SHORT REPORT

Cases of *serpens endocrania symmetrica* in young individuals from Neolithic Western Switzerland: Description and interpretation

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**Abstract**
Endocranial lesions known as *serpens endocrania symmetrica* (SES) appear relatively frequently in the paleopathological record, but their significance often goes undisputed. For the past decade, however, research has proved conclusively that their presence is an indicator of illnesses within the corpus. As such, cases found in the archaeological record can provide clues as to the kinds of diseases that prehistoric populations endured. We report four cases of young individuals from Neolithic Western Switzerland bearing SES on their crania and discuss the implications of such findings in terms of the paleopathological profile of these populations. The following article provides documentation for each case as well as a differential diagnosis including tuberculosis, meningitis, trauma, and metabolic conditions such as scurvy. These four individuals represent the oldest cases of such lesions described for this region.

**Key words**
endocranial lesions, infectious diseases, Neolithic, paleopathology, prehistoric Switzerland

1 | INTRODUCTION

This research is based on the study of 13 sites from the Middle Neolithic (4700–3300 BC), Final Neolithic (3300–2400 BC), and Bell Beaker period (2400–2200 BC) of Western Switzerland. These sites represent a minimum number of individuals of 444.

Two types of burials are found during these periods, succeeding one another chronologically. The first is inhumation within Chamblandes cists, found throughout the Middle Neolithic in the High Rhone Valley and Leman Basin (Moinat, 1998), and consisting of four rock slabs forming a box, with a fifth cover slab protecting the deceased (Moinat & Chambon, 2007). These cists can contain either single or multiple inhumations, in simultaneous deposition or with reopening of the grave in successive deposits (Moinat & Chambon, 2007). During the Final Neolithic and the Bell Beaker period, there is a shift towards collective burials, and megalithic monuments are built and used over centuries to inhume part of the population. In Switzerland, the Petit-Chasseur necropolis exemplifies this shift, and this site contains both our Final Neolithic and Bell Beaker populations (Besse & Mottet, 2009; Gallay, 1972; Mottet & Favre, 1990).

In this report, we investigate four cases of young individuals from these Neolithic sites presenting lesions identified as *serpens endocrania symmetrica* (SES) and discovered during a larger research project aiming to characterise the health of Neolithic populations in Western Switzerland (Abegg, 2019). SES are deep vascular impressions found on the endocranial surface of the cranium, resulting from local blood vessel proliferation, the result being areas of (often discoloured) bone with river-delta-like impressions (Hershkovitz et al., 2002). Although they are encountered relatively often in paleopathology, their significance for the health of a population is seldom discussed, despite the fact that their differential diagnosis includes pathologies such as trauma, shaken baby syndrome, meningitis,
tuberculosis, or severe metabolic problems (Hershkovitz et al., 2002; Lewis, 2004; Sun, Pechenkina, Cao, Zhang, & Qi, 2019). Their sole presence on an individual’s remains does not point to a precise diagnosis, but we do have enough literature to argue that their observation is meaningful in defining the state of health of a population, when all other lesions presented by said population are taken into account. In this article, we aim to present the cases of SES encountered during this research, provide a differential diagnosis, and discuss the significance of these findings within the archaeological context of Neolithic Western Switzerland.

2 | MATERIAL

The materials studied come from 13 Neolithic sites in Western Switzerland (Figure 1). The authors conducted examinations on the human skeletal material between 2014 and 2019 with the aim of establishing a paleopathological profile for this prehistoric population. We also aimed to characterise the influence of factors such as site location, biological profile (age, sex, and stature), and chronology on lesion frequency patterns (Abegg, 2019). All bones therefore received a grade for specific bone lesions presence and severity. During these examinations, this project encountered and further investigated four cases of infants and children presenting SES.

3 | METHODS

3.1 | Anthropological analysis

Observations for each bone of the corpus included taphonomy and completeness. For taphonomy, the gradation used was from Brickley and McKinley (2004), and completeness scores involved a simple scale of fragmentary (0–50% of bone present), incomplete (50–95% of bone present), and complete (95–100% of bone present).

All remains, when representing distinct individual skeletons and not commingled bones, were analysed for sex, age, and stature. Sex was determined using the Diagnose Sexuelle Probabiliste (Brůzek, Santos, Dutailly, Murail, & Cunha, 2017; Chapman et al., 2014; Murail, Bruzek, Houët, & Cunha, 2005) and only attempted on fully fused adult remains. Stature was calculated using Trotter and Gleser (1952) for adults and Ruff (2007) for juveniles.

The method used to determine age depended on the observed maturity stage of the remains. If the skeleton was obviously that of a neonate or infant, bone development (Scheuer, Black, & Schaefer, 2008) and infant tooth maturation (Moorrees, Fanning, & Hunt, 1963a; Moorrees, Fanning, & Hunt, 1963b) helped determine a probable age range. The basis for aging fully fused adult remains was the appearance of the auricular surface of the pelvis (Schmitt, 2001; Schmitt, 2005), as that element appears to be the one that better...
endured taphonomical processes and was the most observable within this population.

3.2 | Paleopathological analysis

All bones were individually registered into an Access Database and systematically observed for nine types of bone lesions (the reference indicates the grading system used): cribra orbitalia (Debard\(^1\)), porotic hyperostosis (as present/absent), degenerative joint disease and vertebral joint disease (Steckel, Larsen, Sciuilli, & Walker, 2005, modified), Schmorl’s nodes (Buikstra & Ubelaker, 1994), osteomyelitis (as present/absent), peristeal reaction (Steckel et al., 2005, modified), posterior sacral dehiscence (as absent/partial/complete), and traumas (as absent/present, unhealed/present, and healing/healed).\(^2\) These lesions were chosen for their probability of appearing in a Neolithic corpus, as well as for representing broader disease categories (metabolic, degenerative, inflammatory/infectious, congenital, and traumatic). Bone lesions that did not fit within the nine systematically scored ones were qualitatively registered into a “notes” section of that individual’s form in the database.

As such, when SES was encountered, it was registered in the qualitative section of the database, and the bone lesions were photographed and observed under a binocular for further characterisation. The identification of such lesions was made after the definition and examples provided by Hershkovitz et al. (2002, p. 202): “a phenomenon involving endocranial area(s) of discoloured bone with variant colour, texture, and a serpentine branching surface excavation”.

4 | RESULTS

Four individuals of this corpus bear lesions identified as SES. One is an infant (0 to 1 year old), and the other three are children. They come from 3 of the 13 sites studied during this research. We present here, for each case, the biological profile of the individual, the other pathologies s/he bore, if any, and the characteristics of the SES observed.

4.1 | Collombey-Muraz Barmaz I, individual R17A

These skeletal remains belong to an 8-year-old child (±2 years). As no complete diaphysis was observable, stature remains undetermined. The only preserved bones include a partial cranium, left and right femur, right tibia, and a fragment of fibula with an uncertain lateralisation (Figure S1).

Individual R17A’s right orbit (left is unobservable) exhibits cribra orbitalia with pitting, and exposure of the diploic space, but with no bone production. SES is present on the occipital bone, and the area affected is delimited, with some marginal pitting observable (Figure 2).

4.2 | Sion Chemin des Collines, individual R17

Individual R17 from Sion Chemin des Collines is one of the youngest from this study corpus. His/her age ranges from between birth and 5 months, putting this individual within the infant age category (0 to 1 year old). Due to high levels of fragmentation, there was no determination for stature (Figure S2).

Despite being fragmented, the different cranial bones bear several pathological traces, including SES, deep grooves, and porosities (Figure 3a). Under binocular magnification, the depth of the grooves as well as the extent of the porosities is readily visible (Figure 3b). Affected bones include the left and right parietales and temporales, the occipital bone, and various fragments attributed to the cranium but whose exact position is unclear. This individual also exhibits a patch of peristeal reaction on the diaphysis of the left tibia (Figure 3c).

\(^1\)Debard J, ongoing. Les conditions socio-économiques pendant l’âge du Fer en Suisse occidentale: intégration des données archéologiques, paléoanthropologiques, paléopathologiques et paléalimentaires. PhD thesis, University of Geneva, Geneva.

\(^2\)For more details regarding the exact staging in the cases where the criteria have been modified, please see Abegg (2019), Chapter 4: Methodology.

**FIGURE 2** Close-up photograph of *serpens endocrania symmetrica* on the occipital bone of R17A. The serpentine branching typical of this kind of lesion is readily visible. The lesion is clearly delimited, with some porosities visible on the margins (a) [Colour figure can be viewed at wileyonlinelibrary.com]
Individual R21 from Sion Chemin des Collines is older than individual R17 from the same site, with an age estimation of between 1 and 2 years old. Though the upper limbs were only partially present, the preservation of the lower limbs allowed for an estimated stature of around 79 cm. The cranium is well preserved, but the facial bones are heavily fragmented, as are the ribs and vertebrae (Figure S3).
This individual presented several types of bone lesions. Cribriform orbitalia was found in both the left and the right orbits, with porosities and exposition of the diploe and both femurs and tibias exhibited periosteal reactions. The endocranial surface presented extensive SES lesions on the frontal, left and right parietales, and occipital bones (Figure S3). These lesions are clearly delimited and take the form of serpentine surface grooving. Viewing through the binocular also revealed porosities throughout the lesion (Figure 4).

4.4 | Sion Petit-Chasseur, individual PCI-SUP/MXI-INT/5A52MAJ

This individual is from the Bell Beaker occupation of the Petit-Chasseur site in Sion. As was the norm at this location, his/her interment was inside a collective grave, in a megalithic chamber, and the bones of all individuals buried became commingled over time. Hence, no postcranial remains can be attributed to this particular individual. S/he was 4 years old (±2 years).

Cranial fragmentation (Figure S4) makes the endocranial surface easily observable. The occipital bone displays serpens endocrania symmetrica lesions that appear to follow the internal occipital crest and the occipital sulcus (Figure 5a). The right parietal shows a small circular lesion (Figure 5b) 0.60 cm in width, which appears to combine a circular erosion with remodelling at the margins and serpens endocrania symmetrica lesions at the periphery. There were no other detectable pathologies on this individual’s cranium.

4.5 | Results summary

All four individuals present lesions identified as SES on their endocranial surfaces. Of these four individuals, two also exhibited cribriform orbitalia, two had periosteal reaction on the lower limb bones, and one had a small circular lesion on a right parietal. The most frequent location for SES lesions was the right and left parietales and the occipital.

In our study corpus, 18 individuals were infants (0 to 1 years old), and 82 were children (2 to 9 years old), for a total of 100 immature individuals. Out of these, four presented occurrences of SES (4%). None of the adults observed presented SES.

5 | DISCUSSION

These cases of SES in young individuals’ skeletal remains are, to the authors’ knowledge, the oldest described for skeletal corpuses of Switzerland. Previous studies have mentioned their presence in medieval and early modern corpuses (Cooper et al., 2016; Somers, Cooper, & AlteraugeA, 2017), but they had so far gone unnoticed in the prehistoric paleopathological record of the country. Numerous reports involving Neolithic corpuses have however described them from the southern Levant coast (Hershkovitz et al., 2008), to Hungary (Masson et al., 2015), and as far as China (Sun et al., 2019), as well as in more recent archaeological samples (Köhler et al., 2017; Lovász et al., 2013; Minozzi, Catalano, Caldarini, & Fornaciari, 2012; Pósa et al., 2013).

There are some obstacles to the study of SES in archaeological samples that require mentioning. The main problem is that unless a cranium is at least partly fragmented, observing the endocranial surface necessitates the systematic use of an endoscope or of imaging technology. As such, unless the observer specifically looks for SES, it often goes unnoticed.

Not all endocranial lesions are SES, and in this research, we only included those that were congruent with the definition given by Hershkovitz et al. (2002). For the lesion to qualify as SES, deep vascular impression in a branching serpentine or “river-delta” pattern had to be observed to qualify. We turned to existing literature to discuss their significance within this archaeological corpus. Numerous studies provide a differential diagnosis for these lesions, among them the

FIGURE 4  (a) Right parietal of individual R21 from Sion Chemin des Collines. (a) Note the extensive area affected by serpens endocrania symmetrica, which appears as a darker shade of grey on the bone. (b) A view of the serpens endocrania symmetrica under a binocular. Note the "river-delta" pattern, the depth of the surface excavation, and the numerous porosities surrounding the margins of the lesion [Colour figure can be viewed at wileyonlinelibrary.com]
FIGURE 5  (a) Close-up photographs of the endocranial surface of individual PCI-SUP/MXI-INT/5A52MAJ from Sion Petit-Chasseur. (a) serpens endocrania symmetrica lesions alongside the occipital crest. (b) Close up of the circular lesion on the endocranial surface of the right parietal, with (A) the circular lesion itself showing bone erosion and remodelling at the margins, and (B) serpens endocrania symmetrica lesions at the periphery [Colour figure can be viewed at wileyonlinelibrary.com]

### TABLE 1  Differential diagnosis of endocranial lesions

| Diagnosis          | Description of endocranial lesions                                      | Other lesion observed                                                                 | Congruent with these cases?                                                                 | Reference                                                                 |
|-------------------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| Tuberculosis      | SES, meningeal abscesses due to tuberculosis-related meningitis        | Pott's disease, lytic lesions in the spine, degenerative joint disease of the pelvis and knee articulations, and periosteal reaction on the visceral surface of the ribs, associated conditions such as hypertrophic osteoarthropathy | SES observed, one of the individual presents a lesion congruent with a meningeal abscess (circular lytic defect, remodelling at the edges). Adult individuals within the corpus present vertebral and rib lesions, as well as hypertrophic osteoarthropathy | Schultz, 1999; Campillo, 2006; Dawson & Robson-Brown, 2012; Pálfi et al., 2012, Spekker, 2018 |
| Non-specific      | SES due to increased cranial vascularisation (especially in young individuals)  | meningeal abscesses, presenting as lytic defect with an erosive pattern, sometimes with remodelling at the edges | SES observed, one of the individual presents a lesion congruent with a meningeal abscess (circular lytic defect, remodelling at the edges). The others do not. | Eerkens et al., 2018; Lewis, 2017                                          |
| meningitis        | Subdural haematomas                                                    | Fractures of the upper limbs and ribs, mandibular fractures                           | The SES observed do not resemble ossified haematomas, and there were no fractures (healed or unhealed) observed on these individuals | Caffey, 1946; Tsioumi and Oates 1998                                       |
| Scurvy            | Abnormal cortical porosities                                          | cribra orbitalia, cortical thinning, periosteal reaction on various bones of the post-cranial (scapula, ilium, long bones...) | Although there are porosities on the edges of the SES lesions observed, they are not congruent with cases of scurvy described in the literature. No ossified haematomas were found on the observable long bones of these individuals. Some of our individuals did present periosteal reaction and/or cribra orbitalia | Stark, 2014; Klaus, 2015; Snoddy et al., 2018                               |

Note. These represent a selection of possibilities. Abbreviation: SES, serpens endocrania symmetrica.
The most likely diagnoses appear to be either trauma or an infectious disease. If it is trauma, then this enriches our discussion on the kind of trauma sustained by these populations and perhaps questions the current view on the topic. Indeed, in the larger research project, the traumas observed within this population are in majority healed and of little severity (Abegg, 2019). Attributing these cases of SES to trauma, perhaps violence, inflicted on young individuals, would change that perception.

Interpreting these lesions as signs of infectious disease within the population makes equal—if not more—sense. As mentioned above, the link between SES and various infectious diseases (especially tuberculosis) is one that finds strong evidence in the literature (Pálfi et al., 2012). In the adult population, several individuals exhibit lesions congruent with the presence of an infectious pathogen, possibly tuberculosis: vertebral and rib lesions, hypertrophic osteoarthropathy, and periosteal reaction on the pleural surface of rib (Figure S5). Although this does not constitute proof, it does seem logical that if adults within the population were exposed to a pathogen, so would immature individuals who might react differently and exhibit SES as a result. Whichever the diagnosis, these cases add to our knowledge of the state of health of this Neolithic population.

6 | CONCLUSION

These cases constitute the oldest reported occurrences of SES in Switzerland. Their presence in young individuals could corroborate the diagnosis of infectious diseases, potentially tuberculosis, made for some individuals within the adult population. However, considering the absence of other diagnostic features as well as the presence of cribra orbitalia and periosteal reaction, trauma, and metabolic diseases remains possible aetiologies.

These cases would benefit from further analysis, especially molecular detection of tuberculosis as well as isotopic analysis, to confirm the presence of this particular pathogen within the population and to investigate the diet of these individuals. In addition, whereas SES has been described and discussed in terms of aetiology in the literature, the mechanism, timing, and conditions under which they form require more precision. No older sites have been excavated in Western Switzerland, and necropolises from the following periods (Bronze age and Iron age) have not yet been studied for SES. Such a chronological approach to these lesions would also be useful in the future.

These four cases of SES from Neolithic Switzerland enrich the paleopathological record for the region and contribute to a better understanding of the health of these prehistoric populations.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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**SUPPORTING INFORMATION**

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