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DOUGLAS H. UBELAKER, ILDIKÓ PAP, KEITLYN ALCANTARA-RUSSELL

SKELETAL EVIDENCE FOR MORBIDITY AND MORTALITY IN SAMPLES FROM NORTHEASTERN HUNGARY DATING FROM THE 10th CENTURY AD

ABSTRACT: In 1993, the first and second authors initiated a project to document temporal trends in the skeletal evidence for morbidity and mortality revealed through study of archeologically recovered human skeletons from northeastern Hungary. This publication focuses on results obtained from the examination of 121 individuals (78 adults and 43 immature individuals) dating from the 10th century and recovered from the site of Tiszafüred-Nagykenderföldek. These data are compared with those previously published in this project dating from the Neolithic, Copper Age, Bronze Age, Iron Age and the (Early) Árpádian Age, all from northeastern Hungary. Broadly, long-term trends across these ages include increased periosteal lesions, dental hypoplasia in permanent teeth, trauma and antemortem tooth loss, which could be related to correspondingly increased life expectancy. Notably, results suggest that temporal change within these populations was minimal, straying from the pattern of increased morbidity and mortality following sedentism found in the Americas.

KEY WORDS: Northeastern Hungary – Tenth Century – Skeletal biology – Morbidity

INTRODUCTION

With increasing frequency, investigations in the fields of human skeletal biology, paleopathology and bioarchaeology have taken a population approach. Such studies seek to examine large, representative samples of human remains from documented archeological contexts. The research emphasis is not on finding interesting single examples of specific conditions or traits, but rather on a broad population perspective on specific issues.

Among studies using a population approach, a key central issue has been documenting evidence for morbidity and mortality and examining likely causal factors. The scholarly roots of such approaches can be found among the studies of Hooton (1930) at Pecos Pueblo, New Mexico, Angel (1947, 1948, 1957) in the Near East, Ubelaker's work in Ecuador (1984, 1992, 1994, 1996), Buikstra's research in Illinois (1982, 1990, 1991), Larsen's publications focusing on coastal Georgia (1982, 1990, 1991) and others. Synthetic works using a population approach in the Americas (Armelagos *et al.* 1991, Cohen, Armelagos 1984, Larsen, Milner 1994, Steckel, Rose 2002, Ubelaker 1994, Verano, Ubelaker 1992) have stimulated much thought and additional recent research.

The syntheses reached in the publications by Cohen and Armelagos (1984), Verano and Ubelaker (1992) and Steckel and Rose (2002) strongly suggested that within the Americas, broad trends of temporally increasing morbidity and mortality could be recognized prior to European contact. Furthermore, the studies suggested that such trends could

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be explained by factors of diet, food production, settlement patterns and population density. Although research in the Americas documented some regional variation, the studies indicated that the increased population density, sedentism and related sanitation problems associated with augmented reliance on agriculture contributed to mortality and morbidity.

In 1993, Ubelaker and Pap initiated a project to examine morbidity and mortality factors in northeastern Hungary (Ubelaker, Pap 1996). If interpretations regarding temporal changes in the Americas were correct, similar changes could be predicted in Hungary. Ancient populations of Hungary experienced comparable temporal developments in settlement pattern, population density, and food production, although at somewhat different dates. Northeastern Hungary was chosen for this study due to its thorough documentation. Past archaeological studies had documented many of the key cultural developments for this region and large skeletal samples were available for analysis from all of the key time periods. In fact, these large, well-documented samples of human remains from northeastern Hungary were all curated at the Department of Anthropology of the Hungarian Natural History Museum in Budapest.

The project began with the study of a large Bronze Age sample from the Middle-Late Bronze Age site of Tiszafüred (1700–1800 BC) (Ubelaker, Pap 1996). Data were collected from 593 individuals using a standard format to provide comparative information for future studies. Data collection protocol consisted of a detailed skeletal and dental inventory (Buikstra, Ubelaker 1994) followed by carefully selected measurements and attributes related to sex, age at death, stature, skeletal robusticity and morbidity, including gross pathology.

Subsequent studies in this project have focused on large skeletal samples dating to the Iron Age (800 BC to beginning of Christian era) (Ubelaker, Pap 1998), Neolithic (Middle to Late, 5330–4380 BC) (Ubelaker *et al*. 2006), Early Árpádian Age (11th century) (Ubelaker, Pap 2008) and Copper Age (4500–2700 BC) (Ubelaker, Pap 2009). These comparative studies suggested minimal variation within some variables and slight temporal increases in bone fractures, alveolar abscesses, ante mortem permanent tooth loss, *cribra orbitalia* and life expectancy at age fifteen (Ubelaker, Pap 2008).

This publication focuses on results obtained from the examination of 121 individuals (78 adults with an age at death greater than 15 years and 43 immature individuals of age 15 or younger). Individuals were recovered from 115 graves at the 10th century site of Tiszafüred-Nagykenderföldek, during excavations led by István Fodor in 1973 and 1975 (Fodor 1974, 1976, 1996a, 1996b). The graves were found within a cemetery that can be dated to between the mid-10th century and 970–980AD, and was the burial place of commoners, as established by the associated artifacts. It is likely that the cemetery originally contained between 150–180 graves (Fodor 1996b). Located in northeastern Hungary in the Tisza river region, this site is contemporary with the Hungarian Conquest Period (895–896 AD to approximately 1000 AD), during which the Hungarian population began to form a state in the Carpathian Basin. Although skeletal remains from other time periods were recovered from this site, the analysis reported here includes only those individuals who could be dated reliably to the tenth century AD. The anthropological material of the site has not previously been subject to detailed analysis. However, prior research conducted on the Tiszafüred-Nagykenderföldek sample includes studies of oral pathology (Pap 1986a), paleosomatology (Pap 1986b), stress markers (Józsa, Pap 1989), way of life (Fóthi, Pap 1990, Józsa *et al.* 1991) and stature (Éry 1998).

TABLE 1. Life table for 10th century Northeast Hungary sample.

x	Dx	dx	lx	qx	Lx	Tx	ex
0–1	3.0	2.5	100.0	0.0248	495.9	3121.8	31.2
1–4	24.0	19.8	97.5	0.2034	442.2	2625.9	26.9
5–10	12.0	9.9	77.7	0.1277	365.7	2183.8	28.1
11–15	4.0	3.3	67.8	0.0488	330.6	1818.1	26.8
16–20	7.0	5.8	64.5	0.0897	307.9	1487.4	23.1
21–25	3.1	2.6	58.7	0.0435	287.0	1179.6	20.1
26–30	6.3	5.2	56.1	0.0926	267.9	892.5	15.9
31–35	7.5	6.2	50.9	0.1210	240.0	624.6	12.3
36–40	20.3	16.7	44.8	0.3740	181.6	384.7	8.6
41–45	17.1	14.1	28.0	0.5029	103.8	203.1	7.3
46–50	7.5	6.2	13.9	0.4424	54.0	99.3	7.1
51–55	6.3	5.2	7.8	0.6690	25.9	45.3	5.8
56–60	1.1	0.9	2.6	0.3365	10.8	19.4	7.5
61–65	1.0	0.9	1.7	0.5000	6.5	8.6	5.0
66–70	1.0	0.9	0.9	1.0000	2.2	2.2	2.5
70+	0.0	0.0	0.0	0.0000	0.0	0.0	0.0

METHODS

The data collection protocol employed in this research followed procedures defined by Ubelaker and Pap (1996, 1998, 2008, 2009) and Ubelaker *et al.* (2006). All human remains were curated at the Department of Anthropology, Hungarian Natural History Museum in Budapest. All skeletal remains were carefully unpacked from their storage materials and placed on examination tables in anatomical order. A careful skeletal and dental inventory was conducted using the standards originally defined by Buikstra and Ubelaker (1994) and previously utilized in the Hungarian project (Ubelaker, Pap 1996, 1998, 2008, 2009, Ubelaker *et al.* 2006). Other data collection also followed those previously employed in the Hungarian project (Ubelaker, Pap 1996, 1998, 2008, 2009, Ubelaker *et al.* 2006). In addition to inventory data, the following attributes were also noted: enamel defects, dental caries, alveolar abscesses, *cribra orbitalia*, porotic hyperostosis, vertebral osteophytosis, trauma, abnormal periosteal bone apposition and measurements of the midshaft circumferences of the tibia and femur. Measurements of intact femora were recorded to facilitate calculations of living stature.

Sex and age at death were evaluated utilizing standard non-destructive methods (Buikstra, Ubelaker 1994, Ubelaker 1989). When the bones of the pelvis were sufficiently preserved, they provided the basis for estimates of sex. When pelvic morphology was not available, the size and robusticity of other bones provided information used in sex estimation.

Age at death of immature remains was estimated using observations of dental formation (Moorrees *et al*. 1963a, 1963b, Ubelaker 1989). Other criteria included dental eruption and factors of skeletal maturation.

Adult age at death was estimated utilizing all information available for each individual. This information included morphology of the pubic symphysis and auricular area of the ilium, the extent of epiphyseal union, dental attrition, vertebral osteophytosis, and other age indicators as needed (Ubelaker 1989).

RESULTS

Inventory revealed a total sample size of 121 individuals. These remains include 33 adult males, 37 adult females, 8 adults of undetermined sex and 43 immature individuals. The adult males ranged in age from 16 to 70 years of age, with a mean of 39.2 years. The adult females ranged in age from 16 to 65 years of age, with a mean of 38.4 years.

Demography

Table 1 presents a life table reconstructed from this tenth century sample. Standard methods were followed to calculate the values within this life table (Ubelaker 1989) from estimated individual ages at death. This calculation assumes a stationary population model. For the 10th century population, the life table suggests a life expectancy at birth of about 31 years, and at age 15 of about 26 years. The distribution of deaths within the various age categories suggests a generally representative sample. Although all age categories are represented, the relatively low number of young infants may reflect preservation or other sampling factors. The decimal values in the Dx column reflect attempts to proportionately assign adults with broad age estimates to their corresponding age categories. For details of this procedure, see Ubelaker (2001) and Ubelaker and Pap (2009).

Dental hypoplasia

Of 1,352 observations of permanent tooth crowns, 77 (5.6%) presented evidence of hypoplasia, all of the linear type (*Table 2*). Enamel hypoplasia was found in 5.9% of mandibular teeth but only 5.4% of maxillary teeth. Hypoplastic defects were more common in males (5.3%) than in females (3.9%). Within maxillary teeth, defects

TABLE 2. Frequency of dental hypoplasia in permanent teeth.

	Maxilla																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	0/13	0/13	0/15	1/18	0/19	2/15	1/13	2/10	0/7	1/11	2/17	0/18	1/21	0/16	1/13	0/9	11/228	4.8
Female	0/14	0/20	0/23	0/24	2/19	4/16	2/16	1/9	2/8	1/14	3/13	0/15	0/22	0/20	0/16	0/10	15/259	5.7
?	0/5	0/12	0/29	0/8	0/8	2/10	2/11	2/9	0/6	0/11	1/11	1/10	1/11	0/21	1/11	0/4	10/177	5.6
Total	0/32	0/45	0/67	1/50	2/46	8/41	5/40	5/28	2/21	2/36	6/41	1/43	2/54	0/57	2/40	0/23	36/664	5.4
%	0	0	0	2.0	4.3	19.5	12.5	17.8	9.5	5.5	14.6	4.6	3.7	0	5.0	0		
	Mandible																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	1/16	1/15	1/15	2/18	0/18	3/13	1/15	2/15	2/12	2/12	5/14	3/18	1/18	0/14	1/17	1/12	26/242	10.7
Female	0/16	0/18	0/17	0/17	0/19	2/20	0/19	0/19	0/15	0/14	3/16	0/18	1/19	0/18	0/17	0/14	6/276	2.2
?	0/5	0/14	0/19	1/11	1/11	2/7	0/8	0/12	1/7	0/6	1/10	1/7	0/9	0/23	1/16	0/5	8/170	4.7
Total	1/37	1/47	1/51	3/46	1/48	7/40	1/42	2/46	3/34	2/32	9/40	4/43	2/46	0/55	2/50	1/31	40/688	5.8
%	2.7	2.1	1.9	6.5	2.0	17.5	2.4	4.3	8.8	6.2	22.5	9.3	4.3	0	4.0	3.2		

TABLE 3. List of individuals with dental hypoplasia.

Individual	Number of hypoplasias	Location
79.5.2.	2	Second right maxillary premolar, second right mandibular premolar
79.5.19.	5	Left maxillary first incisor, right maxillary first premolar, right maxillary first incisor, left maxillary canine, left mandibular canine
79.5.23.	3	Left maxillary canine, left and right mandibular canines
79.5.41.	2	Left first mandibular incisor, left second mandibular incisor
79.5.53.	5	Right maxillary canine, right maxillary first incisor, left maxillary second molar, right mandibular canine, left mandibular second incisor
79.5.59.	8	Left maxillary second incisor, right and left mandibular third molars, right mandibular first molar, left mandibular second molar, right mandibular second premolar, left mandibular canine, left mandibular first premolar
79.5.60.	6	Right mandibular second molar, right mandibular canine, left mandibular canine, first premolar and second molar, right maxillary canine
79.5.70.A	9	Right maxillary and mandibular first incisors, left mandibular first incisor, right mandibular first incisor, left and right mandibular canines, left mandibular first premolar, left maxillary and mandibular second premolars
79.5.71.	2	Left and right maxillary canines
79.5.76.	2	Right maxillary second incisor and left mandibular canine
79.5.77.	2	Left and right maxillary canines
79.5.83.	3	Left and right mandibular canines, right maxillary canines
79.5.85.A.	7	Right maxillary first and second incisors, left maxillary first premolar, left maxillary second molar, right mandibular first and second premolars, left mandibular first incisor
79.5.94	3	Left and right maxillary canines, right mandibular canine
79.5.105.	2	Right mandibular first incisor and left mandibular first premolar
79.5.113	3	Left and right maxillary canines, right mandibular canine
79.5.115.A.	2	Right maxillary canine and left maxillary second incisor
79.5.102.	1	*Deciduous dentition,* left maxillary incisor

TABLE 4. Frequency of permanent teeth with carious lesions.

	Maxilla																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	2/13	0/13	1/15	2/18	0/19	0/15	0/13	0/10	0/7	0/11	0/17	2/18	4/21	1/16	0/13	1/9	13/228	5.7
Female	2/14	1/20	3/23	1/24	1/19	0/16	0/16	0/9	0/8	0/14	0/13	0/15	0/22	2/20	2/16	3/10	15/259	5.7
?	0/5	0/12	3/29	1/8	1/8	0/10	0/11	0/9	0/6	0/11	0/11	0/10	0/11	1/21	0/11	1/4	7/177	3.9
Total	4/32	1/45	7/67	4/50	2/46	0/41	0/40	0/28	0/21	0/36	0/41	2/43	4/54	4/57	2/40	5/23	35/664	5.2
%	12.5	2.2	10.4	8.0	8.6	0.0	0.0	0.0	0.0	0.0	0.0	4.6	7.4	14.0	5.0	21.7		
	Mandible																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	1/16	1/15	1/15	0/18	1/18	0/13	0/15	0/15	0/12	0/12	0/14	1/18	0/18	1/14	0/17	2/12	8/242	3.3
Female	2/16	5/18	2/17	1/17	1/19	1/20	1/19	1/19	1/15	1/14	1/16	1/18	1/19	2/18	3/17	2/14	24/276	8.6
?	0/5	1/14	2/19	0/11	1/11	0/7	0/8	0/12	0/7	0/6	0/10	0/7	0/9	2/23	1/16	0/5	7/170	4.1
Total	3/37	7/47	5/51	1/46	3/48	1/40	1/42	1/46	1/34	1/32	1/40	2/43	1/46	5/55	4/50	4/31	41/688	5.9
%	8.1	14.8	9.8	2.1	6.2	2.5	2.4	2.2	2.9	3.1	2.5	4.6	2.2	9.0	8.0	12.9		

were most commonly found in canines, at 17%. Within mandibular teeth, defects also most commonly occurred in canines, at 20%.

The 77 examples of hypoplasia were found in the dentition of 26 individuals. Of these individuals, nine had single defects, seven had two defects, three had three defects, one had four defects, two had five defects, and one each had six, seven, eight and nine defects. The list above details the teeth affected among those with multiple defects, with the number of defects listed in parentheses (*Table 3*).

Dental caries

Carious lesions were observed in 76 (5.6%) of 1,352 permanent teeth, 5.2% of maxillary teeth and 5.9% of mandibular teeth (*Table 4*). Carious teeth were more

TABLE 5. Frequency of alveolar abscesses in permanent teeth.

	Maxilla																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	0/21	0/22	0/23	0/24	1/24	1/23	0/20	0/18	1/20	0/23	1/25	0/24	0/24	2/23	1/23	1/22	8/359	2.2
Female	1/19	0/23	0/24	0/26	0/24	0/23	0/22	0/16	0/18	0/19	0/19	0/20	0/25	1/22	1/18	2/15	5/333	1.5
?	0/6	0/14	1/29	0/10	0/9	0/11	0/12	0/13	0/10	0/14	0/12	0/11	0/11	0/23	0/12	0/5	1/202	0.4
Total	1/46	0/59	1/76	0/60	1/57	1/57	0/54	0/47	1/48	0/56	1/56	0/55	0/60	3/68	2/53	3/42	14/894	1.5
%	2.17	0	1.31	0	1.75	1.75	0	0	2.08	0	1.78	0	0	4.41	3.77	7.14		

	Mandible																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	0/26	0/25	1/25	0/25	0/24	0/24	0/24	0/23	0/25	0/25	0/23	0/23	0/25	0/24	0/25	0/24	1/390	0.2
Female	0/24	0/27	0/28	0/27	0/27	1/29	1/27	0/28	1/24	0/25	1/26	1/24	0/26	0/28	0/26	0/23	5/419	1.1
?	0/8	0/16	0/21	0/13	0/12	0/10	0/11	0/15	0/10	0/11	0/12	0/10	0/13	0/25	0/17	0/8	0/212	0.0
Total	0/58	0/68	1/74	0/65	0/63	1/63	1/62	0/66	1/59	0/61	1/61	1/57	0/64	0/77	0/68	0/55	6/1021	0.5
%	0	0	1.35	0	0	1.58	1.61	0	1.69	0	1.63	1.75	0	0	0	0		

TABLE 6. Antemortem tooth loss in permanent teeth.

	Maxilla																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	6/21	8/22	6/23	2/24	2/24	2/23	2/20	1/18	2/20	1/23	2/25	1/24	1/24	6/23	10/23	9/22	61/359	15.1
Female	2/19	3/23	1/24	0/26	0/24	0/23	1/22	1/16	1/18	1/19	0/19	1/20	0/25	0/22	2/18	3/15	16/333	4.8
?	0/6	0/14	0/29	0/10	0/9	0/11	0/12	0/13	1/10	1/14	1/12	1/11	0/11	0/23	0/12	0/5	4/202	1.9
Total	8/46	11/59	7/76	2/60	2/57	2/57	3/54	2/47	4/48	3/56	3/56	3/55	1/60	6/68	12/53	12/42	81/894	9.0
%	17.3	18.6	9.2	3.3	3.5	3.5	5.5	4.2	8.3	5.3	5.3	5.4	1.6	8.8	22.6	28.5		

	Mandible																	
	Right								Left									
	M^3	M^2	M^1	PM^2	PM^1	C	I^2	I^1	I^1	I^2	C	PM^1	PM^2	M^1	M^2	M^3	Total	%
Male	8/26	9/25	10/25	2/25	2/24	2/24	0/24	0/23	2/25	0/25	0/23	2/23	2/25	10/24	7/25	9/24	65/390	16.6
Female	7/24	8/27	10/28	7/27	1/27	1/29	2/27	3/28	3/24	3/25	2/26	2/24	5/26	9/28	8/26	7/23	78/419	18.6
?	2/8	2/16	2/21	0/13	0/12	0/10	0/11	1/15	1/10	0/11	0/12	0/10	0/13	2/25	1/17	1/8	12/212	5.6
Total	17/58	19/68	22/74	9/65	3/63	3/63	2/62	4/66	6/59	3/61	2/61	4/57	7/64	21/77	16/68	17/55	155/1021	15.2
%	29.3	27.9	29.7	13.8	4.7	4.7	3.2	6.0	10.2	4.9	3.3	7.0	10.9	27.3	23.5	30.9		

common in females (7.2%) than in males (4.4%). Within the maxilla, carious teeth were found in 5.7% of teeth in both females and males. In the mandible, carious lesions occurred in 8.6% of teeth in females and only 3.3% of teeth in males. Within the maxilla, carious teeth were most commonly found in third molars, at 16.3%. In mandibular teeth, those with caries were most commonly second molars at 11.3%, closely followed by third molars at 10.2%.

Seventy-seven carious lesions were found in 76 permanent teeth. Twelve lesions were within the root of the tooth, 12 were large caries, 31 were cervical, 11 were occlusal, six were distal, four were buccal, and one was mesial.

Alveolar abscesses

Observations on alveolar abscesses were noted in regard to their association with individual teeth (*Table 5*). Of 1,915 observations, only 20 (1.0%) alveolar abscesses were noted. Abscesses were more common in the maxilla (1.5%) than in the mandible (0.5%). Abscesses were slightly more common in females (1.3%) than in males (1.2%). Within the maxilla, abscesses were found most commonly in association with the third molar (4.5%). In the mandible, abscesses were found most commonly in association with the first premolar (1.8%).

A single alveolar abscess was associated with a deciduous mandibular right second molar, belonging to individual 79.5.9., age 1–4.

Ante-mortem tooth loss

Ante-mortem tooth loss represents the condition when a tooth is not present and the associated alveolus presents evidence of remodeling (*Table 6*). Of 1,915 observations for antemortem loss of permanent teeth, 236 teeth had been lost (12.3%). Antemortem loss occurred more commonly in mandibular (15.1%) than in the maxillary teeth (9.0%). Antemortem loss occurred more commonly in males in the maxilla (16.9% vs 4.8%), but was more common in female

TABLE 7. Osteophyte formation within sample.

	Cervical		Thoracic		Lumbar	
	N	%	N	%	N	%
Lacking osteophytes	33/64	51.6	10/64	15.6	12/64	18.7
Stage 1	27/64	42.2	36/64	56.2	29/64	45.3
Stage 2	4/64	6.2	13/64	20.4	13/64	20.3
Stage 3	0/64	0.0	5/64	7.8	10/64	15.7

mandibular teeth (18.6% vs. 16.6%). In the mandible, the most common tooth to be lost antemortem was the third molar at 30.0%. In the maxilla, the third molar was also the most commonly missing ante-mortem tooth at 22.7%.

Deciduous teeth

Observations were possible on 262 deciduous teeth, 132 maxillary and 130 mandibular. Of these, six (2.2%) were carious. One deciduous tooth crown was hypoplastic (0.3%) and one alveolar abscess was present (0.3%).

Cribra orbitalia

Observations regarding *cribra orbitalia* relate to abnormal bony deposits and/or porosity within the superior orbit areas of the frontal. Examples were classified as being bony deposits, fine porosity or extensive porosity. Within adults, *cribra orbitalia* was noted in 4/54 of left orbits (7%) and in 5/55 of right orbits (9%) providing a total adult occurrence of 9/109, or 8%.

In males, 4% of all orbits displayed the condition. In females, 10% of all orbits had *cribra orbitalia*.

In subadults, the condition was observed in 17 of 51 orbits (33.3%). All recorded *cribra orbitalia* exhibited only fine porosity.

Porotic hyperostosis

Observations regarding porotic hyperostosis refer to the presence of abnormal bone deposits and/or porosity on the cranial vault. Only one example of porotic hyperostosis was found in this sample. Extensive porosity was observed on the calvarium of 79.5.118., an adult male of an estimated age at death of 36–40 years.

Vertebral osteophytosis

Osteophyte formation was recorded for each individual as the maximum expression within each group of cervical, thoracic and lumbar vertebrae. These data are presented within *Table 7*. Osteophytosis was documented in all vertebral groups but was especially common in the thoracic vertebrae.

The most severe expression of osteophytosis, stage 3, was most common in the lumbar region, at 15.7%.

Trauma

Examples of remodeled skeletal trauma were found on 26 bones from 15 individuals.

Individual 79.5.1., a 16–20 year old of unknown sex, showed a well remodeled fracture of the upper 1/3 of the left femur.

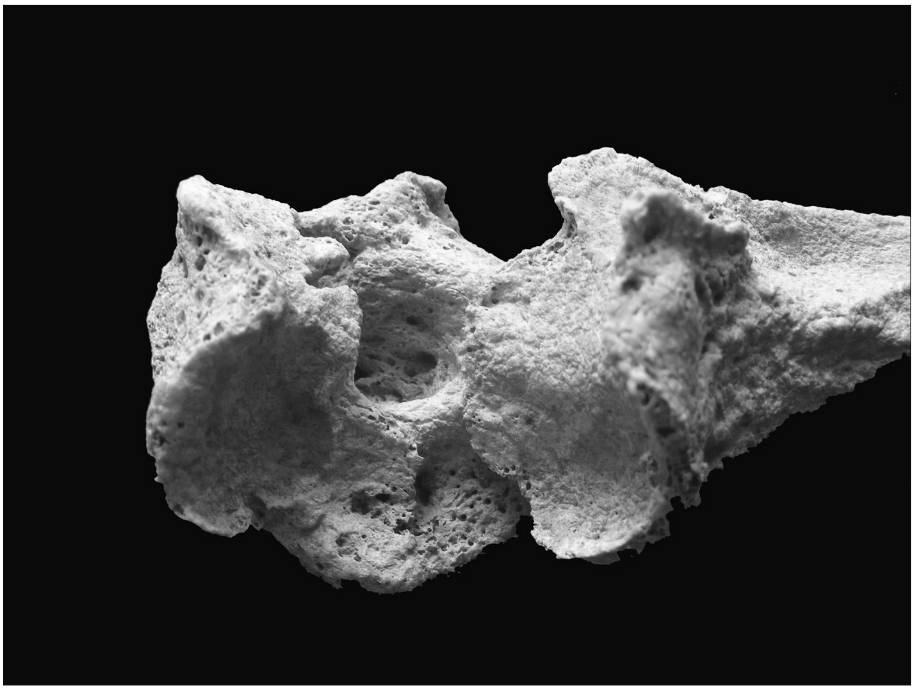


FIGURE 1. Healed fracture of left proximal ulna with severe infection and reactive bone (79.5.17.).

FIGURE 2. Left distal humerus and healed fracture of proximal ulna, showing extensive reactive bone (79.5.17.).

Individual 79.5.17., a 46–50 year old male, showed a healed fracture of the left proximal ulna with severe infection and extensive reactive bone. Additional reactive bone appeared on the distal humerus (*Figure 1, Figure 2*).

Individual 79.5.21., a 36–40 year old male, presented a well-remodeled healed fracture of the right fibula at the upper 1/3 of the diaphysis. In addition, a separated neural arch on the 5th lumbar vertebrae likely resulted from trauma.

Individuals 79.5.30. (male, 51–55), and 79.5.31 (female, 41–45), both had well-remodeled colles' fractures to the right radii.

Individual 79.5.41., a male age 41–45, displayed a well-remodeled and healed fracture of the left ulnar diaphysis, 62 mm from the distal end.

Individual 79.5.43., a male age 41–45, had a healed, well-remodeled fracture of the left ulna at mid-shaft, as well as a two healed left rib fractures, likely pertaining to the 9th and 10th ribs.

FIGURE 3. Depressed fracture of lateral portion of right maxilla, just inferior to malar (79.5.65.B).

FIGURE 4. Well-remodeled reactive bone of the right maxilla (79.5.65.B).

Individual 79.5.65.B, of unknown sex, age 46–50, possessed what appeared to be a depressed fracture of the lateral portion of the right maxilla, just inferior to the malar. The fracture was well remodeled, although it appeared to have been infected. Additional evidence of remodeled periosteal bone was found in the right frontal bone (*Figure 3, Figure 4*).

Individual 79.5.71., male age 41–45 showed well-remodeled fractures of the right radius and ulna. The inferior mid-shaft area showed complete separation of the cortex and misalignment. The location of the trauma is slightly more inferior on the ulna than on the radius, suggesting an angled blow. Additionally, two fractured rib bodies were found, one right, and one whose side was not determined.

Individual 79.5.76., male age 36–40 showed well remodeled fracture of left fibular diaphysis near the distal 1/5, and left tibial diaphysis near the distal ¼. (*Figure 5*).

Individual 79.5.81., a male age 66–70, showed one well-remodeled rib, fractured in the mid rib area.

Individual 79.5.97., a male aged 56–60, displayed a lumbar vertebra with a collapsed centrum, located on the midline, approximately 10 mm in size. The injury was well remodeled.

Individual 79.5.98., a male age 36–40, displayed a depressed fracture, circular in shape, located on the frontal bone near bregma, of approximately 10 mm in size. The injury was well remodeled.

Individual 79.5.110., a female 36–40 years of age, displayed a probable healed fracture of a lower left rib.

Individual 79.5.118., a male age 36–40, displayed a probable healed fracture of the middle area of a left upper rib. Additionally, fused proximal and middle hand phalanges, well remodeled, possibly indicated trauma.

The ratio of the number of bones with trauma (26) to the number of adults (78) in the sample is 0.33. The ratio

FIGURE 5. Well-remodeled fractures of left tibial and fibular diaphyses near distal ends (79.5.76.).

of the number of adults with trauma (15) to the number of adults in the sample (78) is 0.19. The ratio of the number of adults with trauma (15) to the number of individuals (121) in the sample is 0.12.

No trauma was found among immature remains. Of the 26 bones with trauma, most occurred in ribs (seven), followed by the ulna (four), radius (three) and fibula (two). Two frontal bones, lumbar vertebrae and hand phalanges were fractured. The following bones sustained one fracture: tibia, humerus, femur and maxilla.

Abnormal periosteal lesions

Abnormal periosteal lesions refer to periosteal bone deposits on the normal outer surface of the bone. Such deposits may be stimulated by infection, but trauma and other factors cannot be ruled out.

Fourteen bones from this sample displayed abnormal periosteal reactive bone, all well remodeled. These lesions were found in 10 individuals.

Individual 79.5.12., a female age 26–30 showed probable remodeled reactive bone on the inferior posterior margin of her right calcaneus.

Individual 79.5.15.B, a subadult age 1–4 showed slight periosteal reactivity on both occipital condyles as well as the articular facet of the first cervical vertebra.

Individual 79.5.17., a male age 46–50, showed reactive bone on the distal humerus and proximal ulna.

Individual 79.5.19., a female age 41–45 showed a well remodeled area approximately 20x20 cm in size on the medial midshaft of her right tibia.

Individual 79.5.20., a male age 51–55 presented a well remodeled distal right fibula, with an area of reactive bone approximately 15×20 cm in size. This area was located on the medial surface of the distal end, just superior to the distal articular surface.

Individual 79.5.30., a male age 51–55 exhibited a well remodeled distal diaphysis of the left fibula, with remodeling located immediately above the distal articular surface on the lateral side.

Individual 79.5.41., a male age 41–45, showed reactivity on the left fibular midshaft, with remodeling.

Individual 79.5.49.A, a male age 41–45, displayed remodeling of both tibiae at mid-shaft.

Individual 79.5.65.B, an individual of unknown sex, age 46–50 showed reactive bone both on a 23x33 mm 79.5.69.A, a female age 51–55, demonstrated reactive bone at two circular lesions on the left coronal suture.

The ratio of the number of bones with lesions (14) to the number of adults in the sample (78) is 0.18. The ratio of the number of individuals with lesions (10) to the number of individuals in the sample (121) is 0.08.

Most examples of periosteal reactive bone occurred on the fibula (three), tibia (three) and frontal (two). One example each occurred on the calcaneus, occipital, vertebra, ulna, humerus and maxilla.

TABLE 8. Attributes demonstrating minimal variation between the 10th century and periods both prior and subsequent.

	Maximum circumference midshaft (mm)				Alveolar abscesses (%)			Dental Caries (%)			Estimated living stature (cm)		Cribra orbitalia (% of orbits)	
	Femur		Tibia											
Period	Male	Female	Male	Female	Total	Male	Female	Total	Male	Female	Male	Female	Adult	Immature
Neolithic	90	81	85	75	2.6	2.8	2	6.3	5.6	6.7	168	155	13.1	25
Copper Age	89	82	86	75	0.8	1.5	0.5	2.3	3.6	2.2	168	157	4.3	33
Bronze Age	91	81	86	76	0.4	0.6	0.4	3.2	3.7	3.9	168	157	7.4	25
Iron Age	90	80	84	73	1.5	2.3	1.3	3.7	3.1	4.8	169	154	8.5	27
10th Century	93	81	86	77	1.0	1.2	1.3	5.6	4.2	7.6	167	156	8.3	33
Early Árpádian	92	81	82	72	3.2	3.6	3.4	3.8	4.2	4.3	168	156	17.6	44

TABLE 9. Attributes demonstrating increases between 10th century and both prior and subsequent periods.

Period	Life expectancy at birth	Life expectancy at age 15	Trauma, ratio: bones to adults	Periosteal lesions	Antemortem tooth loss (%)			Dental hypoplasia (%)		
					Total	Male	Female	Total	Male	Female
Neolithic	29	21	0.22	0.09	6.0	6.5	6.1	1.4	2.2	0.7
Copper Age	28	17	0.03	0.01	5.2	5.1	8.2	0.7	0.3	1.7
Bronze Age	24	17	0.04	0.08	4.7	4.7	6.5	0.5	0.5	0.1
Iron Age	27	16	0.03	0.08	5.0	6.8	5.1	4.9	1.8	5.7
10th Century	31	26	0.33	0.16	12.3	16.8	12.5	5.6	5.3	3.9
Early Árpádian	22	24	0.46	0.07	13.5	7.8	20.5	1.7	0.7	2.6

Skeletal robusticity

Measurements of the mid-diaphyseal circumference were recorded for all available adult femora and tibiae. A flexible tape measure was utilized to record all measurements in millimeters. When available, left bones were measured. Right bones were utilized when those from the left side were not available.

For males, measurements were taken on 30 femora and 29 tibiae. The femoral measurements ranged from 84 mm to 103 mm with a mean of 93.3 mm and a standard

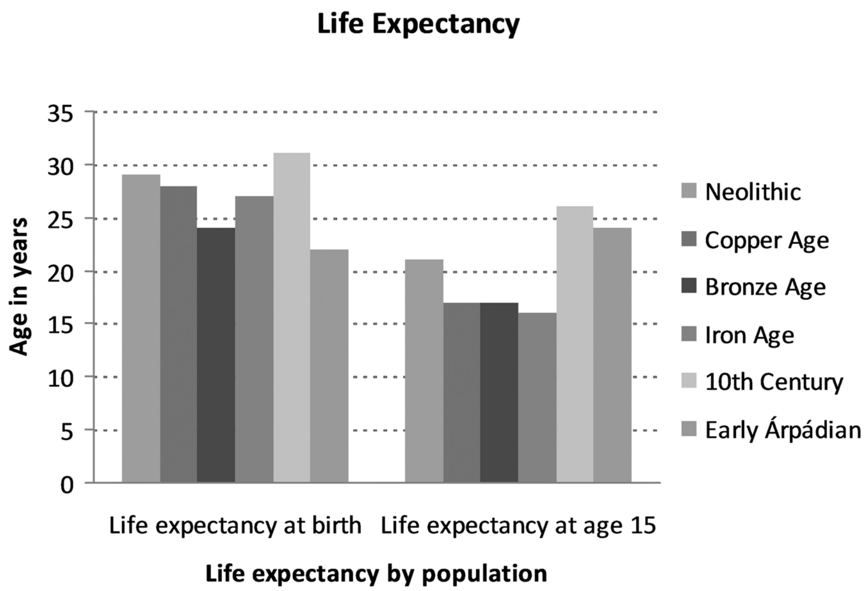


FIGURE 6. Comparative graph of life expectancy by population.

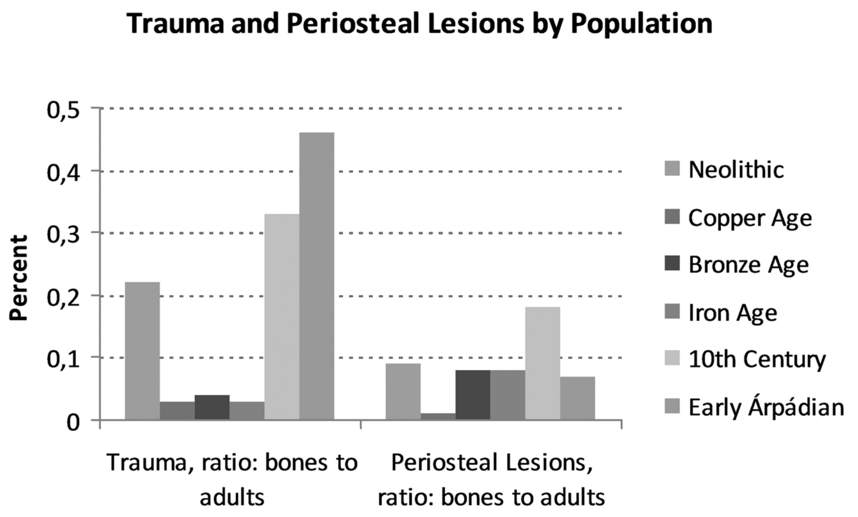


FIGURE 7. Comparative graph of trauma and periosteal lesions by population.

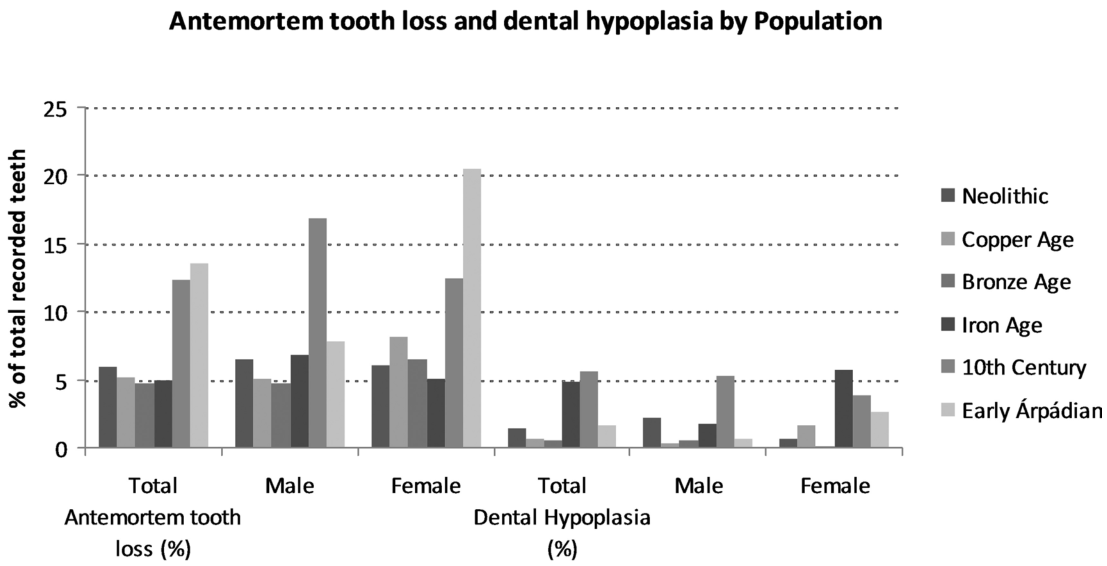


FIGURE 8. Comparative graph of antemortem tooth loss and dental hypoplasia by population.

deviation of 5.0 mm. The tibia measurements ranged from 76 mm to 102 mm with a mean of 86.5 mm and a standard deviation of 5.5 mm.

Measurements for females were recorded on 33 femora and 32 tibiae. The femoral measurements ranged from 69 mm to 91 mm with a mean of 81.6 mm and a standard deviation of 5.8 mm. The tibiae measurements ranged from 66 mm to 88 mm with a mean of 76.96 mm and a standard deviation of 5.6 mm.

Estimated living stature

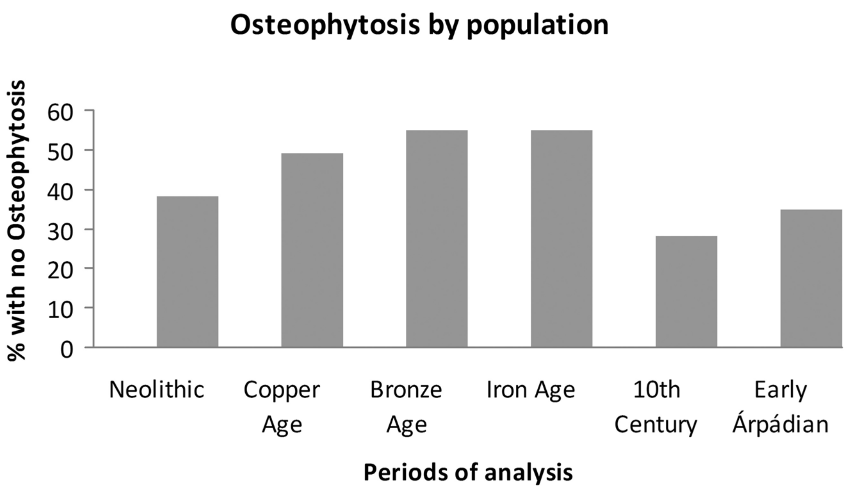
Living stature was estimated for 58 individuals (30 females and 28 males) using the Trotter (1970) formulae for White males and females. Femur lengths were utilized to estimate stature in all individuals except for two individuals (79.5.109. and 79.5.117.) for which the femur was not available and the tibia and fibula were utilized.

TABLE 10. Attributes demonstrating decreases between the 10th century and both prior and subsequent periods.

Period	Osteophytosis: % with stage 0
Neolithic	38
Copper Age	49
Bronze Age	55
Iron Age	55
10th Century	28
Early Árpádian	35

For females, the mean stature was 155.8 cm with a range from 144 cm to 166 cm and a standard deviation of 5.4 cm. For males, the mean stature was 167.4 cm with a range from 145 cm to 184 cm and a standard deviation of 7.0 cm.

FIGURE 9. Comparative graph of osteophytosis by population.



DISCUSSION

The above research results from the analysis of the 10th century Northeast Hungary sample complement those previously reported from earlier dated samples from the region. These published analyses are available from the following periods: Neolithic (Ubelaker *et al.* 2006), Copper Age (Ubelaker, Pap 2009), Bronze Age (Ubelaker, Pap 1996), Iron Age (Ubelaker, Pap 1998), and the Árpádian Age (Ubelaker, Pap 2008). The data presented here from the 10th century are the most recent of those previously reported. All data from all of these northeastern Hungary samples were collected by the same individual using the same standard protocol; thus they are directly comparable. Collectively, they provide deep temporal perspective on the mortality and morbidity variables examined.

Some attributes presented minimal variation in occurrence among the samples examined (*Table 8*). These variables include measures of robusticity, alveolar abscesses, dental caries, estimated living stature and *cribra orbitalia*.

The following variables showed increased values over those previously published from earlier time periods: life expectancy at birth and at age 15, male antemortem tooth loss, the ratio of bones with periosteal lesions to the number of adults in the sample, and total values of dental hypoplasia in permanent teeth (*Table 9, Figures 6, 7, 8*). Values of the ratio of bones with trauma to adults in this 10th century sample joined those of the Early Árpádian age in being elevated over previous time period samples.

Only one variable, the percentage of vertebrae lacking osteophytosis, displayed a lower value than those previously reported from earlier time periods (*Table 10, Figure 9*).

CONCLUSIONS

These newly reported data from the 10th century provide key recent perspective to those previously published studies from northeastern Hungary. Collectively, these data offer tentative documentation of long term temporal trends in the region. These trends generally reveal increasing levels of periosteal lesions, dental hypoplasia in permanent teeth, trauma, male tooth loss and life expectancy. These data suggest that despite elevated levels of trauma, periosteal lesions and childhood morbidity, people in the 10th century enjoyed greater life expectancy. Elevated levels of tooth loss and osteophytosis likely reflected the greater longevity of adult life.

In comparison with the pattern of increased morbidity and mortality following sedentism in populations from the Americas (Armelagos *et al.* 1991, Cohen, Armelagos 1984, Larsen, Milner 1994, Steckel, Rose 2002, Ubelaker 1994, Verano, Ubelaker 1992), temporal change among these Hungarian samples was found to be fairly minimal. An exception may be found in the Neolithic sample, which displayed slightly higher trauma, periosteal lesions, alveolar abscesses, dental caries and *cribra orbitalia* than might be expected in such an early time period. This particular discrepancy might be explained by an unrepresentative sample of the population, or as a response to the preliminary shift towards agriculture and sedentism (Ubelaker *et al.* 2006).

The sampling of a population, as is inevitable in archaeological recovery, can lead to reconstructions of population size and demography that are not representative of the true population. However, in comparison with samples of similar size and demographic composition found in the Americas, the Neolithic, Copper, Bronze, Iron, and Early Árpádian samples, as well as the 10th Century Hungary sample do not appear to conform to the pattern of marked increased mortality linked with sedentism and agriculture. The Hungarian study does suggest temporal increase in some measures of morbidity that could be related to factors similar to those discussed in the Americas. Additional perspective on these issues awaits further research in northeastern Hungary and other regions.

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Douglas H. Ubelaker
Keitlyn Alcantara-Russell
Department of Anthropology
Smithsonian Institution
NMNH, MRC 112
Washington, D.C. 20560-0112
USA
E-mail: ubelaked@si.edu
E-mail: AlcantaraKE@si.edu

Ildikó Pap
Department of Anthropology
Hungarian Natural History Museum
H-1083, Ludovika tér 2.
Budapest
Hungary
E-mail: papi@nhmus.hu