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Virtual reconstitution and new palaeopathological study of the Magdalenian child's skull of Rochereil

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Abstract

A fragmented skull of a child aged between two and four years was discovered within a Magdalenian level (11255 ± 50 BP, OxA-16932) in the cave of Rochereil in the Dordogne 'département', France. The presence of a lacuna in the frontal bone and the general appearance of the skull had led to the conclusion of a postmortem trepanation of one hydrocephalous child. Examination of the tables and of the diploe and, by means of electron microscopy, of the edges shows that the frontal lacuna is a pathological lesion and not a trepanation. Several dysmorphic and dysplasic lesions of deciduous teeth are associated. The virtual three-dimensional reconstruction of the cerebral skull rules out the previous diagnosis of hydrocephaly. The only tenable diagnosis is macrocrania. Numerous aetiologies can be cautiously evoked for the large cranial lacuna and the associated dysmorphic lesions, but no conclusive diagnosis can be put forward for this insulated skull. ***To cite this article: B. Mafart et al., C. R. Palevol 6 (2007).***
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Résumé

Reconstitution virtuelle et nouvelle étude paléopathologique du crâne d'enfant magdalénien de Rochereil. Le crâne très fragmenté d'un enfant âgé de deux à quatre ans avait été découvert dans un niveau magdalénien (11255 ± 50 BP, OxA-16932) dans la grotte de Rochereil, Dordogne, France. L'existence d'une lacune du frontal et l'aspect général du crâne avaient fait conclure à un cas de trépanation post mortem d'un enfant hydrocéphale. L'examen des tables osseuses, de la diploe et de ses berges prouve que cette lacune du frontal est une lésion pathologique et ne résulte pas d'une trépanation. Des lésions dystrophiques et dysplasiques des dents déciduales sont associées. La reconstitution virtuelle du crâne cérébral montre que le diagnostic précédent d'hydrocéphalie ne peut être retenu ; tout au plus s'agit-t-il d'une macrocrânie. Plusieurs étiologies peuvent être prudemment discutées pour cette large lacune frontale associée à des lésions dentaires et à une possible macrocrânie, mais sans qu'aucun diagnostic de certitude puisse être avancé. ***Pour citer cet article : B. Mafart et al., C. R. Palevol 6 (2007).***
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1. Introduction

In 1971, H-V Vallois published the study of a child's skull discovered in 1939 in the cave of Rochereil in a Magdalenian archaeological level [19,37]. This skull was completely crushed in the sediments, and the mandible was fractured during the excavation. An initial reassembly was carried out by H.V. Vallois, but the skull was some years later broken again and was reconstructed a second time before its study. This author estimated the age at death between two and a half and three years. He described one hyperbrachycrany and a disproportion between the face and cerebral skull. That led him to propose a diagnosis of hydrocephaly. The presence of a wide circular opening in the frontal bone was then attributed to a postmortem endocranial trepanation with the aim of removing a disk of skull bone. This case of postmortem trepanation was presented as certain and as the only case observed for the Palaeolithic period. It was related by H.V. Vallois to some religious or perhaps magical hypothetic practices connected with the supposed suffering of this hydrocephalic child [37].

An examination of this skull, conserved at the Institute of Human Palaeontology, Paris, convinced us that the reconstruction was not satisfactory and that these diagnoses were clearly open to question. With the authorization of Prof. de Lumley, director of the Institute, we resumed the study of this fossil with three objectives: (*i*) the realisation of a more anatomically satisfactory reconstruction by means of virtual images, (*ii*) a reinvestigating of the diagnosis of hydrocephaly and (*iii*) a new discussion on the aetiology of the cranial lacuna.

2. Description

Most of the cerebral skull, the upper dental arch, and the anterior part of the palate together with the mandible are preserved. The anterior part of the skull base is missing, including the sphenoid bone and the nasomaxillary area. Most of the bones were fractured in multiple places and, in some cases, deformed. The edges of the paramedian lacuna on the right side of the frontal bone are fractured and non-jointed in its external quarter. The missing parts in this skull had been partially filled with synthetic materials during the course of former reconstruction attempts, in particular the right temporo-parietal area, the left lateral side of the skull from the asterion to the middle of the parietal, the lower posterior and lateral parts of the occipital. At the facial level, the lower and lateral edges of the orbits, the ascending branches of the maxillae and the anterior part of the skull base had been reconstructed. There is a brown varnish that is covering most of the parts, except for the recently fractured areas (Fig. 1).

The left horizontal branch of the mandible, fractured during the excavation behind the canine was reconstructed with a synthetic material and replaced in an excessively internal position. The deciduous teeth are in position on the mandibular and maxillary arches. The lower left canine and first molar and the upper right canine were lost postmortem. The left and right upper central and lateral incisors were reversed during the reconstruction. Their internal edge is rounded and their occlusal edge slanted towards the inside, whereas, anatomically, the external angle is always higher and more rounded than the internal angle, which is straighter. The left incisor was reimplanted in an excessively external position, creating a pseudo interincisive diastema. In the same way, the root of the second left premolar was implanted into a synthetic material at an excessively posterior position, creating a diastema with the first premolar.

The previous restoration was responsible for the incorrect positioning of many bones and bones fragments, especially those of the skull base and of the face. The upper edge of the right temporo-parietal lacuna is displaced of 20 mm towards the exterior, the occipital foramen is tilted forward, and the width of the left orbit is excessive. The position of the maxilla, determined by H.V. Vallois by connecting the mandible with the temporal condyles, is incorrect when the anomalies of the base of skull and the mandible are taken into account.

A dental age of less than three years was proposed by H.V. Vallois. The eruption of the deciduous teeth had occurred, with a minimal wear of the enamel. The crown of the first permanent mandibular molar is formed and included in the bone. The crowns of the upper and lower permanent incisors are two-thirds formed. The crowns of the lateral incisors and the upper canines are formed to mid-height and are in an endopalatal position. There is a lacuna at the base of the right lower canine and no bud is visible either at this level or under the deciduous premolars. There is no start of osseous resorption behind the first permanent lower right molar. These absences of buds may correspond to a delayed growth or an agenesis of the permanent teeth. The age at death estimated using the Uberlaker method [36] is three years $\pm$ 12 months, and, according to the Stermer Beyer–Olsen and Risnes method [33], is between three and four years. The sex of this child is indeterminable. We have retained an estimation of the age at death between 2 and 4 years for this child of unknown sex.

The teeth present many dysplasias and dysmorphias, in particular mandibular. The central incisors are large
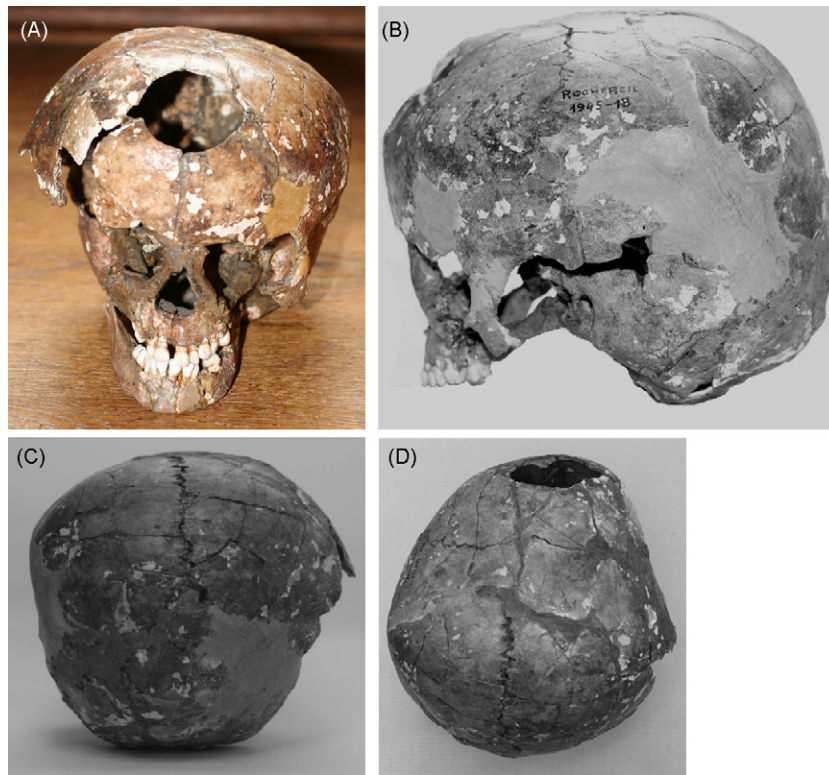
Fig. 1. Rochereil child skull as reconstituted by HV Vallois. (**A**): Cranium with mandible. (**B**), (**C**), (**D**): Cranium (**B**): left side view, (**C**): upper view, (**D**): posterior view).

Fig. 1. Crâne de l'enfant de Rochereil reconstitué par H.V. Vallois. (**A**): crâne articulé avec la mandibule ; (**B**), (**C**), (**D**): crâne seul (**B**): vue latérale gauche, **C**: vue supérieure, **D**: vue postérieure).

and dysmorphic. Their anterior faces have a protuberance at the level of the corono-distal angle, giving them a symmetrical appearance. There is an extension on the root of enamel in the middle of the tooth with a marked corono-radicular angle. Their lateral edges have a long contact with the lateral incisor and overhang its vestibular face. Their lingual face presents a middle ridge from the base of the crown to the middle of the external half of the occlusal edge, which separates them into two asymmetrical depressed zones. The internal depression is covered by the antero-internal edge of the central incisor. The right lateral incisors have a long and narrow crown, especially on the right, and a dysmorphic appearance. The base of their vestibular face is narrow. Their lingual face presents a depression with a ridge, less marked than on the central incisor, from the middle of the base of the crown to the middle of the internal half of the occlusal edge. The canines are hypoplasic and smaller than the lateral incisor, whereas they are normally significantly broader. They do not have any wear, but did not arrive at the occlusal plan. The first right premolar, the only one preserved postmortem, is morphologically

normal. The second premolars are normal, with minimal wear (Fig. 2).

The radiographic and scanographic examination of the mandible shows an image of hypercementosis at the root of the canine. There is a lacuna (0.8 mm in height and a width of 0.5 mm) with hyperdense contours under the root at the normal position of the bud of the permanent canine. This lacuna is in the direct extension

Fig. 2. Mandibular teeth dysmorphies; the small size tooth is the right canine.

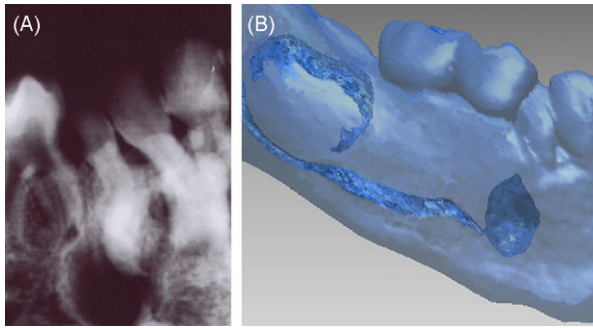Fig. 2. Lésions dysmorphiques des dents inférieures ; la petite dent est la canine droite.

Fig. 3. Lacuna of the mandible. (**A**): Radiographic slide showing the hypercementosis of the root of the canine and the hyperdensity of the borders of the lacuna. (**B**): Three-dimensional imaging of right side of the mandible. The lacuna under the root of the canine is connected with the mandibular canal.

Fig. 3. Lacune de la mandibule. (**A**): Cliché radiographique objectivant l'hypercémentose de la racine de la canine et la présence d'une hyperdensité des bords de la lacune. (**B**): Vue tridimensionnelle de la branche droite de la mandibule. Le canal mandibulaire aboutit dans la lacune située à la base de la canine.

of the mandibular canal, which seems narrowed at this level (Fig. 3). This lacuna may correspond to a dental bud of the canine that remained at the conjunctive stage or to a cystic formation of aetiology that cannot be determined without histologic examination. The left side, completely reconstructed with synthetic materials, cannot be studied.

The preserved maxillary teeth (i.e. incisors, left canine, first left and right premolar, and second left premolar) are morphologically normal, with a minimal wear of the enamel. The left canine presents a dysplasia in the form of a pit on the vestibular face, while the right canine was lost postmortem.

The association of multiple dental dysplasias and dystrophies of the mandible with absence of permanent dental buds and presence of an intraosseous lacuna under the deciduous canine implies that this child suffered early within life from this diffuse pathological process.

Considering the uncertainty of the dating of the archaeological level in which this skull was discovered, we carried out a radiocarbon dating measurement, which confirmed that this child was living at the end of the Upper Palaeolithic (11255 ± 50 BP, OxA-16932).

3. Virtual reconstitution of the skull and the mandible

The postmortem deformations and the anomalies of reassembly raised the problem of the validity of the diagnosis of hydrocephalus. We performed a virtual reconstruction of the skull and mandible by disassembling the fragments, removing the synthetic materials,

and subsequently reassembling the pieces using CT scanning and three-dimensional image processing methods as used for palaeoanthropological studies [23].

The CT scanographic images were captured at the Laveran Military Hospital Radiology Unit in Marseilles, using a helical medical scanner with 1.25-mm slices, a reconstruction interval of 0.625 mm and a rotation time of 0.7 rev/s. The scanning parameters were adjusted to yield maximum spatial resolution and minimum image distortion. We used a matrix of 512×512 pixels, a SFOV of 25 cm and a consequent pixel size of 0.48 mm. The slices are recorded in Dicom format. The 3D reconstructions (G. Guipert) were obtained by postprocessing the CT data using the Yav++ software (developed by H. Delingette, Epidaure Project, INRIA, Sophia Antipolis, France) and the Mimics 8.0 software (Materialise©).

The virtual reconstitution of the skull began with the frontal area, as the best-preserved part of the skull. The virtual separation of the fragments and their repositioning made it possible the reconstruction of the upper and lower right edges of the perforation, previously disjointed. The left side of the frontal bone became less projecting ahead. The reconstruction of the frontal bone altered the curvature of the coronal suture and therefore that of the parietal vault. The fragments of the external portion of the upper surface and lateral surface of the right parietal were repositioned on the base of sagittal symmetry, thereby eliminating the outward divergence of the right parietal. The posterior fragments of each parietal bone were also repositioned. The skull curves and the transitions with the occipital bone (except for the lambdatic area) were merely the result of additions of synthetic material that were removed using virtual technology. The occipital bone and the temporal fragments have been secondarily articulated.

In the reconstruction of 1971, the foramen magnum is tilted forward. All the fragments of the occipital bone had to be virtually separated, most of them being badly positioned (wrong angulation and displacement of internal sinusal structures between two fragments), and the occipital bone had to be completely reconstructed. The articulation of the various fragments was carried out according to the anatomical curves and structures. The spatial positioning between the fragments was based in particular on the layout of the various occipital sinuses (lateral or transverse and longitudinal). The position of the vermian fossa has contributed therefore to the positioning of the edges of the occipital foramen. The curve of the reconstructed occipital bone became regular from the lambda to the basilar extremity and the orientation of the foramen magnum was normalized.

The temporal bones were in a rather good state of preservation; so it was possible to articulate them back to the occipital without a gap or an overlapping, thereby validating this reconstruction.

The restoration of the facial massif could not be entirely done because of the postmortem destruction of several parts, partially replaced by synthetic materials. We have removed virtually the synthetic material when it could be dissociated from very fine bones of the face on the CT scanographic images. The areas of the nasion and the maxillo-frontal junction were not reconstructed because the gaps were too large. The greater part of the maxillae was preserved, except for the right external portion and a small external portion on the left. Without any anatomical connection between these fragments and the rest of the skull, it was not possible to reposition them.

The upper and outer edges of the left orbit were in an aberrant position, with an orbit width of almost 47 mm. They were repositioned as was the left molar fragment. We have reconstructed most of the left orbital cavity by

repositioning the zygomatic bone, except for its lower portion.

There was no direct articulation between the frontal bone and the other facial remains. It was only possible to propose a hypothetical relative position of the maxillary and mandible. The left orbit and the lower part of the frontal bone were positioned by means of overlaying 3D CT-scanner views of a child skull of similar age. The left branch of the mandible was virtually disjointed and repositioned to get a symmetrical mandible. The right mandibular fragment, as the best-conserved side with the greater number of teeth, was secondarily joined to the maxillary molar block and was connected to the temporal bones to enable repositioning of the lower facial block (Fig. 4).

The new virtual reconstruction altered the dimensions and proportions of the skull by comparison with the previous restoration of H.V. Vallois (Table 1). The maximum length increased slightly, whereas the widths (frontal, parietal, and bisphenic) decreased. The bipari-
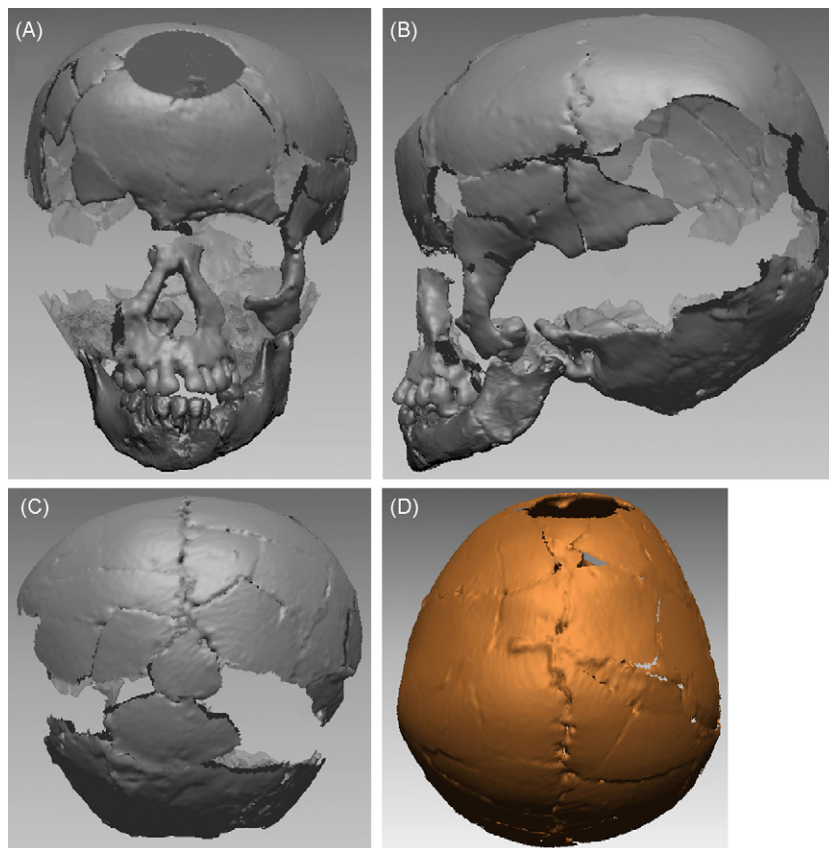

Fig. 4. Three-dimensional reconstitution of Rochereil child's skull with the mandible after the removing of the synthetic material used for the previous reconstitution. (**A**): Front view, (**B**): left three-quarter view, (**C**): posterior view, (**D**): upper view.

Fig. 4. Reconstitution tridimensionnelle du crâne d'enfant de Rochereil, avec mise en connexion de la mandibule après enlèvement virtuelle des matériaux synthétiques de la précédente reconstitution. (**A**) : Vue de face, (**B**) : vue de profil, (**C**) : vue postérieure, (**D**) :vue supérieure.

Table 1
Comparison of the metric data of the Rochereil child's skull for previous and virtual reconstitutions
Tableau 1
Comparaison des mensurations du crâne de l'enfant de Rochereil obtenues à partir de la précédente reconstitution et de la reconstitution virtuelle

Dimensions	Vallois 1971	Virtual 2006
Maximum cranial length	163.5	165
Maximum cranial breadth	151	144
Cranial index	102.1	87.2
Porion-bregma height	97	124
Cranial perimeter	478	496
Cranial capacity (cm³)*	1247.3 ± 92	1422.4 ± 92
Lambda-basion length	105.79	126.21
Maximal frontal breadth	129.5	124
Fronto-parietal transversal index	65.2	60.9
Biporion breadth	80.8	92.2
Bi-asterion breadth	119.5	106
Left orbit height	26	30
Left orbit breadth	47.2	36.6
Bijugal breadth	103.5	89.8
Foramen magnum relative to the orbital plane	131.59°	118.86°

* Cranial capacity obtained with Coqueugniot's method [8].
Capacité crânienne calculée avec la méthode proposée par Coqueugniot [8].

etal vault is narrower and the cranial vault is more symmetrical in norma verticalis. The cranial index dropped from 102.1 to 87.2, from hyperbrachycranial to brachycranial.

The bi-asterionic breadth also decreased, but the biporionic breadth increased. However, the cranial perimeter increased, as did the cranial capacity. The angle of the foramen magnum is normalized. The dimensions of the left orbit are no longer aberrant for a child of 3 ± 1 years. The modifications of the frontal bone as well as the new positioning of the maxilla have contributed to an increase in the length of the facial massif, which is higher and narrower (bijugal breadth estimated by symmetry). These differences are particularly clear on the lateral view of the virtual reconstruction compared with the reconstruction of 1971 (Figs. 1 and 4).

4. Palaeopathological study

The new virtual reconstruction has confirmed the need to reopen the discussion regarding the previously issued diagnosis of hydrocephaly. In modern medical practice, this diagnosis is based, for children, on the association of a significant increase in the dimensions of the cerebral skull of the sick child compared to children of the same age with several dysmorphic osseous elements and

mainly specific cerebral lesions. The definitive diagnosis is founded on criteria that are lacking on a fossil, such as the dimensions of the cerebral ventricles and the increase in the encephalic mass.

The most often used criteria to follow cephalic growth and to track its anomalies are the cranial perimeter and the cranial capacity. The study of these parameters for the Rochereil skull faced with two difficulties: uncertainty regarding its sex and age at death, as they precisely depend on age and sex, and the absence of knowledge on the normal values and variability in the fossil population. In addition, the measurements of the cranial perimeter in modern populations are made on the living people and are therefore greater than the measurement on dry skulls, because of the thickness of the teguments. However, the difference cannot mask the largest variations. The value of the cranial perimeter in the new reconstruction (496 cm), even having increased when compared with the previous one, would be normal for a North-American boy more than two years old [6]. It is only increased significantly for the girls of this population at the age of two years and three months and only at the threshold of 0.75 (average + 1 standard deviation: 500 cm) [7].

The measurement of the cranial capacity also encounters difficulties. The main methods used in medicine are based on internal or external dimensions of the cerebral skull, measured on teleradiographs. The osteological methods have not been established on large enough samples of children to know the variability per year and sex. We used the Haas [15] and Coqueugniot [8] methods, based on external measurements of the skull. The cranial capacity calculated using the Haas method is 1530 cm³. This value is within the normal limits for a boy more than two years old, and is high for a girl between two and three years old. The cranial capacity according to the Coqueugniot method is 1422.4 ± 184 cm³ (two standard deviations). The two measurements do not differ significantly.

Given that the age at the death of the Rochereil child is probably between two and four years, this child would have been a girl who died between two and three years of age, i.e. in the low range of estimation of its age at death, in order to admit the presence of a significantly increased cranial perimeter and therefore the existence of macrocrania; but, anyway, the cranial capacity was normal. Hydrocephaly is one of the causes of macrocrania, but it is not the main one. Many constitutional diseases can cause it, and there are in fact more non-pathological types of macrocrania, notably family macrocrania. Therefore, the values of the cranial perimeter and of the cranial capacity of the Rochereil child do not in any case lead to a diagnosis of hydrocephaly.
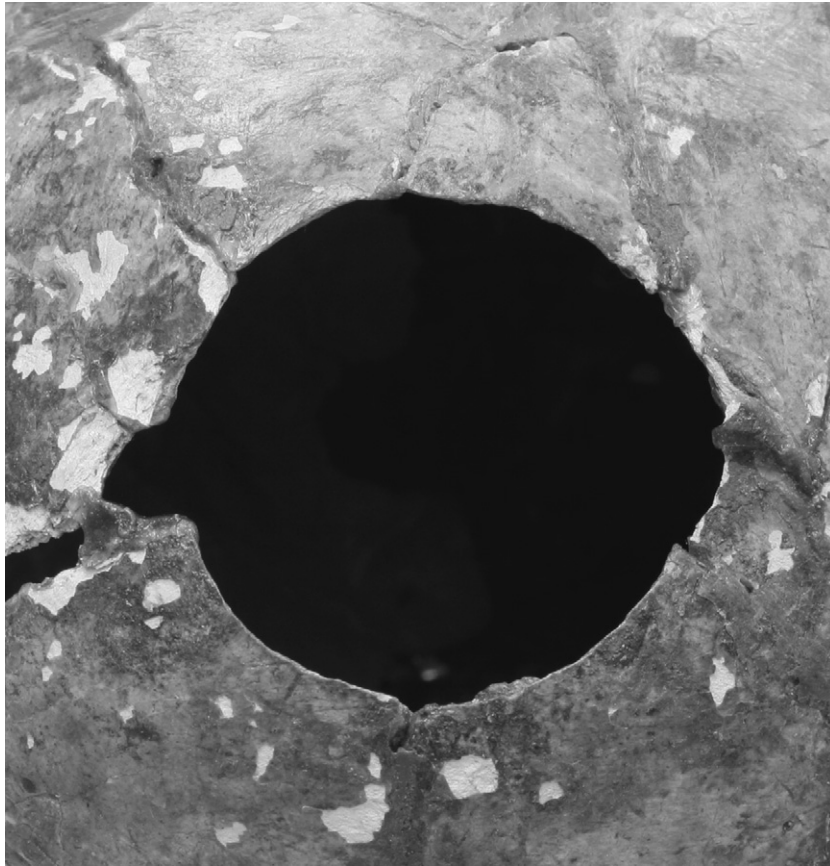
Fig. 5.   External view of the lacuna of the frontal.
Fig. 5.   Vue externe de la lacune du frontal.

A palaeopathological diagnosis of hydrocephaly cannot be sustained without the presence of other osseous lesions that are a mechanical consequence of an internal pressure on the skull bones or are related with the aetiology of hydrocephaly [30]. Thus, for small children, the closure of the fontanels is delayed and the hyperpression will lead to an expansion of the cranial vault and a depression of the orbits and of the base of skull. Traces of the very developed venous sinuses are visible on the endocranium.

3D visualization of the surface of the endocranium by thresholding the CT-scannographic images as well as its visual study are particularly difficult for this fossil, considering its state of conservation and the abundance of old varnish, which attenuates the internal details; however, the imprints of the venous sinus seem normal. The skull's state of conservation does not allow observation of possible anomalies of the orbits, nor of the turcic saddle that has not been preserved. There is thus no convincing argument to sustain the diagnosis of hydrocephaly for the Rochereil skull.

We conclude that this child was probably not hydrocephalous and that the lone palaeopathological diagnosis that could be advanced for its cranial morphology would be a non-specific diagnosis of macrocrania, but only if this child were a girl aged less than 3 years, which seems improbable.

The frontal bone shows a roughly circular opening 40 mm in diameter in the sagittal axis and 45 mm in the transverse axis (Fig. 5). Its posterior edge is 35 mm from the bregma and its anterior edge is 34 mm from the glabella. A quarter of the surface area of this paramedian opening is situated in the left half of the frontal bone and the remaining three quarters are in the right half. The edges of the opening are fragmented, but can quite be studied. The lower and right parts are perfectly analyzable over a length of more than 4 cm. The inner and outer tables are thinned regularly, almost sharp. The central part of the edge is concave towards the centre of the lacuna and its surface is smooth, with a microporous appearance. The spongiosa is not visible (Fig. 6). This appearance is incompatible with a cut of the bone.
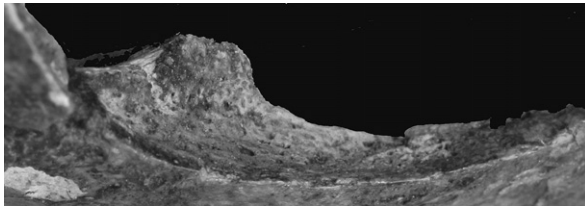
Fig. 6. Lower edge of the lacuna of the frontal bone. The surface of the diploe is concave towards the center of the lacuna and its surface has a smooth and microporous appearance.

Fig. 6.   Bord inférieur de la lacune du frontal. La surface de la diploe est concave vers le centre de la lacune et sa surface est lisse avec un aspect microporeux.

The left edge of the opening was fractured post-mortem and its edges are irregular. The edge of the posterior and right quadrant is internally analyzable and has a bevelled appearance extending towards the back of the edge of the opening. There is no cicatricial process, sediment, or varnish, at the level either of the inner and outer tables or of the diploe in these two fractured zones (Fig. 7). These arguments alone would be enough to recognize a recent origin for these erosions. H.V. Vallois [37] advanced that the fact that the bevel of the fracture was directed towards the interior of the skull proved that it was a case of endocranial cutting. To refute totally this interpretation, a study by means of the electronic microscope of the upper and left edges considered by Vallois as cut was carried out. The inner and outer tables as well as the diploe have highly irregular surfaces without scratches and therefore with no trace of tools or of a sawing process, confirming that this is not a case of trepanation (Fig. 8).

The concave form of the diploe and the appearance of the inner and outer tables of the intact edge of the opening authorize to affirm that this is a pathological lesion.

Fig. 7. Left edge of the lacuna of the frontal bone. There is no cicatricial process, sediment or varnish either at the level on inner and outer tables or of the diploe.

Fig. 7.   Bord gauche de la lacune du frontal. Il n'existe aucun processus cicatriciel et aucune trace de sédiment ou de vernis n'est visible que ce soit au niveau des tables interne et externe comme de la diploe.
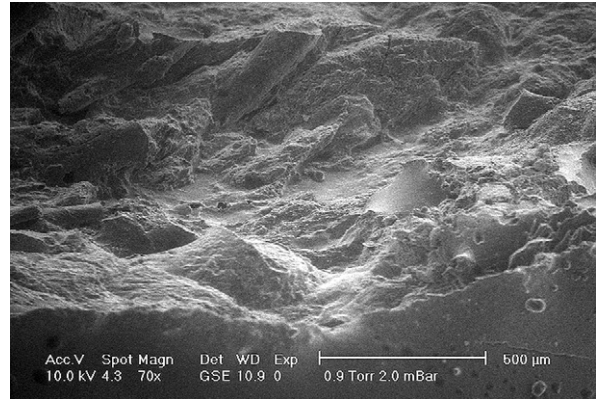

Fig. 8. Scanning electronic microscope view (× 70) of a print the surface of the left edge of the lacuna of the frontal bone. There is no cutmarks or microstriations.

Fig. 8.   Vue au microscope électronique (× 70) d'une empreinte de la surface du bord gauche de la lacune frontal. Aucun trace de sciage ou microstriations n'est visible.

This frontal orifice is, in semiological terms, a cranial lacuna. This lesion is unique as regards the cerebral skull, but the numerous missing areas of the vault and the base of the skull make it impossible to exclude the possibility that there were other associated lesions.

The decisive elements in the aetiologic discussion of a cranial lacuna in modern medical practice (i.e. headache, tumour appearance, modification of the teguments, lesions of the postcranial skeleton, biological and histological data) are of course unavailable. The elements of diagnostic orientation available for this isolated skull are the estimated age at death, the topography of the lesion, the appearance of the inner and outer tables and of the diploe, and the existence of associated lesions [26]. The discussion must be particularly cautious. The diagnosis can be only analogical, allowing that current diseases were present in Prehistory, with the same osseous consequences, and that no pathology that could have since disappeared is responsible for this lesion.

This vast cranial lacuna presents a marginal sclerosis in the lower right quarter, on the best-preserved edges. The inner and outer tables of the frontal bone both beside and far from the lesion are normal. It is therefore a geographical osteolysis of type IA [22].

Several aetiologies of type IA geographical osteolysis have epidemiological or semiological differences with the studied case. The essential osseous cyst is not responsible for a lysis of the osseous corticals. The dermoid cyst is a primarily extra-osseous lesion of the small child, most often localized in the sutures and in particular in the fontanels, and only erosions of the outer

table are described in the cases discovered later in life [25].

Some other diseases can be responsible for a similar lesion. Fibrous dysplasia is responsible for radiological osseous lacunae that are topographically well limited in the young person, affecting the face and the cranial vault, in particular the frontal bone outside the central line as for Rochereil cranium. Cystic lesions of the cranial vault are described in this disease. The edges of the lesions are clearly defined and the diploe is widened. Development usually begins, however, from the outer table, and leaves the inner table intact [10]. The osseous aneurysmal cyst is diagnosed in teenagers and young adults. It causes a rounded lacuna, which is most often isolated. The cortical is thinned and sometimes absent. It normally develops starting from one of the cranial osseous tables with an inflated periosteum, but can extend to the two tables [1]. A traumatic aetiology was suggested by several teams [9].

The cranium is rarely affected in all these diseases [38]. Epidermoid cysts develop in the diploe, but are exceptional (less than one hundred cases were described worldwide to date). Half of them erode the outer tables, but evolve slowly and rarely lead to the perforation of the two osseous tables [5,16].

Two nosological groups may present analogies with the case of Rochereil: the neurofibromatosis and the Langerhans histiocytosis, in particular if the cystic mandibular lesion is regarded as resulting of the same aetiology as the lesion of the frontal bone.

An association of cranial lacuna with mandibular lesions is present in neurofibromatosis (former Recklinghausen's disease). This genetic disease is most frequent of the phakomatoses (approximately 1/3000 births). Transmitted on the dominant autosomal mode, it can occur through spontaneous mutation in 40% of cases and is accompanied by multiple lesions, i.e., cutaneous, neurological, and also osseous. The osseous lacunae are related to a medullary invasion by neurofibromatose cells. The wings of the sphenoid bone, not preserved in the Rochereil case, are most often affected, but lacunae of the frontal, parietal and occipital are described [31]. The mandible is the site of frequent osseous and dental lesions, which are however most often asymmetrical [34]. On the Rochereil mandible, in spite of the state of conservation on the right side, the dental dysmorphias are clearly symmetrical. A total of 13 lesions considered as characteristic of this affliction was collected by Lee [20]. The Rochereil skull displays only two of them: a cystic lesion and the absence of the buds of the second molars [14,20]. Numerical and positional anomalies as well as anomalies of roots are also described

in neurofibromatosis. These lesions are connected with invasion by tumoural cells, in particular of the dental canal. In the Rochereil case, the dental canal, although narrowed in its distality and interrupted by the cystic lesion, does not seem significantly dilated. A macrocrania, doubtful in the studied case, is significantly more frequent in children and adults presenting type-1 neurofibromatosis [12,17,28,39]. The aetiologic mechanism is under discussion and related with the volumetric increase of the gray matter for some authors, of the white for others. There is therefore no determining argument to uphold this diagnosis of type-1 neurofibromatosis for the Rochereil skull.

The Langerhans histiocytosis (former histiocytosis X) is a nosologic group of diseases, which have in common the presence in affected tissues of Langerhans cells inside an eosinophilic granuloma with an antigenic marker of specific surface. These affections are rather rare (1/20 000 births). The eosinophilic granuloma is the focused and the most frequent form (70% of Langerhans histiocytoses). It affects especially children, with a third of the patients aged between three and ten years. Localization in the flat bones of the skull, as the frontal bone, is frequent [13,18,29]. The most characteristic lesion is a plaque of osteolysis measuring up to several centimetres to the outer edges with a fine sclerosis, indicating a peripheral osseous reaction without a periosteal reaction. The lesions have an intra-diploic development, with progressive destruction first of the outer table and then of the inner table [2,11,27]. All these characteristics are compatible with the frontal lesion of the studied skull.

Diagnosis is clearly hampered by the lack of knowledge regarding associated pain, the appearance of the cutaneous tissues, the consistency on palpation of the damaged zone, and above all, the histology. However, the appearance of the lacuna and the young age of the child make eosinophilic granuloma a plausible hypothesis. In the more widespread form of Langerhans' histiocytosis, the Hand–Schüller–Christian disease, several facial lesions are described. Destruction of the periodontium and geographical osteolyses with periapical lacunae that affect the mandibular bone involve loss of teeth and dental buds [21,32]. In the Rochereil case, there is a mandibular lacuna, but no periodontal lesions. In addition, the facial damages are usually not limited to the mandible. They also affect the maxilla, which on this skull is normal. Macrocrania is not observed in Langerhans histiocytosis. The first clinical manifestations appear around the age of three years and the evolution is by thrust, with a reserved prognosis (mortality close to 15%), especially if the child is less than three years old and in case of multiple osseous localiza-

tions. Several palaeopathological cases of Langerhans' histiocytosis have been described, notably for the Upper Palaeolithic [3,4,24,35]. These cases are all multifocal forms and no lacuna of a size comparable with that of the Rochereil skull has been described. Therefore, this diagnosis seems not tenable for the Rochereil skull.

The mandibular lesions and the possible macrocrania may also not have a direct link with the lesion of the frontal bone. Its great size implies that the affliction appeared early in life and might have had harmful consequences for the growing of this child, with the mandibular dental dysmorphias and the dysplasias of the maxillary canine as indirect consequences.

Therefore, and in the absence of the postcranial skeleton, it is not possible to propose a more precise palaeopathological diagnosis. The osseous and dental dysmorphias, and even the death of this child, more than 10 000 years ago, could be a complication of this sizable osseous cystic lesion of uncertain aetiology. Anyway, the present study refuted the previous diagnosis of a postmortem trepanation of a child who died from hydrocephaly.

5. Conclusion

The previous study of the Magdalenian skull of the Rochereil child had led to a diagnosis of hydrocephaly and of postmortem trepanation. The reconstructive techniques based on three-dimensional imaging and virtual tools were used to restore this skull. We have demonstrated the pathological nature of this cranial lacuna, which owes nothing to an intentional human action, and the absence of convincing arguments in support for the diagnosis of hydrocephaly. This child, who died between two and four years, had one extensive cranial lacuna that was associated with dysmorphic dental and osseous lesions. Many kinds of aetiology can be proposed, but no diagnosis of certainty can be put forward for this insulated skull.

Acknowledgments

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