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Skeletal Indicators of Intentional Violence and Injuries in Late Antique and Medieval Populations from Croatia

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A B S T R A C T

The transition from the Late Antique (2nd–5th century AD) to the Medieval period (6th – 11th century AD) in Croatia is documented in historical sources as catastrophic with destruction of urban centers, social collapse, and increased interpersonal violence. In order to investigate the accuracy of these reports, an analysis of the frequency and patterning of bone traumas in two composite skeletal series from these time periods was conducted. A total of 1121 adult skeletons – 674 from the late antique (LA) and 447 from the medieval (MED) series were examined. In order to differentiate between intentional violence and accidental injuries, fracture frequencies were calculated for: the complete skeleton, individual long bones, the craniofacial region, as well as by type of injury (perimortem vs. antemortem).

The results of this analysis show a clear increase in total fracture frequencies when calculated by skeleton, in 'parry' fractures, radial injuries, ulnar fractures, as well as of individuals exhibiting a single skeletal indicators of intentional violence. These data highlight the complexities associated with trauma analysis and imply that factors other than intentional human violence contributed to the increase of fracture frequencies recorded in the medieval period.

Key words: *paleopathology, intentional violence, trauma analyses, Croatia, perimortem trauma*

Introduction

Reconstructing the lifeways of past populations and cultural systems relies on the availability of relevant written sources, recovered material remains, and increasingly on bioarchaeological data[1-3]. This is because human osteological and dental remains from archaeological contexts provide excellent material for bioarchaeologists studying past population life-styles, social behavior, subsistence strategies and diet[1,4,5]. One of the most studied features in archaeological samples are bone fractures[6-9]. Trauma to bone, whether accidental or the result of intentional interpersonal violence has always been a primary concern of bioarchaeologists as it affords a unique opportunity to study ancient violence. From time immemorial, or at least from the time of Herodotus, Polybius, and Livy, people have speculated about the wars, genocides, and murders committed by those who lived before them. And that, of course, has for a long time been the problem – these discussions and written texts were speculations largely based on legends, stories, and heroic poems. Not evidence. From the archaeological point of view evidence derives from four basic sources: defensive architecture and settlement patterns, weaponry and related artifacts, iconographic representations of weaponry, violence and related symbols, and skeletal trauma[10]. Of these, skeletal trauma is the only direct source of information on the degree to which violence was present in a community. Furthermore, because skeletal remains reflect actual individuals and can be sexed and their age at death determined analyses of skeletal trauma can reveal what subsets of an ancient population were exposed to violence, as well as how they coped with it, or what defense mechanism they evolved to circumvent it.

This latter is of particular relevance in the modern world where numerous populations are exposed to social instability and violence[11,12]. Analyzing the effects that violence has on health through the deep time perspective that archaeological and bioarchaeological investigations afford provides unique data on the interactions between violence, health and the environment allowing for conclusions that are particularly relevant to disadvantaged communities throughout the developing world where violence is currently endemic. There is no doubt that infer-

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ences about past lifeways can successfully be utilized to better inform decisions in the present and future.

In this context, Croatian archaeological series from the period between the 2rd – 11th century AD provide a unique opportunity to study the effects that long-term violence had on the health of the populations it afflicted. This is due to the fact that from the end of the 2nd century AD up to the 11th century AD the past inhabitants of Croatia were exposed to high levels of violence caused by a wide variety of factors that include the weakening of central authority in the Roman Empire and recurrent civil wars, barbarian intrusions that culminated in the fall of the Western part of the Roman Empire, the gradual transition to a feudal society, and endemic warfare between Adriatic towns and Venice. Not surprisingly traditional historiography from the end of the 19th and beginning of the 20th century uniformly describes this period as disastrous with destruction of major urban centers, depopulation and famine[13-15.]

This was based on the historical and archaeological evidence for the destruction of large urban centers in the Roman provinces of *Pannonia* (which included modern continental Croatia) and *Dalmatia* (which included Adriatic Croatia). *Sirmium* (modern Srijemska Mitrovica), *Mursa* (Osijek), *Cibalae* (Vinkovci), *Salona* (Solin), *Narona* (Vid) and numerous other urban centers were destroyed and/or abandoned during the second half of the 6th century and the beginning of the 7th century. Additionally, Roman town names disappeared in both provinces – the only Roman town names that have survived to the present from *Pannonia* are Ptuj (Roman *Poetovia*), Sisak (*Siscia*), Rab (*Arrabona*), and possibly Vienna (*Vindobona*). The subsequent establishing of a Croat state did little to reduce violence as it very quickly came into conflict first with the rapidly expanding state of Venice, and secondly with Saracen pirates who from the middle of the 9th century AD started infiltrating the Adriatic Sea. The general consensus among late 19th century historians was that the Late Antique population of Croatia was virtually annihilated, with the surviving refugees fleeing to small defendable centers in the Dinarid mountain range or to the Adriatic islands where they could be protected by the Byzantine fleet. This was then followed by a period of feudal anarchy and constant warfare with Venice and the Saracens.

Recently, historians have begun challenging this interpretation by pointing out important inconsistencies[16-18]. While sustaining the assertion that the transition from the Late Antique (LA) to the Medieval (MED) period was characterized by significant political, social, and economic change, they note that historical sources for this period are almost non-existent. Unlike ethnic groups such as the Ostrogoths and Lombards, who recorded their achievements in written documents, Croats left no written records themselves. Instead, the available historical records derive from Byzantine, Frankish or Church historians who were, for reasons of their own, biased to a large degree[18]. Furthermore, the emigration of large numbers of Roman refugees to the Adriatic islands does not seem likely as none of these islands developed large urban centres comparable to, for instance, Venice or Ravenna on the western Adriatic coast.

Recent bioarchaeological studies also suggest that the period between the 2nd to the 11th century AD was, at least in terms of violence, complicated, and that numerous factors – including ecological habitat, continuity or discontinuity of subsistence strategies, and local military and political considerations played a huge role in the degree of violence to the which the past inhabitants of Croatia were exposed to[19].

The purpose of this study is to assess violence during the transition from the Late Antique to the medieval period in Croatia by analyzing trauma frequencies and distributions in archaeological series from Croatia. Results of the analyses of the skeletal remains will be compared with the available historical and archaeological data to test the hypothesis that this transition was catastrophic.

Materials

For the purposes of this study, analyses were conducted on osteological material recovered from cemeteries assigned to one of two large composite series – a Late Antique series (LA 2nd–6th c.) and a medieval series (MED 6th–11th c.). The geographical location of the analysed sites is shown in Fig. 1, while the number of recovered skeletons is presented in Table 1.

The first sample comprises of skeletal material from five sites – the port towns of Zadar and Vid located on the eastern Adriatic coast, and the sites of Štrbinci, Zmajevac, and Vinkovci that are situated in the continental part of Croatia relatively near to the Danubian *limes*.

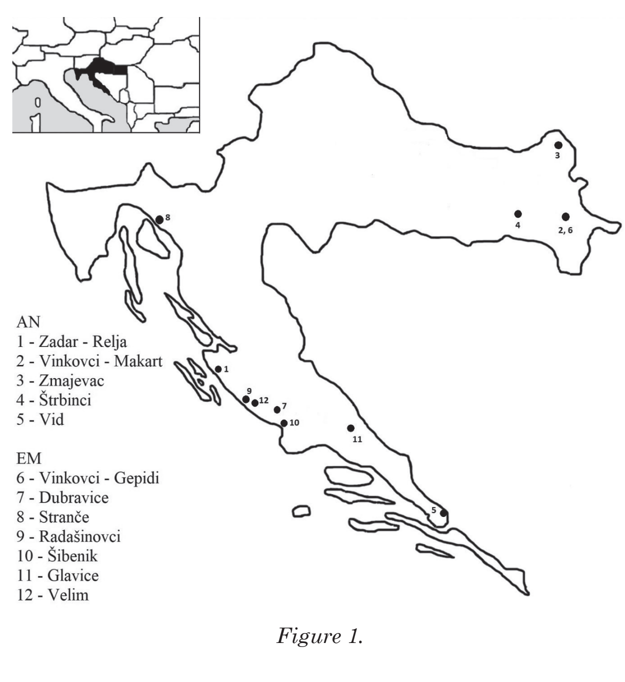

Figure 1.

TABLE 1
ARCHAEOLOGICAL SITES ANALYZED IN THIS STUDY

Site	Dating	Number of skeletons
Late Antique series		
Zadar-Relja, urban	LA (2nd–6th c.)	274
Vinkovci, urban	LA (3rd–5th c.)	73
Zmajevac, rural	LA (4th c.)	136
Štrbinci, urban	LA (4nd–5th c.)	119
Vid, urban	LA (5th–6th c.)	72
Total		674
Medieval series		
Vinkovci, rural	MED (5th–6th c.)	21
Dubravice, rural	MED (7th–9th c.)	69
Strance, rural	MED (8th–11th c.)	35
Radašinovci, rural	MED (9th c.)	78
Šibenik, rural	MED (9th–11th c.)	65
Glavice, rural	MED (8th–9th c.)	78
Velim, rural	MED (8th–9th c.)	101
Total		447
Grand total		1121

The MED sample consists of skeletal material from six sites located on the eastern Adriatic coast and its immediate hinterland (Dubravice, Stranče, Velim, Radašinovci, Šibenik and Glavice), and one site (Vinkovci) situated in continental Croatia. Vinkovci is the only site that has skeletal series from both time periods – an antique population that inhabited the town of *Cibalae* from the 3rd to 5th century AD, and a later Gepid population that inhabited the area during the 5th – 6th century AD.

The LA sample comprises of 674 adult skeletons (374 males and 300 females) from five archaeological sites: Zadar-Relja[20,21], Vinkovci – Makart[22,23], Zmajevac[24,25], Štrbinci[26-28] and Vid[29,30]. Except for Zmajevac that was a large fortified military outpost on the Danubian *limes*, all of the sites were large, well developed urban centres with the status of Roman colonies. Based on recovered grave goods, horizontal stratigraphy and burial rites, skeletons from this composite sample are dated between the 2nd and 6th centuries. The remains were recovered from simple inhumations in plain ground, stone tombs, and graves covered with *tegulae* (roof tiles) or fragments of *amphorae*. Grave goods were modest and include pins, pottery, rare examples of glass, oil lamps, coins, *fibulae* and occasional examples of silver and gold jewellery. Based on the paucity of these finds, as well as on the relatively uniform grave architecture, no social differentiation could be attempted and all of the recovered individuals are treated as a single social category.

The MED sample consists of 447 adult skeletons (238 males and 209 females) from seven small rural settlements: Vinkovci – Gepidi[31], Dubravice[32], Stranče[33], Radašinovci[34], Šibenik[32], Glavice[35], and Velim[36]. Cemeteries from these sites were, based on grave goods, burial rites and radiocarbon dating, in use between the 6th to 11th centuries AD. The vast majority of burials were simple inhumations, dug deep into plain soil or bedrock, aligned in rows and encased and covered with stone slabs. Grave findings were uniform and rare: pottery, knives, coins, and bronze and silver jewellery and therefore, as in the previous series, all individuals are considered to be from a single social category.

Methods

Analyses were conducted only on adult skeletons (individuals over 15 years of age). This study excludes analysis of trauma in subadults for the following reasons: 1) the uniformly poor preservation of subadult skeletons in both composite series caused by the greater fragility of subadult bones and differential burial rites for children; 2) the generally low trauma rates recorded in subadults when compared to adults in both modern and archaeological series[9,19,37]; and 3) problems associated with trauma identification in subadult remains related to features of immature bone that allow quick repair and remodelling of fractures making them hard to identify and resulting in underestimates of subadult trauma frequencies (for a more detailed explanation of problems related to trauma analyses in subadult remains see Lewis[38]).

Sex of the skeletons was determined based on pelvic and cranial morphology, using methods described in Buikstra and Ubelaker[39].

To determine the age-at-death of individuals, methods based on pubic symphysis morphology[40-42], auricular surface morphology[43], sternal rib end changes[44,45], and epiphyseal fusion when dealing with younger adults[46] were used. All adults were assigned to one of three composite age categories: young (between 15 and 30 years), middle aged (between 31 and 45 years) and old (46+ years).

Skeletal trauma was macroscopically analysed using methods proposed by Maples[47] and Lovell[48]. If needed, additional observation was conducted with a magnifying glass. For each injury there is a record of its location, shape, dimensions and possible complications. Complicated fractures were further analysed with radiographic imaging and CT scans. A distinction was made between ante-, – peri and postmortem bone fractures. Antemortem fractures were recognized by evidence of healing, bone remodelling and bony callus. Perimortem fractures were recognized by the absence of healing and new bone formation, fragments of bones attached to each other[49], sharp, smooth, often bevelled fracture lines[50,51], flat or polished surfaces with macroscopically visible striations[52], and by colour on the fractured ends that was the same as on adjacent bone[51]. Perimortem fractures can be mimicked by postmortem fractures which are usually the result of the passage of time and natural forces such as sun bleaching, above- and underground waters, sea, plants and roots, grave collapse, secondary burial, improper excavation of remains, animal activities such as gnawing, grinding etc. To avoid confusion between the two, analysis by colour, pattern and texture of the lesions was conducted according to criteria set up by Sauer[49] and Facchini et al.[53].

Because of the varying degrees of skeletal preservation fracture frequencies were calculated by skeleton, long bone, and cranium.

Trauma frequencies by skeleton were calculated from the number of skeletons exhibiting fractures (including fractures of small bones such as bones of hand and feet, the ribs, etc.) divided by the total number of skeletons, regardless of the degree of skeletal preservation.

When checking for the presence of fractures in long bones, analyses were conducted on the: clavicles, humerii, radii, ulnae, femora, tibiae and fibulae. Only bones with their original surface preserved up to at least 50% or more and with all major articular surfaces present were analysed. Bilateral bone asymmetry, angular deformities, and the presence of bone calluses were considered to be conclusive proof of presence of fracture.

Cranial trauma was analysed only on crania that had all major bones (frontal, both parietal, both temporal, occipital, facial bones, and mandible) preserved up to at least 50% or more. The following types of trauma were analysed: penetrating injuries, blunt force trauma, and sharp force trauma. Penetrating injuries can be identified by internal and external bevelling[54], while partially penetrating wounds exhibit depressed, comminuted fractures that are the result of bone being crushed at the point of impact[55]. Blunt force trauma is associated with concentric fracture lines exhibiting internal bevelling, knapping of fracture surfaces, plastic deformation and fractures radiating from a point of impact[54]. They are usually caused by a relatively low-velocity impact over a relatively large surface and are typically created through contact with a blunt instrument, or during falls[56]. Sharp force trauma is identified by the presence of linear lesions with well-defined sharp edges that have flat, smooth and polished cut surfaces. These lesions exhibit a V-shaped cross-section, and macroscopically or microscopically visible parallel striations perpendicular to the kerf floor[57-59].

Injuries to bone and teeth can be caused through unexpected and unplanned events, or intentionally (i.e. interpersonal violence), by harmful interactions between family members or between members of the same or differing communities[60-62]. Orthopaedists have noticed that accidents are the main cause for injuries in the lower leg (tibia and fibula), clavicle, humerus, radius and femur (particularly the femoral neck)[63]. Fracture types that were found to be more commonly associated with incidents of interpersonal violence are depressed cranial fractures, nasal fractures, ulnar fractures, rib fractures and metacarpal fractures[64-68]. Jurmain et al.[8] argue that patterns of interpersonal aggression in archaeological series can best be understood through the analysis of correlations between different types of injuries in different osseous elements. In this analysis we therefore employ similar criteria to those suggested by Jurmain et al.[8], and record the presence and co-occurrence of four skeletal indicators of deliberate violence: craniofacial injuries (facial and frontal regions combined), sharp force lesions, 'parry' fractures, and perimortem trauma. When a skeleton exhibited a craniofacial fracture that was the result of a sharp force lesion, or a perimortem trauma only one aspect of the injury was recorded. In cases where a skeleton exhibited a perimortem cranial injury, and an antemortem cranial fracture – both traumas were recorded. All other recorded injuries were deemed to have been caused by accidents.

The skeletal samples were compared by chronological period, age, and sex. carried out using IBM SPSS Statistics version 20.0 for Windows OS. The differences between samples were evaluated with the χ^2 test using Yates correction when appropriate. The difference itself was declared statistically significant when probability levels of P were lesser than/equal to 0.05. Before proceeding to the chapter Results, it is important to emphasize that inferential statistical tests are only used when dealing with frequencies related to individuals. If this kind of tests are carried out on frequencies expressed by total number of bones, type 1 error can occur. This happens because bones in individual skeleton are not independent observations. That is why there will be no presenting significant differences in long bone fracture frequencies in this study. The emphasis will be on the observed patterns and possible trends.

Results

Sex and age distribution

The sex and age distributions of the analysed skeletons are shown in Table 2. The LA sample consists of 674 skeletons (374 males and 300 females), the MED of 447 skeletons (238 males and 209 females). The sex ratios (males vs. females) within the samples are as follows: 1.2:1 for the LA sample and 1.1:1 for the MED sample. No significant differences were noted in the male/female age distributions in the analysed samples.

TABLE 2

THE SEX AND AGE DISTRIBUTIONS IN THE ANALYSED SERIES

	LA		MED	
	M	F	M	F
15 – 30	62	69	45	48
31 – 45	207	164	120	95
46+	105	67	73	66
Total	374	300	238	209

M = males; F = females

Fracture frequencies analysed by skeleton

The number of fracture frequencies by skeleton is shown in Table 3. In the LA sample 17.6% of skeletons exhibit one or more fractures while in the MED sample these values increase to 23.3% with the difference between the two series being significant (χ^2=4.962, P=0.025) When sexes are compared within the samples, males from both series exhibit significantly higher fracture frequencies than females (for the LA χ^2=7.494, P=0.006; for the MED χ^2=22.466, P<0.001). Sex comparisons between the samples reveal significantly higher fracture frequencies in males from the medieval sample compared to males from the antique period. (χ^2=8.599, P=0.003). No significant differences were noted between the female subsamples.

TABLE 3

THE SEX DISTRIBUTIONS OF FRACTURE FREQUENCIES CALCULATED BY SKELETON

	LA	MED
	n/N (%)	n/N (%)
Male	80/374 (21.4)	77/238 (32.3)
Female	39/300 (13.0)	27/209 (12.9)
Total	119/674 (17.6)	104/447 (23.3)

n = number of skeletons exhibiting a fracture; N = number of examined skeletons; % = percentage of skeletons exhibiting a fracture

Long bone fractures

Long bone fracture frequencies are shown in Table 4. The LA and MED samples exhibit almost identical fracture frequencies (1.1% vs. 1.2%). Males from both samples exhibit higher fracture frequencies than females, but the difference is significant only in the MED sample (1.3% in males vs. 0.9% in females in the LA series compared to 1.9% in males vs. 0.5% in females in the MED series). Sex comparisons between the series show that MED males exhibit higher fracture frequencies than LA males (MED 1.9% vs. LA 1.3%), while females from antique series display higher fracture frequencies than females from medieval series (0.9% vs. 0.5%).

In both analysed samples, there is a clear positive correlation in both sexes between long bone fracture frequencies and advanced age. This is expected since older adults had more time to experience a bone fracture. Additionally, other factors such as osteoporosis could have also contributed to the higher fracture frequency in older individuals.

Concerning side distribution of the fractures, the LA sample exhibits almost identical total long bone fracture frequencies (upper and lower limbs combined) on the left and right sides (1.2% or 32/2629 on the left side vs. 1.1% or 29/2672 on the right), while the MED sample exhibits significantly higher total long bone fracture frequencies on the left side.

In the LA series, long bone fractures are most commonly found on the radius (2.2%), followed by the tibia (2.1%) (Fig. 2) and clavicle (1.2%). In the MED series, the highest trauma prevalence is also recorded in the radius (3.3%), followed by the ulna (2.6%), and tibia (1.1%). As is apparent from Table 5, both samples share a common trait – a gradual increase in long bone trauma frequencies with advanced age.

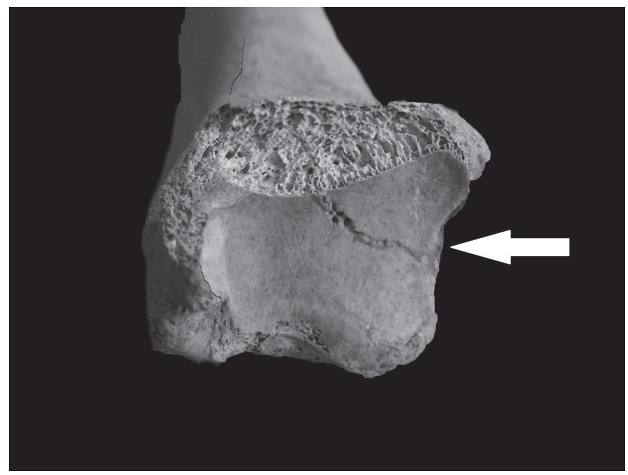

Figure 2.

Since ulnar fractures are often considered to be indicators of intentional interpersonal violence, this type of injury is particularly interesting for bioarchaeologists. It is important, however, to remember that ulnar fractures can be the result of both deliberate violence and accidents. When all ulnar fractures are recorded, the MED sample exhibits higher frequencies than the LA sample (2.6% vs. 1.1%). The same trend is true when just ‘parry’ fractures (Fig. 3) – as defined by Judd (2008) are analysed although in this case the increase is less evident. Six ‘parry’ fractures are recorded in both the LA and MED sample (in LA: 6/707 or 0.8, four in males and two in females; in MED: 6/624 or 1.0%, five in males and one in females).

TABLE 4

LONG BONE FRACTURE FREQUENCIES BY BONE ELEMENT

		Clavicle	Humerus	Radius	Ulna	Femur	Tibia	Fibula	Total
		n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)
LA	Males	5/412 (1.2)	3/427 (0.7)	7/379 (1.8)	4/404 (1.0)	2/535 (0.4)	15/461 (3.2)	4/375 (1.1)	40/2993 (1.3)
	Females	4/347 (1.1)	2/335 (0.6)	8/296 (2.7)	4/303 (1.3)	1/413 (0.2)	2/348 (0.6)	0/266 (0.0)	21/2308 (0.9)
	Total	9/759 (1.2)	5/762 (0.6)	15/675 (2.2)	8/707 (1.1)	3/948 (0.3)	17/809 (2.1)	4/641 (0.6)	61/5301 (1.1)
MED	Males	3/356 (0.8)	4/471 (0.8)	15/335 (4.5)	12/342 (3.5)	2/390 (0.5)	8/373 (2.1)	3/291 (1.0)	47/2458 (1.9)
	Females	0/327 (0.0)	2/333 (0.6)	5/278 (1.8)	4/282 (1.4)	0/366 (0.0)	0/321 (0.0)	0/239 (0.0)	11/2146 (0.5)
	Total	3/683 (0.4)	6/804 (0.7)	20/613 (3.3)	16/624 (2.6)	2/756 (0.3)	8/694 (1.1)	3/530 (0.6)	58/4604 (1.2)

n = number of long bones exhibiting a fracture; N = number of examined long bones; % = percentage of long bones exhibiting a fracture

TABLE 5

LONG BONE FRACTURE FREQUENCIES IN THE TWO SERIES BY SEX AND AGE

	LA			MED		
	Males	Females	Total	Males	Females	Total
	n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)
16 – 30	3/519 (0.6)	2/563 (0.3)	5/1082 (0.5)	4/448 (0.9)	0/506 (0.0)	4/954 (0.4)
31 – 45	21/1594 (1.3)	9/1255 (0.7)	30/2849 (1.1)	22/1266 (1.7)	2/965 (0.2)	24/2231 (1.1)
46+	16/880 (1.8)	10/490 (2.0)	26/1370 (1.9)	21/744 (2.8)	9/675 (1.3)	30/1419 (2.1)
Total	40/2993 (1.3)	21/2308 (0.9)	61/5301 (1.1)	47/2458 (1.9)	11/2146 (0.5)	58/4604 (1.2)

n = number of long bones exhibiting a fracture; N = number of examined long bones; % = percentage of long bones exhibiting a fracture

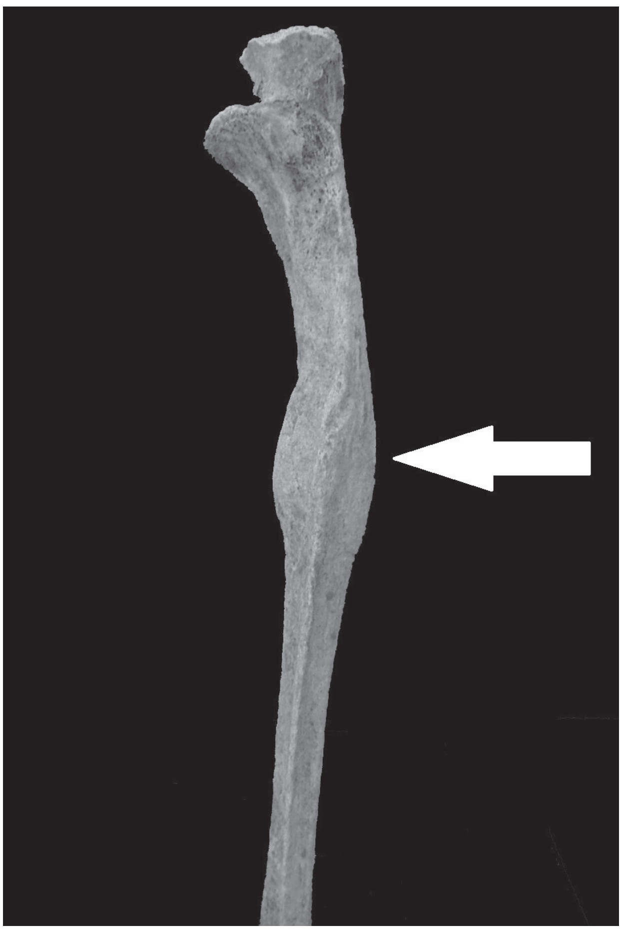

Figure 3.

Craniofacial injuries

The types of craniofacial fractures that are recorded in the analyzed samples include small circular and/or larger irregular depressions, sharp force lesions, penetrating injuries, and nasal fractures (Table 6).

In the LA sample, 311 crania were sufficiently preserved for analysis, and 51 of them (16.4%) exhibit some kind of trauma (Table 7). In the MED sample, 49/323 or 15.2% of crania exhibit evidence of fractures. When comparative analyses between the sexes are made males exhibit higher craniofacial fracture frequencies than females in both series, but the difference achieves significance only in the LA sample (χ^2=5.968, P=0.014). Comparisons between the series at the level of total samples, as well as by sex, show no significant differences.

TABLE 6

FREQUENCIES OF CRANIOFACIAL INJURIES BY TYPE

	Depression	Sharp force	Piercing	Nasal	Total
	n (%)	n (%)	n (%)	n (%)	N (%)
LA	49 (79.0)	8 (12.9)	1 (1.6)	4 (6.4)	62 (100.0)
MED	50 (80.6)	3 (4.8)	0 (0.0)	9 (14.5)	62 (100.0)

n = number of recorded craniofacial injuries by type; % = percentage of total number of recorded craniofacial injuries; N = total number of recorded craniofacial injuries

Both samples exhibit a positive correlation between craniofacial trauma frequencies and advanced age but this achieves significance only in the LA sample (χ^2=7.375, P=0.025).

A total of 62 cranial injuries are recorded in the LA sample: 44 skulls exhibit one trauma, 4 skulls display two, two skulls exhibits three, and one skull displays four traumas. In the MED sample a total of 63 skull injuries are noted – 41 crania exhibit one trauma, 4 crania have two, 3 crania display three traumas, while one cranium displays five injuries.

The distribution of craniofacial injuries by cranial element is shown in Table 8. The frontal bone is the most affected cranial bone in both series (in the LA – 38.3%, in the MED – 36.5%) with both parietal bones being the second most frequently affected bones (left parietal: 36.6% for LA, 30.1% for MED; right parietal: 13.3% for LA, 17.5% for MED). Analysis by sex shows that in the LA sample the largest difference is noted for the right parietal bone while in the MED sample it is in the left parietal bone. None of these differences are, however, significant. In both, the LA and MED series, most cranial injuries are located on the left side of the cranium with the trend achieving significance only in the MED sample (in the LA 54.8% on the left side vs. 45.2% on the right; in the MED 60.3% vs. 39.7%, χ^2=4.571, P=0.032).

TABLE 7

CRANIOFACIAL FRACTURE FREQUENCIES IN THE TWO SERIES BY SEX AND AGE

	LA			MED		
	Males	Females	Total	Males	Females	Total
	n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)	n/N (%)
16– 30	2/29 (6.9)	3/37 (8.1)	5/66 (7.6)	5/33 (15.1)	2/31 (6.4)	7/64 (10.9)
31– 45	20/86 (23.2)	6/81 (7.4)	26/167 (15.6)	16/88 (18.2)	7/63 (11.1)	23/151 (15.2)
46+	14/53 (26.4)	6/25 (24.0)	20/78 (25.6)	12/54 (22.2)	7/54 (13.0)	19/108 (17.6)
Total	36/168 (21.4)	15/143 (10.5)	51/311 (16.4)	33/175 (18.8)	16/148 (10.8)	49/323 (15.2)

n = number of crania exhibiting a fracture; N = number of examined crania; % = percentage of crania exhibiting a fracture

TABLE 8

DISTRIBUTION OF CRANIOFACIAL FRACTURES BY CRANIAL ELEMENT

		FR	LP	RP	LT	RT	OCC	FA	TOT
		n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)	N (%)
LA	Males	16 (37.2)	17 (39.5)	4 (9.3)	0 (0.0)	1 (2.3)	1 (2.3)	4 (9.3)	43 (100.0)
	Females	7 (41.2)	5 (29.4)	4 (23.5)	0 (0.0)	0 (0.0)	0 (0.0)	1 (5.9)	17 (100.0)
	Total	23 (38.3)	22 (36.6)	8 (13.3)	0 (0.0)	1 (1.6)	1 (1.6)	5 (8.3)	60 (100.0)
MED	Males	16 (35.5)	16 (35.5)	8 (17.7)	0 (0.0)	0 (0.0)	0 (0.0)	5 (11.1)	45 (100.0)
	Females	7 (38.9)	3 (16.7)	3 (16.7)	0 (0.0)	0 (0.0)	1 (5.5)	4 (22.2)	18 (100.0)
	Total	23 (36.5)	19 (30.1)	11 (17.5)	0 (0.0)	0 (0.0)	1 (1.6)	9 (14.3)	63 (100.0)

n = number of recorded craniofacial fractures by cranial element; % = percentage of total number of recorded craniofacial fractures; N = total number of recorded craniofacial fractures: FR = frontal bone; LP = left parietal bone; RP = right parietal bone; LT = left temporal bone; RT = right temporal bone; OCC = occipital bone; FA = facial region; TOT = total

Perimortem trauma

Perimortem traumas are noted in eight individuals from the LA and MED samples – four males and one female from the LA sample, and three males from the MED sample. The total frequencies of perimortem traumas calculated by skeleton are identical and very low (0.7%) in the both series (Table 9). Five of the eight skeletons that exhibit perimortem trauma have one lesion, two exhibit four perimortem injuries, and one exhibits three (Table 10). Most injuries are located in the upper part of the skeleton – primarily in the cranium, while additional elements include the right clavicle, second thoracic vertebra, first rib, left scapula, and right ilium. The injuries were inflicted with different types of weapons – five skeletons

TABLE 9

SEX AND AGE DISTRIBUTION OF PERIMORTEM INJURIES BY SKELETON

	LA	MED
	n/N (%)	n/N (%)
Male	4/374 (1.1)	3/238 (1.3)
Female	1/300 (0.3)	0/209 (0.0)
Total	5/674 (0.7)	3/447 (0.7)

n = number of skeletons exhibiting perimortem injuries; N = number of examined skeletons; % = percentage of skeletons exhibiting perimortem injuries

TABLE 10

DESCRIPTION OF THE PERIMORTEM INJURIES

Chronological-period	Site/grave number	Sex/age	Description of perimortem trauma
LA	Zadar-Relja, 378B	M, 30–40	Large cut to the left parietal bone and occipital bone
LA	Vinkovci, 1	M, 30–40	Blunt force trauma to the left parietal bone
LA	Vinkovci, 27	M, 35–40	Three cuts to the frontal bone, and piercing trauma to the ilium of the right innominate bone
LA	Štrbinci, 133	F, 30–35	Cut to the frontal bone
LA	Zadar-Relja, 661	M, 40–50	Piercing trauma to the left parietal bone
MED	Šibenik, 48	M, 30–40	Cut through right parietal and occipital bone, two cuts to right mastoideus, and cut to right clavicle
MED	Velim, 22	M, 30–40	Cut to the left scapula, T2, and 1st left rib
MED	Radašinovci, 48	M, 35–40	Large cut to both parietal bones

exhibit injuries caused by sharp bladed weapons (most likely swords or battle knives; Fig. 4), one skeleton exhibits a penetrating fracture probably caused by a spear (Fig. 5), one skeleton exhibits injury cause by a blunt object (Fig. 6), while one skeleton exhibits both sharp edged and penetrating injuries.

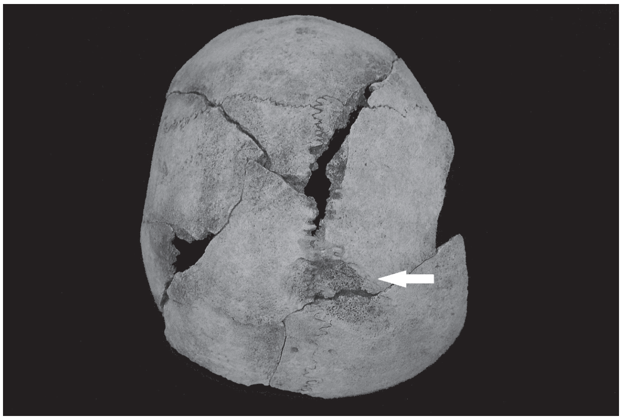

Figure 4.

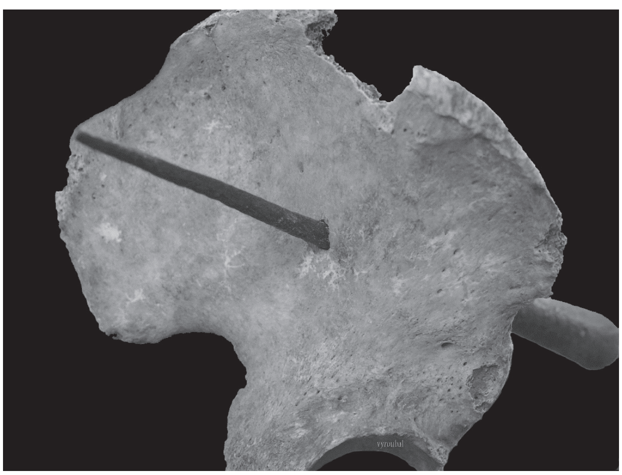

Figure 5.

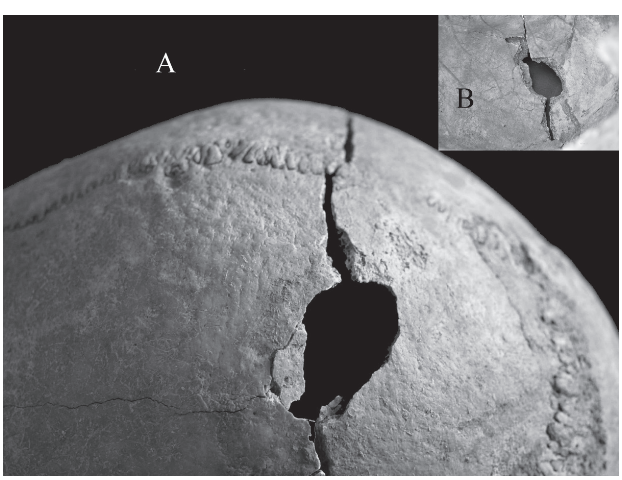

Figure 6.

The frequency and co-occurrence of skeletal indicators of intentional violence

The frequency of single skeletal indicators of deliberate violence increases significantly during the MED period (in the LA 44/674 or 6.5%; in the MED series 53/447 or 11.8%; χ^2=8.992, P=0.003). When multiple indicators of deliberate violence are recorded a slight temporal increase of the frequency of such cases from the LA to the MED sample is also noted (Table 11). In the LA sample three skeletons display multiple indicators of deliberate violence (3/674 or 0.4%), while in the MED sample this is noted in four skeletons (4/447 or 0.9% of the total sample). At the level of the complete analysed sample (both series) males are five times more likely to exhibit multiple indicators of violence than females (6/612 or 1.0% in males compared to 1/509 or 0.2% in females) suggesting either that males may have been specifically targeted during violent conflict, or that they were more likely to have engaged in violent conflict, or simply that more force was required to subdue them.

TABLE 11

CO-OCCURRENCE OF THE SKELETAL INDICATORS OF INTENTIONAL VIOLENCE

Site and sex	Chronological period	Craniofacial	Perimortem	Sharp force	"Parry"
Zadar-Relja, male	LA	X		X	
Zadar-Relja, male	LA	X			X
Vinkovci, male	LA		X	X	
Velim, male	MED		X	X	
Velim, female	MED	X			X
Šibenik, male	MED		X	X	
Šibenik, male	MED	X			X

Discussion

As previously mentioned, historical documents suggest a significant increase in violence from the Late Antique to the medieval period caused by recurrent armed conflicts related to incessant civil wars, barbarian intrusions, the arrival of new ethnic groups, and endemic violence between eastern Adriatic towns and Venetians and Saracens. The purpose of this investigation was to test whether skeletal trauma frequencies and distributions in a large number of skeletons dated to these periods confirm these data or, alternatively, show no increase of deliberate violence. An important consideration that needs to be kept in mind while analysing the skeletal data is that people living in Croatia during these periods also underwent a significant change of lifestyle – from a relatively sophisticated urban existence during the Late Antique period characterised by extensive short and long distance trade and commerce, well developed crafts, and public administration to a predominantly rural type of existence in the Medieval period that was characterized by a marked absence of large towns, and a subsistence strategy based on various forms of agriculture and transhumant pastoralism[18]. Both of these settings carry specific trauma risks – the rural existence of the medieval inhabitants of Croatia made them more vulnerable to accidents related to activities such as plowing, hoeing, mowing and clearing land, loading carts, and working with large domestic animals, while the greater population density of the large Late Antique towns carried a greater risk of interpersonal violence caused by disputes and quarrels.

Before discussing the results of this analyses it is necessary to highlight some ambiguities related to the use of different methods for calculating bone trauma frequencies. As Domett and Tayles[6] noted, using different methods to calculate bone trauma frequencies can produce different results. Calculating trauma frequencies by skeleton results in ambiguous results because skeletons differ widely in their degree of preservation and using only complete skeletons to calculate fracture frequencies is also not an option as it will underestimate the total number of fractures[69]. Consequently, most researchers advocate calculating trauma frequencies by skeletal elements (e.g. Jurmain[70]; Lovell[71]). While these two methods can produce different results, in this study both show a trend of increased bone trauma frequencies in the MED period. However, the picture that emerges from these analyses is not straightforward, and suggests that differences in the levels of intentional violence between the Late Antique and Medieval periods were not as pronounced as traditional historians believed them to be suggesting other factors may have also influenced trauma frequencies.

At the level of complete skeletons, fracture frequencies increase significantly during the Medieval period as do the frequencies of radial injuries, all ulnar fractures, 'parry' fractures of the ulna, and frequencies of individuals exhibiting one or multiple skeletal indicators of intentional violence. At the same time craniofacial injuries decrease during the Medieval period, the prevalence of perimortem injuries remains the same, as do total long bone fracture frequencies.

Analyzing trauma frequencies and distributions by sex can potentially identify the factors responsible for the observed pattern. When sexes are compared within the samples, males from the MED sample exhibit significantly higher fracture frequencies than females, both when calculated by complete skeleton and when calculated by long bone. In the LA series this is not the case – at the level of complete skeletons males exhibit significantly higher fracture frequencies than females, but not so when calculated by long bones. Furthermore, while long bone fracture frequencies in MED males are significantly higher than those in LA males (MED 1.9% vs. LA 1.3%), females from the LA series display higher fracture frequencies than females from the MED series (0.9% vs. 0.5%). As these data pertain not to craniofacial or perimortem injuries, but rather to long bone trauma that is primarily related to accidents, it would seem that during the medieval period there was a sexual division of labour that predisposed males to greater risk of trauma.

Reconstructing the lifeways of rural medieval populations from historical sources is impossible as no such data exists. Data is, however, available for later medieval and modern periods and this may provide useful information. Additionally, modern clinical data from contemporary rural settings is of potential value since the non-mechanized aspects of modern farming are broadly similar to medieval farming. Animal-drawn vehicles and equipment, structures such as haylofts and silos, harvesting, butchering and the use of tools such as axes, mallets, sickles, forks, ladders, and wheelbarrows were in use during the medieval period as much as they are today[72,73].

The available historical and ethnographic data from rural communities in Croatia indicate a clear sexual division of labour in which men were responsible for the more physically demanding tasks such as fieldwork, ploughing, mowing, transporting, fishing, woodcutting, carpentry, and transhumant pastoralism, and generally worked at a distance from the homestead. Women assisted in some field chores such as planting, weeding, and gleaning, but the majority of their work focused on the area around the homestead. Their activities included gardening, fowling, brewing, baking, tending the orchards, milking cows, washing, making butter and cheese, spinning, and weaving[74–78]. The close proximity to the house allowed women to provide vigilant child care, while attending to food preparation for the family and workers[79]. These data are consistent with the observed trauma patterns in MED individuals as higher male fracture frequencies can be attributed to the increased risks associated with their labour[80]. Additionally, this would explain the significantly higher long bone fracture frequencies in MED males when compared to LA males whose urban way of life did not include these risks.

In contrast to the medieval period, males and females from the LA series exhibit similar long bone fracture frequencies. Additionally, females from the LA series display higher fracture frequencies than females from the MED series. This pattern is interesting but by no means unique to LA series from Croatia. Similar distributions have been observed in antique urban populations from Hungary[81] and Italy[82] and may reflect the different role that women had in the economy during the Late Antique period. As Berdowski[83] noted, despite some legal, ideological, and cultural limitations, women played an important role in Roman economy, particularly in some areas of commerce, as well as in brick and tile production, production of pottery and amphorae, food processing, and cloth production. What is important to note is that this participation extended to more than just being a part of the workforce and included holding vital positions such as business managers. In some sectors, such as brick and tile production, the proportions of men and women could almost be equal[83]. It, therefore, appears that the sexual division of labor in antique urban communities was less pronounced than in the rural medieval populations, and that men and women in Roman cities were exposed to relatively similar risk levels while engaged in everyday tasks.

When analyses of fractures are made by side, the LA sample exhibits similar fracture frequencies on both sides, while the MED sample exhibits significantly higher total long bone fracture frequencies on the left side.

It is unclear at present what factors are responsible for long bone fracture side predominance frequencies. In terms of injuries caused by intentional violence, the left side of the body is generally thought to bear the brunt of trauma as right-handed weapon wielders will preferentially strike their opponents on their left side in scenarios involving face-to-face combat. However, not all combat is carried out face-to-face and not all long bone fractures result from intentional violence. Other studies dealing with fracture frequencies in antique and medieval populations from Europe report mixed results – some identify higher long bone fracture frequencies on the right side (e.g. Šlaus and Novak[84]; Gilmour[81]; Novak et al.[85]), while others report higher frequencies on the left side (e.g. Judd and Roberts[86]; Djurić et al.[7]).

Analysis of the bones most affected by trauma support, however, a scenario in which the main cause of long bone fractures in males was accidents. In the LA series the most frequently affected bones were the tibia (3.2%), radius (1.8%), and clavicle (1.2%), in the MED series the radius (4.5%), ulna (3.5%), and tibia (2.1%). With the exception of the ulna, all of these long bone fractures are generally associated with accidents, particularly radial injuries all of which were located on the distal part of the bone. This type of trauma occurs when a falling individual puts out his hand in order to break the fall[87]. The tibial fractures recorded in both series were either oblique or spiral midshaft fractures, or fractures of the proximal and distal epiphyses. Oblique tibial fractures are usually associated with accidents, generally falls from a low height[88], while spiral fractures, also accident-related, occur when the foot is stable and the body is twisted over the foot[89]. Fractures of the proximal and distal epiphysis of the tibia result from repeated loading or are caused by falls from a height[90]. All of these injuries, therefore, most likely occurred by accident and their clear increase in males during the medieval period was probably related to the elevated risks they encountered while performing various agricultural activities in rugged terrain.

Of interest is the fact that the second most afflicted bone in the MED males is the ulna. This bone has frequently been utilized as an indicator of intentional violence, specifically the presence of 'parry' fractures, although the problem of attributing such fractures exclusively to intentional violence has been raised and thoroughly explained by Smith[65] and Judd and Roberts[86]. When criteria established by Judd[91] are applied to ulnar fractures analyzed in this study an increase of 'parry' fractures in the medieval period is evident. The fact that the vast majority of recorded 'parry' fractures in both series are noted in males suggests that interpersonal violence was mostly male-oriented.

Analyses of craniofacial trauma shows relatively high frequencies in both skeletal samples (LA 16.4% vs. MED 15.2%) with no significant differences between the series either at the level of total samples, or when sexes are compared between the series.

Most authors (e.g. Walker[92]; Alvrus[87]; Standen and Arriazza[93]) agree that high rates of head and face trauma are clear proof of intentional violence. As a species, we differentiate ourselves by our facial characteristics and as such these represent, from both a strategic as well as from an emotional point of view, primary targets for assailants. Additionally, retained bruises represent a visible and lasting symbol of the assailant's dominance[94].

In both samples, males exhibit higher frequencies of craniofacial injuries than females which mirrors the distribution recorded in numerous archaeological populations. According to Jurmain[70], nearly all bioarchaeological studies report a higher frequency of cranial injuries in males, which is a result of sexual division of labor, where more difficult and hazardous activities are performed by males, as well as cultural behavior that associates virility with aggressiveness[10,95]. Most of the recorded cranial wounds in both series are depression fractures affecting only the outer table of the skull. Depressed fractures can be described as lesions which have been pushed below the outer surface of the cranial vault, or in other words, have caved inwards, and they come in various sizes, depths and forms[96,97]. The preponderance of these injuries is not unexpected as depressed injuries of the cranial vault are probably the most common type of head injury in archaeological populations[98].

In both series most of the craniofacial injuries are located on the left side, which is expected, since the left side of the skull is the most frequent injury site in face-to-face combat with a right-handed aggressor[7,99]. The distribution of craniofacial injuries by bone element shows that in both samples the frontal bone was the most affected bone of the skull. This pattern is, again, consistent with the presence of interpersonal violence. In his studies dealing with craniofacial injuries in archaeological and modern samples, Walker[92,94] states that the frontal location of cranial fractures is an indicator of deliberate violence. Additional evidence for the presence of deliberate violence in both samples is the presence of nasal fractures, four in the LA sample and nine in the MED sample, (Fig 7.), injuries that have a high specificity for the clinical diagnosis of assault[71]. Nasal fractures are the most common type of fractures suffered from direct blows to the face[94,100], and are relatively common due to the delicate nature of the bones[64,101,102].

Perimortem injuries on the skeleton provide the most direct evidence of intentional violence[87,103]. In this context it is interesting to note that the frequencies of skeletons exhibiting perimortem trauma in both series are identical, and very low (0.7%).

The high proportion of males (7/8) in the sample of individuals with perimortem injuries is consistent with the previously noted male predominance in 'parry' frac-

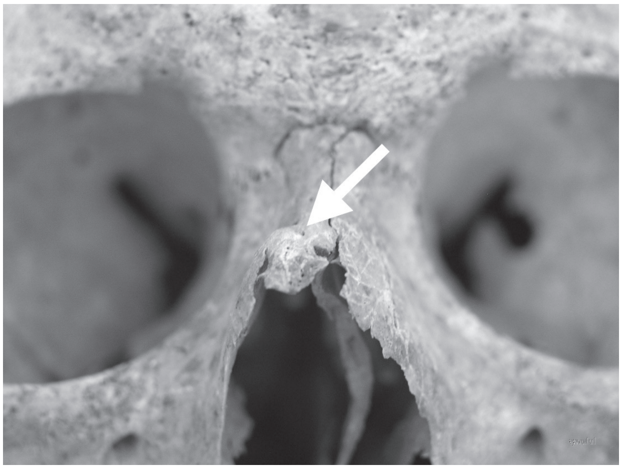

Figure 7.

tures, as well as the higher craniofacial fracture frequencies recorded in men. Together, these data strongly suggest that intentional violence was primarily directed against males.

The majority of the recorded perimortem injuries were caused by sharp-bladed weapons, such as swords or battle knives. Two penetrating wounds were recorded in males from Zadar and Vinkovci, and were most likely caused by an arrow and a spear respectively. One individual from Vinkovci also exhibits blunt force trauma that penetrated the cranial vault. The distribution of perimortem injuries on the skeletons shows that assailants were mostly striking the upper third of the body, particularly the head and neck region.

Analysis of the presence of a single skeletal indicator of deliberate violence shows a significant temporal increase from the LA to the MED period, while analyses of the co-occurrence of two or more skeletal indicators of deliberate violence – injuries of the facial and frontal region of the cranium, sharp force lesions, 'parry' fractures, and perimortem trauma, show a slight temporal increase that does not, however, achieve significance. The predominance of male skeletons (6/7) exhibiting multiple indicators of deliberate violence again points to male-directed interpersonal aggression. The injuries observed in the only female with multiple signs of deliberate violence (Velim – MED period) can, cautiously, be interpreted as domestic assault since this individual exhibits not only a 'parry' fracture and a craniofacial injury, but also two broken ribs. The typical clinical trauma pattern encountered in cases of domestic violence usually involves the upper part of the body – the craniofacial area, neck and throat, breast, abdomen and arms[10,65,92,104-106], a distribution this individual follows.

Conclusion

To conclude, the results of our analyses, performed on two large temporally continuous series from Croatia, show a temporal increase of total fracture frequencies when calculated by skeleton, accident-related radial injuries, ulnar fracture frequencies, 'parry' fracture frequencies, as well as of individuals exhibiting one skeletal indicator of intentional violence. At the same time, no significant temporal increases were noted in the frequencies of craniofacial trauma, or perimortem injuries. These results suggest that the increase in fracture frequencies noted in the Medieval period was most likely caused by a combination of factors that includes both the historically documented increase of intentional violence caused by recurrent armed conflicts, as well as a significant change in lifestyles and subsistence strategies that accompanied the transition from a urban to a rural lifestyle.

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SKELETNI POKAZATELJI NAMJERNOG NASILJA I OZLJEDA NA KASNOANTIČKIM I SREDNJOVJEKOVNIM POPULACIJAMA IZ HRVATSKE

S A Ž E T A K

Prijelaz iz kasne antike (2.–5. st. po. Kr.) u srednji vijek (6.–11.st. po. Kr.) u Hrvatskoj povijesni izvori opisuju kao veliku katastrofu koju je obilježilo uništenje urbanih centara, socijalni kolaps i porast međuljudskog nasilja. S ciljem istraživanja točnosti tih izvješća, napravljena je analiza učestalosti i obrazaca koštanih trauma u dva mješovita skeletna uzorka iz gore navedenih vremenskih razdoblja. Ukupno su istražena 1121 odrasla kostura – 674 iz kasne antike (LA) i 447 iz srednjeg vijeka (MED). U svrhu razlikovanja između namjernog međuljudskog nasilja i slučajnih ozljeda, izračunate su učestalosti fraktura za: cijeli kostur, pojedinačne duge kosti, kraniofacijalno područje, a određeno je i da li su traume perimortalne ili antemortalne. Rezultati analize su pokazali jasno povećanje učestalosti sveukupnog broja fraktura po kosturu, „parry" fraktura, fraktura palčane kosti, fraktura lakatne kosti, kao i povećanje broja osoba koje imaju pojedinačne pokazatelje namjernog nasilja. Ovi podaci naglašavaju složenost povezanu s analizom trauma i impliciraju da osim namjernog međuljudskog nasilja, povećanju učestalosti fraktura u srednjem vijeku doprinose i neki drugi čimbenici.