



Photogrammetric 3D model of a Bronze Age pelvis
from Hainburg, Austria (L. Waltenberger)

FEMALE PELVIC FEATURES

NEW DEVELOPMENTS IN OSTEOARCHAEOLOGY,
MEDICINE AND EVOLUTIONARY BIOLOGY

ABSTRACTS



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Doris Pany-Kucera, Michaela Spannagl-Steiner, Barbara Maurer-Gesek, Wolfgang J. Weninger, Katharina Rebay-Salisbury

The bony sacral preauricular extension and notch as parts of a 'Pelvic Pattern' – can they provide information on past pregnancies and parturitions?

We recorded a set of 10 pelvic features thought to relate to past pregnancies and parturitions. Female sacral remains (52 right side, 34 left side) of three skeletal collections from Bronze Age Austria, and 43 females (both sides preserved) from the Simon collection (Geneva) were analyzed. This collection of modern individuals used for comparison includes information on the number of children each woman had. The analyses were performed within the ongoing ERC-funded project VAMOS, which uses funerary and skeletal data to link females' reproductive and social status in prehistoric societies. In the course of these analyses, we noticed bony modifications located at the ventrosuperior margin of the ala ossis sacri at the level of the terminal line. One is a ventrally pointing osseous extension, termed the 'sacral preauricular extension', the other is a loss of convexity, termed the 'sacral preauricular notch'.

'Pelvic Patterns' combine at least four out of 10 pronounced pelvic features in one individual. The mean frequency of the extension in the Bronze Age specimens is 13.5 % on the right and 14.7 % on the left side, and of the notch 9.6 % (found only on the right side). A Pelvic Pattern was noticed in 53 % of the affected females. In the Simon collection, we found the extension in 4.7 % cases on the right side, and 11.6 % cases on the left; the notch was found in 4.7 % individuals (only on the left). A pelvic pattern was identified in 67 % individuals from the Simon collection.

In both the Bronze Age and Simon collections, the sacral preauricular extension and notch were observed only in females; furthermore, in the Simon collection they were only found in multiparous women (\geq two children).

We conclude from this that the sacral preauricular extension and notch as part of a Pelvic Pattern give vital evidence of motherhood in past populations.

Barbara Maurer-Gesek, Doris Pany-Kucera, Michaela Spannagl-Steiner, Stanislaus Argeny, Catharina Müller, Jakob Nedomansky, Julia Gruber, Wolfgang J. Weninger

Pregnancy and birth-related modifications of the bony pelvic skeleton: the anatomic basics

Objectives: Our aim is to examine the incidence and causality of anatomic features used by modern anthropology in general, and the ERC-funded VAMOS project in particular, as indicators for pregnancies and childbirth in prehistoric skeletons. The focus will rest on the preauricular sulcus, sacral preauricular extension, additive pubic tubercle, piriform tubercle and dorsal pitting on the pubic bone.

Material & Methods: The pelves of 32 body donors (50% male, 50% female) were examined. 12 were fixed in a neutral buffered carbol/formaldehyde (4%/1%) solution and 20 were unfixed. All pelves were imaged with computed tomography (CT), before they were stratigraphically dissected and finally macerated. All important anatomic features and relations were carefully characterised and measured.

Results: Based on quantitative and qualitative analysis of three-dimensional (3D) computer models created from CT data and macerated specimens, we provide descriptions and measurements of the osseous features and comparisons of their occurrence in males and females. The insertions and the topology of muscles and fasciae at and near these features are analysed.

Conclusion: Our results enable us to provide a method to evaluate the value of the preauricular sulcus, sacral preauricular extension, pubic tubercle, piriform tubercle and dorsal pitting at the pubic bone as indicators for pregnancies and childbirths and therefore contributes to evaluating the role women had in prehistoric societies, as researched in the VAMOS project. Furthermore, our data permit the formulation of a hypothesis that explains the predominant occurrence of the examined features in females.

Lukas Waltenberger, Philipp Mitteröcker, Katharina Rebay-Salisbury

Are pelvic scars truly signs of birth? – A geometric morphometric approach

This research uses a geometric morphometric approach to address the association of pelvic scars (preauricular sulcus, dorsal pubic pitting, interosseous groove, sacral preauricular extension, extended pubic tubercle) with birth and pregnancy. Although pelvic scars have been well established in the anthropological literature for many decades, this topic is still controversial, because the causes for the development of pelvic scars are still insufficiently understood.

We placed landmarks on every important anatomical structure on 3D-surface models of the articulated pelvis. Furthermore, we placed semilandmarks along curves on the pelvis to describe differences of curved structures of the pelvis and the birth canal. The pelvis under study are part of an Austrian Bronze Age skeletal collection (n=19) sample and a 19th century anatomical collection with background information about the deceased (n=58). 3D data was gained by photogrammetry.

The data were evaluated using multivariate statistical methods such as principal component analysis to detect patterns of pelvic shapes related to different expressions of pelvic scars. We also present the results of a pilot study on histological thin sections of the preauricular sulcus and the extended pubic tubercle (n=6), which provide new insights in the formation of these features.

Robert G. Tague

Evolution of obstetrical sufficiency of the human pelvis: the road not taken

Sexual size (SS) dimorphism of the human pelvis is inferentially related to obstetrics. Humans give birth to big babies, and the female pelvis is enlarged, relative to that of the male, to be obstetrically sufficient. Three features distinguish female and male pelvises; compared to males, females have (1) longer sacral ala, lower ilium, and pubis, (2) more lateral flare of ilium, ischium, and inferior pubic ramus, and (3) greater angulation of sacroiliac joint. Quantitatively, the principal pelvic SS dimorphisms are of the middle and outlet planes, with females larger than males by 13% to 32% in the subpubic space and the transverse and posterior sagittal diameters. SS dimorphism in pelvic circumference, which represents total space available to the fetus and is larger in females than males, is 4% and 6% at the pelvic inlet and outlet, respectively. However, 36% of females and males between ages 20 and 39 have fusion of the coccyx to the sacrum. Coccygeal fusion in females reduces SS dimorphism in pelvic outlet circumference to 4%, when compared with males who do not have coccygeal fusion. As pelvic outlet circumference among females with coccygeal fusion is inferentially obstetrically adequate, then both male pelvic inlet and outlet circumferences must also be (almost) obstetrically sufficient as both circumferences are 4% smaller (12 mm to 14 mm) than those of females. Why did humans evolved a complex suite of pelvic SS dimorphisms involving accelerated longitudinal growth, lateral flare, and joint orientation when an alternative evolutionary road to pelvic obstetrical sufficiency would be for females to be as large as males (i.e., SS monomorphism of the body) and for coccygeal fusion to be suppressed? Evolutionary and developmental reasons for why this alternative “road not taken” are discussed.

Jaroslav Brůžek, Frédéric Santos, Geneviève Perréard Lopreno

Traces of pregnancy and childbirth on female pelvic bones – fact or fiction: I. historical background

Parturition scarring in the skeleton has historically been associated with the presence of a preauricular groove (Zaaijer, 1866). Although Zaaijer described this feature as a racial characteristic of Javanese females, it was soon rejected by Löhr (1894), who considered the groove a sign of robustness, present in a number of large limb joints, and called it the paraglenoid groove. However, it remains unclear who first reported the preauricular groove as the evidence of pregnancy and birth. The answer to the question of whether or not the morphology of the iliac preauricular surface is related to motherhood oscillates between rejection and acceptance, and is of great importance in bioarchaeology and forensic anthropology. This contribution deals with the history of evaluating sexual dimorphism in the preauricular area. We also mention reasons why medical disciplines

and anatomy lack interest in evaluations of parturition scarring on the human pelvic bone. This is manifested by different localization of both the preauricular groove and the paraglenoid groove in anatomical textbooks, and thus both terms are often considered synonyms (i.e. Martin and Saller, 1957). We present a proposal for evaluation of the preauricular surface with differential diagnosis of the different structures of negative relief as proposed by Novotný (1981) and used in methods of sex estimation suggested by Brůžek (2002) and Santos et al. (2019). Only an approach that accepts the existence of both types of grooves (the preauricular and the paraglenoid groove) is possible for sex estimation methods. The answer to the question of whether the morphology of the iliac preauricular surface is related to pregnancy and birth can only be achieved by analyzing female bony pelvises of individuals of known parity. However, such material carrying data on female obstetrical history is very rare.

Geneviève Perréard Lopreno, Frédéric Santos, Jaroslav Brůžek

*Traces of pregnancy and childbirth on the female pelvic bones – fact or fiction:
II. Test in the SIMON collection of identified skeletons (Switzerland)*

The aim of the study, carried out by two observers, is 1. to test the relevance of observations from the preauricular region according to the three criteria established by Brůžek (2002) in order to identify the female population and 2. to test the relationship between the morphology of the preauricular area and parity. The population under study comprises individuals living in the first half of the 20th century, derived from the Simon Collection of known age and sex skeletons housed in the laboratory of prehistoric archaeology and anthropology, University of Geneva, Swiss (Perréard Lopreno, 2007). The individuals are aged 16 to 81 and age classes have been equally balanced. The sample consists of 506 hip bones (among which 237 pairs) belonging to 269 individuals (134 females and 135 males). The obstetrical history is known for a subgroup of 99 females. Results: 1. The combination of the three morphological aspects observed together makes it possible to assign sex via the preauricular morphology in 85.4% of the female and 88.1% of the male samples respectively, with a low risk of error (0.8% for men and 3.2% for women). The relevance of the criteria for identifying the true preauricular sulcus being demonstrated, then opens up the possibility of testing the relationship of this relief with parity. 2. The study shows that the preauricular groove is present in significant proportions in both nulliparous women (75%) and women who have given birth (86%), therefore, it cannot be considered as an indicator of obstetrical history. The relief becomes more marked with the increasing number of births and probably also with age, leading to decreasing both diagnostic error and indeterminacy. Understanding the true cause of the formation of the preauricular groove is still to be understood.

Barbara Fischer

Pelvic sexual dimorphism in Khoe-San

The click-speaking Khoe-San are a group of indigenous populations of great genomic diversity in South Africa. They likely are the descendents of the most ancient divergence among extant human populations, which occurred more than 100.000 years ago. Their morphological characteristics are therefore of large interest to researchers of human evolution. In this study, we assessed pelvic sexual dimorphism in the Khoe-San. To put the results in context, we compared the pelvic shape differences in Khoe-San to North American Whites.

We performed a geometric morphometric analysis based on a dense set of 3D landmarks, which we measured on 54 individuals (Khoe-San) and 99 individuals (N-Americans), respectively. We identified the well-known patterns of human pelvic sexual dimorphism in both groups. Females had a wider pelvic inlet and a larger subpubic angle. However, the degree of sexual dimorphism was reduced in Khoe-San, compared to N-American Whites. We discuss this finding together with evolutionary implications of neonatal size and adaptation to climate.

Martin Haeusler, Nicole M. Webb, Viktoria A. Krenn, Cinzia Fornai

Why is human childbirth so complex? Implications from virtual reconstructions

Childbirth in modern humans is surprisingly complex and hazardous compared to other mammals.

Traditionally this was attributed to the obstetrical dilemma that ascribes birth difficulty to the antagonistic selective pressures for efficient bipedal locomotion and encephalization. This alleged evolutionary trade-off also explains the neurological immaturity of our newborns and the marked sexual dimorphism in human pelvic shape. Recently, however, the obstetrical dilemma hypothesis has been challenged on multiple fronts. Here, we review the different critiques and alternative hypotheses, including: the assertion that locomotor costs are unrelated to pelvic width, the energetics of gestation and growth hypothesis, the abdominopelvic stability hypothesis, thermoregulatory explanations, and the ecological model. We demonstrate that these alternative hypotheses are not mutually exclusive, while none of them successfully addresses all aspects of the obstetrical dilemma; particularly, the evolution of our complex birth mechanism, the secondary altriciality, and pelvic sexual dimorphism.

To further advance our understanding of the obstetrical dilemma, we focus this study on australopithecines, a group of fossil hominins living 4 to 2 million years ago that were both adapted for climbing and terrestrial bipedalism but did not evidence the brain expansion typical of Homo. Unfortunately, this approach is complicated by conflicting reconstructions of the available specimens. Therefore, to clarify the complex evolutionary processes that ultimately led to our elaborate birth process, we use virtual imaging and geometric morphometric methods in our australopithecine pelvic restorations that permit a higher degree of reproducibility and objectivity compared to former manual reconstructions. Our reconstructions are then used in combination with neonatal head models scaled according to different regression equations to explore the birth process through realistic virtual simulations. The results indicate that fetopelvic constraints were likely already present in australopithecines, yielding independent support for the obstetrical dilemma hypothesis.

Philipp Mitteröcker

Cultural transition, body height, and obstructed labor

Successful childbirth requires the match of fetal size and the dimensions of the maternal birth canal. Skeletal growth, however, is influenced both by prenatal and postnatal living conditions, including nutrition, which have changed tremendously throughout human history. In my talk I show how rapidly improving living conditions and the resulting increase in body size can challenge childbirth: as the fetus is one generation ahead of the mother, the fetus is likely to experience better environmental conditions during development than the mother did, causing a disproportionately large fetus and an increased risk of obstructed labor. Cultural transitions and changes in subsistence strategy may thus have repeatedly affected childbirth and also contribute to the current rise of cesarean section rates.

I test this hypothesis using global data on cesarean section rates, average body height, and various risk factors for obstructed labor. I show that a third of the global variance in current national C-section rate can be explained by the trends of adult body height from the 1970s to the 1990s. A structural equation model revealed that socio-economic development and access to healthcare affect C-section rate via multiple causal pathways, but the strongest direct effect on C-section rate was body height change. These results indicate that the historical trajectory of socio-economic development affects—via its influence on pre- and postnatal growth—the intergenerational relationship between maternal and fetal dimensions and thus the difficulty of labor. This sheds new light on historic and prehistoric transitions of childbirth and questions the WHO suggestion for a global ‘ideal’ C-section rate.

Rebeka Rmoutilová, Jaroslav Brůžek

Asymmetry of the human pelvis and the birth canal: a default state or a consequence?

Pathologically induced types of pelvic asymmetry were a subject of obstetrical interest in the 18th and 19th century. These malformations are often related to inadequate nutrition and can lead to obstructed labor and death. However, skeletal asymmetry can also be physiological or caused by biomechanical requirements. In current medical research, pelvic asymmetry is often considered an inclination in the coronal plane relative to body axis. Only a few anthropological studies have focused on the asymmetry of the pelvis per se and of the birth canal; some have proposed that higher pelvic asymmetry could have led to maternal mortality and overrepresentation of younger females in the archeological record. Others argued that pelvic asymmetry can be physiological to certain degree as pregnancy and birth are naturally lateralized processes. However, studies on

directional asymmetry have obtained incoherent results regarding pelvic asymmetry throughout the obstetric canal planes spreading from spiral asymmetry of the pelvic canal to the complete absence of asymmetry.

We propose a new research using tools of geometric morphometrics that, in contrast to linear measurements used previously, allow evaluation of shape asymmetry and are able to discern between matching and object symmetry. The latter can be important as sacro-iliac joints may cause an asymmetric alignment of ossa coxae and object symmetry can thus be more disrupted than the matching symmetry of separate bones. Furthermore, not only directional but also fluctuating asymmetry of the pelvis should be studied as differences between nulliparous and parous females were found in other mammals with relatively large newborns; the latter ones had higher fluctuating asymmetry. This pattern could be generally valid for mammals due to decalcification during pregnancy and lactation and extensive remodeling of the female skeletal system to the new mechanical environment. To explore this more in humans, a female sample of known reproductive status is necessary.

Engelbert Hanzal

The “obstetric dilemma” as it relates to pelvic floor problems in humans


Pelvic organ prolapse (POP), urinary (UI) and fecal incontinence (FI) are well-known clinical entities, for which age, parity, delivery modes and body-mass-index having been identified as the most important risk factors [Nygaard 2008]. In the course of human childbirth, the soft tissues of the pelvic floor are stretched significantly. In addition, fibers of the pudendal nerve can get stretched out enough to lead to nerve damage with subsequent weakness of the levator ani muscle, giving rise to the development of POP, UI and FI. If the stretching force transgresses the breakage limit, rupture of soft tissues ensues. Perineal lacerations in childbirth are so common that only 10% of primiparae and 30% of multiparae sustain deliveries without them [Smith 2013]. These birth injuries may involve the perineal skin, the vagina, external genital muscles, the anal sphincter complex and the levator ani muscle, which sometimes pulls out of its attachment to the pubic bone. In rare cases, the pressure forces are so strong that joints (pubic symphysis) and bony structures (coccyx) give way.

Interestingly, evolution has favored the healing process in this sensitive anatomic region of the perineum and pelvis, and wound breakdown and infections occur at a lower rate than might be expected. Most women cope with the trauma of childbirth with no, or only minor, long-term consequences. POP, UI and FI are very common diseases in the human female population with a profound effect on quality of life. In addition to age and body-mass index, a strong association with pregnancy and delivery is evident. Evolutionary thinking – still uncommon in the field of medicine and healthcare – provides new avenues of scientific inquiry, addressing common problems in a new light.

Jochen Hofstätter

The hip joint from an orthopaedic point of view

Non-arthritic hip pain as well as osteoarthritis of the hip are common orthopaedic problems. Intra- as well as extra-articular structures of the hip can be the source of pain, primarily due to micro-trauma associated with dynamic movement between the proximal femur and the acetabulum. The most common damaged structures are the acetabular and femoral articular cartilage, the labrum and the ligamentum teres. There are several distinct pathologies that lead to early joint damage: (1) hip instability: Various factors may underlie the clinical diagnosis of hip instability, including insufficient acetabular bony coverage, pathological femoral torsion, femoroacetabular impingement, (FAI)-induced instability, as well as soft tissue laxity. In hip dysplasia, acetabular coverage is typically deficient anteriorly and superolaterally giving rise to a decrease in the lateral centre edge angle (LCEA) and an increase in the acetabular anteversion. (2) Rotational as well as Varus/Valgus deformities of the femur may occur alone or may coexist with acetabular dysplasia or various types of hip impingement. (3) Femoroacetabular impingement is characterized by abnormal contact between the proximal femur and rim of the acetabulum. There is extra- as well as intra-articular FAI with various subtypes. There are three types of intra-articular FAI: (1) Cam-type (2) Pincer and (3) Cam-Pincer FAI. Especially in young men, the presence of cam deformity is very common in athletes. Non-clinical epiphyseal slips as well an adaption to load may be cause of the cam deformity. When left unaddressed, FAI, dysplasia, and structural instability can lead to the progression of acetabular labral tears, chondropathy and osteoarthritic change necessitating total hip replacement at a later stage. There are numerous surgical procedures ranging from periacetabular osteotomies, to derotation osteotomies and finally open and arthroscopic techniques to correct



these deformities. Great surgical advances have been made in recent years to prolong the lifespan of the native hip and to alleviate pain and discomfort. Studies show that women can have a normal pregnancy as well as vaginal birth following a pelvic osteotomy. In the last three months of pregnancy and the first six months after birth, the bone is depleted of calcium, which can lead to insufficiency fractures of the bone. Moreover, the SI- joint is a common source of pain in women after birth. There are predominantly non-surgical treatment options for SI-joint pain. Denervation as well as a fusion of the SI joint are reserved for severe cases.

POSTER ABSTRACTS

Nicole D.S. Grunstra, Tim Langnitschke & Frank Zachos

Bats have big babies too: Obstetric adaptations in the pubic symphysis of small flying mammals

Human childbirth is difficult due to a relatively narrow birth canal and inflexible pubic symphysis. Although the human pubic symphysis gains some flexibility during late pregnancy, this is limited compared to that in various species of small mammals. Female guinea pigs, hedgehogs, tenrecs, and bats (among others) all undergo resorption of the pubic bones (pubiolytic) either before or during pregnancy, with a hyper-elastic ligament forming in place of the symphysis (a syndesmosis). This is also a highly sexually dimorphic character state: males typically do not have an 'open' pelvis, but rather possess a cartilaginous or a fused symphysis (a synostosis). This in itself is evidence for sex-specific selection in females, probably related to obstetrical or pregnancy-related demands. Here, we draw on the pelvic morphology and reproductive biology of bats (Chiroptera) as a comparative 'model' for better understanding the evolution of pubic symphysis flexibility. Bats give birth to neonates that make up 10-40% of maternal mass, enabled by the flexible pubic ligament. We previously hypothesized that the selection pressure acting to constrain the size and flexibility of the human birth canal is not present in bats due to their volant mode of locomotion and particular upside-down roosting behaviour – resulting in reduced pressure on their pelvic floor -- and that bats are therefore free to respond to obstetric selection and increase their pubic 'gap' in proportion to the size of their neonate (Grunstra et al. 2019). Indeed, among a sample of 65 bat species, we found support for this hypothesis in two subclades. We also observed considerable within-species variability in pubic gap size, presumably in relation to parity. We discuss these findings in the context of bat ecology.

Grunstra NDS, Zachos FE, Herdina AN, Fischer B, Pavlićev M, Mitteroecker P (2019). Humans as inverted bats: a comparative approach to the obstetric conundrum. *Am J Human Biol* 31: e23227.

Candace McGovern

A Woman's World: Influences of Pathological and Morphological Risks During Childbirth

Morphological changes required to accommodate bipedal movement and larger foetal brain size in conjunction with poor health including nutritional deficiencies can make a vaginal birth extremely hazardous for women. Previous palaeopathological studies have limited their examination to individual female remains buried with neonates and to obvious complications stemming from a contracted pelvis, an unstable pelvic brim or pelvic fractures. This has resulted in a gap in the literature for a study on past populations which incorporates lesser known morphological or pathological issues including developmental and metabolic, and other diseases or deficiencies which can result in the dislocation or atrophy of lower limbs.

The aim of this study is to establish the frequency of pathological or morphological changes in female skeletal remains during their reproductive period that do not stem from an obstetric dilemma but may result in an increased risk during childbirth. To accomplish this, 402 Romano-British females between 13 and 45 years at death were examined for evidence of pathological or morphological changes which can create complications during a vaginal birth. Within the sample group 37.6% (n=151) displayed such changes, including 32 individuals with prematurely fused coccyges. Although fusion of the coccyx to the sacrum increases with age, in women of a reproductive age this can result in contracted pelvic outlet. The results also confirm previous studies as there was no evidence of major developmentally related pathology which could result in maternal deaths.

Elisa-Maria Praxmarer, Sylvia Kirchengast, Janina Tutkuvienė

Macroscopic Analysis of the Frequency and Morphology of Pelvic Scars and their Relationship with Sex and Age

The formation and manifestation of pelvic scars and their possible use in determining parity history is still a debated issue among anthropologists. Since skeletal collections with known parity history of female individuals are rare, the true relationship between pelvic scars, pregnancy and childbirth could not yet be

conclusively demonstrated. An alternative approach is to investigate other potential factors that might affect their manifestation. The present study examined pelvic scarring in relation to sex and age at death. Pelvic bones of 300 individuals (130 females and 170 males) dating back to between the 14th and 17th centuries from Lithuania were examined. The variability of manifestation and frequency of the dorsal pubic pits and the preauricular sulcus were investigated and compared to sex and age at death.

The statistical analysis showed that pelvic scarring was present in both sexes, however, the degree and frequency were significantly greater in females. Both features were also found among all age groups, whereby the incidence and manifestation either increased or remained unchanged with advancing age. The results suggest that pregnancy and childbirth cannot be the only factors that cause the formation of pelvic scars since men exhibit the features as well. The common cause of pelvic scarring in both sexes may have been the weight-bearing function of the pelvis, whereby pregnancy-related stress may enhance the strain in some women, which could explain the higher incidence of more developed bony imprints.

Chiara Tesi, Elisabetta Bariatti, Ilaria Gorini, Marta Licata

“Accessory” pelvic markers: a new feature detected in paleo-obstetric analyses?

A preliminary study has been conducted on a skeletal sample from the medieval site of San Biagio in Cittiglio (Varese, northern Italy), applying the criteria previously delineated in the anthropological literature, in order to detect the presence and degree of expression of pelvic markers in individuals of both sexes. The purpose was to determine the degree of variation of specific pelvic structures and to assess their potential correlation with pregnancy and birth events in this population.

During the investigation, the presence of a feature, normally recorded as occupational stress, was noted in two cases with different degrees of expression. In particular, in two females, the presence of marked accessory sacroiliac joints and of the so-called sacroiliac complex, formed by an iliac bony projection inserting dorsally into a complementary sacral recess, was observed.

In several clinical studies, these observations find a statistically significant correlation with childbirth, highlighting how their detection increases with the number of pregnancies, as well as with body mass and aging. The origin of these joint extensions could probably be connected to a further support system following an articular hypermobility and changes in the weight balance of the pelvic girdle. These findings, currently limited to the clinical setting, could provide a basis for further investigations in the bioarchaeological field and possibly be added to the other markers detectable on the pelvic bones, in order to reconstruct the events and obstetric history of osteoarchaeological individuals.

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