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Bone Traumas in Late Antique Populations from Croatia

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ABSTRACT

We present the results of the analyses of traumatic bone injuries in two Late Antique (3rd to 5th century AD) skeletal samples from Croatia: Zadar – located on the eastern Adriatic coast, and a composite skeletal series from continental Croatia consisting of skeletons from Osijek, Vinkovci, Štrbinci, and Zmajevac. The osteological series from continental Croatia are related to settlements located on, or near the Danubian military border, while Zadar – 350 km to the west, is located deep in the territory of the Roman Empire. Numerous historical sources describe barbaric incursions, as well as large battles related to civil wars during the Late Antique period in continental Croatia. Conversely, there is no mention of similar events in the Zadar region. In accordance with these data our analysis tests the hypothesis that the inhabitants of continental Croatia were exposed to greater levels of violence than those living in Zadar. Analysis of bone traumas in the two series shows a similar, relatively high prevalence of long bone fractures in both samples, with a slightly higher frequency recorded in Zadar. Both series exhibit a high frequency of cranial injuries with, once again, higher frequencies recorded in the Zadar series. Additionally, two perimortem cranial fractures (one caused by a sword, the other by a blunt object) were observed in Zadar. Some of the recorded traumas in both samples resulted from accidents, but a number of injuries clearly resulted from intentional violence of lesser intensity. Further multidisciplinary research incorporating osteological, archaeological, and historical analyses is necessary to confirm the results obtained from these samples.

Key words: *bone trauma, Late Antique, Zadar, continental Croatia, perimortem trauma, intentional violence*

Introduction

Smith and Wood Jones[1] carried out the first systematic analysis of bone trauma in archaeological populations almost a century ago. Their work, although in many ways ahead of its time, failed to provoke the scientific interest of their colleagues. Thus, bone traumas observed in osteological material from archaeological sites continued to be presented at the level of descriptive portrayals of individual skeletons that accompanied some archaeological publications, more as a curiosity than as a serious attempt to reconstruct the living conditions or quality of life at the analysed sites. The turning point for trauma analyses was marked by the astute and comprehensive analysis of traumas observed at the North American Libben site, carried out by Lovejoy and Heiple[2]. Their methodology was later adopted and refined by numerous authors[3–7].

In recent years there has been increased interest in bioarchaeological research of skeletal populations from Croatia, although traumas have rarely been the primary object of analysis. Data on the frequency and pattern of trauma in different archaeological populations have been published combined with other bioarchaeological data in holistic studies of various archaeological populations that inhabited the territory of Croatia[8–14]. Only two papers[15,16] predominantly address the issue of trauma in Croatian archaeological populations. The lack of such analyses prompted us to write this paper, in which we present the results of the analyses of the frequency and distribution of traumatic injuries in Late Antique osteological samples from the eastern Adriatic coast, and continental Croatia.

The skeletal samples from continental Croatia derive from settlements situated on, or near the Danube River that formed the military border (*limes*) that separated the Roman Empire from barbarian lands. In contrast to this, Zadar is situated on the eastern Adriatic coast, ap-

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proximately 350 km to the southwest of the *limes*, deep in the territory of the Roman Empire. The Zadar region is also physically separated from continental Croatia by the massive Dinarid mountain range.

Historical sources dealing with continental Croatia during the period between the 3rd and 5th centuries AD report on frequent barbarian intrusions, as well as on large battles related to civil wars[17,18]. Civil wars were frequent during this period – for instance, just during the so-called »crisis of the 3rd century« (235–284 AD) 22 Roman emperors exchanged power. The civil unrest often resulted in full-scale battles between various contenders that resulted in numerous casualties. Because continental Croatia is relatively flat with numerous well kept roads and navigable rivers and, in addition, connects the western and eastern parts of the Roman Empire, these conflicts were frequently battled out in this area. The Byzantine historian Zosimus (*Historia nova*) gives a detailed description of a battle that took place in 314 AD near *Cibalae*, where a Gallic army under Constantine I, emperor of the western part of the Roman Empire, attacked troops from *Illyricum* under Licinius, emperor of the eastern part of the Roman Empire[19]. Over 50,000 soldiers on both sides fought in a battle[20] that ended in Licinius' defeat and in the loss of 20,000 soldiers who fought on his side[21]. On the 28th Sep 351 AD a battle near *Mursa* took place where the emperor Constantius defeated the usurper Magnius Magnentius. This event was described as one of the bloodiest battles of the Late Antique period: approximately 54 000 soldiers from both armies died in the battle or drowned in the Drava river[22]. This disastrous loss of human resources seriously affected the defence of the Empire's borders, especially in the area of the Danubian *limes*[17]. Possibly, as a direct consequence of these events, the Visigoths[21] destroyed both *Mursa* and *Cibalae* at the end of 378 AD or the beginning of 379 AD.

Additional archaeological evidence for barbarian intrusion into Pannonia is seen in the presence of various Germanic archaeological artefacts, dated to the Late Antique period, recovered in continental Croatia. These include the Gepid necropolis from Vinkovci[19], the final construction phase of Vinkovci attributed to Germanic populations[19], and numerous other individual finds[19].

At the same time, nothing similar to the level of destruction and civil unrest is mention in the available historical sources for the province of *Dalmatia* (the region consisting of the eastern Adriatic coast and its hinterland). Suić[23] states that all available historical sources, as well as all recovered archaeological finds, suggest that Zadar was not under any type of military pressure. Despite the generalized crisis of the 3rd century, Zadar appears to not have been affected by it, which is best reflected in the many construction works throughout the city that were begun or finished during this time. Measures which were introduced by the Emperor Diocletian in the beginning of the 4th century, such as the separation of power between the two Augustus's, and the two Caesars (the Tetrarchy), inauguration of new fiscal and economic policies and, especially his famous edict on prices, contributed to the political and economic recovery of the Empire, including the Zadar region[23], which manifested itself in a marked population growth (estimates of the size of the city population during the early Empire range from 4 to 10,000[23,24], while the number of inhabitants during the 4th century is estimated to be between 20 and 40,000[25,26]).

The purpose of our study is to analyse and interpret the frequency and distribution of bone traumas in the two large Late Antique skeletal series from Croatia, and see whether the results of these analyses correspond to historical sources that suggest that, because of various barbarian intrusions and frequent civil wars, continental Croatia experienced a higher level of violence during the Late Antique period than Adriatic Croatia.

Materials and Methods

The osteological material analysed in this study is divided into two samples – the skeletal sample from Zadar, and a composite skeletal sample from continental Croatia. The geographical location of the analysed sites is shown in Figure 1.

Zadar was founded as a Roman colony *(Colonia Iulia Iader)* in 48 BC, most likely by Caesar himself. Because of modern urban reconstructions in the Zadar area, a rescue excavation of Roman necropolis was carried out in 1989/1990 and 2005/2006 in the city district Relja. Over 1,000 skeletal and incinerated graves were excavated. Skeletal remains from inhumations, which are one of the focuses of this study, are dated to the period between the 3rd and 4th centuries AD. Dating of the graves was based on grave goods and burial rites[27]. Graves from which osteological material was recovered were either simple

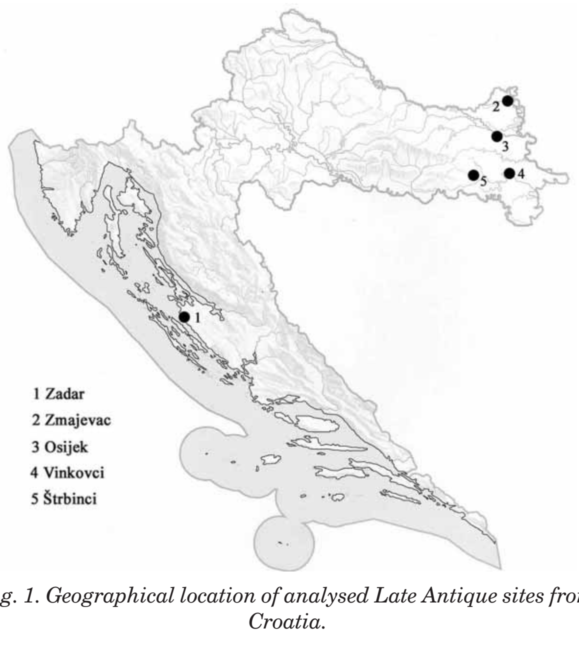

Fig. 1. Geographical location of analysed Late Antique sites from Croatia.

inhumations in plain ground, or graves covered with *tegulae* (roof tiles) or fragments of *amphorae*. Distinction between social categories based on grave goods and burial types in the Zadar sample was not possible. The osteological sample from Zadar consists of 255 well preserved skeletons.

The Late Antique composite series from continental Croatia consists of 323 skeletons from four sites: Vinkovci (31 skeletons), Osijek (62 skeletons), Štrbinci (92 skeletons), and Zmajevac (143 skeletons).

The Romans established Osijek (*Mursa*) at the beginning of the 1st century AD. In 133 AD, during Hadrian's rule, *Mursa* received the status of a colony (*Colonia Aelia Mursa*). The osteological material from *Mursa* was recovered from simple inhumation graves dated to the 4th century AD[28,29].

Vinkovci (*Cibalae*) was granted the status of a colony (*Colonia Aurelia Cibalae*) during the reign of Caracalla (196–217 AD). Inhumation graves discovered during rescue archaeological excavations in Vinkovci are dated to the late 4th century based on grave goods. Three main types of graves were found: simple inhumations, stone sarcophagi and brick graves[19]. Because of subsequent looting osteological material from the obviously higher status graves (the stone sarcophagi) was not available.

Štrbinci (*Certissa*) was a small Roman town whose necropolis is dated to the second half of the 4th and the beginning of the 5th century AD. Three grave types from this necropolis are noted: brick graves, wooden coffins, and simple inhumations in plain ground[30].

Zmajevac (*Ad Novas*) was a large fortified outpost on the Danubian *limes*. Based on grave goods its necropolis is dated to the 4th century AD. Two main types of graves are noted: simple inhumations in plain ground, and brick graves[31].

The recovered osteological material from both samples is related to individuals with simple or modest graves that exhibit uniform grave goods. The skeletal material from the rare luxurious inhumations was not available for study because these graves had been looted and the skeletal remains were either destroyed or dispersed. Differentiation between social categories based on the meagre grave goods and grave architecture could not be performed. Therefore, all individuals from both samples are considered as a single social category.

During anthropological analyses, carried out in the laboratory of the Department of Archaeology of the Croatian Academy of Sciences and Arts in Zagreb, the sex of the recovered individuals was determined on the basis of morphological differences in pelvic and cranial region between male and female skeletons[32–34]. Given that the fractures in subadults were very rare, this analysis primarily focused on adults, i.e. individuals over 15 years of age. Bone traumas in subadults were only described.

Several factors were used to assess age-at-death: the degree of obliteration of the cranial sutures[35], alterations in the pubic symphysis[36,37], alterations in the auricular surface of the ilium[38], changes on the sternal ends of the ribs[39,40], and degree of attrition of the occlusal surfaces of the teeth[41]. The age-at-death of subadults was assessed on the basis of the changes that occur during the development and formation of deciduous and permanent teeth, the degree of bone ossification (closure of the epiphysis and diaphysis), and the length of the diaphysis in long bones[34,42,43]. The age of the adults was given within a five-year range (e.g. 21–25), while the age of subadults was determined within a range of one year.

In this study, bone trauma is defined as a fracture resulting from the use of force or contact with a sharp or blunt object. Analysis of cranial trauma was carried out on crania that had more than 50% of their volume present, while analysis of the postcranial skeleton took into consideration the following bones: the clavicle, humerus, radius, ulna, femur, tibia and fibula. Only bones preserved to an extent of more that 50% of their surface were analysed, and only if at least one articular surface was mostly or completely preserved. The presence of trauma was determined by macroscopic analysis that included checking for bilateral bone asymmetry, angular deformities, and the presence of bone callus. In cases where there were any uncertainties, diagnoses were achieved through radiographic imaging. The frequency of trauma was calculated separately for each analysed bone. Potential differences were evaluated with the chi-square test using Yates correction when appropriate.

Results

Demography of analysed sites

The Late Antique sample from Zadar consists of 255 individuals: 64 subadults, 80 females and 111 males. The average age-at-death of adults (individuals over 15 years of age) from Zadar is 38.0 years (SD=9.33), with minimal differences between males – 38.4 years (SD=9.29), and females – 37.4 years (SD=9.43).

The Late Antique sample from continental Croatia consists of 323 individuals: 78 subadults, 118 females and 127 males. The average age-at-death of adults from continental Croatia is 38.5 years (SD=10.8) with, once again, minimal differences between males – 38.6 years (SD=10.65) and females – 38.3 years (SD=11.04).

In the Zadar sample fractures were observed in three subadult skeletons (3/64 or 4.7%): an antemortem healed depression fracture of the frontal bone, an antemortem healed fracture of the right pubic bone, and an antemortem healed fracture of the right rib. In the sample from continental Croatia bone traumas were observed in only one subadult skeleton (1/78 or 1.3%) – an antemortem healed fracture of the right rib.

In Zadar, fractures were observed in 14.3% (12/84) of skeletons belonging to the »young« adults (between 16 and 35 years) and in 23.4% (25/107) of skeletons belonging to the »old« adults (over 35 years). In continental Croatia, bone traumas were noted in 8.0% (8/100) of skeletons belonging to the »young« adults and in 17.1% (26/152) of skeletons belonging to the »old« adults.

Long bone traumas

In the Zadar series long bone trauma were observed in 12 females and 12 males (12.6% of the complete adult sample) of whom 22 suffered one trauma, while two individuals exhibited two traumas. The proportion of individuals affected with multiple long bone fractures is thus 8.3% of the individuals exhibiting trauma, and 1.0% of the complete adult sample.

The frequency of long bone trauma in the postcranial skeletons from Zadar is shown in Table 1. A total of 1345 long bones were analysed, 26 of which (1.9%) exhibit trauma. At the level of the complete sample, postcranial traumas were most frequent on radius (7/159 or 4.4%), followed by humerus (5/191 or 2.6%), and clavicle (5/220 or 2.3%). At the level of the complete sample there is a slight difference in left (2.4%) and right (1.5%) side involvement, and frequency is different according to sex (males 1.6% and females 2.4%). These differences are not significant. A significant sex difference is noted in the frequency of trauma to the radius where 6 of the 7 affected bones were noted in females (χ^2=4.143; p<0.05).

TABLE 1
DISTRIBUTION OF LONG BONE TRAUMAS BY SIDE AND SEX IN THE LATE ANTIQUE SAMPLE FROM ZADAR

	Left side			Right side		
	N*	n**	%	N	n	%
Clavicle						
Men	64	2	3.1	62	0	0.0
Women	49	3	6.1	45	0	0.0
Humerus						
Men	57	2	3.5	57	1	1.7
Women	41	0	0.0	36	2	5.5
Radius						
Men	46	1	2.2	47	0	0.0
Women	31	2	6.4	35	4	11.4
Ulna						
Men	49	1	2.0	51	1	2.0
Women	25	0	0.0	29	0	0.0
Femur						
Men	69	1	1.4	70	0	0.0
Women	45	0	0.0	48	1	2.1
Tibia						
Men	55	2	3.6	59	1	1.7
Women	38	0	0.0	40	0	0.0
Fibula						
Men	58	1	1.7	62	0	0.0
Women	37	1	2.7	40	0	0.0
Men	398	10	2.5	408	3	0.7
Women	266	6	2.3	273	7	2.6
Total	664	16	2.4	681	10	1.5

*N – total number of long bones.
**n – number of long bones with one or more traumas

The most complicated long bone fractures in the Zadar series were observed in two adult females. The skeleton of a female aged between 46 and 50 years recovered from grave 26 exhibits a badly healed antemortem fracture of right femoral mid-shaft with anterior misalignment, accompanied by severe shortening of the bone (Figure 2). The skeleton of a male aged between 46 and 50 years recovered from grave 359 exhibits a badly healed antemortem fracture of the distal shaft of the right humerus with lateral misalignment, shortening of the bone, and severe post-traumatically induced osteoarthritis on the distal joint surface.

In the Late Antique sample from continental Croatia 11 males and 7 females (7.3% of the complete adult sample) exhibited long bone fractures of whom 15 suffered one long bone trauma, while 3 individuals suffered two long bone fractures. The proportion of individuals affected with multiple long bone fractures is 16.7% of individuals exhibiting trauma, and 1.2% of the complete adult sample.

The frequency of long bone traumas in the postcranial skeletons from continental Croatia is shown in Table 2. A total of 1826 long bones were analysed, and traumas were observed in 21 (1.2%) of the analysed bones. The most frequent location for the trauma was on radius (5/224 or 2.2%), followed by tibia (6/286 or 2.1%), and ulna (4/223 or 1.8%). Once again males (1.3%) and females (1.0%) exhibit very similar total trauma frequencies. In terms of the side location of the trauma, the frequencies for the left (1.0%) and right (1.3%) side are almost identical. There are no significant differences between males and females for any observed bone element. All observed long bone traumas from continental Croatia represent well-healed antemortem fractures of the midshaft without angulation or shortening of the bone.

When comparing the distribution and frequency of long bone traumas between the two Late Antique samples there is only one significant difference, the one in the side distribution of the trauma. In the Zadar sample

Fig. 2. Badly healed antemortem fracture of the right femoral midshaft with anterior misalignment and severe shortening of the bone (Zadar, gr. 26, female 46–50 years).

TABLE 2
DISTRIBUTION OF LONG BONE TRAUMAS BY SIDE AND SEX IN THE LATE ANTIQUE SAMPLE FROM CONTINENTAL CROATIA

	Left side			Right side		
	N*	n**	%	N	n	%
Clavicle						
Men	78	0	0.0	83	1	1.2
Women	70	1	1.4	72	1	1.4
Humerus						
Men	73	1	1.4	67	0	0.0
Women	48	0	0.0	49	0	0.0
Radius						
Men	66	1	1.5	74	2	2.7
Women	44	0	0.0	40	2	5.0
Ulna						
Men	65	1	1.5	70	1	1.4
Women	45	0	0.0	43	2	4.6
Femur						
Men	82	0	0.0	83	0	0.0
Women	68	0	0.0	72	0	0.0
Tibia						
Men	75	3	4.0	78	1	1.3
Women	65	1	1.5	68	1	1.5
Fibula						
Men	72	1	1.4	71	1	1.4
Women	52	0	0.0	53	0	0.0
Men	511	7	1.4	526	6	1.1
Women	392	2	0.5	397	6	1.5
Total	903	9	1.0	923	12	1.3

*N – total number of long bones.
**n – number of long bones with one or more traumas

the frequency of trauma located on the left side of the skeleton is 2.4% (16/664), while in continental Croatia this frequency is 1.0% (9/903; χ^2=4.007; $p<0.05$).

Cranial traumas

Besides long bone trauma, both Croatian Late Antique samples exhibit evidence of cranial trauma.

In the Zadar series cranial trauma was observed in 16 individuals (seven males, seven females and two subadults). Twelve skulls exhibit one injury, three skulls have two traumas, and one skull has three injuries that cumulatively give a total of 21 cranial traumas for the Zadar series. The proportion of adult individuals affected with multiple cranial fractures is 28.6% of individuals with cranial trauma. The frequency of cranial trauma in the adult sample from Zadar is very high: 14 out of 60 preserved adult skulls (23.3%) exhibit some type of trauma, with no statistical difference between males (7/33 or 21.2%) and females (7/27 or 25.9%).

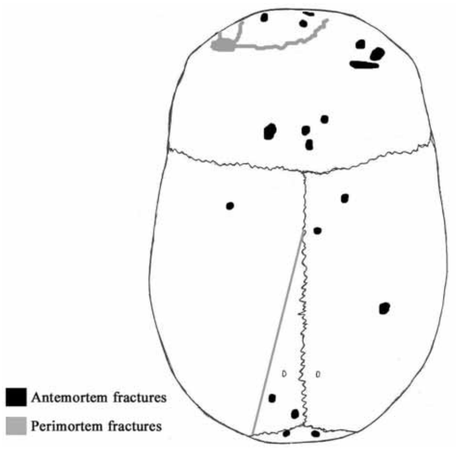

Fig. 3. A schematic distribution of the cranial traumas of adults from Zadar (minus one trauma on parietal bone).

A schematic representation of the distribution of cranial trauma in the Zadar series is shown in Figure 3. More than half of the cranial trauma are located on the frontal bone (55% or 11/20); followed by trauma located on the left parietal bone (20% or 4/20), trauma located on the right parietal bone (15% or 3/20), and trauma located on the occipital bone (10% or 2/20) (Table 3). One trauma is located on a parietal bone but the bone is too badly preserved to determine whether it was a left or right parietal bone.

Most of the observed cranial traumas (19/21) are shallow, antemortem, oval or elongated, well-healed depression fractures caused by blunt objects. Two skulls, however, exhibit perimortem fractures to the cranial vault. The most dramatic cranial trauma is a massive, distinctively straight (93 mm) perimortem fracture to the left parietal and occipital bone (Figure 4) of a male aged between 36 and 40 years (grave 378). Based on the well-defined sharp edges, the v-shaped cross-section, polished cut surface, and macroscopically visible parallel stria-

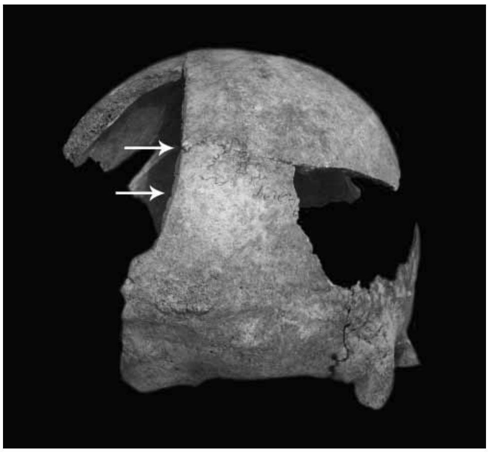

Fig. 4. A massive perimortem fracture to the left parietal and occipital bone possibly caused by a sword (Zadar, gr. 378, male 36–40 years).

TABLE 3
DISTRIBUTION OF CRANIAL FRACTURES BY BONE IN THE LATE ANTIQUE SAMPLES FROM CROATIA

	Frontal		Left parietal		Right parietal		Occipital		Facial region		Total
	N*	%	N	%	N	%	N	%	N	%	N
Zadar	11	55.0	4	20.0	3	15.0	2	10.0	0	0.0	20
Continental Croatia	5	29.4	8	47.0	2	11.8	0.0	0.0	2	11.8	17

*n – number of observed cranial traumas

tions perpendicular to the kerf floor, the injury was inflicted by a sharp bladed object, most likely a sword[44–48]. The blow was inflicted from above in an anterior-posterior direction. The injury penetrated both cranial tables, and during the extraction of the blade almost half of the left parietal bone was detached from the rest of the skull.

The second perimortem trauma is observed on the skull of a female aged between 36 and 40 years (grave 131). This is also a massive injury located on the left side of the frontal bone (approximately 33 mm superior of the left superior orbit) caused by a blunt object (possibly a sling projectile). The injury exhibits three long fracture lines originating from the point of impact. These lines have sharp edges, and exhibit no sign of healing.

Cranial traumas in continental Croatia were observed in 16 individuals (14 males and 2 females). Fifteen skulls exhibit one lesion, while one skull has two injuries giving a total of 17 cranial traumas. The proportion of adult individuals affected with multiple cranial fractures is thus 6.2% of individuals with cranial trauma. The frequency of cranial trauma in the preserved adult skulls from continental Croatia is 14.8% (16/108). Males exhibit a significantly higher frequency of cranial injuries than females (21.9% or 14/64 compared to 4.5% or 2/44; $\chi^2=5.2$, $p<0.05$).

A schematic representation of the distribution of cranial trauma in the sample from continental Croatia is

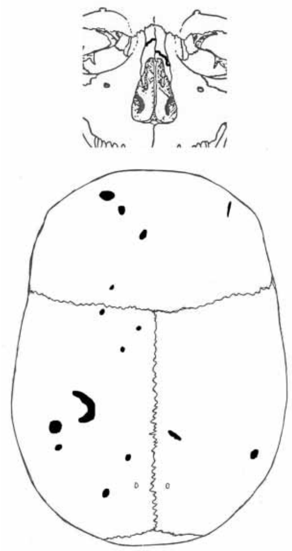

Fig. 5. A schematic distribution of the cranial traumas of adults from continental Croatia.

shown in Figure 5. Most of the cranial trauma are located on the left parietal bone (47.0% or 8/17), five lesions are located on the frontal bone (29.4%), two on the right parietal bone (11.8%), and two in the facial region (nasal bones) (11.8%) (Table 3).

All of the observed cranial trauma in continental Croatia are antemortem, shallow, oval, elongated or 'L' shaped depression fractures caused by blunt objects. The exceptions are two antemortem facial trauma noted in the left nasal bones of two 51 to 55 years old males from Štrbinci. Both fractures are badly healed, and exhibit large calluses as well as misalignment of the bone.

As in the analysis of long bone fractures there is only one significant difference in the frequency of cranial trauma between Zadar and continental Croatia. Females from the Zadar series exhibit a significantly higher frequency of cranial traumas than females from continental Croatia (25.9% or 7/27 compared to 4.5% or 2/44; $\chi^2=5.113$, $p<0.05$).

Individuals with multiple fractures

Of the 44 individuals from Zadar who exhibited evidence of bone traumas, 9 (20.4%) exhibit a minimum of two injuries (seven males and two females). The most severe examples of multiple fractures were observed in two adult males. A male aged between 46 to 50 years exhibits: 1) a healed depression fracture on the frontal bone, 2) fractures of the 7^{th}, 8^{th} and 9^{th} left ribs, and 3) a fracture of the distal right humerus. A male aged between 36 and 40 years exhibits: 1) a massive perimortem injury to the left parietal and occipital bones, 2) two healed depression fractures on the right parietal bone, 3) fractures of the 7^{th}, 8^{th} and 9^{th} left ribs, and 4) a fracture on the distal shaft of the left fibula.

In the sample from continental Croatia 35 skeletons show evidence of bone trauma, 6 of which (17.1%) exhibit a minimum of two injuries. Five of these are males, while one is female. The most severe example is observed in a 41 to 45 years old female from Osijek who exhibits: 1) a well-healed fracture of the right clavicle, 2) fractures of the 2^{nd} left and 3^{rd} right ribs, 3) a healed oblique fracture of the distal shaft of the right ulna, and 4) a healed fracture of the distal right radius.

Discussion and Conclusion

In both analysed samples, bone fractures are more common in skeletons belonging to the older adults in

TABLE 4
COMPARISON OF LONG BONE TRAUMA FREQUENCIES BETWEEN CROATIAN AND BRITISH ROMAN PERIOD SKELETAL SAMPLES

	Zadar			Continental Croatia			Gloucester			Cirencester (south)		
	N*	n**	%	N	n	%	N	n	%	N	n	%
Clavicle	220	5	2.3	303	3	1.0	61	1	1.6	291	3	1.0
Humerus	191	5	2.6	237	1	0.4	75	0	0.0	294	1	0.3
Radius	159	7	4.4	224	5	2.2	56	0	0.0	300	5	1.7
Ulna	154	2	1.3	223	4	1.8	54	0	0.0	272	8	2.9
Femur	232	2	0.9	305	0	0.0	74	0	0.0	335	0	0.0
Tibia	192	3	1.6	286	6	2.1	77	2	2.6	334	8	2.4
Fibula	197	2	1.0	248	2	0.8	69	2	2.9	274	13	4.7
Total	1345	26	1.9	1826	21	1.1	466	5	1.1	2100	38	1.8

*N – total number of long bones.
**n – number of long bones with one or more traumas

comparison with the skeletons belonging to the younger adults. This situation is logical considering that the bone traumas are, like some other pathological changes (e.g. dental diseases), age-dependent, i.e. their frequency increases with advanced age. Simply put, older adults had more time to experience a bone fracture. In addition, factors such as osteoporosis, could also have contributed to the higher frequency of fractures in older adults.

Both Late Antique series from Croatia display similar prevalences of long bone fractures. In an attempt to get a clearer picture of trauma patterns in the analyzed samples, an effort was made to distinguish trauma that were the result of accidents, from those that resulted from deliberate violence. Prevalences of long bone fractures in Zadar and continental Croatia were also compared with the prevalences of long bone fractures in two British Roman period skeletal samples: Cirencester (south)[49] and Gloucester[50].

The most frequent location of fractures in both Zadar and continental Croatia is on the radius (in Zadar 4.4%, and in continental Croatia 2.2%). Most of these were what are usually called »Colles« fractures, a type of fracture that is attributed to accidents, i.e. falling on to the pronated arm and outstretched hands[51,52].

A relatively high frequency of humeral fractures was observed in the Zadar sample (2.6%). Of the five observed fractures on the humerus, one is located on the neck of the bone, while four are shaft fractures. These fractures could have been caused by accidental falls, but also by blows to the arm[53,54].

In addition to fractures of the humerus and radius, one of the most frequent bone traumas in the Zadar sample are clavicular fractures (2.3%), mainly on the midshaft or lateral end of the bone. Bigliani et al.[55] suggested that falls during which the shoulder impacts the ground can cause such fractures, while Judd and Roberts[56] suggested that equestrian accidents (as well as injuries from close work with other large animals) are an important causative factor for these fractures in archaeological settings. Beside these, one of the main causes of clavicle fractures is direct blow from a club or another weapon, especially when the aggressor who seeks to bludgeon an opponent's skull misses the head and instead hits the shoulder and smashes the collar bone[49]. It can not be determined with certainty which clavicular fractures occurred as a result of interpersonal violence and which were the result of accidents but at least some part of these traumas occurred as a result of deliberate interpersonal violence.

The sample from continental Croatia has a relatively high (2.1%) frequency of tibial fractures. Four of those are oblique fractures suggesting falls from a low height[54,57], and two are depression fractures of proximal joint surfaces that are also consistent with falls.

A part of the postcranial skeleton that has frequently been utilized as an indicator of intentional violence is the ulna, particularly the presence of so-called 'parry' fractures on the distal or middle third part of the ulna. This type of injury usually results from an attempt to protect one's head from a blow by raising one's arm and exposing the forearm to the full impact of the blow, often resulting in breakage[1,52,58,59]. The problem of attributing such fractures exclusively to intentional violence was raised, and thoroughly explained by Judd and Roberts[56], and Smith[60]. These authors agree that a fracture of the ulna, especially in its middle third, can indicate that a hard or sharp object to the pronated lower arm delivered a blow. However, they point out that a person who falls, and hits the sharp edge of a rock or tool could suffer the same injury.

Ulnar trauma frequencies in two Roman period samples from Croatia are relatively low and very similar (1.3% in Zadar, and 1.8% of continental Croatia), and as such may not be used as an indisputable indicator of intentional violence in the analysed samples.

Comparison of the long bone trauma frequencies in the Croatian Late Antique samples with samples from Great Britain (Cirencester (south)[49] and Gloucester[50]) show that total long bone trauma frequencies recorded in Zadar and continental Croatia are compatible with the prevalences noted in British sites (Table 4). Simmonds et al.[50] suggested that fracture patterns in Gloucester indicate limited interpersonal violence, and that the patterns of trauma in Gloucester were similar to those reported by Wells[49] for Cirencester (south), primarily in the under-representation of forearm fractures, and the frequency of lower limb fractures. The majority of fractures recorded in Gloucester are likely to have resulted from accidents rather than interpersonal violence[50], a trend that is also seen among other skeletal samples of this period[61] suggesting that the towns of Roman Britain were generally not unruly places[50]. Although the total frequencies of long bone traumas in analysed Croatian and British skeletal samples are almost identical there is a difference in the pattern of trauma (in terms of the elements involved). While the most frequent trauma in British samples are those of the lower extremities (and trauma of the upper extremities are under-represented), in the Croatian samples, particularly in Zadar, most fractures are located on the upper extremities, which is suggestive of a somewhat higher level of interpersonal violence in Croatian samples.

Several authors[4,54,62–64] point out that high frequencies of head and face trauma are conclusive proof of intentional violence. Additionally, fractures of the nasal bones are one of the most typical results of violent bickering, and it is possible that individuals who suffered these traumas were recipients of a well-directed punch to the nose[49]. The frequencies of cranial trauma in both series (Zadar 23.3%, continental Croatia 14.8%) are higher than the frequencies of cranial trauma observed in numerous other osteological samples from around the world[3,65–71]. Unfortunately, the frequency of cranial traumas for two British Roman period samples (Cirencester (south) and Gloucester) are not specified, but Simmonds et al.[50] cited that in Gloucester only one healed blunt force trauma was observed, while Wells[49] reported two nasal fractures, four healed blunt force traumas and several cranial traumas caused by sharp weapons in Cirencester (south). Number of cranial traumas in Cirencester (south) may seem high but it is necessary to bear in mind that the majority of males buried in this necropolis were retired legionaries[49] who probably sustained most of the observed injuries during a long military service. Few authors have recorded frequencies similar to those in the Late Antique samples from Croatia. Walker[4] noted that the frequency of cranial trauma in a population from the Santa Barbara Channel region was around 19.9%, Alvrus[54] observed a fracture rate of 17.9% in a Nubian sample from Semna south, while Heinrich[72] reported a fracture rate of 18.7% at the Late Mediaeval site of Eggenburg in Austria. In Croatia, Šlaus and Novak[16] recorded a frequency of 16.7% for the Late Mediaeval populations from Crkvari and Kliškovac, while Novak et al.[73] recorded a frequency of 17.8% in the Early Modern period skeletal sample from Koprivno. The vast majority of cranial lesions observed in both Croatian Late Antique samples are shallow, oval or elongated fractures. According to Wells[49] this type of injury »…could have been caused by an accidental blow on the head…or…a fall against a corner of the table…[or]…a battle wound caused by an accurately directed slingshot«. In conclusion, the high frequencies of cranial traumas in Zadar and continental Croatia strongly suggest a relatively high risk of intentional violence in both of these samples.

Additional arguments for the presence of intentional violence in the two Croatian samples are the significantly higher frequency of cranial trauma in males recorded in the sample from continental Croatia, and the presence of two perimortem cranial injuries in the Zadar sample.

In terms of the hypothesis tested in this paper – the higher frequencies of both postcranial and cranial fractures in the Zadar series, as well the presence of two perimortem injuries in this sample, contradict the assumption that the Late Antique inhabitants of continental Croatia were exposed to higher level of violence because of their proximity to the military border.

The following reasons may have contributed to this.

Late Antique Zadar was situated on a relatively small peninsula on an area of barely 50 hectares (1,000×500 meters), surrounded by massive stone walls. It was characterized by high population density: some authors estimate that Zadar had between 20 and 25,000 inhabitants in the 4th century AD[25], while others estimate the number of inhabitants in this period closer to 40,000[26]. In overcrowded communities, and Roman *Iader* definitively was such a community, there is a high potential for both accidents as well as episodes of interhuman violence. This fact may be responsible for the high frequency of cranial trauma, and a higher frequency of long bone trauma (especially trauma of the forearm) in this series when compared to the sample from continental Croatia. Some of the observed fractures in Zadar suggest some type of accident (some of the clavicular fractures, fractures of the lower extremities – especially of the tibia and fibula), but some were definitely a result of intentional interpersonal violence of, most likely, lesser intensity such as street fights, and tavern brawls with only the occasional use of sharp-edged weapons[74].

Previous analyses of continental Croatia during the Late Antique period by Šlaus et al.[12] suggested that the relatively similar levels of osteological and dental markers of stress between the inhabitants of a fortified settlement on the Danube *limes,* and the inhabitants of three settlements in its hinterland, might be the result of long-term strategies that fundamentally changed the role of the *limes* during the Late Antique period. These strategies that diminished the defensive importance of the *limes* began to be implemented in the 2nd century AD when the emperor Marcus Aurelius started using tribes settled outside of the Empire in the defence of the *limes*[29]. In accordance with this strategy during the 3rd century AD the emperor Gallienus stationed cavalry troops for the defence of the *limes* not on, or near the border, but well to its rear[75]. This strategy may be responsible for the slightly lower trauma frequencies recorded in continental Croatia. Following the withdrawal of large military units deeper into the Empire, the *limes* and settlements adjacent to it, lost their strategic importance, and gradually became less populated. This decline in both importance and population may be responsible for the slightly lower trauma frequencies recorded in continental Croatia, as well as for the total lack of perimortem injuries recorded in this series. We found no evidence suggesting that any of the bone trauma recorded in the sample from continental Croatia were a result of deliberate violence of greater intensity, such as, for instance, large battles or town sieges.

It is, however, necessary to mention that all of the skeletal material from continental Croatia derives from individual graves from official town cemeteries. Archaeological excavations did not reveal signs of mass graves that might suggest that the buried individuals were victims of an armed battle or a siege. The whereabouts of the remains of the victims of the numerous battles related to civil wars and barbarian incursions described in the historical sources of the times is, at present, unknown. It is possible that they were cremated on massive pyres in order to avoid the spread of infectious diseases.

The high frequency of cranial fractures (especially trauma of nasal bones), combined with a presence of two 'parry' fractures of the ulnae in the Zadar sample suggests sporadic episodes of intentional interpersonal violence of a lesser intensity.

In conclusion, the results of our analyses indicate little difference between the frequencies and distribution of bone trauma in two Late Antique skeletal samples from Croatia – one located on, or near the military border, the other deep in the territory of the Roman Empire. Both samples exhibit similar, relatively high frequencies of long bone trauma, and a very high frequency of cranial trauma. Our analysis does not confirm reports from written sources that suggest a significantly higher risk of intentional interpersonal violence in the region of continental Croatia. Some of the observed fractures in both samples were caused by accident, but some were definitely the result of intentional interpersonal violence of lesser intensity, rather than the more overtly violent confrontations such as large battles or town sieges. Comparison of long bone trauma frequencies between Croatian and British Roman period samples show that the total frequencies in all samples are very similar with, however, differences in the pattern of trauma – in British samples the most frequent trauma are those of the lower extremities, while in Croatian samples the most frequent location for trauma are the upper extremities. Unfortunately, the comparison of the frequency of cranial trauma between Croatian and British samples was not possible but the fact that only one cranial trauma was observed in Gloucester is very indicative. A somewhat higher number of cranial traumas in Cirencester (south) is explained by the fact that the majority of male skeletons from this sample belonged to retired legionaries who sustained most of the observed injuries during a military service before retirement. The presented data and comparison between Croatian and British skeletal samples suggests a somewhat higher level of interpersonal violence in the Croatian samples during the Late Antique period. Clearly, additional research of Late Antique Croatian skeletal samples is necessary to determine if data from these samples will support the results of the analysis presented in this paper. Furthermore, collaboration with archaeologists and historians is of vital importance if we are to shed more light on the events, and long-term processes that took place during the Late Antique period in the region of modern age Croatia.

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KOŠTANE TRAUME U KASNOANTIČKIM POPULACIJAMA IZ HRVATSKE

S A Ž E T A K

Članak donosi rezultate analize učestalosti i distribucije traumatskih koštanih povreda u dva kasnoantička (3.–5. st.) skeletna uzorka s područja Hrvatske: Zadar (istočna jadranska obala) i kompozitni uzorak iz kontinentalne Hrvatske (Osijek, Vinkovci, Štrbinci, i Zmajevac). Skeletni uzorak iz kontinentalne Hrvatske potječe s nalazišta smještenih uz dunavski limes, za razliku od Zadra koji se nalazi na istočnoj jadranskoj obali, u dubini Rimskog Carstva. Brojni povijesni izvori opisuju česte barbarske upade i bitke u građanskim ratovima na području kontinentalne Hrvatske između 3. i 5. st. Istodobno nisu poznati povijesni izvori koji bi svjedočili o sličnim događajima u zadarskom području. Analiza koštanih trauma pokazala je vrlo sličnu, relativno visoku učestalost fraktura dugih kostiju u oba kasnoantička uzorka, s nešto višom učestalošću u Zadru, kao i vrlo visoku učestalost trauma glave u oba uzorka s višom učestalošću u uzorku iz Zadra. Dvije perimortalne ozljede glave pojavljuju se u uzorku iz Zadra (jedna prouzročena mačem, druga tupim predmetom). Dio uočenih trauma u oba uzorka najvjerojatnije je nastala nenamjerno, nesretnim slučajem, no određeni broj ozljeda zasigurno je posljedica namjernog međuljudskog nasilja manjeg intenziteta. Potrebna su daljnja multidisciplinarna istraživanja koja će obuhvatiti osteološke, arheološke i povijesne analize, kako bi se potvrdili rezultati proizašli iz analize ovih uzoraka i razjasnili razlozi koji su doveli do uočenih razlika u učestalosti i distribuciji koštanih trauma između dva kasnoantička skeletna uzorka iz Hrvatske.