American Journal of Biological Anthropology

WILEY

AMERICAN JOURNAL OF BIOLOGICAL ANTHROPOLOGY

RESEARCH ARTICLE OPEN ACCESS

Exploring Pelvic Changes: Do Pregnancy and Birth Leave Scars?

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Received: 19 August 2025 | **Revised:** 4 March 2026 | **Accepted:** 1 April 2026

Keywords: childbirth | parity status | pelvic features | preauricular sulcus | urinary incontinence

ABSTRACT

Objectives: Selected pelvic features, formerly "parturition scars," have long been interpreted as osteological indicators of pregnancy and childbirth, presumably caused by biomechanical stresses. Yet, most evidence derives from archaeological collections lacking detailed documented reproductive histories. This study examined whether parity is associated with classic pelvic features in a clinical sample of women with known reproductive histories and, for comparison, in men. In addition, we evaluated urinary incontinence as a functional outcome related to reproductive histories.

Materials and Methods: Pelvic CT scans from 84 individuals (39 parous women, 20 nulliparous women, 25 men) were assessed for five pelvic features: dorsal pubic pitting, extended pubic tubercle, preauricular sulcus, sacral preauricular extension, sacral preauricular notch. Reproductive history and urinary incontinence were recorded. Group differences were analyzed using nonparametric and χ^2 tests. Age-adjusted binary logistic regression was performed to assess the association between parity and urinary incontinence.

Results: Skeletal pelvic features were similarly frequent in parous and nulliparous women. The preauricular sulcus was present in approximately half of all women and absent in men, indicating a sex-associated pattern rather than an association with parity. No other individual pelvic feature showed consistent differences by parity, only by sex. Combinations of pelvic features were rare. Urinary incontinence was more prevalent among parous women; parity remained associated with incontinence after age adjustment. Incontinent women had a slightly higher number of pelvic features, on average, but this association was not statistically significant.

Conclusion: Classic skeletal pelvic features lack specificity for pregnancy or childbirth and cannot reliably predict parity.

1 | Introduction

Childbirth is a life-transforming event that can have profound implications for a woman's physical and mental health. Pelvic features (formerly called parturition scars) have long been hypothesized to result from the biomechanical and physiological stresses associated with pregnancy and childbirth (Angel 1969; Houghton 1974, 1975; Putschar 1976; Stewart 1970; Ullrich 1975;

Pany-Kucera et al. 2019). The formation and identification of these bony pelvic features has therefore been a central topic of debate in biological anthropology. More than 50 years ago, Angel (Angel 1969) proposed that pregnancy and childbirth may leave observable alterations such as depressions, pits, grooves, or exostoses on the female bony pelvis (Angel 1969; McFadden and Oxenham 2018; Praxmarer et al. 2020). Shortly thereafter, Stewart (Stewart 1970) introduced the term "scars of parturition" for dorsal pubic pits and suggested that these features might serve as indicators of reproductive history. Pelvic features can manifest at several anatomically distinct sites: (i) on the pubic bone as dorsal pits, or ventral lesions or exostoses, and an extended pubic tubercle (Snodgrass and Galloway 2003; Pany-Kucera, Spannagl-Steiner, Maurer-Gesek, et al. 2022); (ii) on the os ilium as the preauricular sulcus (Houghton 1974, 1975; Loehr 1884; Schemmer et al. 1995; Derry 1909; Zaaijer 1866; Dee 1981), and (iii) more rarely, on the sacrum as the margo auricularis groove (Maass 2012) or sacral preauricular extension or notch (Ullrich 1975; Rebay-Salisbury et al. 2018). Of these features, the imprints on the pubic bone and the extended pubic tubercle have received particular attention as putative osteological markers of pregnancy and childbirth. The preauricular sulcus lies along the inferior margin of the iliac auricular surface and shows pronounced sexual dimorphism: Houghton (1974, 1975) distinguished a smooth, shallow "groove of ligament", also known as paraglenoid sulcus, from a deeper, irregular "groove of pregnancy," the latter reported only in females and interpreted as a possible consequence of parturition. Subsequent research, however, has emphasized that the presence and expression of the preauricular sulcus are more consistently associated with sex than with reproductive history (McFadden and Oxenham 2018). Similarly, grooves along the margin of the sacral auricular facet, often referred to as "sacral scarring" (M. J. Cox 1989) or margo auricularis groove, occur adjacent to the iliac preauricular sulcus and appear to correlate more strongly with age and sex than with reproductive history (M. Cox 2000).

Bony pelvic features have traditionally been attributed to pregnancy and childbirth based on the assumption that hormonal changes, ligamentous stretching, and potential tearing at attachment sites lead to hemorrhage, inflammation, and subsequent bony remodeling (Maurer-Gesek et al. 2022; Becker et al. 2010). However, this explanatory framework has been increasingly questioned, as the underlying mechanisms remain poorly understood. Several studies have demonstrated that pelvic features may be absent in some parous women while occurring in nulliparous women and even in men (Adams Holt 1978; Lopreno et al. 2022), suggesting that pregnancy and childbirth are unlikely to be the sole causes of their formation (Cox and Scott 1992; Kelley 1979; McArthur et al. 2016). Instead, accumulating evidence indicates associations with age (Praxmarer et al. 2020), sex (McFadden and Oxenham 2018), and high body mass index (BMI) (Snodgrass and Galloway 2003). These findings highlight the limitations of inferring reproductive history from individual pelvic features.

More recently, attention has shifted toward combined patterns of pelvic features, summarized using the Pelvic Pattern Index (PPI), a composite score capturing the co-occurrence of multiple pelvic features within individuals (Pany-Kucera, Spannagl-Steiner, Maurer-Gesek, et al. 2022; Waltenberger et al. 2025). In identified skeletal collections, specific combinations such as a preauricular sulcus and dorsal pubic pitting, together with either an extended pubic tubercle or a sacral preauricular extension or notch, have been reported almost exclusively in women with documented childbirth and were absent in nulliparous women and men. These findings led to the proposal that a high PPI value may serve as an osteological indicator of past motherhood when birth records are unavailable (Pany-Kucera et al. 2019; Pany-Kucera, Spannagl-Steiner, Maurer-Gesek, et al. 2022; Pany-Kucera, Spannagl-Steiner, Desideri, and Rebay-Salisbury 2022; Waltenberger et al. 2022a). At the same time, the etiology of some of these features remains unclear, highlighting the need for cautious interpretation.

Postpartum incontinence, most commonly urinary incontinence, is associated with pregnancy and childbirth, although its causal pathways are not completely understood, similar to those underlying bony pelvic features (Schimpf 2016). Urinary incontinence affects up to 43% of women within the first two years after childbirth (Bonasia et al. 2023; Åhlund et al. 2020), and is therefore highly clinically relevant. Established risk factors include pregnancy- and birth-related changes of the pelvic floor such as hormonal and connective tissue adaptations, mechanical strain during (instrumental) vaginal birth, advanced maternal age, higher BMI, and multiparity (Diez-Itza 2026). Additionally, pelvic floor disorders have also been linked to mediolaterally wider bony pelves, reflecting increased biomechanical load associated with certain pelvic morphologies (Stansfield et al. 2021; Brown et al. 2013). From a biological anthropological perspective, urinary incontinence does not constitute a bioarchaeological variable per se, as it leaves no skeletal traces. However, it represents an important clinically documented functional outcome related to pelvic floor loading and reproductive history and is at least partly caused by the stresses and strains acting during birth that also cause the bony pelvic features analyzed here. Functional outcomes such as urinary incontinence therefore provide an additional clinical perspective and can be evaluated as a correlate of bony pelvic features. Because previous research on pelvic features has relied largely on historical skeletal collections lacking reliable obstetric documentation, modern clinical datasets with recorded reproductive histories offer the opportunity to reassess hypothesized associations between sex, parity and pelvic features. Our study addresses this critical gap by analyzing standard CT scans from living female patients whose data on parity, mode of delivery, obstetric histories and incontinence occurring after childbirth were prospectively documented. This design allows a direct assessment of a number of bony pelvic features such as dorsal pubic pitting, extended pubic tubercle, preauricular sulcus, sacral preauricular extension and the sacral preauricular notch in relation to verified pregnancy data, while avoiding the confounders inherent in archaeological samples (unknown parity, variable obstetric care, and postmortem alteration). We hypothesize that pregnancy and childbirth can result in detectable pelvic features on contemporary CT imaging. In particular, we expect dorsal pubic pitting, an extended pubic tubercle, a well-defined preauricular sulcus, a pronounced sacral preauricular extension and sacral preauricular notch to occur significantly more often in parous women than in nulliparous women, and to be rare or absent in men. In addition, we examine whether urinary incontinence, as a clinical outcome associated with pregnancy and childbirth, co-occurs with the bony pelvic features listed above.

TABLE 1 | Characteristics of the study population.

Variable	Total, $n=84$	Group 1, $n=39$	Group 2, $n=20$	Group 3, $n=25$	p-Value
Age median (IQR)	60.5 (50–69)	62 (54–69)	43 (28–57)	64 (58–71)	
BMI median (IQR)	25.26 (23–28)	24.84 (22–28)	25.4 (21–28)	24.62 (23–28)	
Dorsal pubic pitting *n* (%)					0.261
Present	5 (6%)	4 (10%)	1 (5%)	0 (0%)	
Absent	79 (94%)	35 (90%)	19 (95%)	25 (100%)	
Extended pubic tubercle *n* (%)					0.935
Present	12 (14%)	6 (15%)	3 (15%)	3 (12%)	
Absent	72 (86%)	33 (85%)	17 (85%)	22 (88%)	
Preauricular sulcus *n* (%)					**< 0.001**
Present	30 (36%)	20 (51%)	10 (50%)	0 (0%)	
Absent	54 (64%)	19 (49%)	10 (50%)	25 (100%)	
Sacral preauricular extension *n* (%)					0.687
Present	7 (8%)	4 (10%)	2 (10%)	1 (4%)	
Absent	77 (92%)	35 (90%)	18 (90%)	24 (96%)	
Symptoms of incontinence *n* (%)					**0.002**
Present	13 (15%)	12 (31%)	0 (0%)	1 (4%)	
Absent	71 (85%)	27 (69%)	20 (100%)	24 (96%)	

Note: Group 1: Primi−/multiparous females; group 2: Nulliparous females; group 3: Males. Indicated are median and interquartile range (IQR) for age (in years) and BMI (body mass index, kg/m^2) for each group. Presence or absence of pelvic features is indicated as percent for each group. Bold values indicate statistical significance at $p < 0.05$.

2 | Material and Methods

2.1 | Study Design and Recruitment

This cross-sectional study was based on clinically acquired pelvic CT scans of 104 patients, in addition to obstetric and clinical data for the same individuals. All included individuals were patients at the University Hospital in Vienna, Department of Biomedical Imaging and Image-guided Therapy, between October 2022 and August 2023. Individuals aged 18 years and older who underwent any kind of pelvic CT scan out of a medical condition were invited to participate. Parous women, nulliparous women, and men were eligible for inclusion. Participants who consented to take part completed a detailed obstetric questionnaire and an additional telephone interview and agreed to the use of their CT data in this study. Standard demographic and biometric data such as body height, body weight, and age were recorded. Obstetric data was collected for female participants including parity, incidence of still birth, date of delivery, duration of pregnancy, mode of delivery (vaginal delivery, vacuum extraction, forceps delivery or cesarean section), indication for mode of delivery, presence of soft tissue birth trauma, and neonatal weight, length and head circumference. Information on urinary incontinence was collected as a binary variable (self-reported presence or absence of urinary incontinence symptoms). We subsequently completed this information by contacting patients individually by telephone after their CT appointment. Exclusion criteria included a history of cesarean section only (i.e., no vaginal deliveries), secondary blastoma to any bone, prior pelvic trauma and incomplete CT datasets lacking one or more standard imaging planes (axial, coronal, sagittal). The majority of the study participants self-identified as Central European, including 35 parous females, 18 nulliparous females and 23 males. Additional study participants reported from other ethnicities included Eastern European (2 nulliparous females), Asian (3 parous females, 2 males), and African origins (1 parous female). The assignment was made by self-attribution. Detailed demographic and anthropometric characteristics of the study population are provided in Table 1.

2.2 | CT Imaging and Assessment of Pelvic Features

Pelvic CT images were evaluated for the presence or absence of five pelvic features: Dorsal pubic pitting (pits on the dorsal aspect of the pubic bone, lateral to the pubic symphysis; Figure 1), extended pubic tubercle (exostosis along the ventral third of the arcuate line of the superior pubic ramus; Figure 2), preauricular sulcus (elongated depression on the iliac bone, adjacent, anterior and parallel to the inferior surface of the sacroiliac joint; Figure 3), sacral preauricular extension (thin bony extension at the ventral sacral apex of the ala of the sacrum; Figures 4 and 5) and sacral preauricular notch (loss of convexity at the ventral apex of the sacrum; Figure 6). All CT scans were independently assessed by three trained observers. Prior to image evaluation, the observers participated in joint training sessions and consensus discussions to standardize the assessment criteria and minimize interobserver bias. This process ensured consistent

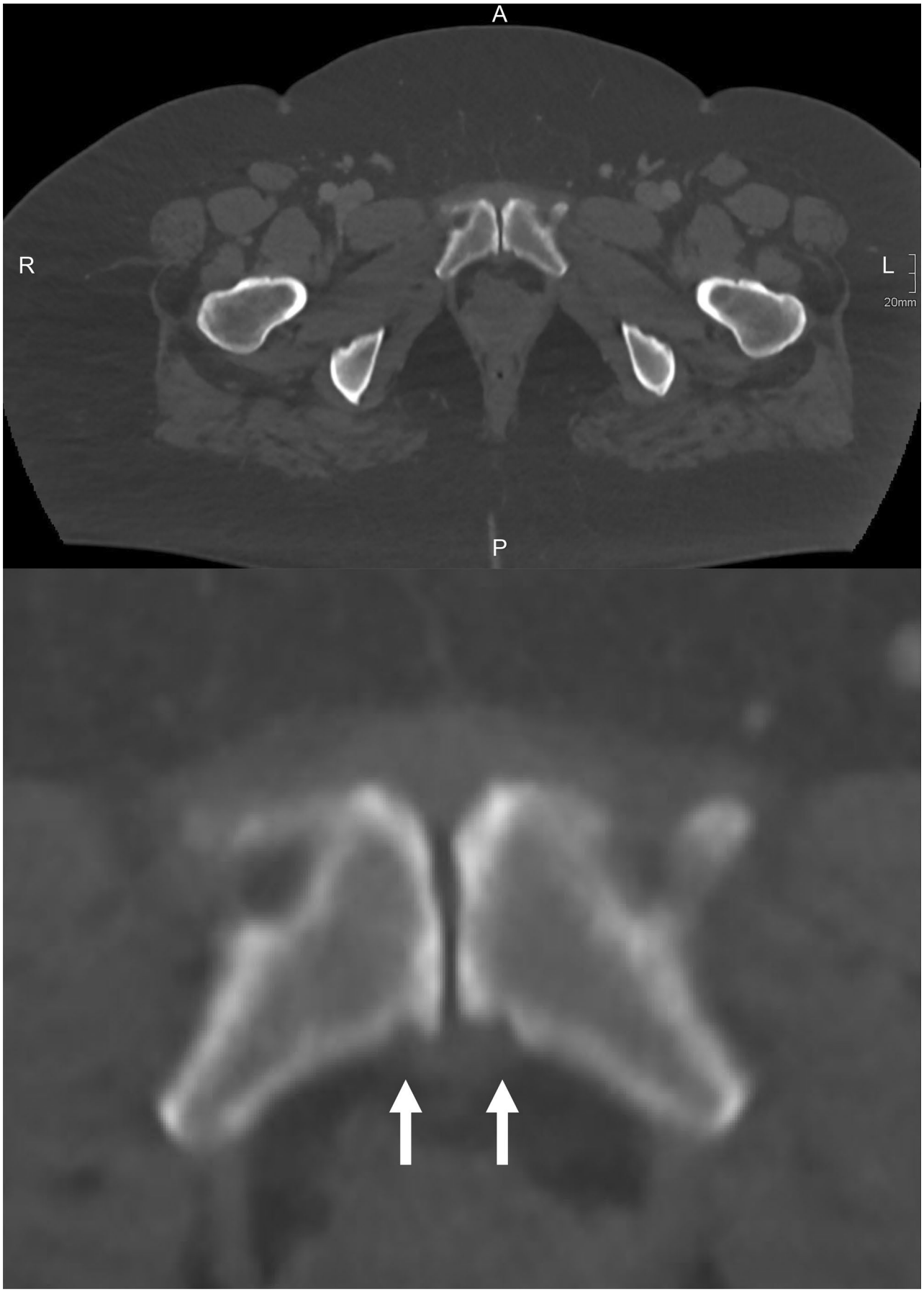

FIGURE 1 | Axial CT scan of a female bony pelvis showing dorsal pubic pitting. White arrows indicating dorsal pubic pitting. R = right, L = left, A = anterior, P = posterior.

FIGURE 2 | Sagittal CT scan of a female pelvis showing the extended pubic tubercle. White arrow indicating the extended pubic tubercle. A = anterior, P = posterior.

identification and interpretation of all pelvic features across evaluators. The observers were able to see only the CT images; they were blinded to sex, parity, age, and all other clinical and obstetric information. Each pelvic feature was graded dichotomously as present or absent. CT scans were performed using Siemens Healthineers Somatom Drive, Force, and Naeotom Alpha scanners with a slice thickness of 2 or 3 mm.

2.3 | Statistical Analysis

Associations between pelvic features and reproductive history were evaluated using χ^2 tests for categorical variables and Wilcoxon rank-sum or Kruskal–Wallis tests for continuous variables. Associations between urinary incontinence and the number of pelvic features were evaluated using Welch's *t*-tests and descriptive statistics. In addition, binary logistic regression models were fitted to examine the association between parity and urinary incontinence while adjusting for age. All statistical tests were two-tailed, and a significance level of $\alpha = 0.05$ was used. All statistical analyses were performed in R (Version 4.3.1) (R Core Team 2023).

FIGURE 3 | Coronal CT scan of a female pelvis showing the preauricular sulcus. White arrows indicating the preauricular sulcus.

2.4 | Ethics Approval

The study was approved by the ethics committee of the Medical University of Vienna (application number: 1544/2019) and performed in accordance with the Declaration of Helsinki and the Good Scientific Practice guidelines. All patient data were pseudonymized prior to the analyses by assigning consecutive numbers to each individual.

3 | Results

3.1 | Sample

Following the assessment of CT scans and telephone interviews, 20 participants were excluded based on the predefined exclusion criteria (history of cesarean section only: $n = 2$, secondary blastoma to the bone: $n = 6$, pelvic trauma: $n = 10$, or missing radiological planes: $n = 2$). The final sample therefore comprised 84 participants. The study population was subsequently divided

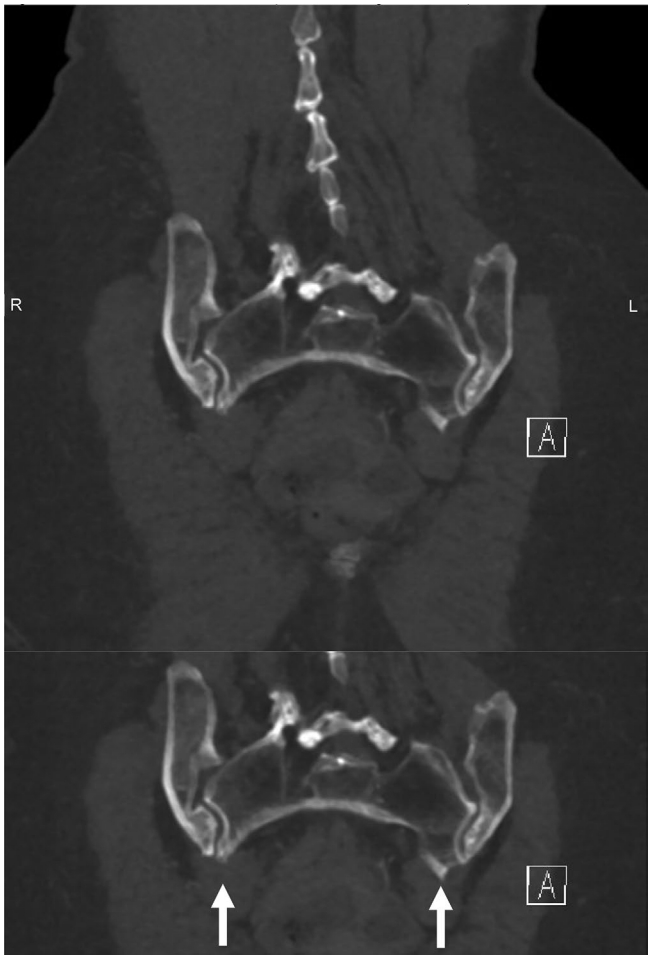

FIGURE 4 | Coronal CT scan of a female pelvis showing the sacral preauricular extension. White arrows indicating the sacral preauricular extension. *R* = right, L = left.

FIGURE 5 | Sacral preauricular extension at the right side of the sacrum (for demonstration purposes); photo: W. Reichmann, NHM Wien.

into three groups (group 1: 39 primi–/multiparous females; group 2: 20 nulliparous females; group 3: 25 male patients).

Among parous women, the median fetal birth weight was 3080 g (IQR: 3013–3500 g) and the median maternal weight gain during pregnancy was 12 kg (IQR: 9–16 kg). Median age at first birth

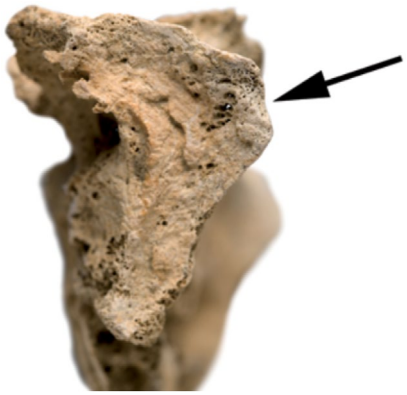

FIGURE 6 | Sacral notch at right side of the sacrum (for demonstration purposes); Photo: W. Reichmann, NHM Wien.

was 24 years (IQR: 19–28 years), and median age at last birth was 27 years (IQR: 24–32 years; data not shown). Individual-level obstetric data are provided in Supporting Information Table S1.

3.2 | Pelvic Features and Group Comparisons

The prevalence of pelvic features across the three study groups is summarized in Table 1. When pelvic traits were considered cumulatively (number of features per individual), pelvic features were almost equally frequent among parous women, who had 0.82 pelvic features (SD = 0.97) on average. Nulliparous women had 0.80 pelvic features (SD = 0.89) on average, whereas men had only 0.16 pelvic features (SD = 0.37) on average. A significant difference between the groups was observed for preauricular sulcus, which was present in 51% of parous women, 50% of nulliparous women, and in none of the male participants (χ^2 test, $p < 0.001$). This distribution reflects a strong sex-associated pattern rather than an association with parity, as prevalence was comparable between parous and nulliparous women. No statistically significant group differences were observed for dorsal pubic pitting, extended pubic tubercle, sacral preauricular extension, or sacral preauricular notch (all $p > 0.05$). A sacral preauricular notch was not observed in any individual.

3.3 | Urinary Incontinence

Urinary incontinence was reported by 31% of parous women, by none of the nulliparous women and by 4% of men (Table 1). The overall distribution of urinary incontinence symptoms differed significantly between groups (χ^2, $p = 0.002$, Figure 7). Incontinent individuals ($n = 13$) had a mean of 0.92 pelvic features (SD = 1.19), whereas continent individuals ($n = 71$) had a mean of 0.59 pelvic features (SD = 0.80) (Figure 7). Among parous women ($n = 39$), incontinent women ($n = 12$) had a mean of 1.00 pelvic features (SD = 1.22), while continent women ($n = 27$) had a mean of 0.82 pelvic features (SD = 0.88) (Figure 7). These findings seem to suggest that pelvic features are less frequent among continent parous women than among incontinent parous women, but the difference was small and not statistically significant.

In an age-adjusted binary logistic regression using the data on women only and modeling incontinence status as a function of

parity and age, parity remained significantly associated with urinary incontinence after adjustment for age (likelihood-ratio test, $p = 0.005$). The association between age and incontinence was not statistically significant in this model ($p = 0.18$).

3.4 | Patterns of Co-Occurring Pelvic Features

Patterns of co-occurring pelvic features were analyzed within each study group. In parous women, the preauricular sulcus was the most prevalent single feature ($n = 20$), followed by the extended pubic tubercle ($n = 6$). The two most common paired combinations were a preauricular sulcus with an extended pubic tubercle and a preauricular sulcus paired with a sacral preauricular extension (each $n = 4$; Table 2).

Among nulliparous women, the preauricular sulcus was again the most frequent solitary feature ($n = 10$), followed by the extended pubic tubercle ($n = 3$). The patterns of (i) a preauricular sulcus with an extended pubic tubercle; or (ii) a preauricular sulcus with a sacral preauricular extension were the most frequent combinations of pelvic features ($n = 2$ respectively, Table 3).

In men, the extended pubic tubercle was the most frequently observed single feature ($n = 3$), and no paired combinations were identified (Table 4).

4 | Discussion

For almost five decades, bony "scars of parturition" have been cited as osteological evidence of pregnancy and childbirth, yet their definitions and etiology remain debated. Previous studies interpreted dorsal pubic pits, extended pubic tubercles, interosseous grooves and, most prominently, the preauricular sulcus as direct consequences of pregnancy and vaginal delivery (Angel 1969). Subsequent research, however, demonstrated that these pelvic features can also be present in nulliparous women and, in some cases, even in men, thereby challenging their specificity as indicators of reproductive history (Stewart 1970; Adams Holt 1978; Suchey et al. 1979; Maass and Friedling 2016). A recent meta-analysis further concluded that neither dorsal pubic pits nor the preauricular sulcus can be considered as reliable markers of parity, although the former shows a moderate predominance in females, and the latter represents a sex-associated pelvic feature (McFadden and

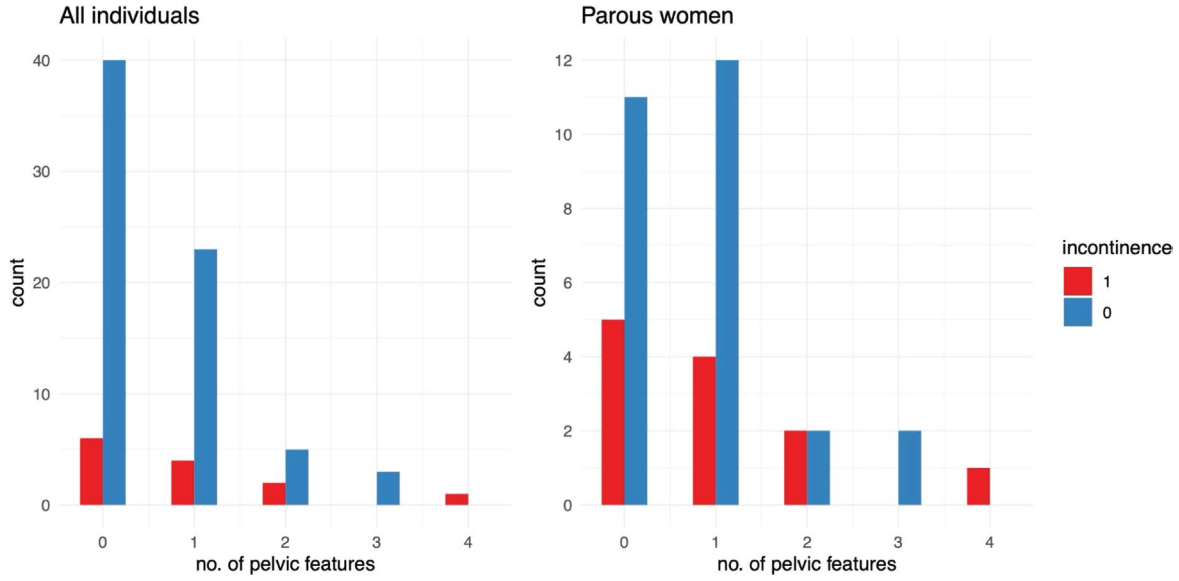

FIGURE 7 | Distribution of the number of pelvic features with respect to the incontinence status. Distribution of the number of pelvic features for all individuals (nulliparous women, parous women and men; left panel) and for parous women only (right panel), with respect to their incontinence status: 1 = urinary incontinent, 0 = continent.

TABLE 2 | Combination of pelvic features in parous females.

	Dorsal pubic pitting	Extended pubic tubercle	Preauricular sulcus	Sacral preauricular extension	Sacral preauricular notch
Dorsal pubic pitting	4	1	3	2	0
Extended pubic tubercle	1	6	4	2	0
Preauricular sulcus	3	4	20	4	0
Sacral preauricular extension	2	2	4	4	0
Sacral preauricular notch	0	0	0	0	0

Note: Indicated are the absolute numbers of individuals with a certain combination of pelvic features.

Oxenham 2018; Lopreno et al. 2022). Our imaging-based study of living individuals with known reproductive histories supports this interpretation. Across all pelvic features examined, no consistent associations with parity were observed. Dorsal pubic pitting was slightly more frequent among parous than nulliparous women, but the feature was not restricted to women with reproductive histories. Similarly, extended pubic tubercles and sacral pelvic features showed no clear relationship with parity. These findings indicate that individual pelvic features cannot be interpreted as specific osteological markers of pregnancy or childbirth.

4.1 | The Preauricular Sulcus as a Sex-Associated Feature

The preauricular sulcus on the *os ilium* emerged as the most prevalent pelvic feature in our study, present in roughly half of the women regardless of parity and entirely absent in men. These findings are consistent with previous radiographic and imaging studies identifying the preauricular sulcus as a sex-associated pelvic feature rather than an indicator of pregnancy or childbirth (Dee 1981; Lim et al. 2023; Cole 2022; Spring et al. 1989). Our results are consistent with previous studies demonstrating that the preauricular sulcus occurs in nulliparous women, which is in line with its interpretation as a sex-associated pelvic feature rather than a marker of childbirth. Dee (1981) reported the presence of preauricular sulcus in 25% of females based on pelvic radiographs, while a more recent study found that the preauricular sulcus was only present in the female pelvis, but the study lacked information on parity status (Lim et al. 2023). Further research has shown that the preauricular sulcus may also occur in subadult populations, supporting its interpretation as a sex-associated feature rather than a marker of childbirth (Cole 2022). Studies focusing on the depth of the preauricular sulcus likewise concluded that the presence of a deep, radiographic preauricular sulcus is not necessarily indicative of past pregnancy, as it has been found in nulliparous females too (Spring et al. 1989).

4.2 | Other Pelvic Features and Biomechanical Considerations

In the current study dorsal pubic pitting was observed in 10% of parous women and in 5% of nulliparous women, representing a twofold difference that did not reach statistical significance due to the limited sample size. McArthur et al. (McArthur et al. 2016) reported a significant association between vaginal birth and the presence of dorsal pubic pitting in CT-based analyses. By including nulliparous women, our study allowed direct comparison across parity groups and showed that dorsal pubic pitting, while

TABLE 3 | Combination of pelvic features in nulliparous females.

	Dorsal pubic pitting	Extended pubic tubercle	Preauricular sulcus	Sacral preauricular extension	Sacral preauricular notch
Dorsal pubic pitting	1	0	1	1	0
Extended pubic tubercle	0	3	2	0	0
Preauricular sulcus	1	2	10	2	0
Sacral preauricular extension	1	0	2	2	0
Sacral preauricular notch	0	0	0	0	0

Note: Indicated are the absolute numbers of individuals with a certain combination of pelvic features.

TABLE 4 | Combination of pelvic features in male participants.

	Dorsal pubic pitting	Extended pubic tubercle	Preauricular sulcus	Sacral preauricular extension	Sacral preauricular notch
Dorsal pubic pitting	0	0	0	0	0
Extended pubic tubercle	0	3	0	0	0
Preauricular sulcus	0	0	0	0	0
Sacral preauricular extension	0	0	0	1	0
Sacral preauricular notch	0	0	0	0	0

Note: Indicated are the absolute numbers of individuals with a certain combination of pelvic features.

somewhat more frequent in parous women, is not exclusive to them. Other research likewise indicates weak associations between dorsal pubic pitting and parity, with age emerging as an additional contributor (Waltenberger et al. 2022a). Snodgrass and Galloway (2003) demonstrated that in women over 50 years of age, dorsal pubic pitting was more strongly associated with BMI than with number of births. Associations with stature and pelvic dimensions suggest that biomechanical strain contributes to feature expression (Waltenberger et al. 2021).

Pelvic-floor trauma represents a plausible biomechanical mechanism underlying pelvic features. The levator ani originates on the dorsal pubis and may be substantially stretched during vaginal birth, potentially leading to localized remodeling at its enthesis (Ashton-Miller and DeLancey 2007; Miller et al. 2010). Repeated mechanical loading and inflammatory processes may therefore contribute to dorsal pubic pitting (Snodgrass and Galloway 2003; Pany-Kucera, Spannagl-Steiner, Maurer-Gesek, et al. 2022; Derry 1909; Maurer-Gesek et al. 2022).

4.3 | Age-Related Pelvic Remodeling

Age-related pelvic remodeling in females appears in both humans and nonhuman primates (Auerbach et al. 2018; Huseynov et al. 2016; Mitteroecker and Fischer 2016; Morimoto et al. 2023). Waltenberger et al. (2022b) showed that pelvic features in women increase until 40 years of age and then plateau, whereas men exhibit only a minimal age-dependent increase. This pattern has been attributed to interactions between hormone-mediated and mechanically induced bone remodeling. Praxmarer et al. (Praxmarer et al. 2020) likewise reported that pelvic features are more common in females than in males and increase or remain stable with advancing age. In our sample, parous women (median = 62 years) were older than nulliparous women (median = 43 years) but slightly younger than men (median = 64 years). While parous women exhibited the highest prevalence of a preauricular sulcus, its absence in men and similar frequency in parous and nulliparous women indicate that sex, rather than parity alone, is the dominant factor. Age may nonetheless contribute to cumulative pelvic remodeling over the life course.

4.4 | Pelvic Feature Combinations and Biomechanical Context

Only few combinations of pelvic features were observed in our study sample. When present, combinations occurred predominantly among parous women and were absent in men. However, childbirth-related mechanical stress likely produces pelvic modifications that cannot be fully captured by the presence or absence of individual pelvic features alone. Lim et al. (2023) and Waltenberger et al. (2021) reported that a distinct preauricular sulcus is linked to a narrow birth canal and to the acetabula orientation, potentially increasing biomechanical stress on the pelvic joints and the risk of birth complications (Lim et al. 2023; Waltenberger et al. 2021). These findings suggest that pelvic morphology, biomechanical loading, and reproductive history are interrelated, but not directly interchangeable, and that pattern-based interpretations should be approached with caution.

4.5 | Urinary Incontinence as a Functional Outcome

Against this morphological background, urinary incontinence was examined as a functional outcome related to pelvic floor loading and reproductive history. In our sample, incontinence was reported exclusively by parous women (31%) and one male participant (4%), whereas no nulliparous woman reported incontinence symptoms. Age-adjusted logistic regression analyses confirmed that parity remained significantly associated with urinary incontinence, while age was not independently associated within this cohort. Reported prevalence estimates of postpartum urinary incontinence vary widely across studies, ranging from 3% to 43%, depending on population characteristics, follow-up interval, and assessment methods (Bonasia et al. 2023; Åhlund et al. 2020; Thom and Rortveit 2010; Wesnes et al. 2009). Even in the low-risk primiparous population, obstetric variables such as the duration of the second stage of labor, neonatal head circumference, and birth weight often fail to predict any association with the prevalence of urinary incontinence (Åhlund et al. 2020). Although incontinent parous women exhibited slightly higher mean numbers of pelvic features than continent parous women, these differences were small and not statistically significant. The absence of a clear co-occurrence pattern in our sample suggests that while pelvic features and incontinence may be caused by the same biomechanical forces acting during birth, their association is probably weak. Furthermore, the number of women exhibiting both pelvic features and urinary incontinence symptoms was small, which limited the power to detect small effects.

5 | Limitations

This study has several limitations that should be considered when interpreting the results. First, the identification of pelvic features on clinical CT scan images and their binary classification may have been influenced by image resolution and observer experience, particularly for minor morphological manifestations. A clear limiting factor of this study was the sample size, especially for group comparisons, which restricted the inclusion of additional covariates in the analysis. In particular, the number of women exhibiting both bony pelvic features and incontinence was small. In addition, urinary incontinence was assessed by self-report and was not clinically validated, which may have introduced bias. Finally, the study population was relatively homogenous, with the majority of the participants of Central European origin potentially limiting the generalizability of the findings. Future studies based on larger, more diverse clinical datasets will be necessary to further clarify the interactions between pelvic morphology, pelvic features, reproductive history, age, and functional pelvic floor outcomes.

6 | Conclusion

In conclusion, our findings suggest that classic pelvic skeletal features, whether considered individually or in combination, do not reliably reflect pregnancy or childbirth in living individuals with known reproductive histories. The preauricular sulcus emerges primarily as a sex-associated pelvic feature rather than

a marker of parity. Our findings underscore the need for cautious interpretation of pelvic features as a proxy for reproductive history in biological anthropological and bioarchaeological contexts.

Author Contributions

Anja Catic: methodology, formal analysis, investigation, data curation, writing – original draft, writing – review and editing. **Lukas Waltenberger:** conceptualization, writing – original draft, writing – review and editing, formal analysis. **Katharina E. Pink:** writing – original draft, writing – review and editing, formal analysis. **Doris Pany-Kucera:** conceptualization, writing – review and editing. **Barbara Fischer:** formal analysis, writing – review and editing. **Julia Hummel Jimenez:** data curation. **Andrea Maier:** conceptualization. **Pascal Baltzer:** methodology, writing – review and editing. **Engelbert Hanzal:** writing – review and editing. **Barbara Bodner-Adler:** writing – review and editing. **Florian Heinzl:** software, formal analysis, writing – review and editing. **Wolfgang Umek:** conceptualization, methodology, writing – review and editing, supervision.

Acknowledgements

Open Access funding provided by Medizinische Universitat Wien/KEMÖ.

Funding

The authors have nothing to report.

Ethics Statement

The study was conducted in accordance with the Declaration of Helsinki and good clinical practice and was approved by the Ethics Committee of the Medical University of Vienna (reference number 1644/2019).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. **Table S1:** Individual patient characteristics of parous females