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New evidence of prehistoric neurosurgery in Italy: the case of Castello del Tartaro

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Running Head: Trepanation and deviant burial

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ABSTRACT

Archaeological evidences of trepanation during the European Bronze Age are numerous, and testify a wide application of neurosurgical practices during Prehistory. In some particular cases, trepanations may be associated with other peculiar evidences concerning funerary practices. The aim of this paper is to present the case of a woman from the Recent Bronze Age site of Castello del Tartaro (Verona, Italy), who was buried in a prone position and whose skeletal remains presented evidences of a probable frontal trepanation. The association between a deviant burial and a trepanation could be of interest in better understanding the history and the perception of neurosurgical practices during Prehistory.

Key words: trepanation; head injury; Recent Bronze Age; Italy; deviant burial; prone burial; neurosurgery.

1 INTRODUCTION

2 The practice of trepanation has been documented as one of the most ancient surgical intervention ever
3 discovered, presenting almost worldwide evidences from Prehistory to more recent periods¹⁻¹⁰. This practice
4 is defined as the surgical removal of a portion of the neurocranium through different techniques with the aim
5 to treat several typologies of disorders (epilepsy, fever, traumas or infections, cephalic disorders related to
6 high intracranial pressure and others)¹¹⁻¹⁵. Evidences of trepanations are momentous in the archaeological
7 record, since they testify the presence and the evolution of neurosurgical practices throughout the history and
8 prehistory of mankind; moreover, their association with other unusual findings is of particular interest,
9 implying a peculiar context related to the practice itself⁵. Recent studies have shown cases of trepanation
10 associated to other remarkable conditions, usually related to clinical circumstances, such as childbirth⁵, as
11 well as to therapeutic or post-traumatic treatments, both on human and animals^{3,6,15-22}; some cases of post-
12 mortem trepanations have also been reported, in which the procedure has been linked to pharmacological or
13 thaumaturgical practices²³. The association of peculiar funerary practices with evidences of trepanation could
14 also represent a significant finding. Several scholars highlighted the archaeological relevance of deviant
15 burials, i.e. burials characterized by funerary practices intentionally different from those of the same cultural
16 area, usually interpreted in a negative connotation and reserved to individuals rejected by their societies,
17 although this point might be questionable due to its interpretative nature²⁴.

18
19 In the present study, we investigate the nature of a cranial lesion found on the skeletal remains of a woman
20 from the Recent Bronze Age necropolis in Castello del Tartaro (Verona, Italy), who was intentionally buried
21 in a prone position. Our aim is to evaluate a possible relation between the lesion and the unconventional
22 funerary practice, and to verify whether the lesion could be interpreted as frontal trepanation. The association
23 of an anomalous funerary practice and the evidence of a possible trepanation may represent an interesting
24 case of study, contributing with a new evidence of neurosurgical treatments during Italian Bronze Age.

25

26 MATERIALS AND METHODS

27 Materials – Archaeological context

28 Excavations in Castello del Tartaro (Verona, Northern Italy) led to the discovery in 1989 of a necropolis of
29 several hundred burials, dated to the Recent Bronze Age (14th-12th centuries BCE) and located about 100
30 meters Northwest from the archaeological remains of a settlement. Likely other necropolis from the Recent
31 Bronze Age Veneto, this site presents the coexistence of two different mortuary practices (inhumation and
32 cremation)^{25,26}. Burials are mostly oriented in West-East direction, and some of them are associated with
33 burial goods (bronze rings, earrings and brooches). Several graves show clear differences in the funerary
34 practice compared to the others from the same site, and can be thus defined as deviant burials. Among these,
35 Burial 396 was also characterized by the presence of a sub-circular traumatic evidence, identified as a
36 probable frontal trepanation.

37

38 Methods

39 The anthropological analysis of the skeleton from Burial 396 was carried out at the Laboratory of Archaeo-
40 Anthropology and Forensic Anthropology of the University of Ferrara (Italy). The human rests underwent
41 through cleaning and restoration processes before the biological profile of the individual could be
42 determined. Due to the fragmentation of the skeletal remains, estimation of the age at death was carried out
43 on dental features (i.e., degrees of development, eruption, and wear)²⁷⁻³⁰, stages of ossification of cranial
44 sutures^{29,31} and stages of epiphyseal-diaphyseal fusion^{29,30,32}. Sex determination of the individual was
45 performed by applying morphologic methods^{29,32,33}. We undertook differential diagnosis of the traumatic
46 lesion following classical anthropological standards^{11,34-39}, in order to establish the nature of the wound and
47 to assess whether it was inferred ante-mortem, peri-mortem or post-mortem. To this purpose, we have also
48 conducted a microscopic study on the wound's margins using a Leica Stereozoom[®] S6D stereomicroscope at
49 12.5x magnification equipped with a digital camera for image acquisition.

50 RESULTS

51 Anthropological analysis have shown that skeletal remains from Burial 396 belonged to an adult female (25-
52 35 years of age), who was buried in a prone position, and East-West oriented. The skeleton was fragmented,
53 yet the original burial position and anatomical connections were maintained: the right upper limb was
54 observed to be aligned to the body, and the left one was located beneath the thorax, while the lower limbs
55 were outstretched with the knees closed together, and the dorsal portion of the feet facing the ground (Fig.

56 1A); the head was oriented facing South. The body position undoubtedly indicates a prone deposition of the
57 corpse. Underneath the right humerus two bronze double-spiral pins were found, and a small amber bead
58 was placed over the head (Fig. 1B). No pathological feature was detected, apart from some dental features
59 (accented wear especially on incisors and canines; linear enamel hypoplasia on incisors, and visible pits of
60 C¹ dentition).

61 Despite the poor conditions of preservation of the skeleton, we observed evidences of a penetrating injury on
62 the left side of the frontal bone above the supraorbital margin (Fig. 2-3), exhibiting an oval shape and a
63 tronco-conical section with irregular and rounded edges, as well as a slight introflexion inwards. The
64 maximum diameter of the lesion (on transverse axis) measures 19 mm on the ectocranial surface and 12 mm
65 on the endocranial surface. On the frontal view, the slope of the edge gradually decline close to the left *tuber*
66 *frontalis*. A taphonomic origin of the hole was excluded by the bone pigmentation and its general features,
67 while the total absence of healing or inflammatory processes suggests the peri-mortem nature of the
68 injury^{34,36,37,40}, and indicates that the woman did not survive the traumatic event.

70 DISCUSSION

71 The cranial wound shows features related to a perforating injury; more specifically, several typical traits of a
72 trepanation have been observed. The oval shape and the rounded margins of the lesion, along with the slight
73 introflexion from the outer table to the endocranial vault may indicate a trepanation applied with scraping
74 technique. This procedure is the most ancient documented typology of trepanation¹¹ and is usually performed
75 using mineral, shell or metal scrapers, which produce rounded and oval openings in the neurocranium due to
76 a controlled rotatory movement on the cranial surface, until a hole is created^{11,39,41}. The peri-mortem nature
77 of the injury is confirmed by the absence of healing processes, suggesting that the death of the woman
78 occurred during the intervention or at least within five days from the surgical treatment^{36,37,40}. Many studies
79 point out that trepanation was applied in case of traumatic injuries or pathological disorders and discourages
80 its association with ritual practices (at least in ante-mortem and peri-mortem cases)^{3,42,43}. Thus, it is
81 reasonable to hypothesize that the cause of death of this woman was due to a traumatic event or a
82 pathological condition which cannot be observed on the skeletal remains, either because of the bad condition

83 of preservation or because of the nature of the pathology itself. The cause of death may also be represented
84 by a bad outcome of the surgical treatment, since direct injury to the brain may occur during trepanation
85 processes⁴⁴; hemorrhage or severe and fast infection processes could have also been likely consequences of
86 ancient trepanations, due to the absence of aseptic conditions during the surgery⁴⁵. Though, in most cases, it
87 is impossible to establish with certainty the reason for a trepanation observed on skeletal remains¹².

88 A peculiar trait of this case is represented by the association of the trepanation with a deviant burial.
89 Abnormal burials, i.e. deviant, are those which differ from the normative burial ritual of the respective
90 period, region or cemetery^{24,46}. Indubitably, the majority of the burials in Castello del Tartaro are supine
91 single inhumations with the head facing the West-East direction, while 2 out of more than 700 graves host
92 bodies in prone position. Thus, it sounds reasonable to consider the case presented in this study a proper
93 deviant burial.

94 Specifically, the phenomenon of prone burials is widely documented, attesting more than 600 cases from
95 Prehistory to the Contemporary era^{47,48}, and usually occurs in European necropolis with victims of violence
96 or execution or individuals presenting disabilities, diseases or abnormalities⁴⁹⁻⁵¹. Its occurrence is generally
97 associated with an intention of careless and contempt towards the interred body^{47,49}. Evidences of prone
98 depositions have been documented in the European, in general, and Italian, in particular, archaeological
99 record⁵²⁻⁵⁶. Usually, a clear difference between an intentional and a careless or casual prone burial is
100 detectable, indicating a possible funerary practice in the first case, and haste or inaccuracy in the latter⁴⁹. An
101 intentional prone deposition can be identified by several distinctive elements, which are usually considered
102 as signs of differentiation or marginality of the individual compared to his or her community^{46,50,51,57}: the use
103 of an anomalous tomb structure; the liminality of a prone burial, which is usually located far from the rest of
104 the necropolis; the presence or absence and position of burial goods compared to other burials in the area; the
105 presence of traumatic or pathological evidences. Conversely, prone burials from hasty interment usually
106 present features such as shallow pits, limbs forming unnatural angles and absence of burial goods⁵⁰.

107 This case presents all typical characteristics of an intentional prone interment: the woman was placed at the
108 edge of the necropolis, far from the rest of the graves; only a few other burials were found in association with
109 burial goods beside Burial 396, which was the only one presenting an amber bead; the evidence of
110 trepanation suggests a particular medical condition, or at least a sign of traumatic violence on the individual.

111 Therefore, given the presence of several unique elements and the absence of post-mortem disturbing factors
112 in the burial context, the hypothesis of an intentional prone burial sounds plausible.

113 Similarly to Burial 396 of Castello del Tartaro, Burials 56 and 255 from the Bronze Age necropolis of Olmo
114 di Nogara (Verona, Italy)⁵⁸ show intentional prone positions with upper limbs crossed under the chest and
115 lower limbs closed to each other. This recurrence in a similar cultural context may indicate a particular
116 funerary habit, which was recurrent in Bronze Age cemeteries of the region. Differently, Burial 61 from
117 Gazzo Veronese and a case from Oppeano (Verona, Italy)^{58,59} show a different depositional context, which
118 indicates an urge to throw a sprawled body into the pit, rather than a customary funerary practice.

119 Other cases of trepanation from the same period are also well documented: several findings from the Bronze
120 Age Greece^{1,60,61}, from the Anatolian area^{62,63} and also from Italy^{3,6,20,64-66} attest the wide diffusion of this
121 neurosurgical practice in Bronze Age Europe. Among the numerous cases of prone deposition and
122 trepanation, this is the first case of association between a surgical treatment and a deviant burial known by
123 now in Italy. We can only point out that an association between trepanation and a different orientation of the
124 skull has been reported for a Celtic burial from Casalecchio di Reno (Bologna, Italy, 4th-3rd Century BC);
125 since the individual was the only body of the necropolis being buried facing the East direction, authors
126 suggested a ritual correlation with the depositional method and the presence of a trepanation⁶⁷. A similar case
127 from Jericho (Tomb G88, 2200-2000 cal. BC) presents the association of deviant burial and evidence of four
128 trepanations on an adult male individual suffering from a peculiar set of pathological conditions⁶⁸. As
129 proposed by the author, the physical condition of the individual may have altered his relationship with the
130 community, and the abnormal perception of the man may be reflected by the different burial assessment.

131 Prone burials and disabilities may sometimes be found in association^{48,49,51}, although the possible lack of
132 bone alterations and the scarceness of cases of disabilities themselves make this relation an extremely rare
133 finding in the archaeological record. It could be of interest to note how Blake (1918) in a study of the Irish
134 folklore⁶⁹ reported that epileptics were referred as "*talmáidheach*" ("*one prone to the earth*"), due to their
135 tendency to land face down during seizures. Considering the most common reasons for trepanation
136 (schizophrenia, epilepsy and seizures, cephalgia and neurological disorders connected to high intracranial
137 pressure, among others)^{11,12,39,44,70}, it may not be excluded that one of these disorders affected the woman. If
138 therapeutic-magic motivations are invoked in the case of no traumatic evidence⁴⁴, *a fortiori* these may be

139 considered a valid explanation for surgeries performed in Prehistory on individuals who were then buried
140 with anomalous modalities.

141 Apart from interpretative matters, the case of Burial 396 from Castello del Tartaro represents a rare bird in
142 the documented archaeological record, which offers new perspectives on the history of neurosurgical
143 treatments during ancient ages.

144

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- 150 1. Alusik T. Skull Trepanations in Bronze Age Greece: An Archaeologist's View. *World Neurosurg.*
151 2015;84(2):214-217. doi:10.1016/j.wneu.2015.02.010
- 152 2. Guinto G, Guinto-Nishimura Y. Ancient trepanations. *World Neurosurg.* 2014;81(2):298-299.
153 doi:10.1016/j.wneu.2013.02.048
- 154 3. Giuffra V, Fornaciari G. Trepanation in Italy: A Review. *Int J Osteoarchaeol.* 2017;27(5):745-767.
155 doi:10.1002/oa.2591
- 156 4. Goodrich JT. The ancient art of trepanation - A Greek bronze age "hole in the skull." *World*
157 *Neurosurg.* 2014;81(2):296-297. doi:10.1016/j.wneu.2013.02.047
- 158 5. Pasini A, Manzon VS, Gonzalez-Muro X, Gualdi-Russo E. Neurosurgery on a Pregnant Woman with
159 Post Mortem Fetal Extrusion: An Unusual Case from Medieval Italy. *World Neurosurg.* 2018;113:78-
160 81. doi:10.1016/j.wneu.2018.02.044
- 161 6. Petrone P, Niola M, Di Lorenzo P, et al. Early medical skull surgery for treatment of post-traumatic
162 osteomyelitis 5,000 years ago. *PLoS One.* 2015;10(5):7-11. doi:10.1371/journal.pone.0124790
- 163 7. Moghaddam N, Mailler-Burch S, Kara L, Kanz F, Jackowski C, Lösch S. Survival after trepanation-
164 Early cranial surgery from Late Iron Age Switzerland. *Int J Paleopathol.* 2015.
165 doi:10.1016/j.ijpp.2015.08.002
- 166 8. Lv X, Li Z, Li Y. Prehistoric skull trepanation in china. *World Neurosurg.* 2013;80(6):897-899.
167 doi:10.1016/j.wneu.2012.08.009
- 168 9. De Divitiis E. The prehistoric practice of trepanation. *World Neurosurg.* 2013;80(6):821-823.
169 doi:10.1016/j.wneu.2013.01.069
- 170 10. Vasilyev S V, Sviridov AA. Trepanation and enlarged parietal foramen on skulls from the Loyalty
171 Islands (Melanesia). *Acta Med Hist Adriat.* 2017;15(1):67-72.
- 172 11. Verano JW. Differential diagnosis: Trepanation. *Int J Paleopathol.* 2017.

- 173 doi:10.1016/j.ijpp.2017.03.004
- 174 12. Arnott R, Finger S, Smith C. *Trepanation: History, Discovery, Theory*. (Arnott R, Finger S, Smith C,
175 eds.). Swets & Zeitlinger Publisher; 2003.
- 176 13. González-darder JM. Cranial trepanation in primitive cultures. *Neurocirugia*. 2017;28(1):28-40.
177 doi:10.1016/j.neucie.2016.04.001
- 178 14. Tsoucalas G, Kousoulis AA, Mariolis-sapsakos T, Sgantzios M. Trepanation Practices in Asclepieia :
179 Systematizing a Neurosurgical Innovation. *World Neurosurg*. 2017;103:501-503.
180 doi:10.1016/j.wneu.2017.04.022
- 181 15. Facchini F, Rastelli E, Ferrero L, Fulcheri E. Cranial trepanation in two skulls of early medieval Italy.
182 *HOMO - J Comp Hum Biol*. 2003;53(3):247-254. doi:10.1078/0018-442X-00047
- 183 16. Riccomi G, Fornaciari G, Vitiello A, Bini A, Caramella D, Giuffra V. Trepanation to Treat a Head
184 Wound: A Case of Neurosurgery from 13th-Century Tuscany. *World Neurosurg*. 2017;104:9-13.
185 doi:10.1016/j.wneu.2017.04.160
- 186 17. Ramirez Rozzi F, Froment A. Earliest Animal Cranial Surgery: from Cow to Man in the Neolithic.
187 *Sci Rep*. 2018;8(1):5536. doi:10.1038/s41598-018-23914-1
- 188 18. Málaga MRP, Makowski K. Bioarchaeological evidence of care provided to a physically disabled
189 individual from Pachacamac , Peru. *Int J Paleopathol*. 2018;(May):1-11.
190 doi:10.1016/j.ijpp.2018.08.002
- 191 19. Tulumello G, Riccomi G, Minozzi S, Longo S, Longo M, Giuffra V. Linear Cutting Trepanation in
192 Italy: A Unique Case from Hellenistic Sicily (Third Century BC). *World Neurosurg*. 2018.
193 doi:10.1016/j.wneu.2018.05.058
- 194 20. Baggieri G, Di Giacomo M. A trepanned skull of the Eneolithic Age from Palombara Sabina (Rome).
195 *Paleopathol Newsl*. 2004;125:9-10.
- 196 21. Baggieri G, Di Giacomo M. New cases of trepanation. In: Arnott R, Finger S, Smith C, eds.

- 197 *Trepanation: History, Discovery, Theory*. Lisse: Swets & Zeitlinger Publishers; 2003:137-146.
- 198 22. Charlier P, Brun L, Pantano W, Catalano P, Augias A, Huynh-Charlier I. An incomplete fatal
199 trepanation diagnosed on cremation remains (Rome, Italy, 2nd c. AD). *Acta Med Hist Adriat*.
200 2014;12(2):315-320.
- 201 23. Giuffra V, Fornaciari G. Pulverized human skull in pharmacological preparations: Possible evidence
202 from the “martyrs of Otranto” (southern Italy, 1480). *J Ethnopharmacol*. 2015;160:133-139.
203 doi:10.1016/j.jep.2014.11.042
- 204 24. Murphy EM, ed. *Deviant Burial in the Archaeological Record*. Oxford, UK; Oakville, USA: Oxbow
205 Books; 2008.
- 206 25. De Marinis RC. Riti funerari e problemi di paleo-demografia dell’antica età del Bronzo nell’Italia
207 settentrionale. *Not Archeol bergomensis*. 2003;11:5-78.
- 208 26. Salzani L, Donati R, Gualdi-Russo E. Dati antropologici preliminari su alcune sepolture del Bronzo
209 recente provenienti dalla necropoli di Castello del Tartaro (Verona). In: Leonardi G, Tiné V, eds.
210 *Studi Di Preistoria e Protostoria 2 - Preistoria e Protostoria Del Veneto*. Firenze: Istituto Italiano di
211 Preistoria e Protostoria; 2015:777-780.
- 212 27. Brothwell DR. *Digging up Bones. The Excavation, Treatment and Study of Human Skeletal Remains*.
213 London: British Museum (Natural History), Cornell University Press; 1981.
- 214 28. Lovejoy CO. Dental wear in the Libben population: Its functional pattern and role in the
215 determination of adult skeletal age at death. *Am J Phys Anthropol*. 1985.
216 doi:10.1002/ajpa.1330680105
- 217 29. Buikstra JE, Ubelaker DH. *Standards for Data Collection From Human Skeletal Remains*. Arkansas
218 Archaeological Survey Research Series; 1994. doi:10.1002/ajhb.1310070519
- 219 30. Ubelaker DH. *Human Skeletal Remains: Excavation, Analysis, Interpretation*. 2nd ed. Washington
220 DC: Taraxacum; 1989.

- 221 31. Holck P. Estimation of age. In: *Cremated Bones: A Medical-Anthropological Study of an*
222 *Archaeological Material on Cremation Burials. Antropologiska Skrifter, Volume 1.* 3rd ed. University
223 of Oslo; 1997:61-72.
- 224 32. Ferembach D, Schwydeski I, Stloukal M. Recommendations for age and sex diagnoses of skeletons. *J*
225 *Hum Evol.* 1980;9:517-549.
- 226 33. Acsádi, G., Nemeskéri J. *History of Human Life Span and Mortality.* Budapest: Akadémiai Kiadó;
227 1970.
- 228 34. Lovell NC. Trauma Analysis in Paleopathology. *Yrbk Phys Anthr.* 1997;40:139-170.
- 229 35. Konstantinos Moraitis. Identification and Differential Diagnosis of Perimortem Blunt Force Trauma
230 in Tubular Long Bones. *Forensic Sci Med Pathol.* 2006;2(3):165. doi:10.1385/Forensic
- 231 36. Sauer NJ. Manner of Death: Skeletal Evidence of Blunt and Sharp Instrument Wounds. In: Rathbun
232 TA, Buikstra JE, eds. *Human Identification: Case Studies in Forensic Anthropology.* Springfield (IL):
233 Charles C Thomas; 1984:177-184.
- 234 37. Sauer NJ. The Timing of Injuries and Manner of Death: Distinguishing Among Antemortem,
235 Perimortem and Postmortem Trauma In: Reichs, K. J., ed. In: Reichs KJ, ed. *Forensic Osteology:*
236 *Advances in the Identification of Human Remains.* Springfield (IL): Charles Thomas Publisher;
237 1998:321-332.
- 238 38. Kimmerle EH, Baraybar JP. *Skeletal Trauma: Identification of Injuries Resulting from Human Rights*
239 *Abuse and Armed Conflict.* Boca Raton: CRC Press; 2008. doi:10.1007/s12024-008-9048-6
- 240 39. P. J. Ortner. *Identification of Pathological Conditions in Human Skeletal Remains.*; 2003.
- 241 40. Barbian LT, Sledzik PS. Healing following cranial trauma. *J Forensic Sci.* 2008;53(2):263-268.
242 doi:10.1111/j.1556-4029.2007.00651.x
- 243 41. Kirkup J. The evolution of cranial saws and related instruments. In: Arnott R, Finger S, Smith C, eds.
244 *Trepanation: History, Discovery, Theory.* Lisse: Swets and Zeitlinger; 2003:290-304.

- 245 42. Martin G. Why trepan? Contributions from medical history and the South Pacific. In: Arnott R,
246 Finger S, Smith C, eds. *Trepanation: History, Discovery, Theory*. Lisse: Swets and Zeitlinger;
247 2003:323-345.
- 248 43. Gross CC. Trepanation from the paleolithic to the internet. In: Arnott R, Finger S, Smith C, eds.
249 *Trepanation: History, Discovery, Theorytheory*. Lisse: Swets and Zeitlinger; 2003:307–322.
- 250 44. Kushner DS, Verano JW, Titelbaum AR. Trepanation Procedures/Outcomes: Comparison of
251 Prehistoric Peru with Other Ancient, Medieval, and American Civil War Cranial Surgery. *World*
252 *Neurosurg*. 2018;114:245-251. doi:10.1016/j.wneu.2018.03.143
- 253 45. O' Donnabhaim B. Trepanation and pseudo trepanation: evidences of cranial surgery from prehistoric
254 and early historic Ireland. In: Arnott R, Finger S, Smith C, eds. *Trepanation: History, Discovery,*
255 *Theory*. Swets & Zeitlinger Publisher; 2003:79-94.
- 256 46. Aspöck E. What actually is a 'Deviant Burial'? Comparing German-language and anglophone
257 research on 'Deviant Burials.' In: Murphy EM, ed. *Deviant Burial in the Archaeological Record*.
258 Oxbow Books; 2008:17-34.
- 259 47. Zamboni L, Zanoni V. Giaciture non convenzionali in Italia nord-occidentale durante l'età del Ferro.
260 In: Belcastro MG, Ortalli J, eds. *Sepulture Anomale. Indagini Archeologiche Ed Antropologiche*
261 *Dall'epoca Classica Al Medioevo in Emilia Romagna*. Borgo S. Lorenzo (Firenze): All'Insegna del
262 Giglio; 2010:147-160.
- 263 48. Arcini C. Buried Face Down. *Curr Archaeol*. 2009;231:30-35.
- 264 49. Taylor A. Aspects of deviant burial in Roman Britain. In: Murphy EM, ed. *Deviant Burial in the*
265 *Archaeological Record*. Oxford, UK; Oakville, USA: Oxbow Books.; 2008:91-114.
- 266 50. Perego E. Anomalous mortuary behaviour and social exclusion in Iron Age Italy: a case study from
267 the Veneto region. *J Mediterr Archaeol*. 2018;27(2):161-186. doi:10.1558/jmea.v27i2.161
- 268 51. Saracino M, Perego E, Zamboni L. Funerary deviancy and social inequality in protohistoric Italy:

- 269 what the dead can tell. *Preist Alp*. 2017;49(February):73-83.
- 270 52. Ortalli J. Morti inquiete e tombe anomale tra storia, antropologia e archeologia. In: Belcastro MG,
271 Ortalli J, eds. *Sepulture Anomale. Indagini Archeologiche Ed Antropologiche Dall'epoca Classica Al*
272 *Medioevo in Emilia Romagna*. Borgo S. Lorenzo (Firenze): All'Insegna del Giglio; 2010:23-38.
- 273 53. Mainardi S, Pacciani E. Nota antropologica sullo scheletro umano rinvenuto a Castenaso-via Gramsci
274 nella struttura η. In: Forte M, Von Eles P, eds. *La Pianura Bolognese Nel Villanoviano. Insediamenti*
275 *Della Prima Età Del Ferro. Catalogo Della Mostra Archeologica Di Villanova Di Castenaso (1994-*
276 *1995)*. Firenze: All'Insegna del Giglio; 1994:213-217.
- 277 54. Forte M. Lo scavo dell'insediamento di Castenaso-via Gramsci: le strutture (1981). In: Forte M, Von
278 Eles P, eds. *La Pianura Bolognese Nel Villanoviano. Insediamenti Della Prima Età Del Ferro.*
279 *Catalogo Della Mostra Archeologica Di Villanova Di Castenaso (1994-1995)*. Firenze: All'Insegna
280 del Giglio; 1994:193-199.
- 281 55. Giot P-R. Trépanations de la nécropole gauloise de Saint-Urmel en Plomeur. *Bull Mem Soc Anthropol*
282 *Paris*. 1949;10(1):59-69. doi:10.3406/bmsap.1949.2849
- 283 56. de Pennery P. Rencontre des civilisations Danubienne et SOM dans la haute vallée de la Seine. Les
284 sépultures de Mousseaux-les-Bray. *Bull la Société préhistorique française*. 1964;61(1):124-134.
285 doi:10.3406/bspf.1964.3976
- 286 57. Gardeła L. Face down: the phenomenon of prone burial in Early Medieval Poland. *Analecta Archaeol*
287 *Ressoviensia*. 2015;10:99-136.
- 288 58. Salzani L. *La Necropoli Dell'età Del Bronzo All'Olmo Di Nogara*. Verona: Comune di Verona; 2005.
- 289 59. Salzani L, Casarotto F, Cherubini V, Rosi S, Starita I. Le campagne di scavo della Soprintendenza.
290 In: Guidi A, Salzani L, eds. *Oppeano. Vecchi e Nuovi Dati Sul Centro Proto Urbano*. Canova,
291 Venezia; 2008:21-115.
- 292 60. Papagrigorakis MJ, Toulas P, Tsilivakos MG, et al. Neurosurgery during the Bronze Age: A skull

- 293 trepanation in 1900 BC Greece. *World Neurosurg.* 2014;81(2):431-435.
294 doi:10.1016/j.wneu.2013.01.044
- 295 61. Mountrakis C, Georgaki S, Manolis SK. A trephined late bronze age skull from peloponnesus,
296 Greece. *Mediterr Archaeol Archaeom.* 2011;11(1):1-8.
- 297 62. Mogliazza S. An example of cranial trepanation dating to the middle bronze age from Ebla, Syria. *J*
298 *Anthropol Sci.* 2009;87(February 2009):187-192.
- 299 63. Erdal YS, Erdal ÖD. A review of trepanations in Anatolia with new cases. *Int J Osteoarchaeol.*
300 2011;21(5):505-534. doi:10.1002/oa.1154
- 301 64. Germanà F, Di Salvo M. Il cranio trapanato di Stretto Partanna nel quadro delle pratiche chirurgiche
302 di epoca preistorica. In: Tusa S, ed. *La Preistoria Del Basso Belice e Della Sicilia Meridionale Nel*
303 *Quadro Della Preistoria Siciliana e Mediterranea.* Palermo: Società di Storia Patria; 1994:411-422.
- 304 65. Piombino-Mascoli D, Bartoli F, Mallegni F, Fornaciari G. I crani trapanati preistorici di Saint-Martin-
305 de-Corléans (2300–1900 a.C.). In: Pessina A, Visentini P, eds. *Preistoria Dell'Italia Settentrionale.*
306 *Studi in Ricordo Di Bernardino Bagolini. Atti Del Convegno Udine.* Edizioni del Museo Friulano di
307 Storia Naturale; 2006:555-562.
- 308 66. Capasso L, Michetti E, Pierfelice L, D'Anastasio R. Neurosurgery 7000 years ago in central Italy.
309 *Lancet.* 2002;359(9324):2206. doi:10.1016/S0140-6736(02)09084-0
- 310 67. Pancaldi P, Raggi N. La tomba 23 della necropoli celtica (IV-III sec. a. C.) di Casalecchio di Reno
311 (Bo). In: Belcastro MG, Ortalli J, eds. *Sepulture Anomale. Indagini Archeologiche Ed Antropologiche*
312 *Dall'epoca Classica Al Medioevo in Emilia Romagna.* Borgo S. Lorenzo (Firenze): All'Insegna del
313 Giglio; 2010:69-83.
- 314 68. Shay T. Differentiated treatment revealed in anthropological of deviancy at death as and
315 archeological material. *J Anthropol Archaeol.* 1985;4:221-241.
- 316 69. Blake MR. Folk Lore. *J Cty Louth Archaeol Soc.* 1918;4:217-225.

- 317 70. Roberts C, Manchester K. *The Archaeology of Disease*. New York: Cornell University Press Ithaca;
318 2007.

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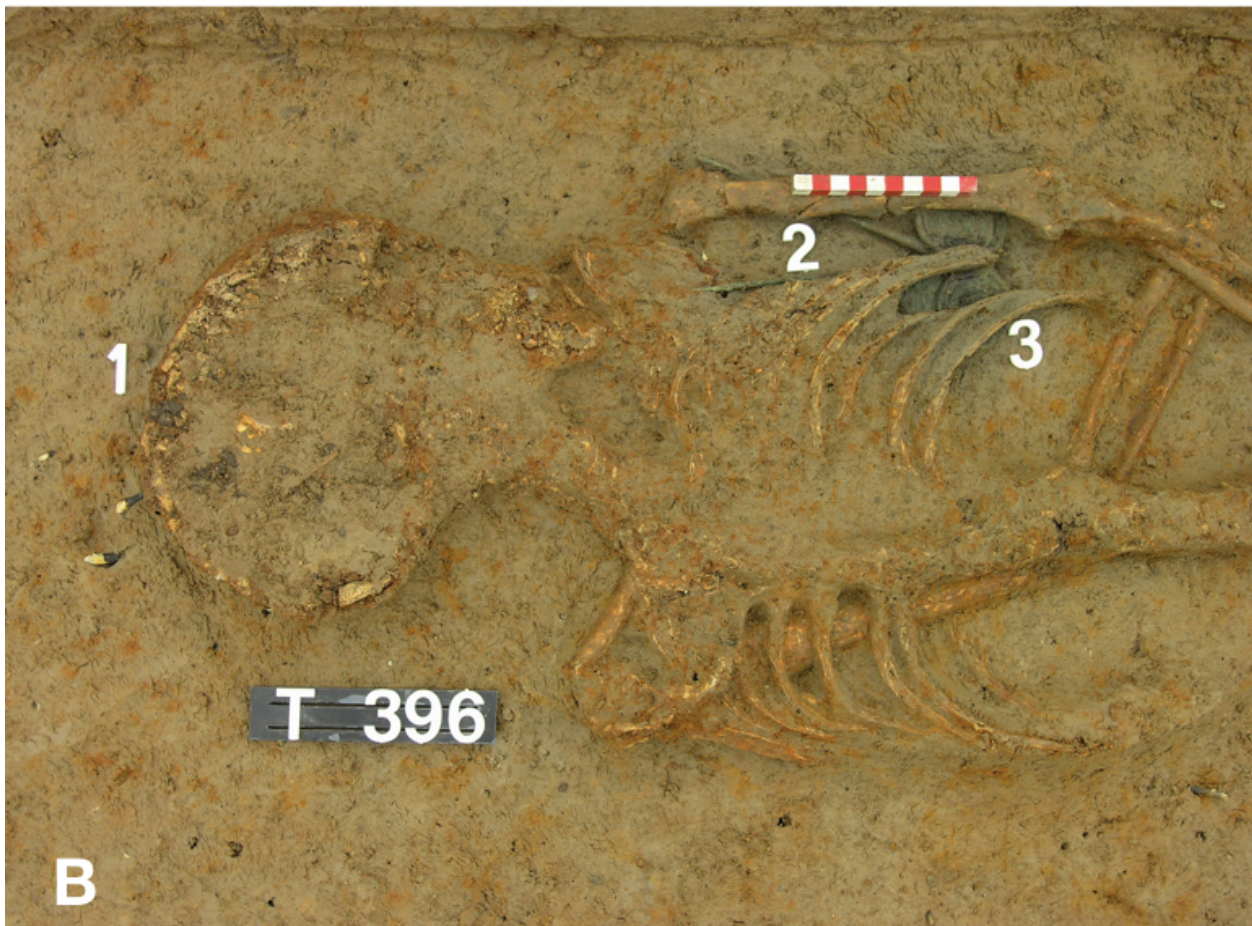
321 **Figures captions**

322 **Fig 1:** Individual from the grave 396 and details of grave goods. The prone position is clearly detectable
323 from the upper limbs, which are located underneath the trunk.

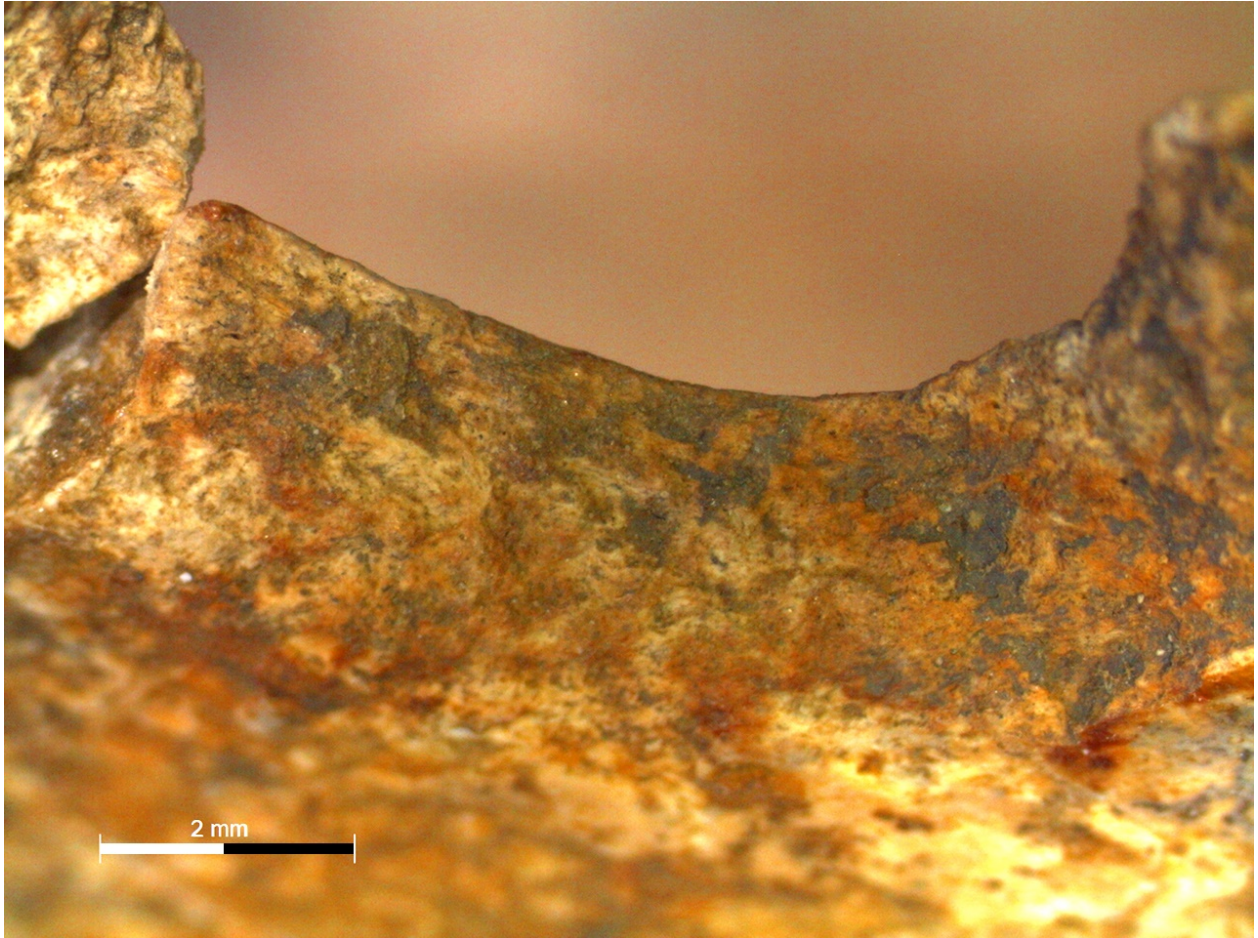
324 **Fig 2:** A) The neurocranium after restoration process; the perforation is highlighted by the white square; B)
325 detail of the traumatic evidence.

326 **Fig 3:** 12.5x magnification of the inner section of the lesion. Rounded edges and absence of bone healing
327 processes suggest an ante-mortem nature of the injury. Images at stereomicroscope Leica® S6D.

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Abbreviations list

There aren't abbreviations in this manuscript.

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