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INJURY CHARACTERISTICS FROM THE POLÁKY-DOLANY SITE: PATTERNS, PREVALENCE AND VIOLENCE-RELATED TRAUMA IN A SMALL EARLY MEDIEVAL BOHEMIAN VILLAGE

JOANNA WITAN – VĚRA SUŠICKÁ

Abstract: *The Poláky-Dolany (Chomutov district) site represents one of a few villages in Bohemia that have been archaeologically studied based on the discovery of an early mediaeval cemetery. According to archaeological evidence, the settlement existed in the 11th century. Nevertheless, in the late 1960s the whole village was demolished due to the construction of the Nechranice Reservoir. Subsequently, the surrounding area was flooded, which significantly hampered research on the site. The archaeological excavation took place during the very dry years of 2015 and 2018, when the water level in the reservoir dropped so much that a large part of the burial site could be explored. Archaeological data indicates that the Dolany inhabitants were farmers benefiting from the nearby river, and they ran a local smithy. This study, conducted on individuals buried in the cemetery of the above-mentioned village based on skeletal trauma seeks to supplement the information about daily life and the dangers that the individuals buried on the Poláky-Dolany site had to face. Signs of trauma were found in 20/119 individuals; the majority of them were accident-related. However, the trauma that was probably associated with violence also occurred.*

Key words: *fracture – accident – occupational hazard – rural population – North-west Bohemia – Poláky-Dolany.*

Charakteristika zranění z lokality Poláky-Dolany: vzorce, prevalence a násilná traumata v malé raně středověké české vesnici

Abstrakt: *Lokalita Poláky-Dolany (okr. Chomutov) představuje jednu z mála vesnic v Čechách, která byla archeologicky zkoumána především díky objevu raně středověkého pohřebiště. Podle archeologických nálezů poblíž existovala osada již v 11. století. Nicméně koncem 60. let 20. století byla celá vesnice Dolany zbořena kvůli výstavbě Vodní nádrže Nechranice. Následně bylo okolí zatopeno, což značně ztížilo výzkum lokality. Záchranný archeologický výzkum zde probíhal v průběhu velmi suchých let 2015 a 2018, kdy hladina vodní nádrže klesla natolik, že bylo možné velkou část pohřebiště prozkoumat. Archeologické údaje naznačují, že obyvatelé Dolan byli zemědělci, čerpali užitek z nedaleké řeky a provozovali místní kovárnu. Tato studie se na základě kosterních úrazových změn u jedinců pohřbených na hřbitově výše zmíněné vesnice snaží doplnit informace o každodenním životě a nebezpečích, kterým museli jedinci pohřbení v Dolanech čelit. Známky úrazu byly nalezeny u 20 jedinců; většina z nich souvisela s nehodami. Vyskytla se však i zranění pravděpodobně spojená s násilím.*

Klíčová slova: *zlomenina – nehoda – nebezpečná povolání – venkovské populace – severozápadní Čechy – Poláky-Dolany.*

1 Introduction

Palaeopathological analyses have always been one of the important elements in the anthropological analysis of human remains. One of the most common groups of palaeopathological lesions in an archaeological context is trauma. In analyses, fractures are used to identify injuries in individuals but it is rare that non-violence-related fractures are used to generate population-level injury characteristics (Larsen 1997). For the past decades scientists involved in the broad study of archaeological populations have been using trauma analysis to better understand the causes, mechanisms or reflexes that are specific to a particular type of fracture, sharp-force trauma or blunt-force trauma (Lovell 2008). A detailed analysis of the incidence and types of injury is a valuable source of information on daily activities, environment as well as social behaviour including caring for the injured person (Grauer–Roberts 1996). Additionally, specific practices in different cultures, such as skull modifications or foot restraints, can be considered post-traumatic changes (Mayall et al. 2017; Molnár 2014 et al.) or therapeutic practices as it was recognised

e.g. trepanation (Lorkiewicz et al. 2018; Roberts–McKinley 2003). Specifying the mechanism of trauma is extremely important to determine its immediate cause. It usually concerns the identification of whether the injury was caused by an accident or by deliberateviolence. Many authors emphasise that the majority of the observed trauma is strongly associated with accidents in daily activities or is directly related to the performed occupation (Molleson 2007; Capasso et al. 1998). In the Middle Ages differences in the prevalence and patterns of injury between urban and rural areas started to become apparent, which confirms that their inhabitants were exposed to a different type of injury risk by their lifestyle and type of work (Agnew et al. 2015). Dittmar et al. (2020) note factors that might imply the increased risk of injury and these are: the performance of physical work (unskilled workers), socio-economic protection from the dangers of everyday life (which are not experienced by poorer people) and the general level of aggressive/assertive behaviour experienced, which is observed in greater severity for male individuals. The improved preservation and greater availability of bone material in studied modern and historical populations allows to create a complete trauma characterisation that reliably describes their quality of daily life and living conditions (Collier–Primeau 2019).

The investigation and recognition of trauma associated with violence is a rather complex task. Although in cases of perimortem sharp-force trauma it can be inferred that they were inflicted as a result of an act of aggression, in cases of multiple fully healed fractures, e.g. parry fractures or craniofacial fractures, there is some likelihood that they were caused by an unfortunate accident (Judd 2008; Šlaus et al. 2012). Bioarchaeological research in the field of trauma is mainly based on analyses of battlefield casualtie which provide important information on injury patterns associated with aggression (Boucherie et al. 2017; Nicklisch et al. 2017; Novak 2007; Appleby et al. 2015). In addition, contemporary forensic anthropology and medical case studies provide research and numerous guidelines through which individual injuries can be linked to violent actions – e.g. hat brim line, injuries on the left side of the skull vault, etc (Henriques et al. 2023; Kremer et al. 2008). Although obvious evidence of direct interpersonal aggression in archaeological material is relatively rare, Krakowka (2017) and Šlaus with coauthors (2012), shows that interpersonal violence in mediaeval rural and urban populations was a small part of their daily lives.

The early mediaeval period in central Europe is a period of important political and cultural change. The formation and slow stabilisation of early medieval states such as Bohemia and Poland took place back then. This process was hugely influenced by the Holy Roman Empire and Christianity, which was not only adopted by the Slavs but was also modified by the fusion with pagan beliefs and rituals (Tolstaya 2021). While the relationship of the Bohemian Principality with Poland was quite tense and there were frequent battles for a long time over the establishment of borders and dominance in the region (Krafl 2013), the relationship with the Holy Roman Empire was stable, as the state was a vassal of the empire. This dependency, however, contributed to the later rapid development of cities, tradeship and industry under the Přemyslid dynasty.

Before and during the early Middle Ages there is also a twofold transformation of the funerary rites. Cremation burials characteristic for Slavs in central Europe between the second half of the 8th and the beginning of the 10th century were replaced by inhumation which was later organised into row cemeteries close to settlements (Štefan 2007). Likewise, the transition from burials in row cemeteries to burials in cemeteries around churches took place in a long process as it occurred between the 9th and 12th centuries.

An example of a cemetery from the turn of the 11th and 12th century which crowns the tradition of row burial includes the remains of the Dolany cemetery which nowadays belongs to the cadastre of Poláky. Therefore, both names are used in the designation of the archaeological site. The first certain written mention comes from the year 1347 (Sedláček z kinh. Lobkov. v Roudnici; Profous–Svoboda 1947) and 1352 (RDP, 87) so that the existence of the settlement and its cemetery in the 11th century is proved only by archaeological finds . However, the settlement's beginnings can be determined by the oldest pottery found, which corresponds to ceramics from the Hradec u Kadaně stronghold and can be dated to the mid-11th century (Sušická–Derner

2015). Nevertheless, the inhabitants of Dolany were probably mostly peasants engaged mainly in agriculture and small-scale production. No historical evidence of any battles or conflict-related incidents in the area was found, as it was also a time of relative peace in the region (Choc 1967).

The aim of this research is to conduct a comprehensive analysis of the trauma experienced by the inhabitants of the early mediaeval village of Dolany and to show the relationship of the incidence of these injuries to lifestyle, physical labour as well as violent behaviour.

2 Materials and methods

2.1 Site and burials description

The archaeological site of Poláky-Dolany is unique as currently it is located underwater in the southern part of the Nechranice Reservoir (Fig. 1). The reservoir is situated in the north-western Bohemia (Chomutov district, Ústecký Region) and was built on the river Ohře which flows through the region. The remains of the early medieval settlement and the adjacent cemetery lie on a slope of a hill located 500–600 metres north-west from the centre of the Poláky village. Due to the demolition of the village of Dolany during the preparations for the construction of the Nechranice Reservoir in 1967, currently investigated areas belong to the cadastre of Poláky.

First speculations of a cemetery's existence were made in the 1970s when a test of emptying the reservoir was carried out. However, full rescue excavations did not take place at that time. Exceptional droughts in 2015 and 2018 allowed for excavation work conducted by the Institute for the Preservation of Archaeological Heritage of North-west Bohemia. In 2018 the remains of St. Wenceslas' monument were found. It helped to place the archaeological site in space in old aerial photographs and the map of Dolany (Fig. 2).

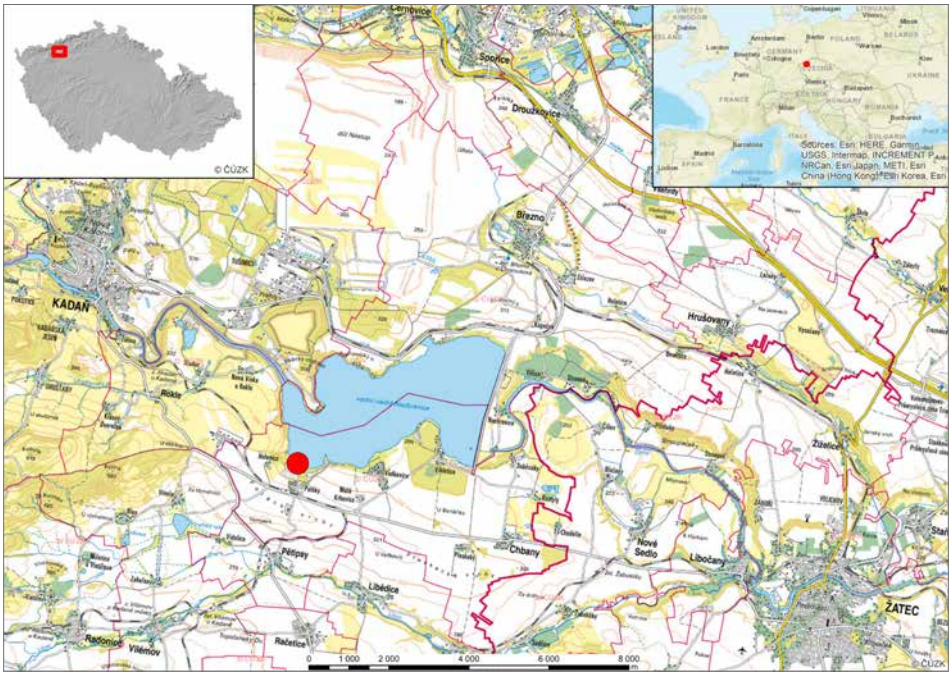

Fig. 1. Geographical location of the site Poláky-Dolany.

Obr. 1. Geografická poloha lokality Poláky-Dolany.

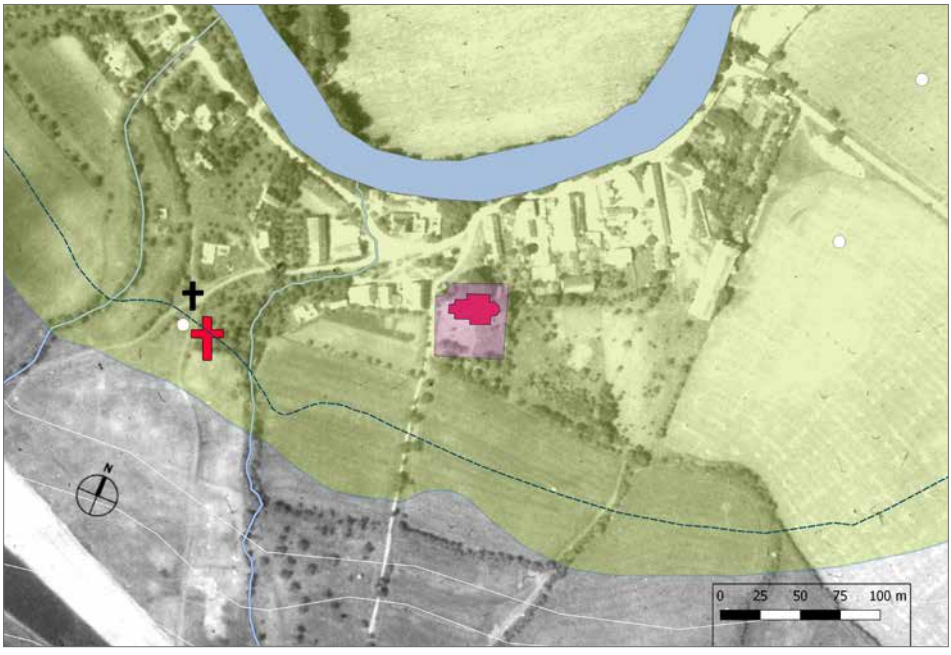

Fig. 2. Location of the excavation on the basis of an aerial map from 1952. In red ground plan – church, red cross – cemetery.
Obr. 2. Poloha výkopu na základě letecké mapy z roku 1952. Červeně půdorys – kostel, červený kříž – pohřebiště.

Due to the nature and purpose of the excavation, which was to rescue as many skeletons as possible, the archaeological excavation was not extended to parts of the settlement. The settlement was characterised mainly by a large number of medium-sized pottery sherds spread over a large area, with a maximum concentration between the burial site and a shallow field cut by a nameless stream. A surface collection of ceramic fragments in a grid of squares helped to establish a theoretical settlement dimension. The settlement occupied the whole area of a wide promontory gently sloping to the north-east between two watercourses. The upper (southern) edge of the settlement may have been formed by the rising slope towards Poláky, the lower one by the steeper slope towards the Ohře River. In the south-eastern part of the settlement there was the site of a (metallurgical) smithy, as evidenced by the large amount of slag. Moreover, the location of the habitation is evidenced by settlement pits present in the immediate vicinity of the graves which do not disturb them (Sušická–Derner 2015; Sušická et al. 2018). The pottery found in the pits (Fig. 3) is consistent with the late Hillfort Period ceramics of Hradec u Kadaně and places the lower dating range in the mid-11th century. In contrast, the youngest rim fragments date the local settlement t to the beginning of the 13th century (Sušická–Derner 2015).

During two research seasons, 13 burial rows were found with 119 regular graves – including one ossuary – H89 (Fig. 4). As a result of water erosion, the skeletons lay very shallow, usually at a depth of 20–40 cm, and are rested in an upright position on their backs with their upper limbs placed along their bodies or with their hands resting on their stomachs. The orientation of the burials was SEE-NWW with slight deviations. Row arrangement of graves as well as S-shaped templerings (Fig. 5) allowed the cemetery to be dated to the 12th century. It is also confirmed by the C^{14} analysis carried out by the Nuclear Physics Institute CAS, which dated samples taken from 6 individuals to the first half of the 11th up to almost the end of the 12th century (Table 1). The cemetery has not been fully excavated so the number of estimated burials may increase in the future. Therefore, the results and interpretations presented in this paper are partial and should be treated with some caution as they are subject to future changes.

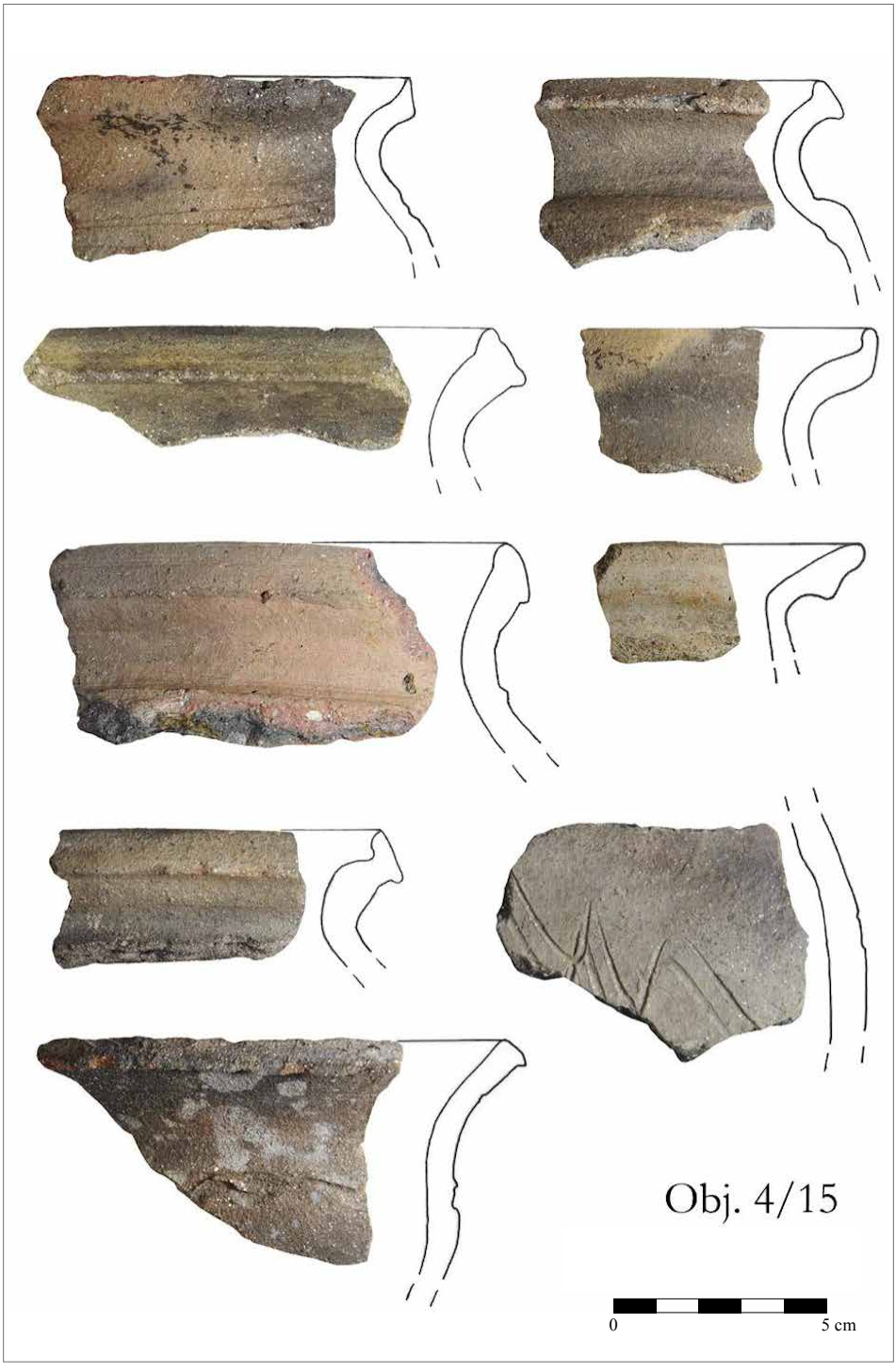

Fig. 3. Selection from the photographic documentation of ceramics from pit 4.

Obr. 3. Výběr z fotodokumentace keramiky z objektu 4.

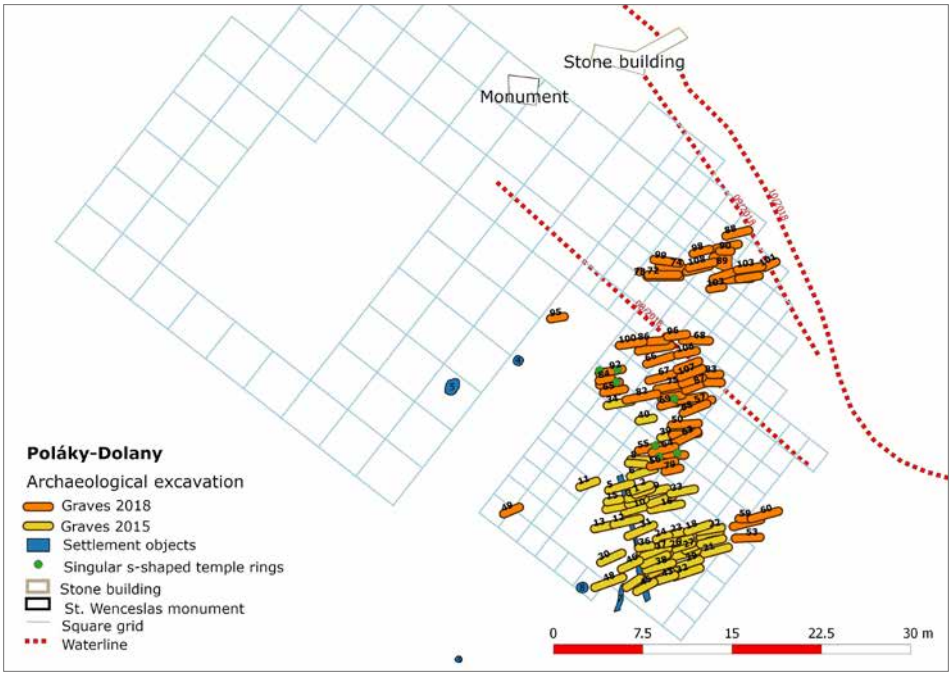

Fig. 4. Plan of the excavation.

Obr. 4. Plán výzkumu.

Tab. 1. C14 results from the Poláky-Dolany cemetery.

Tab. 1. Výsledky C14 ze hřbitova Poláky-Dolany.

No. of sample	Grave number	Collagen concentration (mg/g)	Sex of individual	Age of individual	Conventional radiocarbon age (years BP)	Calibrated age (years AD)	P (%)
20_754	H 43	54	F	20–30	925 ± 16	1040–1165	95
20_755	H 49	55	M	30–50	922 ± 16	1040–1170	95
20_756	H 55	53	N	9–12	975 ± 15	1025–1152	96
20_757	H 59	78	F	16–18	964 ± 15	1029–1154	96
20_758	H 88	169	F	45–55	947 ± 15	1035–1157	96
20_759	H 103b	177	N	5–7	914 ± 15	1044–179	92

Analysis carried out by Department of Radiation Dosimetry Nuclear Physic Institute CAS.

2.2 Osteological material

All of the graves as well as the skeletal remains from the ossuary have been analysed anthropologically. The number of individuals deposited in regular graves was 119 (Table 2), additionally the *Minimum Number of Individuals* (Lambacher et al. 2016) of ossuary was calculated on the basis of completely preserved right femurs, which was finally determined to be 23 individuals.

The material was analysed macroscopically according to research techniques accepted in physical anthropology. Sex was determined in adult individuals, based on the evaluation of the cranial (Stevenson et al. 2009; Buikstra–Ubelaker 1994) and pelvic morphology (Bass 2005; Bruzek 2002).

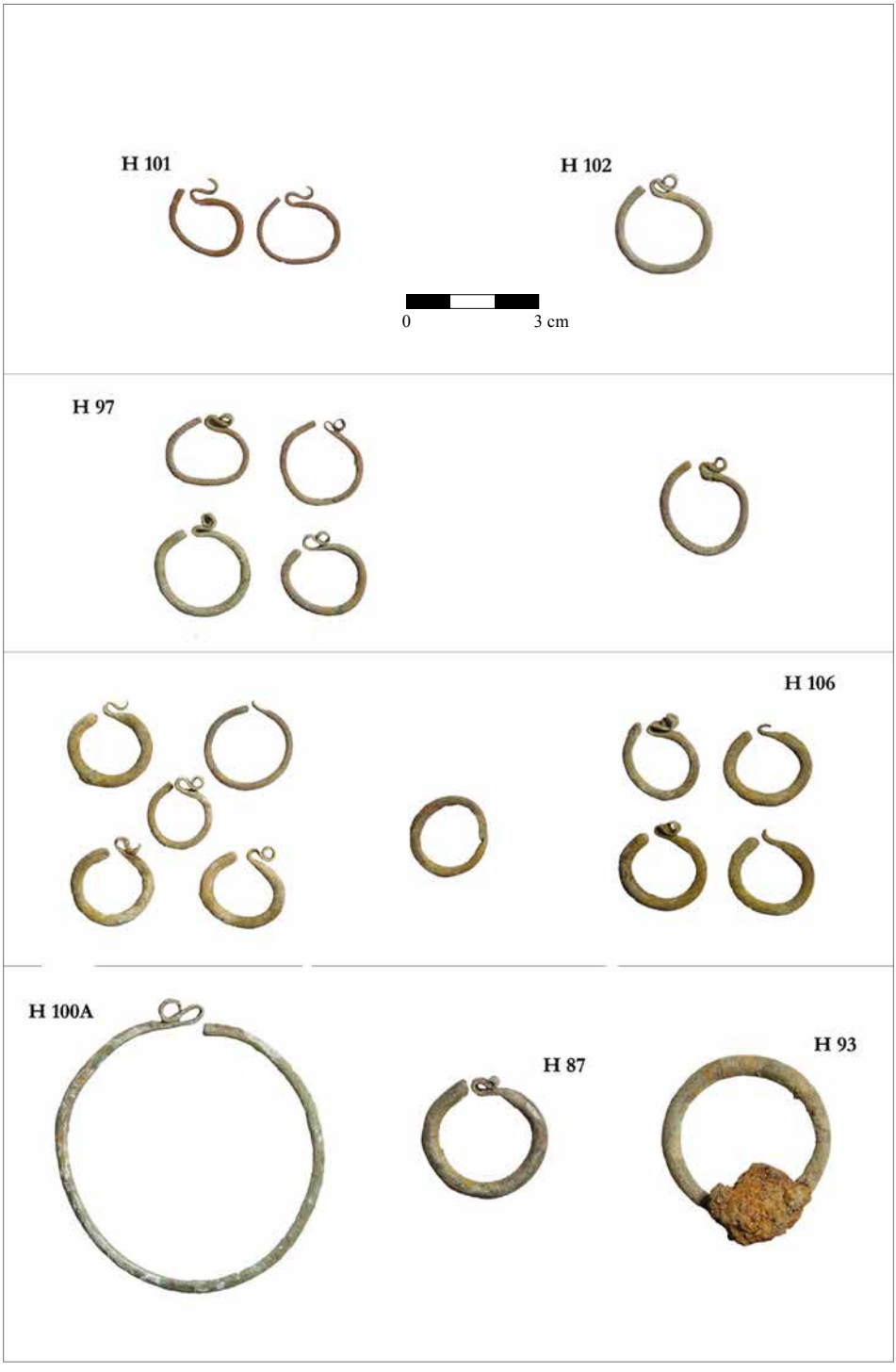

Fig. 5. Bronze S-shaped temple rings from graves.

Obr. 5. Bronzové esovité záušnice z hrobů.

Tab. 2. Age and sex structure.
Tab. 2. Věková a pohlavní struktura.

Age category	Sex			Total
	Male	Female	Indetermined	n
Infnas I	–	–	12	12
Infans II	–	–	9	9
Infans I / Infans II	–	–	4	4
Juvenis	2	6	3	11
Adultus	10	12	–	22
Adultus/Maturus	6	2	–	8
Maturus	24	11	–	35
Maturus/Senilis	6	2	–	8
Senilis	1	–	–	1
Indetermined	1	2	6	9
Total	**50**	**35**	**31**	**119**

Age estimation was made on the basis of pubic symphysis morphology (Brooks–Suchey 1990), the degree of obliteration of the cranial sutures (Meindl–Lovejoy 1985), the changes of auricular surface (Buckberry–Chamberlain 2002; Lovejoy et al. 1985), and the degree of dental crown wear (Lovejoy 1985). The age of non-adult individuals was estimated by the evaluation of the epiphysis ossification, long bone shaft maximum length, teeth eruption and ossification (Scheuer–Black 2000; Ubelaker 1999; Stloukal–Hanáková 1978; Gustafson–Koch 1974). Sex for non-adults was not determined due to the fact that determinations of sex at skeletal remains are most accurate after the individual reaches maturity (White et al. 2012). The studied individuals were assigned to one of the age groups on an age scale (Malinowski 1997): Infans I (younger childhood from 0 to about 6–7 years), Infans II (older childhood from 6 to 12–14 years), Juvenis (age from 14 to 20–22 years), Adultus (age from 22 to 30–35 years), Maturus (age from 35 to 50–55 years), Senilis (over 55 years).

2.3 Trauma

Because crude trauma prevalence of a site is recommended (Lovell 2008) in trauma analysis, all bones and fragments larger than half of the total bone from regular graves (n = 8497) and ossuary (n = 711) were analysed for trauma (Table 3). Analysis was performed macroscopically as well by using X-ray and CT. X-rays were performed at the MEDICINA hospital in Podbořany with DIMOND MODEL TYPE VAREX IMAGINE X-Ray with parameters 53 kVp and 3.6 mAs. CT scans were performed at University Hospital Center in Zagreb with Siemens SOMATOM EMOTION CT scanner with parameters 110 kVp and 150 mAs. Any lesion that completely or incompletely interrupted the continuity of the bone was referred to as a fracture. The obtained trauma prevalence rates were applied to either true bone fractures and crude fracture per individual to examine patterns and distribution of injuries.

In the analysis of human remains, bone fractures are the most common, which is why the words trauma and fracture are often used synonymously. Fracture evaluation included: identification of the lesion component and its exact location on the bone (side, anatomical location and anatomical structure involved), timing, mechanism and type of fracture estimation. The timing was determined based on the signs of healing; if there was any it was classified as an antemortem (occurring before death) lesion. Perimortem trauma (near the time of death) without signs of healing and postmortem (after death) fractures/damages were distinguished by colouration of fracture,

Tab. 3. Incidence of trauma on individual bones.
Tab. 3. Výskyt úrazů u jednotlivých kostí.

Area/Bone	Number of bones analysed ossuary (H89)	Number of injured bones ossuary (H89)	Number of bones analysed regular graves	Number of injured bones regular graves	Crude rate regular graves
Upper limb					
Clavicula	11	0	174	1	0.57
Scapula	17	0	187	0	0
Humerus	31	1	196	1	0.51
Ulna	30	1	196	5	2.55
Radius	16	0	184	1	0.55
Carpal and hand bones	28	0	1,955	2	0.1
Lower limb					
Coxa	25	0	179	0	0
Femur	41	0	178	2	1.12
Patella	4	0	92	0	0
Tibia	30	0	147	1	0.68
Fibula	14	0	141	1	0.71
Tarsal and foot bones	39	0	1,181	2	0.17
Torso					
Ribs	103	1	1,334	12	0.9
Vertebrae	164	0	2,024	2	0.1
Sternum	3	0	148	0	0
Skull					
Cranium / cranial bones	138	0	94	5	5.32
Mandible	17	0	87	0	0
Total	**711**	**3**	**8,497**	**35**	–

fracturing pattern, morphology, shape and angle of the edges according to the recommendations to study of Fleming-Farell and coauthors (2013) as well as Galloway and coauthors (2014).

Perceived fractures were described by Lovell recommendation (1997), which subdivide fractures into: penetrating, comminuted, crush, transverse, oblique, spiral, impacted/compressed, greenstick, avulsion. In addition, a special type of fracture such as parry fractures has been assessed in accordance with the recommendations of Judd (2008). All observed trauma werealso classified by the nature of their origin; i.e. fractures associated with labour and accidents (Lovell 2008) as well as trauma related with violence (Lovell 2008; Walker 2001). Injuries characteristic for intentional violence are considered to be weapon-inflicted wounds, peri-mortem injuries, multiple injuries to a single individual, as well as cranial vault and facial injuries (Šlaus et al. 2012). The most frequently observed in the archaeological context and the best studied types of violence-related trauma are blunt force and sharp force trauma. Blunt force trauma is created when compression and bending forces are applied dynamically on a vast surface of bone. They are usually caused by a struck on a skull with a blunt object, although hitting the head on protruding areas damages the skull in a way that may indicate blunt force trauma. However, some criteria do exist by which we can determine the high probability of this type of injury being caused by violent behaviour. These include: presence

above the hat brim line, presence of concurrent facial fractures and that the injury is located on the left side of the cranial vault (Guyomarc'h et al. 2010; Kremer et al. 2008). Nevertheless, blunt force trauma are very specific and in order to correctly separate them from fractures the presence of a depression/fracture pattern that radiates is required (Kranioti 2015). Further injuries that are associated with aggression are sharp force trauma. These are created from the use of various tools or weapons and are characterised by at least one sharp outline, fracture outline being elliptical or straight, smooth surface (Redfernd–Roberts 2019) and the opposite margin of cut is irregular, often showing flaking and roughened appearance (Boylston 2006; Knüsel 2005). Sharp force injuries can be subdivided into incision, chopping and penetrating injuries, each with characteristics that make it easier to identify them correctly (Forsom–Smith 2017; Langley 2017). However, the characteristics of all the subtypes of these injuries have only been used to determine the occurrence of the injury, not to differentiate it. To assess statistical significance between the different injury patterns, a chi-square and comparison of two structure indicators tests were used. The JASP software was used for the statistical analyses. The level of statistical significance was set at 0.05.

3 Results

Twenty individuals out of one hundred and nineteen (16.8 %) showed evidence of trauma, with the exclusion of non-adults (25 indiviuals), this rate rises to 21.3 %. The majority of all trauma, 70 % (14/20), were observed in males, 25 % (5/20) in females and 5 % (1/20) in an adult whose sex was not determined. Nevertheless, no evidence of skeletal trauma was distinguished in the non-adult individuals (under 15 years old). The data shows that the occurrence of trauma in sex category was more common in males 28 % (14/50) than in females 14.3 % (5/35; Table 4; $\chi^2 = 17.77$ df = 1 $p > 0.05$). Lesions were observed on 35 out of 8.479 bones, which puts the actual injury prevalence at 0.04 %. In the case of prevalence rates of crude bone lesions, the majority of fractured bonesbelong to males (27/35), among females and one individual of undetermined sex there were respectively 7 and 1 lesions ($\chi^2 = 13.59$ df = 2 $p > 0.05$).

During the analysis, no case of perimortem trauma was observed. 34/35 of the lesions were completely healed and only in the case of one injury is the wound still open and a running healing process is visible. As precise age determination was not possible for three individuals, the analysis in terms of age included only 17 cases. Fractures were far more numerous in the maturus and maturus/senilis group of age (Table 4) as they represented more than 70.6 % of the examined

Tab. 4. Prevalence of trauma in age and sex category
Tab. 4. Prevalence úrazů v kategoriích věku a pohlaví.

Age category	Male		Female		Indefinite	Total
	n	N	n	N	n	
Infans I	–	–	–	–	0	0/12
Infans II	–	–	–	–	0	0/9
Infans I/II	–	–	–	–	0	0/4
Juvenis	0	2	0	6	0	0/11
Adultus	2	10	1	12	–	3/22
Adultus/Maturus	0	6	0	2	–	0/8
Maturus	10	24	2	11	–	12/35
Maturus/Senilis	2	6	0	2	–	2/8
Adult	0	1	2	2	1	3/9
Total	**14**	**50**	**5**	**35**	**1**	**20/119 (16.8 %)**

group. Injuries were significantly less prevalent in young individuals (under 35 years of age; comparison of two structure indicators p = 0.0019).

In the ossuary, where the MNI was determined to be 23 individuals, four fractures were observed: spiral fracture of the tibia, oblique fracture of the ulna, oblique fracture of the rib, and spiral fracture of the humerus. The actual incidence of injury in this case was: 0.56 %.

3.1 Trauma characteristic

In the individuals buried in the early medieval cemetery at Dolany, most trauma occurred on the appendicular skeleton (16/35) and on the axial skeleton (14/35). Cranial trauma were the least numerous group (5/35) of injuries. The most frequently injured bones were the ribs (6/20 individuals) and the ulna (5/20 individuals). However, when converted to the crude rate of injury within a particular bone, the highest frequencies were observed in the skull (5/94) and the ulna (5/196; Table 4). In individuals with trauma, fractures dominated (32/35), sharp-force trauma occurred in only 3 lesions. A description of the trauma for each individual is summarised in Table 5.

Tab. 5. Trauma location, quantity and type by individuals.

Tab. 5. Umístění, množství a typ úrazu podle jednotlivých osob.

Individual	Sex	Age	Location	Side	Fracture type	Total no. of lesions
H1	M	adultus	femur	right	depression fracture	1
H3	M	maturus	tibia	right	oblique	1
H10A	N	adult	ulna	left	tranverse	1
H12	F	adult	radius	left	impacted	1
H18	M	maturus	ribs	right	transverse	2
H19	F	maturus	hand phalanx	right	oblique	1
H32	M	maturus	cranium; ulna	medially/ left	direct/transverse	2
H34	M	adultus	vertebrae	medially	sharp-force trauma	1
H38	M	maturus	cranium; vertebra ribs;ulna	right/medially/ left/right	depression fracture/ transverse/alvulsion/ oblique	5
H44	F	adultus	clavicula; humerus	left/right	spiral/oblique	2
H45	F	adult	femur	right	direct trauma	1
H49	M	maturus	cranium	left	penetraning sharp-force trauma	1
H66	M	maturus	fibula	left	direct trauma	1
H71B	M	maturus/senilis	ribs	right	transverse	4
H80	M	maturus	ribs; phalanx	right	penetraning/oblique	3
H82	M	maturus/senilis	ulna	right	transverse	1
H93	M	adultus	cranium	right	sharp-force trauma, depression fracture	2
H104	M	maturus	ribs	left	oblique	1
H107	M	maturus	metatarsus	left	transverse	2
H109	F	maturus	rib;ulna	right/left	transverse	2

3.1.1 Cranial trauma

All preserved 94 craniums and 87 mandibles in varying states of preservation from cranium to calotte (Malinowski–Bożiłow 1997, 212) were assessed for trauma. Five injuries were observed in four male individuals, representing 14.3 % of the total number of trauma in the studied population. Among these, fractures and sharp-force trauma were recognized. Fractures represented 3 lesions in the cranial vault from which one was an eliptical lesion 20 mm long in the midline of the frontal bone (Fig. 6) and the rest of them were small, well-healed depressions on frontal and occipital bones. Two individuals experienced sharp force trauma, in which the individual H93 injury was located on the right side of the frontal bone and was fully healed (Fig. 7). In a case of individual H49 left parietal bone was affected due to using a sharp-edged tool or a weapon (Fig. 8). Bone is not fully healed but strong remodelling on the edges indicates long-term survival.

3.1.2 Postcranial trauma

Within the appendicular and axial skeleton trauma occurred in similar severity, 45.7 % (16/35) and 40 % (14/35) respectively. Among the bones of the axial skeleton ribs were the most frequently injured, as they accounted for 34.3 % (12/35) of all observed trauma. These fractures occurred in 6 out of 20 individuals with the highest number occurring in individual H71B in who 4 ribs were fractured simultaneously (Fig. 9). There were two incidents of trauma to the spine. The first concerns individual H38 who sustained a clay-shoveler fracture (fracture of the spinous process of the lower cervical or upper thoracic spine) on the Th1 vertebra (Fig. 10). The second injury occurred in individual H34, who had a penetrating sharp-force trauma on the C7 vertebra, which led to a fracture of the arcus and spinous process and subsequent healing to fusion of the Th1–Th2 vertebra (Fig. 11).

For the appendicular skeleton there were observed 16 injuries with the most predominant injuries being ulna fractures (5/16). Four of these were isolated, transverse and located on the distal part of the shaft and occurred in three men and one woman (Table 5) affecting two right and two left ulnar bones (Fig. 12). The last fracture of the ulna was an isolated fracture of the proximal part of the bone shaft, very close to the epiphysis. Fractures at this height are relatively rare and the most likely classification of this lesion is Monteggia fracture (Fig. 13) which is the result of a fall on an outstretched hand with the forearm in excessive pronation. A similar mechanism of onset but without pronation has a Colles' fracture that occurred in individual H12 (Fig. 14). Trauma in the upper limb bones occurred in 3 more individuals. In the case of individual H44 it is an oblique fracture of the right clavicle and distal shaft of the humerus (Fig. 15). Such an injury involving two bones would most likely have been caused by a high energy incident as fall/ rotational injury or by directed trauma like a blow (Lovell 2008). Individuals H19 and H80 experienced fractures in the phalanges of the hand (Fig. 16). H80 individual had an oblique fracture with a displacement and the H19 individual developed a pseudarthritic joint during the healing process.

Within the bones of the lower limbs 6 fractures were observed in 5 individuals – four males and one female in adultus and maturs age category. The two small depression fractures on H1 and H45 individuals' femurs were very similar to each other as they both occurred over the distal epiphysis and were most likely the result of a direct impact on the bone. Individual H3 had an oblique fracture of the tibia in the distal part of the shaft, however, his grave was damaged, and no fibulae were preserved for analysis. Therefore, it is impossible to determine the mechanism of injury. Individual H66 who sustained a fracture of the fibula near the distal epiphysis most likely suffered an injury due to ankle rotation. The last injuries observed in the elements of lower limbs were transverse fractures of the third and fourth metatarsal bone. Such fractures are common and usually result from dropping a heavy object on the foot. However, in the case of the H107 individual, trauma developed complications probably in the vascular system (Fig. 17), as although the fracture was healed all the bones of the foot show signs of bone atrophy.

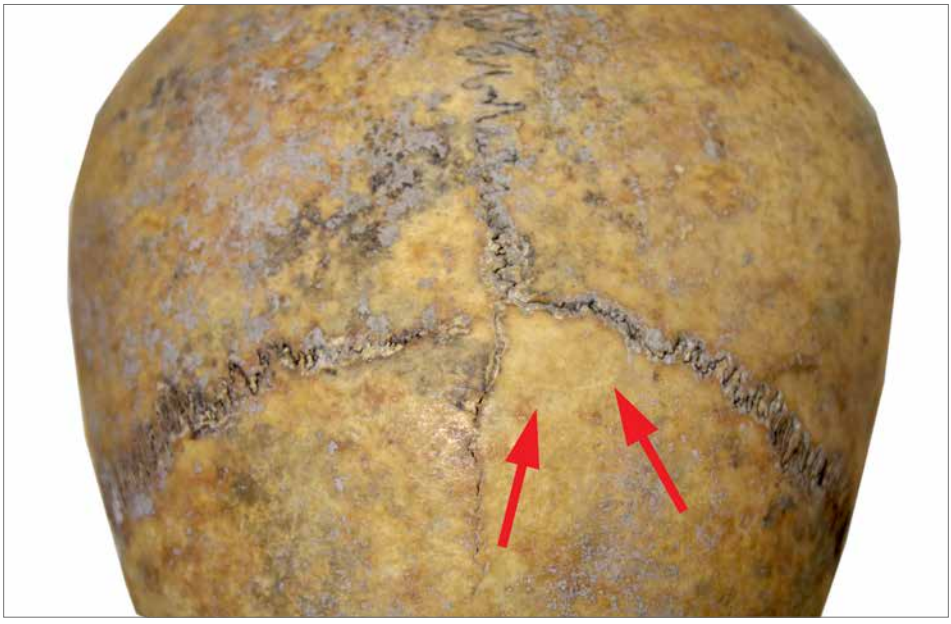

Fig. 6. Well-healed skull fracture in individual H32.

Obr. 6. Dobře zhojená zlomenina lebky u jedince H32.

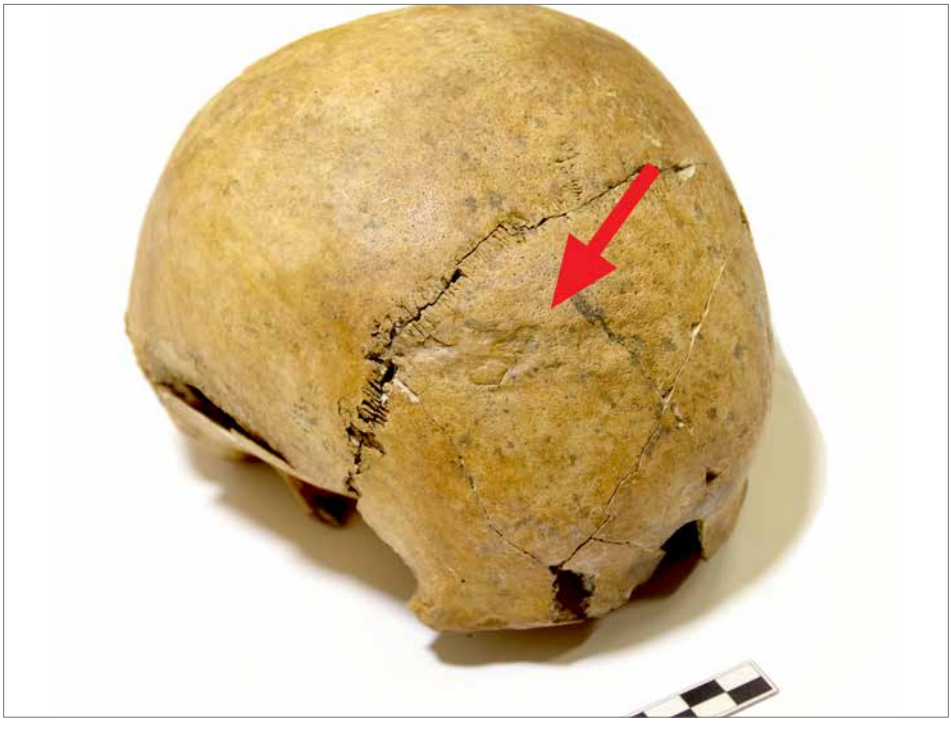

Fig. 7. Well-healed skull sharp-force trauma in individual H93.

Obr. 7. Dobře zhojené poranění lebky způsobené ostrým předmětem u jedince H93.

Fig. 8. Sharp-force trauma on the left parietal bone in individual H49.

Obr. 8. Poranění levé temenní kosti způsobené ostrým předmětem u jedince H49.

Fig. 9. Multiple rib fracture in individual H71B.
Obr. 9. Zlomení mnoha žeber u jedince H71B.

Fig. 10. Clay-shoveler fracture of Th1 vertebra in individual H38.
Obr. 10. Zlomenina typu clay-shoveler obratle Th1 u jedince H38.

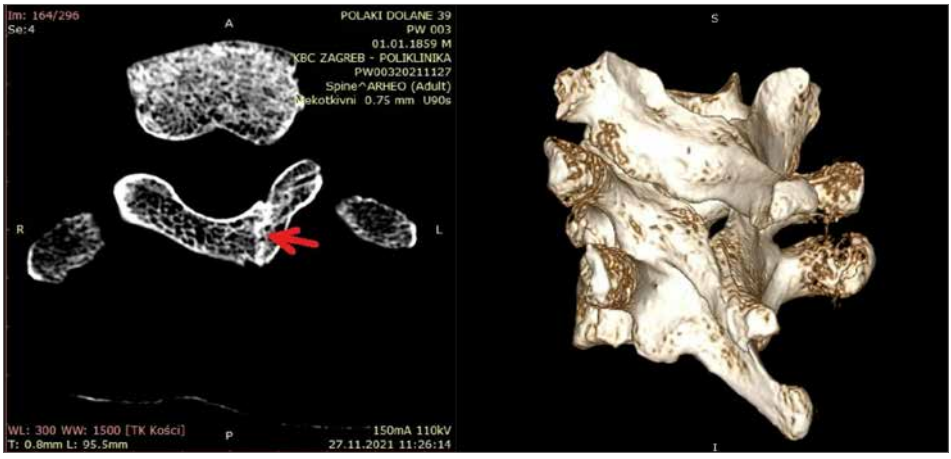

Fig. 11. Penetrating sharp-force trauma on the C7 vertebra of H34 individual.
Obr. 11. Penetrující úraz ostrým předmětem na obratli C7 jedince H34.

Fig. 12. Parry fracture of ulna in individual H38.
Obr. 12. Zlomenina loketní kosti u jedince H38.

Fig. 13. Monteggia fracture in individual H10A
Obr. 13. Monteggiova zlomenina u jedince H10A.

3.1.3 Individuals with multiple trauma

Nine individuals had multiple fractures and injuries and it is this group that generates 69 % (24/35) of all observed injuries. In the case of individuals H18 and H71B rib fractures occur almost in parallel so we can assume that there most likely was a single incident resulting in the fractures. A similar situation may have occurred with H107 – one incident resulted in the simultaneous fracture of two metatarsal bones. Two skeletal injuries each on different skeletal parts were observed in individuals H32, H44, H109. However, in the case of the woman from grave H44, it is possible that both fractures were the result of a single high-energy accident, as only the bones on the right side – the clavicle and humerus – are affected. The highest number of trauma was observed in individual H38, as up to five fractures occur on: the occipital bone, the Th1 vertebra, two ribs and the right ulna.

Fig. 14. X-ray of Colles' fracture – individual H12.

Obr. 14. Rentgenový snímek Collesovy zlomeniny – jedinec H12.

Fig. 15. Fracture of right humerus in individual H44.

Obr. 15. Zlomenina pravé pažní kosti u jedince H44.

4 Discussion

4.1 Trauma in mediaeval Europe

The issue of trauma among historical European populations has been studied by many researchers (Table 6). Compared to the geographically closest mediaeval populations from Poland and the Czech Republic, the Poláky-Dolany site has a relatively high prevalence of trauma 16.8 %. As for the Czech Republic, this incidence in rural populations ranges between 1.9 % (Libkovice – north-western Bohemia; Mackiewicz et al. 2021; Kwiatkowska et al. 2019; 2020), 3.28 % (Přezletice, Prague East District; Koštová et al. 2022), 4.83 % (Lahovice, Prague 5; Stránská et al. 2010), 4.16 % (Zeleneč, central Bohemia; Stloukal 2020, 70–77), 7.2 % (Radomyšl, south Bohemia; Blajerová 1999, 252–271), up to 43.3 % in the case of the studied sample from the Teplá monastery. However, in this case even 69 % of all trauma were related to violence (Pankowská et al. 2019). Across Poland the incidence of trauma takes on similar values, as it is 6 % in the rural population

Fig. 16. Injury to the phalanges of the hand in individual H19 (right) and H80 (left).
Obr. 16. Úraz prstních článků ruky u jedince H19 (vpravo) a H80 (vlevo).

Fig. 17. Fracture of metatarsal bones in individual H107.
Obr. 17. Zlomenina metatarzální kosti u jedince H107.

from Gruczno (Kozłowski 1993) and as high as 9.6 % when excluding non-adult individuals. Furthermore, the study of Agnew et al. (2015) illustrates a huge difference that highlights the disproportion between urban and rural environmental impact that occurred in the prevalence of trauma in residents of a neighbouring city (Poznań-Śródka) and village (Giecz), as it was 4 % and 48 %, respectively.

More similar trauma rates to the Poláky-Dolany site (16.8 %) occurred in populations from northern Italy (early mediaeval Säben-Sabiona – 16 %) Britain (mediaeval Raunds – 19.4 %), mediaeval Denmark (Randers – 16.5 % and Tjærby – 14 %) and Late Antiquity populations from Croatia (Zdar – 17.3 % and continental population – 15.1 %; Tumler et al. 2021; Judd–Roberts 1999; Collier–Primeau 2019; Novak–Šlaus 2010). The distribution of injuries in sex categories of the studied sample shows a predominance of trauma incidence among males, with the rate being most similar with populations from Raunds (60.6 % males; 39.4 % females) and Säben-Sabiona (78.4 % males; 10.8 % females). However, in all the mentioned populations, it was males who were significantly more likely to be affected by trauma. Which indicates that it was common in mediaeval Europe for men to do heavier and more dangerous types of work that put them at high risk of injury. Similarities to the two above-mentioned populations were observed for the incidence of trauma in individuals over 35 years of age. This is a common phenomenon of overlaping trauma with age because, as in cases such as degenerative changes, older individuals had more time to experience trauma during their lives. Also associated with this is the characteristic low trauma severity in children. For instance at the Poláky-Dolany site no case of trauma was recorded while in populations with similar trauma incidence (Randers, Tjærby, Säben-Sabiona, Zdar, Continental Croatia), between 1 and 3 individuals with trauma were observed in non-adults under 11 years of age. Which may suggest that the children were not involved in hard and hazardous labour.

4.2 Rural environment and trauma risk

One of the most relevant factors considered in the studies is the influence of the place of residence on the incidence of trauma, as lifestyles and labour performed by urban and rural inhabitants differed considerably. In the High Middle Ages there was a clear distinction between the labour performed by urban and rural residents. The intensification of urbanisation in the 13th century saw a change in the distribution of manufacturing, as non-agricultural production was concentrated in the cities, and while in Prague or Brno, as in other mediaeval cities, work in small-scale manufacturing and crafts was predominant (Klápště 2016, 159–185), rural residents were mainly obliged to produce food or provide semi-finished products for crafts. However, between the 11th/17th century, the villagers were involved not only in agricultural activities but also precisely in small-scale manufacturing (Klápště 2016, 34–35), which, in the case of the Dolany village, is evidenced by the outpouring of slag on a strip of land 100 metres from the cemetery. It provides information about the existence of an artisanal establishment in the area of 11th-century Dolany, which was a smithy. Unfortunately, there are no historical sources on which we can rely on when attempting to reconstruct the lifestyle and work of the inhabitants of the village. However, archaeological evidence in the form of numerous animal bones found on the sites, the species composition which includes livestock such as domestic cattle, horse, pig and small ruminants such as sheep and goats (thanks to Rene Kyselý) suggest that one of the occupations of the Dolany inhabitants was animal husbandry. Involvement in fishing cannot be ruled out either, due to the settlement's direct location on the Ohře River. In addition, it is most likely that, like most of the villagers in the region, Dolany inhabitants were involved in the cultivation of cereals and food crops. This is evidenced by archaeobotanical analyses from the nearby (approximately 15 km) early mediaeval agglomeration of Žatec in which 44 species of cultivated plants were found, of which mainly cereal plants such as wheat, rye and millet, oats and barley predominated. In addition, remains of legumes, oil plants, vegetables and fruits were observed in the anthropogenic layers (Čech et al. 2013, 22–29).

Tab. 6. Trauma prevalence in historical European populations.

Tab. 6. Prevalence úrazů v historických evropských populacích.

Author	Country / Site	Date	Population type	Incidence of trauma	Incidence of trauma by sex	
Kozłowski 1993	Poland – Gruczno	Medieval	Preurban	6 %	**Males:** 80.4 % **Females:** 17.7 %	
Judd–Roberts 1999	UK – Raunds	10th–11th century	Rural	19.4 % (fracture incidence)	**Males:** 60.6 % **Females:** 39.4 %	
Novak–Šalus 2012	Croatia – Dugopolje	13th–16th century	Rural	Long bone fracture: 1.5 % (29/1910) Cranial injury: 21.8 %	**Males:** 24/1066 (2.2 %) **Females:** 5/844 (0.6 %)	
Agnew et al. 2015	Poland – Giecz Poznań Śródka	10th–13th century	Giecz – Rural	48 %	**Males:** Trunk: 57 % Upper limb: 14.5 % Lower limb: 0 % **Females:** Trunk: 28.6 % Upper limb: 6.3 % Lower limb: 2 %	
			Poznań Śródka – Urban	4 %	**Males:** Trunk: 4.4 % Upper limb: 5.9 % Lower limb: 7.7 % **Females:** Trunk: 3.3 % Upper limb: 0 % Lower limb: 0 %	
Dittmar et al. 2015	UK – Cambridge	10th–13th century	Urban – 3 locations with different social context	32 %	**Males:** 40 % **Females:** 26 %	
Collier–Primeau 2019	Danmark – Randers Tjærby	10th–16th century	Randers – Urban	16.5 %	**Males:** 26.9 % **Females:** 23.4 % **Indeterminate sex:** 15.4 %	
			Tjærby – Rural	14 %	**Males:** 27.7 % **Females:** 21.7 % **Indeterminate sex:** 38.7 %	
Tumler et al. 2020	Italy – Säben-Sabiona	5th–8th century	Urban?	16 %	**Males:** 78.4 % **Females:** 10.8 % **Indeterminate sex:** 5.4 %	

	Incidence of trauma by age category			The most numerous antemortem injury	Occurrence of sharp-force trauma
	0–6: 0.9 % **6–14:** 0.9 % **14–20:** 0.9 % **20–35:** 14 % **35–55:** 68.2 % **55+:** 6.5 % **Adults:** 8.4 %			Ulna Hand bones	Yes – on the skulls
	18–24: 13.2 % **25–34:** 20. % **35–44:** 25.8 % **45+:** 25 %			Male: clavicle and fibula fracture Female: ulna, radius and clavicle fracture	No data
	16–30: 4.5 % **31–45:** 17.4 % **45+:** 46.4 %			Ulna Radius Tibia	Yes
	Young adult: Trunk: 28.9 % Upper limb: 4.7 % Lower limb: 4.9 %	**Middle adult:** Trunk: 54.7 % Upper limb: 10.7 % Lower limb: 5.6 %	**Older adult:** Trunk: 57.1 % Upper limb: 38.5 % Lower limb: 7.7 %	Ribs, vertebrae	No
	Young adult: Trunk: 16.7 % Upper limb: 0 % Lower limb: 0 %	**Middle adult:** Trunk: 0 % Upper limb: 5.9 % Lower limb: 0 %	**Older adult:** Trunk: 0 % Upper limb: 0 % Lower limb: 0 %		Nonspecific
	Adolescent: 6.2 % **Young adult:** 8.3 % **Middle adult:** 32.6 % **Mature adult:** 41.4 % **Old adult:** 59.4 % **Adult:** 10.5 %			Ribs, vertebrae	Yes
	Younger sub-adult: 4.3 % **Older sub-adult:** 20 % **Young adult:** 23.1 % **Middle adult:** 18.7 % **Old adult:** 42.8 % **Adult:** 0 %			Randers: Vertebrae, ribs, hand bones	No
	Younger sub-adult: 2.9 % **Older sub-adult:** 8.1 % **Young adult:** 10.3 % **Middle adult:** 31.1 % **Old adult:** 33.3 % **Adult:** 28.6 %			Tjærby: Ribs, vertebrae, radius, cranium	Yes
	Individuals over 40 years old the most office affected.			Axial skeleton	Yes

Agriculture was , and continues to be, one of the most dangerous occupations that can lead to injuries and fatalities – as analyses show, agriculture is accompanied by a strong morbidity and mortality associated with accidents (Pfortmuller et al. 2013). Despite technological developments and a strong mechanisation of farm work many similarities are still present between activities and work-related injuries performed both in the Middle Ages and today (Roberts–Manchester 2005). Agriculture requires a high level of work involvement and repetition of the same activities each day with varying risks of injury. As a research on modern agriculture in the USA shows it is animal care, working with mechanical equipment or falls that are the most frequently recorded work accidents (Myers 1998). Each of these accidents is reflected in injuries specific to them. Farmers are particularly vulnerable to accidental kicks by livestock to the head and torso area (Bury et al. 2012) additionally if these are inflicted by a large animal such as a cow or horse then such an injury can be fatal (Dogan–Demirci 2011). In the case of falls, the bones of the limbs and the spine are more susceptible (Lovell 1997).

In the Dolany population it is likely that the majority of injuries arose from accidents or occupational accidents. In individuals with healed fractures, oblique and transverse types are predominant and are often seen during accidents (Gilmour et al. 2015). Within the axial skeleton rib injuries predominate, which is a characteristic of most historical communities and is closely related to the differing levels of hazardous activities undertaken by males and females (Brickley 2006). In modern populations rib fractures are mainly associated with falls; however, it can also be connected to lifting heavy objects or animal kicks (Waldron 2009). Therefore, it cannot be linked to the specific activities undertaken by the residents of Dolany. Nevertheless, individuals with multiple fractures in one area of the ribs, or the ones who had a fracture of a rib and another skeletal element, may have experienced blunt trauma from a direct blow or fall (Sirmali et al. 2003). Which in the case of the Dolany population, applies to almost all individuals with rib fracture, as all males had at least two broken ribs. Surprisingly, there were no vertebral compression fractures in the population from Dolany. Considering that in the Polish rural population from Giecz such fractures occurred in 42.1 % of individuals, due to the mechanism of compression fractures of the spine (Myers–Wilson 1997) it could be concluded that the Czech study group was not so heavily burdened by overexertion associated with lifting. In the appendicular skeleton, upper limb fractures are the most numerous – isolated fractures of the ulna predominate, which is quite an exceptional situation, as the injury incidence in the other elements of the upper limb skeleton is relatively low – one Colles' fracture, two phalangeal injuries. Only H44 individual (woman, adultus age category) had a fracture of the clavicle and humerus most likely due to high-energy trauma as it was observed. However, an isolated ulnar fracture can occur as a result of a rotational force being applied to the wrist (Galloway et al. 2014) or can occur as a result of shielding from a direct blow – so-called parry fracture. Similar patterns and dominance of ribs and upper limb skeleton injuries also occurred in populations from Polish Giecz, Continental Croatia and Zdar, British Cambridge or Randers and Danish Tjærby (Agnew et al. 2015; Novak–Šlaus 2010; Dittmar et al. 2020; Collier–Primeau 2019).

4.3 Violence-related trauma and parry fracture

Between all the skeletal injuries in the sample, fractures and antemortem trauma in areas attributed to association with aggressive behaviour or interpersonal violence were identified. This mainly refers to cranial injuries (n = 5), parry fractures (n = 4) or multiple rib fractures (n = 4). In the case of cranial injuries, the HBL (hat brim line) is important because it is assumed that if a fracture occurs above the HBL it may be related to a direct conflict, while those occurring around the HBL may be related to violence/accident (Kremer et al. 2008). In the case of this study population, cranial trauma occurred only in males where 4/5 of them occurred above the HBL. Two of these – in individuals H93 and H49 – which could be directly linked to violence and weapon use (Figs. 7; 8). These additionally occurred on the frontal and parietal bones, where,

according to research, injuries associated with violence are usually most commonly located (Krakowka 2017; Šlaus et al. 2012). Additional attention should be paid to individual H32, who had a 20 mm well healed transverse injury in the midline of the frontal bone above the HBL (Fig. 6) as well as a paired fracture of the left ulna, which further increases the likelihood that he may have been a victim of intentional violence.

Indisputable contact with violence occurred in individual H34 – male, between 25 and 34 years of age. He sustained a fracture of the Th1 vertebral arch and spinous process, most likely as a result of a stabbing with a sharp-edged weapon – sharp fissures from a bone incision are present on the Th1 arch and spinous process and the inferior of the C7 spinous process (Fig. 11). Due to its location between the spinous processes, the puncture would have had to be delivered from below or when the victim was in a slight anterior position, so that the weapon penetrated the intervertebral space quite deeply. The resulting fracture reached the spinal canal, but did not damage the spinal cord. Spinal cord injuries in this area can be fatal (Skadorwa–Ciszek 2013). It is also most likely that there was no damage to the motor nerves – no atrophic changes are visible on the appendicular skeleton and bone dimensions are within the average for males in this population. In the case of individual H34, there was a full recovery of the injury and the only consequence was fusion of the injured vertebra with the Th2 vertebra.

One of the most commonly mentioned indicators of deliberate violence in the upper extremity in the literature is parry fractures. It is problematic to associate isolated fractures of the ulna solely with an act of personal violence because, as explained by Smith (1996) and Judd and Roberts (1999), they can also arise from, for example, a fall. The criteria established by Judd (2008) were also applied to this paper and of the 5 isolated ulna fractures observed, 4 met the assumptions classifying them as parry fractures. These occurred in 3 males and one female – the trauma occurred on two right and two left ulnar bones. It is assumed that it is the injury to the left ulna that is more suggestive of an act of aggression (Hadzic 2019) and, in the case of the Dolany population; these occurred in two individuals – the previously mentioned individual H32 and the female H93 in whom an additional rib fracture was observed. However, in the H38 individual in which a parry fracture of the right ulna occurred, it also cannot be ruled out that it was caused by interpersonal violence, by the fact that it suffered injuries to the skull, ribs and vertebrae.

5 Conclusions

The high prevalence of skeletal injuries in the population is a phenomenon worth looking into and analysing in more depth, as there is a multitude of causes and factors influencing this parameter. Examining the types of injury, their location and their distribution in terms of age and gender can yield a great deal of information about daily life, work and the risks involved. The occurrence of sharp-force trauma additionally provides information on violence-related behaviours that, according to literature, increased during periods of political change (Šlaus et al. 2012; Smith 2017). The inhabitants of the Dolany village worked mainly in agriculture, animal husbandry and small crafts, making most of them exposed to trauma every day during labour. The predominance of transverse, spiral and oblique fracture types and the high incidence of fractures in the upper limbs and ribs confirms that they were most likely connected with daily activities or work accidents. However, the crude value of the incidence of trauma per individual alone shows that the farm work as well as the living environment was not among the safest. Moreover, the difference in injury incidence between sexes is clearly visible in the population studied, suggesting an undoubted division in the activity and type of work undertaken by men and women in the early Middle Ages in north-west Bohemia. Men from Dolany were most likely to have performed jobs with a higher risk of injury and, in addition, they were mainly the victims of violent acts, as illustrated by the sharp-force trauma they experienced.

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Shrnutí

Charakteristika zranění z lokality Poláky-Dolany: vzorce, prevalence a násilná traumata v malé raně středověké české vesnici

Lokalita Poláky-Dolany (okres Chomutov, Ústecký kraj) vděčí za svou jedinečnost tomu, že se již 60 let nachází pod hladinou Nechranické přehrady. Kvůli velkému suchu v letech 2015 a 2018 mohlo být prozkoumáno místní pohřebiště a sídliště, které zde podle archeologických nálezů koexistovaly v průběhu 11.–12. století. V určité fázi se však sídliště přesunulo o několik set metrů dál od raně středověké lokality. Údaje naznačují, že obyvatelé raně středověkých Dolan byli zemědělci, čerpali užitek z řeky Ohře a provozovali malou místní výrobu, například kovárnu. Zdá se, že se jednalo o průměrnou zemědělskou vesnici. Mnoho informací o zdravotním stavu a životním prostředí osob pohřbených na dolanském hřbitově poskytuje paleopatologický výzkum. Především analýza kosterních poranění má za cíl rozšířit informace o životním stylu, každodenní práci a s ní spojených nebezpečích, kterým museli lidé pohřbení v Dolanech čelit.

Pro určení typu zlomeniny bylo vybráno 119 jedinců a jedna kostnice (MNI = 23). Známky úrazu byly zjištěny u 20 jedinců, většina z nich souvisela s nehodou. U šesti jedinců však byly zjištěny zlomeniny pravděpodobně související s úrazem způsobeným násilným činem, z toho u dvou jedinců se jednalo o zranění ostrým nástrojem. Lze tedy konstatovat, že život obyvatel byl sice obecně klidný, ale existovalo i riziko pracovních úrazů. Kromě toho se u obyvatel občas vyskytly úrazy v důsledku možného násilí, které nejsou neobvyklé, ale u venkovského obyvatelstva poměrně vzácné.

Poděkování

Velké poděkování patří všem, kteří pracovali na archeologické lokalitě Poláky-Dolany, zejména PhDr. V. Peksovi a MUDr. et Mgr. K. Dernerovi za jejich přínos archeologickému kontextu.

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