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## Preliminary report on the paleopathological research of the skeletal material from the Szeged medieval castle excavation

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**ABSTRACT** This study introduces some diseases occurred among the medieval population of Szeged. Hitherto 641 individuals have undergone general anthropological investigations. The identification of abnormal bone conditions was mainly performed by gross examination, but in several cases further investigations were required. One of the most common pathological disorders was spinal osteoarthritis. There were some skeletal evidences of trauma identifiable; particularly fractures of the ribs and upper limbs. The incidence of developmental defects in our skeletal population is moderate. We observed some cases of widespread skeletal hyperostosis (DISH) as well as localized cranial hyperostosis (HFI) and also traces of osteoporotic processes. Porotic hyperostosis, a skeletal symptom of some nutritional deficiencies and also specific diseases, is a common phenomenon in our material. We could notice traces of non-specific infections like isolated periostitis or osteomyelitis and also that of slight bone alterations that can be indicative of early stage tuberculosis. However, the typical angular kyphosis found in one case proves that TB was present in medieval Szeged. Three skeletons showed bone lesions caused possibly by acquired syphilis. In two cases the radiocarbon and archaeological dating suggested precolumbian origin. These treponemal cases complete the list of evidences of pre-Columbian treponematoses in the Old World.

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**KEY WORDS**

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Paleopathological investigations – of course along with the basic anthropological data – can refer to the people of ancient times; what diseases they suffered from, how patients were treated and what kinds of medicines and therapies were in custom. Learning these data renders it possible for us to come to further consequences about living and health conditions and about the way of life in a given historical population. Thus it can be stated that the synthesis of the results of different paleopathological investigations is beyond individuals but focuses on reconstructing health status at population level (Ortner 2003; Józsa 2006).

Beyond getting to know our ancestors' everyday life, paleopathologic researches can widen our knowledge on medical sciences too, since we can investigate the paleoepidemiology of some special infectious diseases, such as TB, treponematoses or leprosy. These investigations have recently become timely, as TB re-emerges nowadays; not only in the

Third World but also in developed countries, often in coinfection with HIV (Pálfi et al. 1999). It is essential to learn as much as possible about pathogens that have great capability of adapting to changes – as it has been proved by the appearance of multidrug-resistant strains of TB bacilli (WHO 2008). Detecting and diagnosing any osseous symptoms related to these infectious diseases might help modern physicians to diagnosing early changes or set new diagnostic criteria.

With this end in view this study concentrates on presenting the preliminary results of paleopathological investigation of the skeletal material from the Szeged-Castle site through demonstrating some special or important cases

The excavation at the former castle of Szeged has been started in 1999. In the middle of the fortress the archaeologists revealed a gothic church built in the first half of the 14<sup>th</sup> century. The burial place was used first up to 1543, then after when the Turkish occupation in Hungary ended (1686), up to 1713 again (Hajnal et al. 2004; Horváth 2009).

Up to now 970 graves and several other objects such as ossuaries and crypts have been uncovered. The investigation

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**Figure 1.** Butterfly vertebrae on the thoracic spine (grave 81. female?, 15-17 yrs).

of the human remains began in 2004 at the Department of Anthropology of the University of Szeged and it is going forward as long as any skeletons are unearthed.

In the future, after the excavation has been finished, our results can be completed and in the frameworks of a general study we will be able to understand the pathological processes the medieval population of Szeged suffered from and also to clarify the prevalence of past diseases.

### Material and Methods

This presentation focuses on the skeletal material that came to light between 1999 and 2007.

Due to the high burial density in the cemetery, which is a quite common phenomenon in case of medieval graveyards; it is not unusual to find intrusive human bones from other individuals, mixed with the remains of the owner of the grave. It could also happen that remains of two or even more different skeletons could be separated from one grave. Thus the total

**Table 1.** – Sex- and age groups of the observed Szeged-Castle medieval osteoarchaeological sample.

Age group	Male	Female	Undetermin- able	Total
Neonatus	-	-	17	17
Inf1	-	-	106	106
Inf1/Inf2	-	-	18	18
Inf2	-	-	85	85
Inf?	-	-	2	2
Inf2/Juv	-	-	22	22
Juv	15	15	24	54
Ad	37	46	9	92
Ad-Mat	10	6	1	17
Mat	62	28	11	101
Mat-Sen	21	11	6	38
Sen	9	18	3	30
?(Adult)	12	17	30	59
Total	166	141	334	641

number of individuals (from burials) might come to higher, though we included in our research only those identifiable as one distinct individual.

The whole material contains further some hundred individuals coming from large ossuaries and crypts and cannot be identified exactly. We included in our study only the skeletons originating from isolated burial, so the total number of graves examined is 641. All the same, we scrutinized all the osseous material in order to find any interesting pathological alteration.

The general state of bone preservation is quite bad; there are lots of incomplete skeletons and often the available bones are fragmentary at that or their surfaces are also in moderate condition.

To determine sex and age at death we used the accepted anthropological methods (Schour and Massler 1941; Nemeskéri et al. 1960; Éry et al. 1963; Stloukal and Hanáková 1978; Szilvássy 1978; Brothwell 1981; Ubelaker 1984; Lovejoy et al. 1985; Loth and Isçan 1989).

From graves the bones of 337 adults – 151 males, 126 females, 60 undetermined - and that of 304 subadults (younger than 23 years) are available for paleopathological investigations (Table 1.)

The identification of paleopathological conditions was performed particularly by gross observation (e.g. Ortner and Putschar 1985, Ortner 2003; Roberts 2007). In several cases further investigations were required such as radiological or histological analyses. Paleomicrobiological and chemical analyses are still in progress. Radiocarbon dating was carried out by ATOMKI, Debrecen, Hungary and 14C CHRONO Centre Queens University Belfast, Northern Ireland on two samples of considerable importance. As the data collection – and even the excavation - is still in progress and especially because of the commingled, fragmentary or incomplete skeletons, this material is not adequate for precise

**Table 2.** Localisation and sex-distribution of the observed fracture cases.

Localisation of the fractura	Male	Female	?	Sub-adult	Total
Costa(e)	10	3	-	2	15
Clavicula	4	-	1	-	5
Scapula	1	1	-	-	2
Ulna	8	2	4	-	14
Radius	2	3	-	-	5
Femur	1	-	-	-	1
Fibula	2	-	-	1	3
Os metatarsus	1	-	-	-	1
Vertebra	1	-	-	-	1
Mandibula	-	1	-	-	1
Total	30	10	5	3	48

statistical analyses. It is, however, really valuable, since it furnishes precious data about the occurrences of diseases in medieval Szeged and it also points out general tendencies in their incidence.

## Results and Discussion

Skeletal traces of a large series of osteo-articular diseases were identified. As the classification of the paleopathological lesions and diseases is not uniform in the literature (e.g. Aufderheide and Rodríguez-Martín 1998; Ortner 2003; Józsa 2006; Roberts 2007), we prefer to use the following six categories: developmental defects, traumas, joint diseases, metabolic and nutritional disorders, infectious conditions and other diseases. This latter category includes some diseases the incidence of which are relatively low or those which cannot really be considered as pathological abnormalities. Therefore we do not detail them in this paper.

### Developmental defects

Developmental defects manifest themselves as abnormal structures and they carry the possibility of having pathological function (Ortner 2003; Józsa 2006). As a rule, they can be caused by genetic and non-genetic (environmental) factors. They vary from minor malformations that may go unnoticed by the individual to real life threatening congenital diseases (Roberts 2007).

The frequency of observable developmental anomalies in the Szeged material is low; mainly minor defects on axial skeleton could be detected. The most frequent malformations occurred in our sample affect the sacral region of the spine. Sacralisation when non-sacral elements – mostly the first coccygeal vertebra and less often 5<sup>th</sup> lumbar vertebra – become similar in shape and fuse or partially fuse with sacrum as well as the incomplete development of the neural arch of one or more vertebrae, which is called partial bifid spine on the sacrum, were common. These alterations did not show any age related occurrence or sexual dimorphism. Our results

are similar to those reported in literature, since according to many descriptions malformation of spinal elements are the most common congenital disorders (Marcsik 1998; Molnár 2000; Hegyi 2003; Ortner 2003; Józsa 2006).

Beyond the typical developmental anomalies we detected some rare defects which are important to touch upon since there are only a few reported cases in paleopathological literature.

In case of a juvenile individual (Grave no. 81.) a congenital maldevelopment on thoracic vertebral bodies is seen (Fig. 1). The malformation affects at least two thoracic vertebrae (Th9 and Th11) resulting in congenital division of the vertebral body into two lateral halves with an intervening sagittal cleft. If the cleft occurs in the midsagittal plane it is called “butterfly” vertebra. The background of this anomaly is that chorda dorsalis persists in vertebral body due to bilateral deficiency of sclerotomic substance causing failure in normal ossification in early embryonic period (e.g. Fischer and Vandemark 1945; Müller et al. 1986; Molnár and Marcsik 2003). It is a very rare anomaly, especially when it affects more than one vertebra (Patinharayil et al. 2008), although according to Brasili et al (2002) it may involve two adjacent vertebral bodies. Most instances have been described in lumbar region (Müller et al. 1986). In our case, as it is seen, the defect occurred at the very least in two sites (“hot spots”) on the thoracic spine.

The skull remains of an infant about 4-5 years of age (grave 181.) shows abnormal deformity – we observed a remarkable triangular prominence of the frontal bone. This rare condition specified as trigonocephaly is a result of early fusion of the metopic (forehead) suture. It might be related to syndromes but it can occur alone as well (e.g. Flatz et al. 1984; Hegyi 2003). In our case we cannot come to any conclusion regarding its background, since the skeleton is incomplete, only fragments of the skull and the trunk are available. Nevertheless it might be supposed that the typical facial dysmorphism related to “trigonocephaly sequence” were present (Schaap et al. 1992).

### Trauma

Trauma most commonly represents extrinsic influences on the skeleton that result from many factors, such as accidental and intentional violence, cultural cosmetic or therapeutic practices that affect bone, and some other pathological conditions (Aufderheide and Rodríguez-Martín 1998; Ortner 2003). Usually fractures, dislocation of joints and many other (rare or less severe) injuries are included in group of traumas.

Fractures are the most frequent traumas observed in our material. In case of 42 affected individuals, the traces of 48 fractures could be detected, particularly breaks of the upper limb and of ribs occurred (Table 2.). Fractures are three times as common in males as in females and adults are most frequently affected. We can say that the most of the injuries



**Figure 2.** Trauma (ulna fracture) induced pseudoarthrosis (grave 541. male, 30-50 yrs).

healed well, without complications; still we could notice some cases where accompanied infection set in or were followed by severe degenerative alterations.

Sometimes breaks occurred in more than one bone; as it is seen in case of an adult male (grave 185.) where multiple rib fractures as well as break of the clavicle and scapula can be detected. Regarding the fact that all of these injuries occurred on the right side and they are by and large at similar healing stage we might suppose that they can be attributed to the same event.

In case of the individual 441. (undeterminable sex, 50-59 years old) we observed the fracture of the left ulna and at the same time the right one is remodelled, reduced in length, with macroporosity on the distal end of the bone fragment. We assume, although the distal part - as the adjacent radius - is not available, that nonunion (pseudarthrosis) of a fracture was present there.

Another example of complications secondary to trauma is observable on the forearm bones of the skeleton from grave 541.

In case of this middle-aged man we could observe the fracture of the right ulna healed with callus and inflammation, and as concomitant sign a pseudoarthrosis developed with the radius (Fig. 2). This defect must have considerably diminished the normal biomechanical function of the forearm. A severe degenerative process occurred on the left elbow joint,

probably secondarily to the extreme usage of that arm.

Besides fractures we observed also symptoms of post-traumatic dislocations; two cases of shoulder and one case of hip dislocation.

Except injuries of the postcranial skeleton in six cases there could be detected wounds on cranial bones too; of which one depressed fracture produced by a sharp edged tool might be a perimortem injury (grave 48.).

### Joint diseases

Joint diseases are one of the commonest disorders observable in paleopathology (e.g. Jurmain 1977; Aufderheide and Rodríguez-Martín 1998; Roberts 2007). Still, perhaps they are the most difficult to diagnose specifically; since the several hundred diseases known in clinical practice can produce identical bone alterations. So classification of joint diseases in paleopathology differs from that accepted in modern practical rheumatology (Józsa 2006).

The grouping of specific joint diseases is not uniform in paleopathological literature, still bone changes and distribution patterns of different arthropathies are clearly described.

On the basis of their characteristics joint lesions observed in Szeged-Castle material could be included in two categories: degenerative joint diseases (DJD - vertebral and extravertebral) and inflammatory joint diseases.

According to many authors DJD – also known as osteoarthritis - can be described as a non-inflammatory, progressive, chronic process that may be bone destroying, bone forming or both (Roberts 2007) and can be usually subdivided as primary or idiopathic, in which no clear etiology is known, and secondary, in which some factors – the most frequent macro- or microtraumatic effects - have already affected the joints as primary causative agent. Differentiation between the two forms is usually complicated and sometimes impossible in paleopathology (Aufderheide and Rodríguez-Martín 1998; Józsa 2006).

Bone changes are principally characterised by loss of articular cartilage and subsequent subchondral lesions due to direct bone-to-bone contact. Eburnation, porosity, osteophyte formation (marginal or central) and joint contour change are the main diagnostic features in DJD (Rogers and Waldron 1987). In vertebral osteoarthritis degeneration of intervertebral disc (intervertebral osteochondrosis) may lead to osteophyte forming on vertebral rim (spondylosis deformans and with weakening of annulus fibrosus to protruding of nucleus pulposus (Schmorl's nodes). These features can be observed in spinal DJD together with the osteoarthritis of apophyseal joints (spondylarthrosis deformans; Kerr and Resnick 1984).

DJD – either vertebral or extravertebral or both – was detected on almost one third of the skeletal remains coming from the Szeged-Castle burials. The coincidence of spinal and extraspinal degenerative alterations was high, showing

that they might have been caused by the same factors. Such predisposing factors are principally increased age and maybe constant and severe functional stress, but other background contributing agents must not be ignored, either (Jurmain 1977).

Prevalence of spinal DJD in our material increases with advanced age corresponding the findings of other studies (e.g. Pálfi et al. 1992; Knüsel et al. 1997; Molnár 2000; Rojas-Sepúlveda et al. 2008). Intervertebral osteochondrosis, spondylosis and spondylarthrosis deformans were seen mostly in of “mature” or middle-aged age group (older than approximately 40 years old) while Schmorl’s nodes occurred also in younger – in four cases in subadult - spine elements. That finding is not surprising as intervertebral disc herniation can occur not only as a result of degenerative processes but also can be caused by the presence of congenitally weakened areas in the cartilaginous endplate or also by trauma (Kerr and Resnick 1984).

The incidence of extravertebral DJD is quite high in our material; still most of these alterations are very mild. Some severe secunder arthrosis could be detected subsequently to traumas. Secunder osteoarthritis in the elbow joint of individual No. 541 has previously described (see “Trauma”), and traumatic dislocations were also followed by degenerative changes in the affected joint in case of two males with shoulder dislocation.

### **Metabolic and nutritional disorders**

As a rule, these two groups of diseases are treated as separated categories in the paleopathological literature (e.g. Aufderheide and Rodríguez-Martín 1998; Ortner 2003); nevertheless we think they cannot be categorically divided from each other, since they are often associated, occur together and sometimes they have the same aetiology in the background. We classified here pathologic conditions related to the metabolic and haemopoetic system, such as endocrine diseases, anemias and illnesses caused by insufficient intake of food, vitamins or trace elements.

Increasing bone production just as increasing loss of bone mass are typical symptoms of metabolic disorders. We observed five cases of extensive hyperostosis in which the diagnosis of Diffuse Idiopathic Hyperostosis (DISH) or Forstier disease is very likely. All of them have been determined as middle-aged or older males (above 40 years of age) what is concordant with clinical findings (e.g. Resnick 1976; Rogers and Waldron 2001). Excessive hypertrophic bone formation could be observed at joint margins and the entheses on the appendicular and axial skeleton as characteristic features.

According to Resnick’s criteria (Resnick 1976) the most relevant diagnostic feature of DISH is fusion of at least four vertebral bodies. This abnormal ossification takes place under the anterior longitudinal ligament; however, this extensive bony hypertrophy is usually limited to the right side (Fig.



**Figure 3.** Diffuse idiopathic skeletal hyperostosis (DISH) of the spine (grave 290. male, 50-60 yrs).

3). Radiological analysis of the block vertebra revealed that vertebral end-plates are intact and the disk spaces are not significantly narrowed (Fig. 4). This phenomenon along with the observation that the apophyseal joints are also unaffected by any pathological changes confirm our diagnosis. The exact aetiology of DISH is unknown but several studies have shown a strong association with obesity and type II diabetes. Another authors report on the association of DISH with other metabolic disturbances including alterations in lipid metabolism and hyperuricaemia (Rogers and Waldron 2001; Kiss et al. 2002). In archeological studies a high prevalence of DISH has been demonstrated in ancient clergymen and it has been hypothesised that the “monastic way of life” might be a predisposing factor of DISH (Rogers and Waldron 2001; Verlaan et al. 2007).

Another phenomenon manifests in hyperostosis is usually localised at the cranial vault especially on the frontal bone. In our material the skulls of some individuals showed marked thickening on the frontal (or parietal) bone and on the inner table tiny bony outgrowths occurred. The female skeleton from grave 133 has already been described (Ósz and Hajnal, 2005) as a case of Hyperostosis Frontalis Interna (HFI) however there are further six suspicious cases found in our skeletal sample related to this disease.

This disorder is part of Morgagni–Stewart–Morel–Moore syndrome which is described as co-occurrence of HFI, obe-

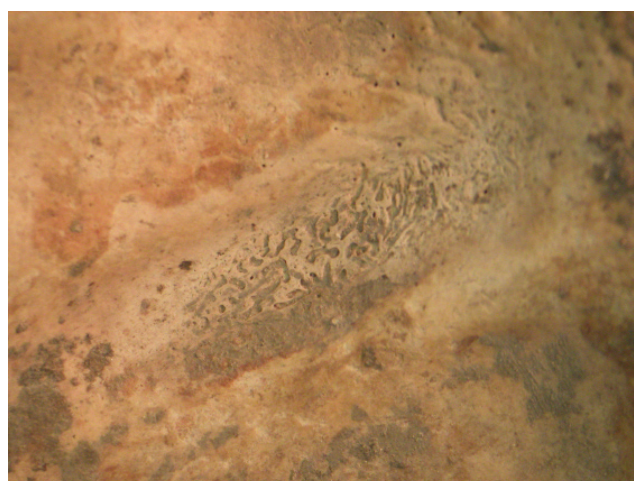


**Figure 4.** Lateral radiograph of the fused thoracic vertebrae in DISH (grave 290, male, 50-60).

sity, hirsutism, diabetes and other hormonal disturbances in postmenopausal women (e.g. Chaljub et al 1999; Ortner 2003; Belcastro et al. 2006; Glab et al. 2006) and might have a genetic base (Glab et al. 2006). However, according to radiological finding of Chaljub et al. (1999) the presence of HFI itself cannot be considered as a disease; it is a normal and benign phenomenon especially in elder women. There have been only a few cases of HFI published in paleoanthropological literature, though among them there is a higher male prevalence than expected on the evidences of today's clinical findings (Rühli et al. 2004).

Not only increased bone producing processes could be observed among the Szeged-Castle skeletons, but also – and more often – an abnormal reduction of bone mass very probably related to osteoporosis. Mainly a slight loss of bone quantity increasingly with age was detectably associated in some cases with other bone changes. Thus we noticed the symmetrical thinning of parietal bones in five cases and further two individuals had wedged vertebral bodies due to compression fracture.

Porotic hyperostosis (PH) can be regarded as a general



**Figure 5.** Periosteal new bone formation on the occipital bone (grave 250, infant, ~ 3yrs).

stress factor (Roberts 2007), since it is present when there is an increased demand on producing red blood cells. The main causes of that condition are anaemias resulted by any failure in haemoglobin synthesis, for example in iron-deficiency or in any type of hemoglobinopathies. Anemia can also be the result of abnormal blood loss through bleeding from a variety of causes, including the infection of the gastrointestinal track and menstruation (Ortner 2003). As ascorbic acid has an important role in absorbing iron, vitamin C deficiency may lead to anaemia too. PH, however, can appear as a concomitant symptom of infectious diseases due to decreased iron-level as part of the defence mechanism of the body (Stuart-Macadam 1992).

The bone alterations can occur either on the skull vault (porotic hyperostosis or *cribra cranii*) or on the orbital roof (*cribra orbitalia*) and are usually bilateral in distribution. Bone abnormalities are the result of thinning of the outer table of the skull and expansion of the diploë.

The occurrence of PH is reasonably high in the Szeged material; in 90 cases either form of the lesion could be detected from mild (porous) alterations to trabecular outgrowth (though latter occurs only in a few cases). It is conspicuous that the ratio of subadults is outstanding while we don't find any sexual differences among adults.

In case of 5 children *cribra orbitalia* (which was well-marked in most cases) was accompanied by fine pitting at several region of the skull such as on the jaws, on the frontal and sphenoidal bone and on the basis of the occipital bone. Beyond that endocranial lesions can be noticed mostly on the inner surface of parietal and occipital bones (Fig. 5).

According to our hypothesis the above seen symptoms might be suggestive of some disease resulting by Vitamin C deficiency; as this disorder cause chronic bleeding that

stimulates an inflammatory response resulting in bone lesions, particularly on the skull, scapula, and metaphyseal ends of subadult bones (Ortner et al. 2001). Still we have to consider the possibility of any infectious disease. To confirm our diagnosis chemical analysis of these samples is in progress.

### **Infectious diseases**

In ancient times it was the group of infectious diseases that might have been responsible for most of the deaths. Even among nature people living today infection of the digestive system results in the death of many children. After the development settlements and people lived close to each other often together with animals, any more infectious diseases became endemic in human populations. Civilization, with the development of crowded cities, accompanied epidemics that often killed thousands within a short time (Ortner 2003). Nowadays epidemics have remained a serious problem especially in developing countries. Thus it would be essential to learn about past diseases as much as we can. Paleopathologists still have to face up to the fact that there are only few illnesses which leave indistinguishable traces on bones. Most of the infections are acute processes which can heal or which can lead to death within a few days without affecting the bones at all. However, there are several diseases vestiges of which can be well detected.

Traditionally, infectious diseases include non-specific and specific infections (e.g. Aufderheide and Rodríguez-Martín 1998; Ortner 2003; Roberts 2007, etc.).

### **Non-specific infections**

Non-specific infectious condition can occur on any bone of the skeleton and leaves well identifiable lesions according to its nature. Though, care must be taken when setting a diagnosis, since mechanical stress on periosteum, for example trauma or subperiosteal bleeding as it is seen in scurvy (Ortner et al. 2001; Schultz 2001), can produce very similar alterations.

Infections can affect either the periosteum (periostitis) or the cortex of the bone (osteitis) or it can occur in medullar cavity (osteomyelitis).

Osteomyelitis, the prevalence of which was very low in our skeletal material, is usually caused by pyogenic bacteria in most cases by *Staphylococcus aureus*. The infection can spread via bloodstream from a distant septic focus (hematogenous osteomyelitis) or from a local infection of adjacent soft tissue or can be a complication of a trauma e.g. compound fracture. Acute hematogenous osteomyelitis occurs predominantly in children, while in adults, osteomyelitis is usually a subacute or chronic infection that develops secondary to a local infection of an open wound (Carek et al. 2001).

One example for the infection of the medullar cavity can be seen on the skeletal remains of an adult male from grave No. 291. resulting in fusion of the right tibia and talus (Fig. 6).



**Figure 6.** 3D CT-image of the right tibia and talus (grave 291. male, 50-60 yrs). Chronic osteomyelitis of the right tibia with ankylosis of the ankle joint.

The cortex of the tibial diaphysis widened significantly from the proximal towards the distal end with lamellar periosteal new bone formation at some places. In the distal third of the bone an irregular cavity with a partly sclerotic margin can be seen, which opens at the surface through multiple fistulae (Fig. 7). The talus is distorted and it completely fused with the tibia. This picture can be considered as chronic osteomyelitis most likely due to post-traumatic pyogenic infection; however the possibility of haematogenous osteomyelitis (among others tuberculous origin) cannot be disclosed either.

Another instance for chronic inflammation in medullar cavity was detected in case of an old man (grave 288.). On near midshaft of his left femur localised periosteal bone for-



Figure 7. CT-image of tibiotalar ankylosis (grave 291, male, 50-60 yrs). Cloaca with partly sclerotic margin in the distal end of the tibia.

mation with cavitation at the centre has been macroscopically described. The ct-image shows that this cavity penetrates the cortex and sequester can be detected. At the same place the endosteum slightly thickened. The cortex of the diaphysis became a bit more bulky proximal to the lesion. This picture might be indicative of chronic osteomyelitis with sequestration.

Bone lesions due to periosteal reactions were common among our samples and occurred mainly on the bones of the leg. It has to be noted, though, that the very high number of individuals with any osseous changes on the bone surface does not show the real amount of infections, since not all periosteal alterations are of infectious origin (Ortner and Putschar 1985).

Recently it has been suggested that lesions manifesting on certain bones or areas can refer to the aetiology of the alterations. Such predilectional places are for example the maxillary sinuses (evidence for sinusitis), the endocranial



Figure 8. Gibbus resulting from the fusion of seven vertebrae (Th9-L3) and from the collapse of the vertebral bodies Th11-12 and L1-2 (grave 483, female, 30-40 yrs).

surfaces of the skull (referring to meningitis) and the visceral surface of ribs (suggesting the infection of the lung; Schultz 1999; 2001; Roberts 2007).

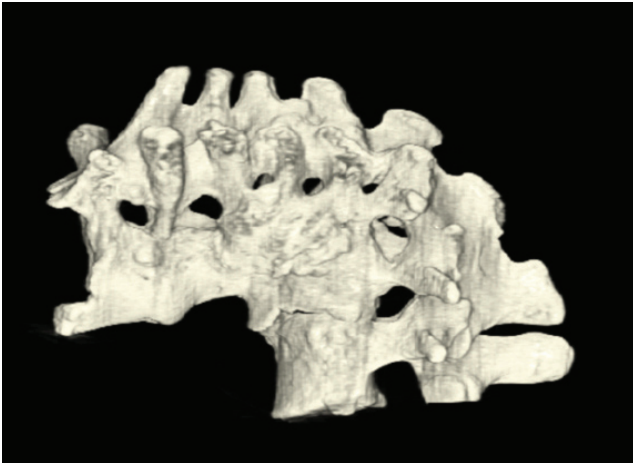
In the Szeged-Castle material we could observe all of the above mentioned bone changes, although in most cases only slight alterations were seen.

Due to their moderate state of preservation in some cases we could observe periosteal new bone formation on the walls of maxillary sinuses; however it is very likely that the prevalence of maxillary sinusitis was higher in our material.

### Specific infections – Tuberculosis (TB) and Treponemal diseases

One of the most widespread specific infectious diseases in the Middle Ages was tuberculosis (e.g. Pálfi et al. 1999; Marcsik et al. 2007) caused by bacteria of the *Mycobacterium tuberculosis* complex; principally by *Mycobacterium tuberculosis* and *Mycobacterium bovis*. The localisation of the primary infection in human hosts is determined by the way of transmission depending on the specific pathogen. TB is transmitted either directly from cattle to human by consuming contaminated cattle products or from human to human usually by droplet infection through the respiratory system. Thus primary TB occurs either in lung or in the intestinal wall. As a rule, bones may be infected secondary via haematogenous dissemination; however the skeleton is affected only in about 3% of TB patients (Ortner 2003). Spinal TB (Pott's disease) is the most common bony lesion in recent clinical patients and also in paleopathological cases; authors report on vertebral involvement of 36-50% of all cases with skeletal involvement (Weber et al. 2004; Roberts 2007). The lesions are localized mostly in the thoracolumbar region and involve the vertebral bodies of one to three maybe four vertebrae at the most (Ortner 2003; Weber et al. 2004). Tuberculous





**Figure 9.** 3D CT-image of severe angular kyphosis on the thoracolumbar spine (grave 483, female, 30-40 yrs).

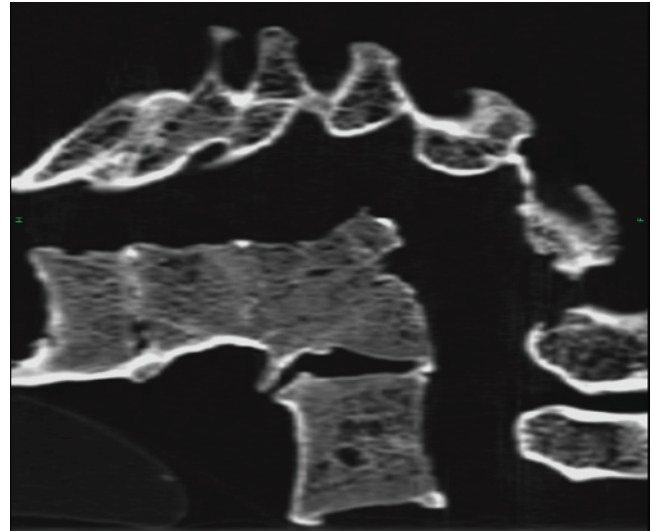
changes on posterior element of vertebrae are uncommon, as the bacteria are deposited particularly in areas of cancellous bone, which has a high circulatory rate. The infection may spread over to the paraspinal tissues - involvement of psoas muscle is commonly seen – resulting in forming a paravertebral abscess (Pott's abscess). Bony alterations on the vertebral bodies are mostly purely lytic, reactive new bone formation is rarely seen. Because of the primarily destructive nature of the disease collapsing of vertebral bodies and subsequent angular kyphosis is not uncommon in advanced stages (Burrill et al. 2007).

One example of such an abnormal gibbus formation was found in Szeged-Castle material (Fig. 8), which can undoubtedly be interpreted as a Pott's disease. This individual (grave 483, female, 30-40 years old) had a severe angular kyphosis resulted by the collapse and fusion of seven vertebrae at the thoracolumbar spine. In case of the caudal five vertebrae the bodies are destroyed, collapsed with anterior and central dominance, showing anterior wedging, and forming dorsal kyphotic prominence of the spine as gibbus. The angulation is approximately 90 degrees.

The borders of the vertebral bodies cannot be well differentiated, and the bony structures are abnormal at the maximum of the kyphotic deformity (Fig. 9). At the same level the bony spinal canal is narrowed. The foramina are narrowed too; the facet articulations are ankylotic.

Involving the lower-mid segment there is an asymmetric calcified, paravertebral mass, mainly on the left side in conjunction with the vertebrae (Fig. 10). The amorphous calcification may be due to healed vertebral/paravertebral soft tissue infection.

Another two possible cases of Pott's disease were found among our samples. In case of grave 561. (undeterminable sex, 50-60 years) destruction of at least three lumbar verte-



**Figure 10.** CT-image of the same block vertebra demonstrating the narrowing of the spinal canal and lytic foci in the vertebral bodies (grave 483, female, 30-40 yrs).

brae was observed accompanied by vestiges of an inflammatory process. Lumbo-sacral TB is the suggested aetiology of the lesion seen on the skeletal remains of individual 487. (male, 40-60 years). The pelvic surface of the sacrum has an abnormal irregular appearance due to periosteal new bone forming and erosive lesions. Traces of an inflammatory process are detected in the retroauricular region of the pelvis. On this skeleton some nonspecific/atypical lesions can also be recognised; diffuse periostitis on the shafts of the long bones and on the bones of the feet as well as slight endocranial changes on the skull bones appeared maybe as concomitant signs of the disease.

Skeletal tuberculosis is not restricted to spine; weight bearing joints (knee and hip) can also be involved due to their good blood supply which provide optimal environment for tubercle bacilli.

In one case (grave 152. adolescent) traces of a serious inflammatory process were seen in the distal end of the right femur. The bone shortened and the distal epiphysis slipped backward and abnormal ossification occurred. Dorsally on the area of the metaphysis remodelled periosteal new bone formation can be noticed; however there is no evidence of sequestering as in osteomyelitis. The femora just as tibiae are postmortally damaged, still remodelling of the cancellous bone is seen. At the same time some other skeletal lesion was present such as marked hypervascularisation of the bodies of Th7-11 vertebrae, slight endocranial lesion and also mild periostitis on the fragments of both tibiae femora and fibulae. On the basis of macromorphological picture the diagnosis of (possibly healed) tuberculous gonitis is presumed. The young age of this individual also supports our assumption, as



**Figure 11.** Stereo-microscopic picture of parietal bone with serpegious cavitation and perforation with about 1 cm in diameter. (grave 2. female, 45-55 yrs).

tuberculosis of the knee affect particularly small children and adolescents (Ortner 2003). Until our previous diagnosis is not confirmed by paleomicrobial and by chemical analyses the possibility of other diseases cannot be precluded, either.

As recently more and more paleopathological reports are published on the diagnostic value of some atypical bone changes, it has become widely accepted among paleopathologists that these minor osseous changes might be considered as early signs of tuberculosis (Maczel 2003).

It is worth to mention that in 59 cases and especially on infant skeletons endocranial changes (abnormal blood vessel impressions and fine new bone formation) on the skull bones – particularly on the inner surface of parietal and occipital bones – could be detected. We have also described irregular bony alterations, possibly traces of old periosteal reactions, on ribs (36 cases). Rib lesions occurred, however, in all age groups, though adults were mostly involved (25 cases).

These bony alterations - endocranial lesions and periosteal remodelling on the visceral surfaces of ribs – along with some other osseous lesions such as diffuse periostitis on one or more postcranial bones and vertebral hypervascularisation could be associated with tuberculosis (e.g. Roberts et al. 1994; Baker 1999; Schultz, 1999; 2001; Hershkovitz et al. 2002; Pálfi 2002; Maczel 2003; Santos and Roberts 2006).

There are a considerable number of skeletons (at least 30 individuals) in our material in case of which at least two of the above mentioned bony alterations co-occurred. To establish a correct diagnosis biomolecular analyses of these samples have been going on.

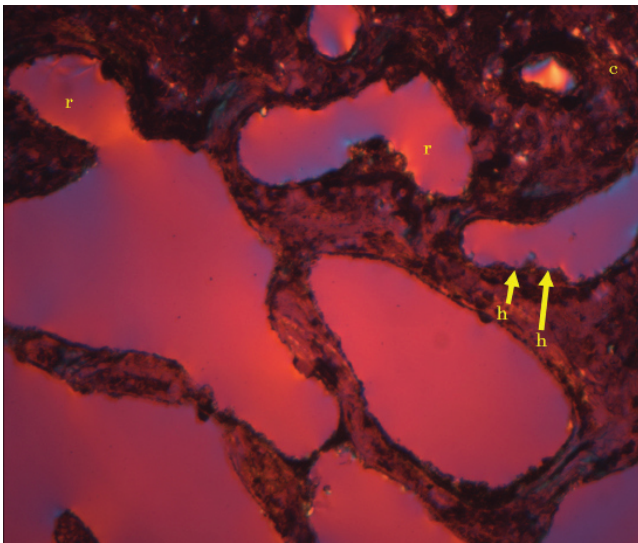
Other specific infection detected in Szeged-Castle material was treponematosi. The remains of three individuals showed serious bone lesion related to treponemal disease which was identified as acquired syphilis. The diagnosis was based on



**Figure 12.** CT-image of the left radius (grave 2. female, 45-55 yrs). Lytic bone defect with sharp edges at the distal end and marked, irregular periosteal thickening on the medial surface almost all along the whole diaphysis.

morphological observations after the diagnostic criteria of Hackett (1976) and in two cases (grave 2. and 16./4. skull) our findings have already been supplied by further (radiological and histological) investigations. Chemical analysis of the samples (including grave 61.) is in progress.

On the skull of a mature woman (grave 2.) especially on the parietal and frontal bones the typical stages of caries sicca (Hackett 1976) are noticeable (Fig. 11). Clustered pits, confluent clustered pits, focal superficial cavitation, serpiginous cavitation, depressions and perforations can be recognised (Ósz et al. 2006). Her postcranial bones have been also affected by periosteal alterations; osteomyelitis gummosa as well as periostitis has occurred on several long bones. On the AP radiograph of the examined long bones cortical thickening and narrowing of the medullary cavity can be also seen. The ct-image of the left radius shows a lytic bone defect with sharp edges is seen at the distal end (Fig. 12). There is a marked, irregular periosteal thickening on the medial surface almost all along the whole diaphysis. This picture can refer to a chronic process.



**Figure 13.** Cross section through the right fibula (grave 2. female, 45-55 yrs). Inflammatory process suggested by the presence of resorption holes (r) with Howship's lacunae (h).– Undecalcified thin ground section, viewed through the microscope in polarized light. Magnification, x 25.

In case of this individual we had the possibility to carry out histological investigations too (Ósz et al. 2007). Though, unfortunately, the original bone substance was strongly damaged post-mortem due to diagenesis, so the only thing we could establish was that the resorption holes suggested the presence of an inflammatory process, however it is not characteristic of acquired syphilis exclusively (Schultz 2001) (Fig. 13).

The result of the radiocarbon dating suggests that the date of death can be estimated between 1420 and 1490 AD.

Although we include in our study skeletons derived from single graves, we must not disregard any pathological alterations found in skeletal remains coming from ossuaries. During the anthropological and paleopathological examination of the material of ossuary No. 16, remarkable paleopathological lesions were found on a young adult female skull (Fig. 14). The cranial vault exhibits multifocal lytic lesions and wide-spread superficial pitting. On the frontal and parietal bones circumvallate and nodular cavitation appear. The alterations of the external table are typical gummatous lesions characterized by a mixture of new bone formation and destruction creating an irregular lumpy appearance. The mentioned lesions can be identified as different stages of *caries sicca*. The healed foci of *caries sicca* leave depressed, sclerotic radial scars (Fig. 15 and 16). CT image revealed destructive changes on the basis of the skull and also in the sphenoid body.

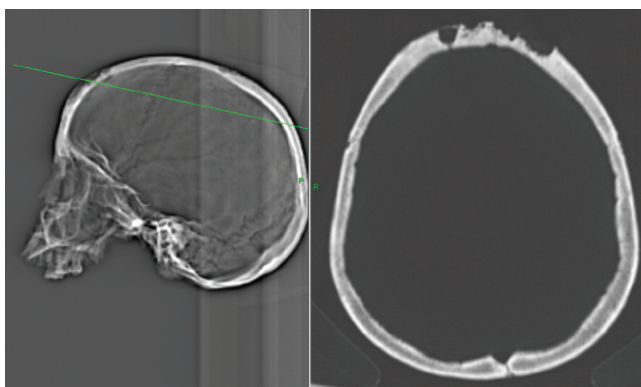
On the facial bones multifocal lytic lesions occurred destroying the outer bone surface around the aperture of the nasal cavity.



**Figure 14.** Widespread bony alterations (*caries sicca*) on the frontal bone and lytic lesions on the facial bones (skull No. 16/4. female young adult).

On the maxilla and on the zygomatic bone lytic lesions as well as naso-palatinal destruction are observable. Traces of periosteal inflammatory reaction (pitting) can be observed around the lytic focus. Both orbital roofs exhibit well-marked *cribra orbitalia*, which might have been interrelated with the infection (Stuart-Macadam 1992).

The lack of the postcranial skeleton normally decreases the value of a paleopathological diagnosis. However, according to Ortner (2003) the cranial vault and the bones surrounding the nasal cavity are among the greatly predilected areas in acquired syphilis. Together with tibia, these three regions are affected by syphilitic bone lesions in about 70 % of all cases. In spite of the absence of examinable postcranial bones we consider our case as paleopathological example of acquired syphilis, since the examined lesions are highly pathognomic and show all stages of Hackett's classification (eg. radial scars, circumvallate and serpiginous cavitations). The archeological dating places the death of this individual around the second third of the 15th century necessarily anterior to 1490. As according to the archeological evidences the church at the castle of Szeged was restored in the second half of the 15th century during the rule of King Mathias (1458-1490). The graves found in course of the construction had been dug up and put into an ossuary. Crypt No. 16. was filled at that time too, therefore the skeletal material certainly dates back earlier than 1490. The bones might belong to the people deceased in the middle of the 15th century.



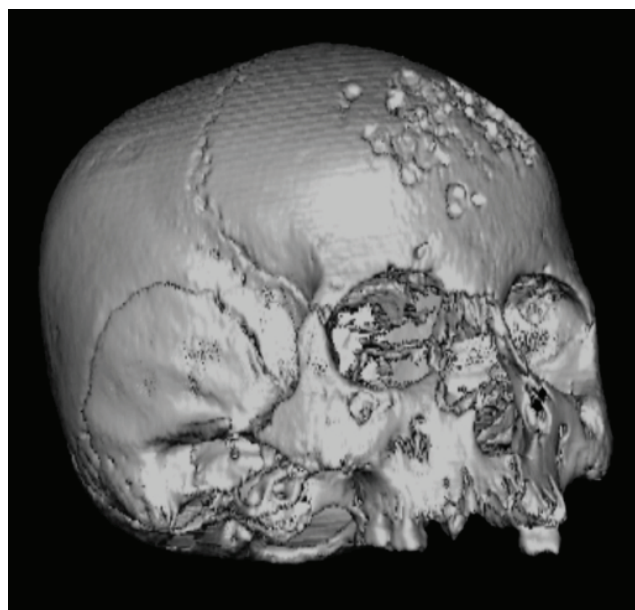
**Figure 15.** – CT-image of the skull skull No. 16/4. female, young adult). Multiplex lytic lesions with irregular margins on the outer table and in the diploë.

The importance of this case required a radiocarbon control of the archeological dating. The  $^{14}\text{C}$  investigation of the lower right third molar presumes that the individual must have been entombed between 1423-1512 AD (at 2 sigma range) and within that period the time of the death falls in the range AD 1435-1472 with a high probability (at 1 sigma range). The results of the radiocarbon analysis correspond to the archaeological data.

There has been much debate on the origins and spread of treponematoses caused by the spirochete *Treponema pallidum* and its subspecies. The paleoepidemiology of acquired syphilis is particularly controversial. The most discussed question has been for years, whether this infectious disease had been present in the Old-World before 1495 when the first well-known and registered epidemic broke out. According to the previously accepted opinion, the disease has been brought from the New World by Columbus's crew. However, there has been more and more paleopathological evidences proving that treponematoses (and among them acquired syphilis) could have existed in our continent even in the pre-Columbian times (e.g. Stirland 1991; Pálfi et al. 1992; Dutour et al. 1994; Mays et al. 2003; Mitchell 2003; Alduc-Le Bagousse et al. 2009).

## Conclusions

Paleopathological study of the human osteoarchaeological material from the Szeged-Castle excavation has furnished invaluable information concerning the health status of the medieval inhabitants of Szeged. However, as the investigation is still going on, no definitive conclusions can be drawn yet. Still, fortunately some really interesting and important cases and processes could be detected and also some general tendencies related to their occurrence were recognised in the Szeged-Castle material. These findings, though, allow us to obtain the first insight into the everyday life of the people of the medieval Szeged.



**Figure 16.** – 3D CT-image of the skull skull No. 16/4. female, young adult). Caries sicca.

The relatively low incidence of developmental defects and traumas in our skeletal population suggests that the humanity of medieval Szeged was a settled but not endogamous urban population. The cemetery around the castle church was probably used by the citizens and not by soldiers, as only a few evidences of war injuries was observable. Among the detected metabolic disorders, we have to mention the well developed DISH cases, without more precise etiological explanation at the actual level of our studies. Age- and functional stress-related degenerative joint diseases – either in vertebral or extravertebral localisation – was detected on almost one third of the examined skeletal remains.

The observed typical Pott's disease and the other, less typical forms of probable TB infection prove that tuberculosis must have been present among the inhabitants of Szeged, even though we could detect mainly slight or early stage skeletal alterations of the disease. The chemical and molecular analyses of these cases with atypical bony alterations are in progress. Consequently, it is quite possible that the number of confirmed TB-cases from the Medieval Szeged will increase. Two cases of typical form of acquired syphilis could be identified in the examined part of the Szeged-Castle osteoarchaeological material. We have to mention that these early treponemal cases give the first pre-Columbian examples of the disease in Hungary. These observations from the Carpathian Basin complete the list of evidences of pre-Columbian treponematoses in the Old-World that is constantly getting richer and richer. We also have to take into consideration that the osseous symptoms of TB and syphilis develop only

in a small percent of the infected patients. Consequently, the prevalence of these specific infectious diseases could have been higher in the medieval human populations of Szeged.

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