an individual, the cause of violation of ventilation and drainage of the paranasal sinuses, and as a result of this - the recurrence of sinusitis, were: enlarged bulla ethmoidalis, enlarged pneumatized middle turbinate. Pneumatization of the middle turbinate was associated with a significant nasal septum deviation (Figure 6).
The indentation in Figure 7 is in the front portion of the lower leg bone (i.e., Tibia). This is caused is from habitually squatting and is known as a squatting facet.
The 10th thoracic through 1st lumbar vertebrae displayed Schmorl's nodes (inferior aspects and superior aspects) (Figure 8).
Individual has evidence of buccal maxillary abscess (P2) (Figure 4b). And also shows alveolar resorption indicative of antemortem absence left first maxillary molar (Figure 4b). Above the left first maxillary molar there is an irregular area with pitting on the internal and external surfaces, indicating the spread of infection from the dentition into the maxilla above the alveolus. Periodontal disease is also evident in the first maxillary molar (Figure 4b). Caries occur on the right maxillary second premolar. Dental calculus was observed on 4 teeth. The teeth involved were the right upper canine (Figure 6), the second molar and the canines of the mandible.

Discussion and Conclusions

In the present study skull had rare prebasioccipital arch. A bony arch is noted at the tip of clivus which is continuous laterally with occipital condyles. Prebasioccipital arch also known as hypocondylar arch is a bony, bulging complete arch at the front rim of the occipital foramen magnum. Hyperostotic traits are believed to be as age- progressive changes and more frequently on left side and hypostatic traits are age-regressive changes (39). The cranial bone variations could be due to the maternal environment (39), or genetic variation or adaptation to environment including postnatal stress factors (40). These enlarged paramedian bony masses ventral to the foramen may form a pseudojoint with the apical segment of the odontoid process or anterior arch of the atlas, thereby affecting the kinetic anatomy and integrity of the atlantooccipital articulation (41), may decrease the periphery of the foramen or cause asymmetry (42, 43). Presence of this arch may lead to limitation in the range of motion of the craniovertebral junction (44). This kind of diversity of discrete cranial traits in modern humans may be due to retention of ancestral pattern or result of the process of population differentiation (40). Menezes and Fenoy (45) reported their extensive experience on the subject and discussed their management issues. Von Hayek (46) found such a bone formation regularly in lower animals.
The vertebral artery groove is transformed into an accessory foramen (foramen arcuale) of atlas. It is an anatomical variant, and when present, the foramen arcuale partially or completely encircles the suboccipital nerve, vertebral venous plexus, and V3 segment of vertebral artery as it exits the transverse foramen (13). The foramen arcuale has been widely described in the literature, with the first reports of its incidence dating back to the 19th century (47). Foramen arcuale is a potential clinical/surgical significant anatomical variant of the atlas; leads to symptomatic entrapment, additional compression of the vertebral artery by a lateral ponticle could very likely result in stenosis of the vertebral artery (13). Foramen arcuale is associated with Barre-Lieou syndrome (12), which represents symptoms of headache, vertigo (48), migraines (12, 49), retro-orbital pain, vasomotor disturbance of the face and recurrent disturbances of vision, swallowing and phonation due to alteration of blood flow within the vertebral arteries and an associated disturbance of periarterial disturbance of periarterial nerve plexus (50). Additionally, potential compression of the vertebral artery may occur as a result of an altered movement of the vessel during flexion or extension of the neck when a foramen arcuale is present (50).
Geographical analysis demonstrated that the complete foramen arcuale is most prevalent in North Americans, with a prevalence of 11.3%, followed by Europeans, Africans, and South Americans, with a prevalence of 11.2%, 8.9%, and 8.7%, respectively. It was least common in Asians, with a prevalence of only 7.5%. The high variability among Asian populations is interesting. The prevalence of the complete FA was significantly lower in the Chinese (4.4%) and South Koreans (5.8%) than among the populations in studies originating from India (7.6%) (51). Here we describe of the first cases of foramen arcuale in the recorded in the paleomaterials of Armenia.
Foramen transversarium is a specific feature which is present in the transverse process of cervical vertebrae. The transverse process of

adult anatomy is morphologically a compound structure containing the foramen transversarium. It displays anterior and posterior roots or bars which terminate laterally as anterior and posterior tubercles. It is formed by the vestigial costal element fused to the body and the true transverse process of the vertebra. The foramen transversarium present on the transverse process of cervical vertebrae are known to transmit the vertebral artery, vertebral veins and sympathetic nerves (52). These foramina are known to exhibit variations with respect to the shape, size and sometimes are multiple or absent. Their etiology may be related to variations of the course of vertebral artery and is developmental (52). An accessory transverse foramen, posterior to and smaller than the primary foramen, may be found in the sixth vertebra, and less frequently in the adjacent vertebrae (53). Under such circumstances, the course of the vertebral artery may be distorted. The variations in number and size of foramina transversaria of cervical spine may be one of the causes for complaints like headache, migraine, and fainting attacks and are due to the compression of vertebral artery (54).

Clinical studies indicate that most fractures in modern societies occur due to daily activities rather than interpersonal violence or unusual events – most fractures in females occur at home while most fractures in males occur at work or during sports (34). Could the woman's from burial 2 injuries have been accidental? Distinguishing between accidental and intentional injuries in individual cases is problematic in skeletal. A 2004 study by Judd showed that skeletal remains from the ancient city of Kerma showed fracture distribution patterns that differed drastically from the clinical injury distributions in two modern samples where falls were the primary mechanism of injury (55). Accidental trauma includes injuries that occur as a result of an accident (dizziness, bad feeling, etc.) and often reflect the hazards of everyday life and the daily interactions between people and their physical environment (34, 56). The injuries mentioned in this article may be related to the presence of a foramen arcuale and an accessory foramen. A crack may form if dropped on the face. Alternatively, the trauma was caused by an assault (by blow). The pattern of fractures originating from the parietal region is also indicative of a massive impact trauma in the parieto-temporal region of the left side. Such injuries could occur as a result of a fall, but it cannot be excluded that the blow to the head was a result of deliberate human action. The situation is similar with the femoral injury.

Clavicular fractures are usually the result of a direct blow to the shoulder (57-59), but fall should not be ruled out either (60). Extensive lamellar remodelling in the left clavicle of Beniamin indicates that the fracture occurred some years before death and they are of accidental origin.

Therefore, we can conclude that the presence of the above anomalies, traumatic lesions observed on skeleton are related to the fall. In the present study the Bulla ethmoidalis coexisted with crack in the facial bone. Probably, inflammation penetrated through the eye socket and/or through periodontal inflammation lesions. These are usually associated with abnormal air flow and impaired patency of the openings of sinuses into the middle nasal passage, because the hypertrophy of the middle turbinate obstructs the ethmoidal infundibulum and leads to recurrent sinusitis.

Schmorl's nodes are vertebral lesions caused by prolapsed inter-vertebral discs, bone forms to prevent further intrusion of disc material and results in a lesion on either the superior or inferior surface of the vertebral body (61). Whilst Schmorl's nodes have been thought to be caused by bearing heavy loads, other possible causes include developmental problems and trauma. Some authors believe the presence of the foramen arcuale can be caused by degenerative changes and that prevalence increases with age due to calcification (62-64).

Five main aspects of dental pathology are recorded (caries, calculus, antemortem lost teeth, periodontitis and periapical lesions). Gingivitis (inflammation of the gum) will, if left untreated, develop into periodontitis causing loss of alveolar bone (65). There is a general reduction of alveolar bone in the maxilla and the mandible. The roots of the teeth are partly exposed. The area of the first molar of the left upper jaw is severely affected. There are periapical cavities at the root of the left first molar. They have smooth, rounded openings on the buccal side. The surrounding alveolar bone displays some porosity. Periapical lesions, most commonly developed from periapical granuloma by the accumulation of pus, are diagnosed following (66). Lesions are recorded at the parent tooth position according to the location of the largest sinus drainage (external, internal or maxillary sinus). Antemortem tooth loss is a complex and multifaceted process involving diet, nutritional deficiencies, oral health status (caries, pulp exposure due to heavy tooth wear,

periodontal disease: which occurs when inflammation of the gums, gingivitis, spreads to the underlying bone), traumatic injury and cultural practices. Calculus is noted where mineralized plaque can be seen adhering to the tooth surface. In the individual, the calculus is very fragile and parts of it fall off. Calculus is the mineralization of bacterial plaque resulting from, among other things, a high protein diet (67).
Many studies have reported an association between above anomalies (foramen arcuale, foramen transversarium) and neurological symptoms such as vertigo and migraine et all. So, falls, accidents are the causes of injuries in a woman. It can be argued that woman entered a sedentary lifestyle. Her cause of death is likely are associated with severe a trauma to the occipital bone when falling.

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Declaration of Interest
None

Author Contributions
The study was designed and conceivedby Anahit Yu. Khudaverdyan. Fieldwork was carried out by Hamazasp H. Khachatryan. Formal Analysis and interpretation were conducted by Anahit Yu. Khudaverdyan, Azat A. Yengibaryan, Shota A. Vardanyan, Oskar Nowak. The man-uscript was written by Anahit Yu. Khudaverdyan.

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