The case of hip dysplasia of an adult from the Roman Period site of Velebit (Serbia)

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Received October 3rd, 2021
Accepted for publication November 26th, 2021
Online First November 30th, 2021

Keywords: hip dysplasia, perimortem cranial trauma, Roman Period, Serbia.

Abstract

Objective: This study is designed to reveal the diagnosis of a rare hip condition with an estimation of the possible cause of death.

Materials: Archaeological site of Velebit dated between the 3rd and 4th century AD is located in northern Serbia. Grave No 24 differs from others in the unusual position of the skeletal remains in situ.

Methods: The bioanthropological analyses included an estimation of skeletal preservation, cranial and postcranial skeletal measurements, estimation of sex and age at the moment of death, dental analysis and a paleopathological examination. This skeleton was analysed for signs of bone disease, using diagnostic paleopathological procedures comprising gross examination and CT scanning.

Results: The results revealed that the analysed male individual was 40 to 55 years of age. The bioanthropological analyses showed two deformities of the pelvic bones, each on the outer surface, located posteriorly and superiorly of the acetabular area. The observed lesions were characterised as type 4 of developmental dysplasia of the hip. In addition, a sharp lesion was observed in the right posterior region of squama of the occipital bone.

Conclusions: Our results clearly suggest that this individual had been suffering from hip dysplasia. The possible cause of death could be the observed head lesion. In addition, there is no skeletal conformation of unfavourable living conditions related to physiological stress and diet.

Introduction

Hip dysplasia is defined as a modelling failure of the acetabulum and, subsequently, the femoral head. People who suffer from hip dysplasia are born with the condition. In neonates, the condition is connected to a variety of anatomic abnormalities, from dysplastic to severe morphological findings that occur in rare idiopathic teratologic dislocations, usually in association with neurological diseases (Morrissy and Weinstein, 2006). Initially, this condition is commonly presented with delayed ossification of the lateral epiphysis of the acetabulum, which could lead to secondary dislocation during the first few months of life (Hefti et al., 2007). This occurs as the possible consequence of a subtle lack of coverage of the femoral head by the acetabulum i.e. a noncongruent femoral head and acetabulum (Manaster et al., 2016).
关节可以部分或完全脱位。半脱位的髋关节比完全部位的髋关节更容易出现症状（Morrissy and Weinstein, 2006）。通常，疼痛在儿童时期没有出现，但在青春期和成年期最常见（Hefti et al., 2007; Manaster et al., 2016; https://hipdysplasia.org/developmental-dysplasia-of-the-hip/infant-signs-and-symptomshipdysplasia.org）。

地理上的发病率变化。该疾病已知的发病率，并且遗传和环境因素被公认为背景因素（Roberts and Manchester, 2007; Hefti et al., 2007; Mitchell and Redfern, 2007; Morrissy and Weinstein, 2006）。在当代人口中，该病的发病率1:1000，女性略多于男性（1:5-8）。此外，双侧发生率记录为20%的情况下（Manaster et al., 2016）。在考古人口中，髋关节发育不良也倾向于在女性中比男性更常见，且最常见于左侧（Anderson, 2000）。分析了572例来自伦敦中世纪的人，Mitchell and Redfern（2011）指出，发育性髋关节发育不良（DDH）等（髋臼发育不良、半脱位或脱位）在该研究中占1.7%的调查人群（Mitchell and Redfern, 2011）。

在生物人类学文献中，只有少数几篇系统性论文包含了该病理状况的多例报道（Mitchell and Redfern, 2007; 2011）。然而，该状况的重要性不仅在于其罕见性，还在于它对个人日常生活的影响。

研究的目的。该研究的目的是展示来自Velebit（塞尔维亚）罗马时期遗址的髋关节发育不良案例。我们将讨论观察到的病理状况的诊断，概述该个体在生前的发展过程。此外，我们还将评估在该个体死亡后颅骨的创伤情况，以及可能的后果。

材料和方法

该研究的考古遗址Velebit位于塞尔维亚北部Senta市。根据未发表的考古记录，Velebit是2-3世纪AD的多层遗址。在发掘的坟墓中，第24号坟墓与其他坟墓不同，因为其骨骼在位时的位置不寻常。坟墓位置位于humus土壤中，保存良好的骨架在位为伸展的仰卧位。然而，下肢的位置不寻常，因为双腿弯曲在膝盖，右侧腿比左侧腿弯曲得更多，右腿放在左侧腿上方。该个体的朝向是SW-NE，偏离15度朝北。没有随葬品。

生物人类学分析包括骨骼保存程度的评估、颅骨和颅外骨骼的测量、死亡时的年龄和性别的评估、体高的重建、牙科分析和病态学检查。保存程度的评估根据修改后的Mikić方案进行，该方案考虑了骨的完整性及骨碎片（Mikić, 1978）。测量遵循标准的骨骼学程序（Buikstra and Ubelaker, 1994）。年龄评估基于耻骨联合的形态学特征，这符合Suchey-Brooks的建议（Brooks and Suchey, 1990）。最后的评估还包含了Iscan的方法（Iscan et al., 1984, 1985），基于肋骨的末段、颅骨缝合的闭合（Meindl and Lovejoy, 1985）、牙齿磨损（Gustafson, 1950）和骨骼的退化变化。由于在人类骨骼中，耻骨是性别最可靠的指示器（Djuric et al., 2007），因此在该研究中，性别的确定主要是基于耻骨的二态特征（Buikstra and Ubelaker, 1994）。

此外，还通过颅骨形态学和标准的生物人类学标准对性别进行了评估。
Ubelaker, 1994). The reconstruction of body height was based on the length of the long bones (Trotter and Gleser, 1958). This skeleton was analysed for signs of bone disease, using diagnostic paleopathological procedures, comprising gross examination and CT scanning. The gross examination was based on a macroscopic observation of each bone including a detailed written and photographic description following the recommendation of Buikstra (2019), while CT scanning was conducted using a Siemens SOMATOM Sensation 16 with study reading in Carestream Vue PACS Power Viewer (ver. 12.0.0.5756).

Results

The skeletal remains of this individual were in a relatively good state of preservation (Fig 1). Based on the maximum length of the humerus and ulna, the body height has been reconstructed and estimated to be approximately 169 cm. Bioanthropological analyses revealed that the male individual buried in this grave was 40 to 55 years of age at the moment of death. During the bioanthropological analyses, two deformities of the pelvic bones were noted, each on the outer surface, located posteriorly and superiorly of the acetabular area (Fig 2).

The surface bone was changed in comparison to the surrounding area, in the form of an oval bone impression, moderately deep with partially obtuse margins. A subtle new bone formation could be observed in the caudal half of the lesion periphery. The observed changes represented a false acetabulum. The condition was characterised as a type 4 developmental dysplasia of the hip, represented with a completely dislocated hip, and an inversion and highly possible hypotrophy of the labrum during life (Resnick and Kransdorf, 2005). On the left pelvic bone, in the expected area of true acetabulum, a triangular, narrow cavity with an uneven surface could be observed. This feature was partially preserved and represented an undeveloped true acetabulum. Unfortunately, on the right pelvic bone the expected area of the true acetabulum was not preserved.

A sharp lesion was observed in the right posterior region of the squama of the occipital bone (Figs 3 and 4). The find was described as a linear fracture with diastatic, dominantly sharp margins followed inferiorly by a tangential defect in the outer lamina, a possible repercussion of a loose fragment. Signs of discrete

Figure 1: Skeletal remains from grave no. 24 (Photo and modification by Tamara Pavlović).

Figure 2: Deformities of pelvic bones (Photo and modification by Tamara Pavlović).
Figure 3: Occipital lesion (macroscopic oblique view) (Photo and modification by Tamara Pavlović).

Figure 4: Occipital lesion (MDCT Volume Rendering, posterior view) (Photo and modification by Petar Milenković).
callus formations were observed during radiological analyses, with the most pronounced records in the caudal third of the lesion, especially on the right side (Fig 5). At the same level on the left side, only the outer tabula were involved (Fig 6), while in the cranial and middle third, destruction affected both tabulas as well as the diploe.

In addition, malnutrition traces such as enamel hypoplasia, cribra orbitalia, subperiosteal inflammation, specific infectious diseases or metabolic diseases have not been noticed.

Discussion and Conclusion

Discussion

The normal development of the acetabulum occurs not only through growth of adjacent hip bones and the proximal femur, but is also highly influenced by vascularisation, muscle tone and forces transmitted through muscle attachments, as well as across the hip joint (Morrissy and Weinstein, 2006). The disturbance of physiological balance in these factors induce numerous health issues. Some of them are mild, such as asymmetry in the skin folds of the gluteal, thigh or labial region, while others are of more importance like limb length discrepancy, limited range of motion, waddling gait, and hyperlordosis of the lumbar spine (Morrissy and Weinstein, 2006). The most common disability is represented in a limitation of abduction as a consequence of adductor shortening due to hip subluxation or dislocation (Morrissy and Weinstein, 2006). Hip dysplasia can damage the cartilage lining the joint, leading to the early onset of osteoarthritis. This is the reason why, in cases with an early occurrence of osteoarthritis, attention should be focused on the possible underlying development of hip dysplasia (Manaster et al 2016). Although rare, a complication of untreated hip dislocation could be avascular necrosis of the femoral head, causing morphological alterations of the proximal femur that further leads to limb shortening, rotation and, finally, movement constriction. Even with complete dislocation, the

Figure 5: Calus formations (MDCT MPR Reconstructions) (Photo and modification by Petar Milenković).
affected person may be with little or no functional disability. The level of disability is mainly affected by bilaterality and the state of development of the false acetabulum (Morrissy and Weinstein, 2006).

In hip dislocation there is a lack of physiological stimulus for acetabular development provided by the femoral head (Morrissy and Weinstein, 2006). The true acetabulum would be misshaped and filled with fibrofatty material (Resnick and Kransdorf, 2005). This results in the most severe form of the disease characterised by an absence of a formed acetabulum, with the femoral head articulating with the iliac bone, creating a pseudoacetabulum i.e. a false acetabulum (Manaster et al 2016). The absence of a false acetabulum allows a good range of motion and little functional disability, while a well-developed false acetabulum leads to degenerative joint diseases (Morrissy and Weinstein, 2006).

In the present case, the anatomical features of the true acetabulum indicated an early abruption of physiological development, which resulted in an irregular shape, size and surface. Based on the aforementioned, the presence of a false acetabulum undoubtedly leads to a diagnosis of hip dysplasia. Due to the morphological characteristics, the affected person probably suffered from the so-called swaying gait.

Abnormal gait, incapacitating pain, and the occurrence of severe arthritis certainly would be limiting factors in the performance of any daily activity that includes the action of the lower limbs. Therefore, an active role in activities such as hunting, agriculture or even warfare, which in many ancient societies represented the basis of economic development, must have been restricted or even not possible (Roberts and Manchester, 2007). Moreover, the health situation in which these people found themselves also demanded some form of care that had to be constant and daily. In the presented case, based on the results of bioanthropological analysis, traces of some malnutrition conditions, such as enamel hypoplasia, cribra orbitalia, subperiosteal inflammation, specific infectious diseases or metabolic diseases, were not noticed. Although very generally, this could suggest that this person had a satisfactory diet and living conditions throughout their life, despite the potential limitations that may have arisen as a result of the presented hip disease.

Taking into account that in ancient societies this condition became visible in the period when a child started walking, it seems that the application of any treatment would be too late and with poor results (Roberts and Manchester, 2007). The fact that the developmental hip dysplasia would not resolve spontaneously in the absence of treatment (Mitchell and Redfern, 2007) further outlines the importance of early detection, even today. Even from the standpoint of modern medicine, it is not possible to predict the outcome of developmental hip dysplasia in neonates, therefore, all cases with clinically detectable hip instability should be treated (Morrissy and Weinstein, 2006). According to contemporary medical practice, secondary adaptive changes in the hip joint take place even after six months of life, making simple treatment...
options ineffective and leaving techniques of closed and open reduction as the only possible options (Morrissy and Weinstein, 2006). Until the age of three, closed reduction is recommended, while open reduction is applied only in unsuccessful cases. Later in the course of life, i.e. after the age of five, operative treatment is only recommended in unilateral dislocations, while bilateral dislocations are treated with open reduction only if a false acetabulum has already been formed (Hefti et al., 2007). The possibility of normal acetabular development is less likely with an increased age of detection (Morrissy and Weinstein, 2006). It is obvious that modern diagnostic techniques were not possible in that time and that any applied treatment would have been too late, leaving the possibility of visible marks on dry bones. To our knowledge, there is no evidence of any effective treatment of this condition during the Roman Period, although some simple techniques would have been possible. Thus, any traces of pathological conditions in the region of the spine, hips, or feet should be precisely recorded and carefully investigated. If there is the possibility, analyses of factors such as cultural practices, attitude towards health or available obstetric care should not be neglected.

The previously described blow to the head would cause laceration of the occipital brain tissue, due to the direct effect of the blade and bone fragment displacement intracranially. Usually, this is followed by the development of hemorrhagic contusion sites, traumatic subarachnoid hemorrhage, the formation of a subdural or epidural hematoma with a compression effect, and pneumocephalus. The formation of "bridging" bone tissue between fragments suggests that this individual did not subdue to the primary effects of head trauma, but later, due to secondary effects, most possibly an infection of the soft tissue (meningitis, encephalitis) (Osborne 2018). The partial obtuse margins of the skull lesion showed diminished signs of healing, suggesting perimortal trauma delivered by a long, sharp weapon. The observed head lesion should be considered as a possible cause of death.

**Conclusion**

The results of our analyses clearly suggest that this individual had been living with a health problem for decades, suffering from hip dysplasia during life. The condition was progressive and led to an abnormal development of the hips, with the presence of a false acetabulum. The position in the grave suggested the presence of lower limb contractures, which could develop in untreated cases of developmental hip dysplasia. The observed features could have evolved throughout life, incapacitating normal function, making even simple everyday activities challenging and painful. This led us to the conclusion that any previously applied treatment in this case would have been unsuccessful. Unfortunately, the poor preservation of the proximal end of both femurs as well as vertebrae limited more detailed analyses of this condition. The possible cause of death could be the observed head lesion. However, signs of healing signal that this person did not succumb to the injury on the spot, but most likely sometime after, probably due to an infection of the brain tissue.

In addition, there is no confirmation of unfavourable living conditions related to diet. It is important, however, to note that, in this particular grave, archaeologists found no grave goods, so the social status of this individual cannot be discussed.

A detailed examination and reconstruction of health problems that were incurable and that prevented an individual performing day-to-day activities would allow us to better understand the overall attitude of the community towards disabled persons and health in general.

**Acknowledgements**

This work was supported by the Ministry of Education, Science and Technological Development of Serbia; Grant number: III 45005.

**References**

Anderson, T. (2000). ‘Congenital conditions and neoplastic disease in palaeopathology’ In M. Cox, S. Mays (Eds.), Human Osteology in Archaeology and Forensic Science (pp. 199-225). Cambridge: Cambridge University Press.

Brooks, S. Suchey, J. M. (1990). Skeletal age determination based on the os pubis: A comparison of the Acsádi-Nemeskéri and Suchey-Brooks methods. Human Evolution 5(3), 227-38. https://doi.org/10.1007/BF02437238
Buikstra, J.U., & Ubelaker, D. (1994). Standards for Data Collection from Human Skeletal Remains. Arkansas: Archaeological Survey Press.

Djuric, M., Dunjic, D., Djonic, D., Skinner, M. (2007). Identification of victims from two mass graves in Serbia: a critical evaluation of classical markers of identity. Forensic Science International 172(2-3), 125-129. doi:10.1016/j.forsciint.2007.01.003

Gustafson, G. (1950). Age determination on teeth. Journal of the American Dental Association 41(1), 45-54. doi:10.14219/jada.archive.1950.0132

Hefti, F., Brunner, R., Hasler, C.C., Jundt, G. (2007). Pediatric Orthopedics in Practice. Berlin-Heidelberg: Springer.

International Hip Dysplasia Institute SAD (2018). Hip Dysplasia-Infant and Child. https://hipdysplasia.org/developmental-dysplasia-of-the-hip/infant-signs-and-symptoms/ (accessed 13 Jun 2019).

İşcan, M.Y., Loth, S.R., Wright, R.K. (1984). Metamorphosis at the sternal rib end: A new method to estimate age at death in white males. American Journal of Physical Anthropology 65(2), 147-56. doi:10.1002/ajpa.1330650206

İşcan, M.Y., Loth, S.R., Wright, R.K. (1985). Age estimation from the rib by phase analysis: white females. Journal of Forensic Science 30(3), 853-63. doi:10.1520/jfs11776j

Manaster, B.J. (2016). Diagnostic Imaging. Muskuloskeletal: non-traumatic disease. Philadelphia: Elsevier.

Meindl, R.S., Lovejoy, C.O. (1985). Ectocranial suture closure: a revised method for the determination of skeletal age at death based on the lateral-anterior sutures. American Journal of Physical Anthropology 68(1), 57-66. doi:10.1002/ajpa.1330680106

Mikić, Ž. (1978). O antropološkoj metodologiji terenske obrade skeletnih ostataka. Godišnjak Centra za balkanološka ispitivanja ANUBiH 16/14, 201-242.

Mitchell, P.D., Redfern, C.R. (2007). The Prevalence of Dislocation in Developmental Dysplasia of the Hip in Britain Over the Past Thousand Years. Journal of Pediatric Orthopaedics 27 (8), 890-892. doi:10.1097/bpo.0b013e31815a6091

Mitchell, P.D., Redfern, C.R. (2011). Brief communication: Developmental dysplasia of the hip in medieval London. American Journal of Physical Anthropology 144 (3), 478-484. doi:10.1002/ajpa.21448

Morrissey, R.T., Weinstein, S.L. (2006). Lovell & Winter’s Pediatric Orthopaedics. Philadelphia: Lippincott Williams & Wilkins.

Osborn, G. A. (2018). Anne G. Osborn’s Brain: Imaging, Pathology, and Anatomy. Elsevier.

Resnick, D., Kransdorf, M.J. (2005). Bone and joint imaging. Philadelphia: Elsevier.

Roberts, C. & Manchester, K. (2007). The Archaeology of Disease. Ithaca: Cornell University Press.

Trotter, M. & Gleser, G. (1958). A re-evaluation of estimation of stature based on measurements taken during life and the long bones after death. American Journal of Physical Anthropology 16, 79–123. doi: 10.1002/ajpa.1330160106