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**SYMPOSIUM**

# Application and role of anthropological research in the practice of forensic medicine

Ferenc Kósa*

Department of Forensic Medicine, University of Szeged, Szeged, Hungary

**ABSTRACT** Whereas in anthropology the application of the new methods is predominantly taken at random and is characteristic of basic research, in forensic medicine the objectives, motives and results of osteological research are of prime interest, due to its role in criminology and administration of justice. Because of the significance of professional assessments in judicial verdicts, it demands the application of the most modern methods of analysis that can later on be recommended as practical methods used in both palaeoanthropological analyses and research work. With his scientific achievements the author indicates how the forensic medical profession promoted historical anthropological research and in return how classical anthropology (anthropometry) promoted forensic medical expertise work, among others the identification of skeletons of unknown origin, and also how scientific achievements can mutually be used for the benefit of the development of both fields.
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Forensic medicine is an interdisciplinary science which in everyday practice applies all the knowledge that medical sciences, widely speaking the natural sciences, have accepted as reliable and scientifically solid facts or processes, and qualitative or quantitative definitions with the help of which accurate and reliable statements can be made. This is also true for other fields of sciences and it can be a true statement with the restriction that in forensic medicine only those factual data, scientific knowledge and professional processes can be applied as methods of analyses which meet the requirement that it has to comply with the present state of science and its application cannot be offended or rejected. These statements are closely connected to significant individual and social interests. On the basis of groundless forensic medical statements incorrect judicial verdicts may be brought. Unfortunately, mistakes and "professional accidents" may occur even with the most meticulous forensic medical examinations that are called "iustice mord" cases in legal practice. We can come across with news in the press that in the United States someone was sentenced to death on the charges of rape and murder, and analyses have now proven that the crime in the indictment had not been committed by the person who was sentenced on the basis of an unfounded and mistaken verdict has already spent 35 years in prison. Thirty five years ago DNA analyses were not yet possible. These new and modern analyses are capable of proving the identity of the person who committed the crime on the basis of the DNA characteristics of the sample taken from the vagina. If these characteristics do not coincide with the DNA characteristics of the indicted person, he cannot be the one who committed the rape.

Nowadays there are categories of crime where the cooperation of forensic medical experts is vital, *e.g.* DNA analyses in parentage cases; individual personal identification cases with the help of the analyses of the DNA, biological traces, body discharge, skeleton and bones; seduction cases (where the offended party is a 14-year-old girl) where the DNA analysis of the nonviable fetus resulting from the arterficial abortion of the unwanted pregnancy can identify the rapist.

In accordance with the criminal procedural law a forensic medical expert has to be hired in cases it is necessary to judge a fact that needs special expertise. In general in the various criminal cases the analyses of bones and skeletons of unidentified persons need the peculiar expertise with which the decision-making person in criminal investigation and administration of justice does not possess. The examination of bones found in "suspicious" circumstances can be such a case, *e.g.* if in the prime approach it has to be determined whether a bone is of human or animal origin. If it is undoubtedly of animal origin, it will not fall within the interest of the administration of justice but if it is of human origin, it has to be further analysed to determine its "chronological age" and its age in ordinary sense.

In Hungarian legal practice and jurisdiction crimes become forfeited after 20 years. In case of finding of a skeleton the forensic medical expert's prime task is to

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*Phone: 36(62)545-905, Fax: 36(62)426-229, E-mail: kosa@anat-fm.szote.u-szeged.hu

determine whether the bones got to the place of finding prior to this date or after it. War crimes do not become forfeited in accordance with the current laws, therefore, bones or mass graves originating from the years of the Second World War may be important in the aspect of a crime or criminal investigation. It is more frequent, however, that skeletons are found in building sites and are most certainly not remains of crimes. Skeletons are often unearthed in and around Szeged during excavations that are considerably eroded, yellowish coloured, impregnated with lime salts and are most likely "several hundred years old". Obviously, these bones fall outside the field of interest of forensic medicine.

Yet, they are the cases that await answers and where two professions (forensic osteology and anthropology) meet paleoanthropology and paleopathology in practice because, regarding their working methods, the two sciences do not differ considerably. It is only the subject and the objective of the examination that mostly differ.

Forensic medical and osteological examinations are restricted to skeletons buried or placed in strange conditions where the most important task is to identify the person and the conditions and the cause of death (Kósa et al. 1994; Kósa 1995). They are always "fresh", *i.e.* recent bones and when determining the individual characteristics like height, sex, age, etc., the same methods are applied that anthropologists have developed and apply regularly in the case of paleoanthropological findings. In this respect the two fields are not separated by the methods of examination but by the substratum and objective of the examination.

If there is no significant difference between the methods of examination in the two fields, the knowledge of the professionals and their spheres of interest cannot differ considerably either.

As to the persons performing the examinations, it is the customs of the given state, its jurisdiction and the training system at university level that play a decisive role. In Europe, especially in German speaking territories and in the regions under its influence, including Hungary as well, it is the forensic expert (regularly forensic pathologist) who performs examinations of bones for the court and has appropriate training and theoretical and practical knowledge based on regular work, which qualifies him for the job. In case of hidden and concealed murders (defence) mostly decomposed, frequently skeletonized bodies are found. The forensic pathologist has to be familiar with the questions to be answered and the applicable methods.

In the United States of America, the examination of skeletonized bodies and parts of skeletons or even full skeletons are entirely different from criminological point of view. Such examinations are carried out by specially trained forensic anthropologists, who is generally not a physician but a biologist. The solution of the problem is more or less the same. The approach is from an opposite direction, the direction of two interdisciplinary professions and later on it developed on the basis of skills and professional practical expertise.

On the basis of the interdisciplinary character of the profession it is not strange if forensic anthropologists also take part in the paleoanthropological research work as I have been doing it for years cooperating with Hungarian and foreign anthropologists.

For this reason, the content of the title of my lecture is not only true regarding to what extent and in what form the anthropological research results are applied in forensic medical practice but on the other hand, shows how forensic medical osteological research work have aided the development of anthropology.

Societies need the application of effective means and interventions to push back crimes and to decrease their negative effects on individual citizens and entire societies. Unfortunately, the means of criminals are often ahead of the effectiveness of the means and persons available in criminal investigation and administration of justice. Even if criminology as the science of criminal investigation is not always lagging behind crimes, it has to show special determination to reveal and repress crimes with increasingly thorough examinations that are committed with the help of new scientific achievements in a very refined way. Due to the cases that need a special, unique and individual approach, forensic osteology and anthropology provide those impulses for the development of classical anthropology that make scientifically sound answers possible to questions arising even in such cases (Kósa 1990a, 1993a, 1993b, 1993c, 1993d, 1993e, 1993f).

Fortunately, in Hungary and in Western-European countries the "death sentence" is abolished. Apart from this, however, due to the weight of his professional opinion on the basis of which even the strictest verdict could be reached, the responsibility of a forensic medical expert has always been greater than that of a paleoanthropologist who may have been mistaken regarding the sexes of skeletons when unearthing a cemetery.

After outlining such relationships and thoughts, let me present some of the most interesting episodes of my forensic medical research work that did not only contribute to the increase of the level of forensic medical work but at the same time widened the range of methods applicable in historical anthropology (Marcsik 1992; Farkas et al. 1994; Kósa et al. 1994; Antal et al. 1994; Kósa and Tiszlavicz 1997). It did not happen differently in my case either than it is indicated by the cooperation of the two professions. The motivations, the ideas and the research plans for my osteological research work have been provided by the actual forensic medical problems occurring in practice. My paleoanthropological activity and scientific cooperation with others also started with and was made continuous by my anthropologist friends who asked me special and unique questions that could provide new information for paleoanthropology itself on the basis of the results I achieved in earlier research work (e.g. application of histological and scanning electron microscopic methods to determine causes of pathological osseous deformations, change in the inorganic content of bones, the time of lying in the ground, *i.e.* the absolute chronology of bones and the scanning electron microscopic examination of the dentine structure of teeth to determine individual age, etc.).

## The significance of descriptive anatomical and anthropological examinations

I have been engaged in forensic osteology for about 35 years. My first publication was published in 1965 in the field of fetal bones, which was followed by many others that provided the material for my thesis of candidacy (Ph.D.), which I defended in 1971. As co-authors, Professor Fazekas and I wrote a book about our examinations that was entitled "Forensic Fetal Osteology" and published by the Publishing House of the Academy of Sciences in 1978. In this encyclopaedic book of 414 pages we summarized all the knowledge that can occur in the practice of forensic medical and historical anthropological examinations of the fetal skeleton. In this work we have developed one major field of forensic and historical anthropology and provided knowledge that has been long needed as compared to the previous knowledge and practice (Fazekas and Kósa 1978).

Under the editorship of Professor H. Hunger and D. Leopold a book of 520 pages entitled "Identifikation" was published in 1978 in which I was asked to write a chapter of 40 pages about the forensic medical examination of fetal bones (Kósa 1978).

I wrote about the forensic medical and anthropological analysis of fetal bones in the chapter called "Age Estimation from Fetal Skeleton" of a book entitled "Age Markers in the Human Skeleton" that was edited by Professor Y. Iscan (Florida Atlantic University) in 1989.

In 1992 the noted English odontologist, D. H. Clark published a significant work on individual personal identification. One chapter of it was written by Professor J. G. Clement and myself (Clement and Kósa 1992).

One of the greatest representatives of German forensic osteology asked me to write a chapter in his book called "Identifikation unbekannter Toter. Interdisciplinare Methodik, forensische Osteologie" that was published as the 22$^{nd}$ volume of Criminological Working Methods in Medicine and Natural Sciences (Kósa 1998). The chapter of 52 pages called "Knochen des Feten und Neugeborenen" summarises all the expertise that are useful and exemplary for a forensic medical expert and a paleontologist in the analysis of fetal bones. Apart from the age determination of a fetus, the chapter deals with the working methods aiming at the determination of the sex in the fetal period and the race of the fetus based on the anthropological characteristics of white and black skeletons (Kósa 1998).

## The objective and methods of the structural examination of human bones and teeth

The determination of the individual and chronological age of the bones is a field of forensic osteology and historical anthropology that needs a great deal of theoretical and practical expertise and has greatly developed recently, due to the latest new analytical methods. With it the reliability of forensic medical proving based on the examination of bones has considerably increased. We carried out several examinations at the Department of Forensic Medicine, University of Szeged. Forensic osteological research work was supported and given priority by the Ministry of Health in the periods of 1976-80 and 1981-85. Then we developed cooperation with the associate institutes of our university, e.g. the Central Research Laboratory, Institute of Medical Chemistry as well as institutes outside the university, like the Biological Research Centre of the Hungarian Academy of Sciences, the Department of Anthropology and Mineralogy at University of Szeged and the Institute of Computer Sciences at University of Debrecen.

In 1991, I defended my academic doctoral dissertation entitled "The individual and chronological age of human bones" on the basis of my extensive scientific work in the field of the examination of bones and teeth.

For a long time individual age determination was only possible on the basis of the morphological (macroscopic anatomy) features of bones and teeth and the changes caused by aging. The analysis of the elements of "hard" tissues were made possible partly by new information gained by the analytical observations of the previous structure and partly by the increased technical level of modern laboratory tests. During these examinations significant relationships indicating ages were found in the materials, structure and sizes of bones and teeth that are suitable for age determination.

Apart from the metric methods, we applied modern instrumental laboratory methods like the atomic absorption spectrophotometric analysis of the elements forming bones, the light microscopic, polarization optical, microradiographic, thermogravimetric, scanning electron microscopic and electron microprobe analysis of the structural changes of bones and teeth, the quantitative determination of amino acids forming collagen in connection with the organic substance of bones, etc. The results of my forensic anthropological research can be divided into 4 groups:

### Metric and structural analysis of fetal bones

While forensic osteology (in general the anthropological and forensic medical examination of adult bones) has developed into a growing special field of medical sciences, the development of forensic fetal osteology has been lagging behind. Before our systematic examinations there were no practical methods applicable for all fetal bones with the help of which the age of a fetus could be determined on the basis of the bone sizes.

In forensic medicine it frequently happens that in case of abortion or the murder of a newborn baby only the skeleton or some of its parts can be found and examined. In such cases the age of the fetus in the womb has to be decided on the basis of the bone sizes, *i.e.* how many lunar months old the fetus was and whether it was born immature or mature.

It happened quite frequently that it was the fetal skeletal sizes necessary for the practical examinations that were missing in literature (Toldt 1882; Szász 1938; Siebert 1941; Saettele 1951; Landois 1986). For this reason, the age of the fetus in lunar months provided a problem or was only possible with greater tolerance of miscalculations.

In the literature there are calculation methods (Langer 1872; Balthazard and Devieux 1921; Olivier and Pineau 1960) that with the help of formulae on the basis of certain bone sizes (mainly the sizes of the diaphysis of the limbs) can estimate the age of the fetus with reasonable accuracy. These methods, however, do not always provide reliable data on the age of the fetus. The field of their applicability is limited and cannot be applied in cases when the limbs are missing. For this reason, there was a need for a method that makes it possible to determine the age of the fetus quite accurately on the basis of any other fetal bone sizes that are available during the criminological investigation.

In order to eliminate the inaccurate statements resulting from the few data on skeletal sizes in literature we carried out the examinations that have led to the correct and systematic determination of fetal bone sizes (Fazekas and Kósa 1965a, 1965b, 1966a, 1966b, 1966c, 1966d, 1967a, 1967b, 1967c, 1967d, 1969, 1978; Kósa 1969, 1978, 1974; Kósa and Fazekas 1972a, 1972b, 1973a, 1973b, 1973c) With the help of these data the body length and the age of the fetus can be determined accurately, if needed.

In order to determine the body length and age on the basis of bone sizes we measured 48 different bones of skeletons of 138 human fetuses (71 male, 67 female) born of pregnancies of III-IX lunar months. Usually two (or more) sizes were measured, while taking into account the most characteristic anatomical points. During the measurement of a fetal skeleton 80 bone sizes were determined, *i.e.* we made a total number of 11,040 measurements. We have developed 4 methods of determination any of which can accurately determine fetal body length and age. These methods are as follows:

- comparison of the examined bone sizes to the data in the tables published;
- determination of the body length and the age by using ratios;
- determination of body length and age with regression diagrams;
- determination of body length and age with the so-called fast method on the basis of the ideal relationship between a few bone sizes and the body length (Kósa 1969; Fazekas and Kósa 1978).

We examined the development of the forms of the fetal bones on the basis of which – without any metric data – we can estimate a phase of development of a fetus, e.g. the beginning of viability or the time of reaching maturity, etc. (Kósa and Fazekas 1972a, 1972b).

We carried out regression examinations on the basis of the bone sizes to determine the sex of the fetuses and applied multivariant discriminant analysis.

By relating the length and depth of the incisura ischiadica to each other, as well as to the length of the os ilium and the femur an index could be determined from the regression equation which can be used 70-80% successfully in the determination of the sex of the fetus when determined on the basis of the skeleton (Fazekas and Kósa 1969).

With the modern mathematical statistical methods our aim was to provide a more reliable method for the determination of the sexes of fetuses. During these examinations we set up 21 indices for the expression of morphological characteristics on the basis of 12 sizes of the ilium (lengths and widths of the os ilium, the incisura ischiadica, the articular surface of the acetabulum, the os ischii and the os pubis and the length of the sacral edge and the supra-articular edge of the os ilium) and 3 sizes of the limbs (the length of the humerus, radius and femur). The sizes of the ilium were determined on 42 skeletons of fetuses and newborn babies.

Using the metric sizes and the indices of male and female fetuses in the multivariant discriminant analysis the determination of the actual sexes was successful in 72.12% of the cases.

According to the discriminant functional analysis, only four of the examined factors play a role in the determination of sexes.

The relationship can be expressed in the following equation:

$$(-0.3xM6)+(0.95x14)+(1.46x17)+(25.8x120)-16.57$$

where:

M6 = width of the articular surface of the acetabulum,

14 = incisura ischiadica index / os ilium index,

17 = length of the os ilium / length of the incisura ischiadica,

120 = length of the incisura ischiadica + length of the articular surface of the acetabulum + length of the supra-articular edge of the os ilium / length of the insicura ischiadica.

According to this, if the received value in the range from 0-(+4) shows an average value of 0.7634, it is a male fetus, whereas if the received value in the range from 0-(-4) shows an average value of –1.2723, it is a female fetus (Kósa 1993e, 1995a).

During the morphological and structural examination of the fetal bones we carried out polarization optical and micro-radiographic tests. With a polarization microscope we can conclude on the double fraction of the bone structure as well as the own double fraction of the individual structural elements from which we can draw safer conclusions about the developmental state of the bone than it was possible before (Clement et al. 1987; Mojzes et al. 1979) by traditional histology.

We simultaneously carried out microradiograph examinations on the same bone samples. With this method the structural changes of the age group in the tubular fetal bones can be traced more accurately than on traditional histological sections (after decalcification). The development of the osteonic structure, the appearance of regular osteones, their number and their relationship to their basic substance clearly indicate the different phases of fetal development (Clement et al. 1987).

The atomicabsorption spectrophotometric examination of fetal bones in the case of fragmentary skeletons or if the bones are burnt can provide reliable information for the determination of the age of the fetus. From the changes in the compound of the inorganic substances of fetal bones the individual age can be estimated (Kósa et al. 1980).

We examined the inorganic substances (Ca, Na, K, Mg, Fe, Zn. Mn, Cu, Pb) of the bone samples taken (by sawing) from the diaphysis of the femur of 27 male fetal skeletons and 71 female skeletons from the fetal bone collection of our Department with atomicabsorption spectrophotometric method. It was only the Ca that indicated significant relationship between the inorganic content and the age ($P<0.05$).

## Racial differences on fetal bones

In 1991 I spent 3 months in the Smithsonian Institution and carried out metric and comparative anatomical (anthropological) examinations on the fetal bone collection of the Anthropological Institute of the National Museum of Natural History (NMNH) in Washington D.C. The examinations resulted in the new scientific achievements that major racial morphological differences within the two main races (between the Caucasoid and the Negroid) can be indicated as early as in the fetal or newborn period. Prior to my examinations no data existed about it in the literature of physical anthropology.

Regarding the skulls, the most characteristic racial differences are on the squama of the temporal bone and the frontal process and the palatine surface of the maxilla, the vomer, lateral plate of the cranial part of the occipital bone (pars lateralis ossis occipitalis) and the basal area of the plate of the occipital bone.

The race of the unknown fetus or newborn baby can be determined by taking into account the characteristics of both the intact skull and the individual bones of the skull on the basis of the referred morphological characteristics during the anthropological examinations and in the cases occurring in forensic medical practice (Kósa 1991a, 1991b, 1992c, 1993b, 1994a, 1994b, 1996).

To demonstrate morphological differences we only show the formal characteristics of the temporal bone. The squama of the temporal bone of white fetuses is regular semicircular (Fig. 1), whereas those of black fetuses are similar to a rectangle (Fig. 2). In case of a mixed type (mulatto) the dominant manifestation can be seen (Fig. 3). It means that the curved form of the upper edge of the squama is dominant in white fetuses, whereas the "flatter" form of the squama is characteristic of black fetuses.

With this new anthropological knowledge in the examination of an unknown fetus and a newborn baby the significant fetal characteristics can be taken into consideration just as they are generally given an expert opinion about during the identification of an adult skeleton. In the case of fetuses the body length also indicates age, therefore, if apart from this important characteristic we can refer to the sex and the main race, the conclusions drawn from the examinations are as exact as in the case of the examination of adult bones.

### Examination of adult bones

According to our examinations the determination of inorganic content in bones can support the determination of the changes in the bone structure and the degree of decomposition.

We used various (tubular and flat) bone samples of 20 skeletons buried 14-25 years before that were exhumed

**Figure 1.** Squama of the temporal bone of a white fetus.

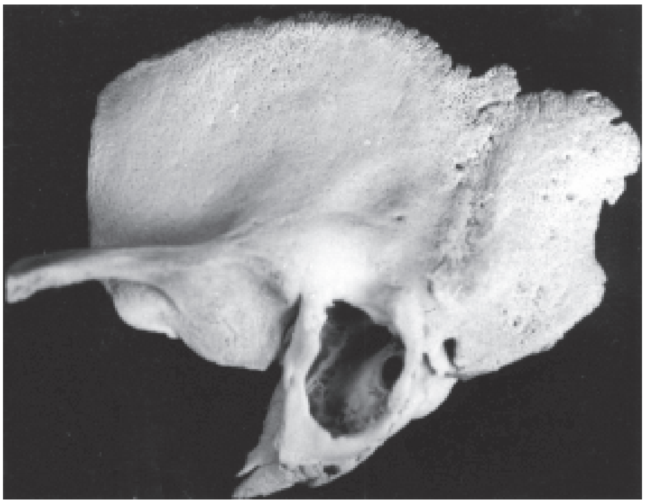

**Figure 2.** Squama of the temporal bone of a black fetus.

**Figure 3.** Squama of the temporal bone of a mixed-typed (mulatto) fetus.

during the relocation of a cemetery (Földes et al. 1982). The bone samples (compact substance of the diaphysis of the femur) of 100 dissected corpses were used as a standard (control) group and so were 38 bone samples of 200-3000 years old skeletons originating from archaeological excavations.

We determined the Ca, Na, K, Mg, Fe, Zn, Mn, Cu and Pb content of bones examined with atom absorption spectrophotometric method. The Ca, Na, K and Mg content as compared to the control group did not show a major difference ($P>0.01$). The Fe and Mn concentrate in bones, however, increased significantly. The "indicative metals" impregnated the bones. They could be found in much greater concentrate in the spongiosa of looser compound than in the compact one (Kósa et al. 1992).

According to our examinations, in direct ratio with the time they spent lying in the ground the spongiosa/compact ratio of the impregnated elements is a characteristic feature in the determination of the chronological age of the bone finding (Kósa et al. 1979a, 1980b; Földes and Kósa 1980; Kósa et al. 1982).

The thermogravimetric (derivatographic) examination of historical anthropological bone samples was a reliable method for the determination of the chronological age of bones (Kósa et al. 1982). In the practice of forensic medicine the method is not applicable in the practice of forensic medicine because there is no difference between the fresh adult and fetal bones in the weight loss in % during a time unit, depending on the steady increase of temperature (Kósa 1983). At the same time there is no significant difference between the sexes in the derivatogramms either. Neither did the derivatographic examination of a skeleton buried 55 years ago differ significantly from the average value of the derivatogramms of fresh bones ($P>0.05$).

After the electrical decalcification and hydrolyzation of bone samples forming a chronological line we determined the amino acid concentrate of structural proteins with automatic amino acid analysis (Kósa et al. 1985). The amino acid contents of the samples change with the chronological age. From the quantitative changes of certain amino acids (alanine, glycine, proline, tyrosine, valine, glutamine acid) conclusions can be drawn on the chronological age of bones. In recent bones the changes are not significant ($P>0.05$).

The atomicabsorption spectrophotometric examinations showed that in corpses buried in metal coffins it was not the inorganic materials of the earth but the materials of the coffin that had impregnated in the bones. The Zn content showed a 9.21-fold increase, as compared to the concentrate of fresh bones, and the Mn content showed an 18.2% increase, which changes are significant ($P<0.05$).

The rather high concentrate of metallic elements in the bones of those buried in zinc coffins makes the proving of poisoning with such poisons doubtful (Földes et al. 1982).

In bones originating from wartime mass graves there is increased Fe and Mn content. The Fe content can reach a 50-fold increase, which means the one-sixth of the concentrate in the ground sample. These changes can be considered in a way that in case of exhumation within 15 years' time the change in the Mn content of bones is the best "indicator" for the determination of chronological age (Kósa et al. 1989).

We carried out chemical and structural examinations in order to determine the individual age of adult bones, i.e. to determine the age of unknown persons. We determined the inorganic content (Ca, Na, K, Mg, Fe, Zn, Mn, Cu, Pb) in the compact substance of the femur of 100 (52 male, 48 female) corpses taken by random from the collection of our Department with atomicabsorption spectrophotometric method. We did not find any significant sexual and age difference in the inorganic content of bones for the examined elements ($P>0.05$) (Kósa et al. 1992).

During the scanning electron microscopic examination of human bones we used Kerley's method for the individual age determination, which the author had originally developed for the traditional histological light microscopic examination (Kósa and Farkas 1992).

The scanning electron microscopic analysis provides a method as reliable for the age determination on the basis of the examination of bones as the traditional method. Its advantage is that with a sufficient laboratory background the examination can be carried out immediately, without any lengthy laboratory preparation on the surfaces of fractures in the bone samples (Kósa et al. 1992; Kósa 1990).

With electron microprobe analysis we determined the calcium and phosphor concentrate and the Ca/P ratio of weight in the compact substance of the sample taken from the right femur of 25 persons of different age and sex (Kósa et al. 1989).

There is a close relationship between the Ca/P ratio of weight and the age that makes possible that during the forensic medical and paleoanthropological examinations it can be applied successfully in the estimation or determination of the individual age.

## Forensic odontological examinations

The special field of forensic odontology is the determination of individual age on the basis of the examination of teeth (Kósa 1993).

Teeth, similarly to bones, are of one of the most durable human tissues resistant to traumatic and post mortem changes. At the same time the macroscopic, microscopic and structural chemical analysis of teeth may provide equally valuable information on individual age as it was experienced in the case of bones (Kósa et al. 1983; Marcsik and Kósa 1989).

The age-dependent phenomenon of transparency on the root of teeth is suitable for the determination of individual age on both recent and historical anthropological materials.

During the stereomicroscopic analysis of the sizes of the dental canals (canalis dentis) at a magnification of x24 and x100 we examined the characteristics, sizes and number of openings of the dental canals at the root tip (Kósa and Antal, 1989).

We took X-ray photos of the examined teeth and then in the projected pictures at a certain height of the root (in cervical, central and special parts) we measured the radii of the dental canals and the root at the same height as well as the length of the projected teeth. We found that the secondary dentin development results in a change in size that correlates with age. With the help of such data any given person's age can be estimated at least as accurately as with any other regressive phenomenon on the teeth.

In order to determine the sizes (numbers and diameters) of the dentine tubules we used scanning electron microscopic examinations. Apart from the diameter of the dentine tubules we analysed their density and the basic surface area of the total cross-section of the dental tubules in an area of the same size in $\mu^2$ in which relation the structural relations of the dentine tubules according to age groups were significant ($P<0.01$).

Age can be estimated reasonably on the basis of the overall size of the basic surface area of the dentin tubules, therefore, the method can be applied in forensic medical practice (Kósa 1984).

We also used scanning electron microscopic (SEM) analyses in the study of the finer structure of the dentine substance that is characteristic of younger age (Kósa 1984).

The homogenous structure of the inter-tubular substance of the dentine on the teeth of elderly people (above 50 years of age) changes to a granule basic substance of loose structure. An expressed calcification, a hypermineralization, develops around the few tapering dentine tubules. On the basis of the SEM analyses of the dentine substance of teeth structural changes characteristic of the age can be seen with the help of which the age of the given person can be estimated as correctly as on the basis of the other macroscopic phenomena of teeth that can be considered on the basis of the Gustafson method (Kósa 1993b).

During the atomicabsorption spectrophotometric analyses of the inorganic content of teeth we determined the Ca, Na, K, Mg, Fe, Zn, Mn, Cu, Pb and Li elements. The concentrate of inorganic elements in teeth is significantly higher than in bones and this difference is significant in the case of all the elements ($P<0.05$) (Földes et al. 1981).

During the electron microprobe analysis of teeth we managed to prove that in the hypermineralized area around the dentine tubules the Ca/P ratio of weight is higher than in the basic substance between the tubuli. The electron microprobe analyses provide a good opportunity for the individual age determination on the basis of teeth (Kósa et al. 1990; Kósa 1993a, 1995b).

## Historical anthropological analyses of bones

We applied macroscopic, microscopic and scanning electron microscopic examinations in the case of historical anthropological bone findings in order to clarify the pathological processes of the cribra orbitalia. We found in the morphological, histological and (scanning)electron microscopic examinations that the three forms of the poroticus hyperostosis can be traced back to a general pathological process, even in the appearance of transitional forms. The early stage of the bone deformation as part of a disease of the same aetiological basis is porous, the median is cribriform and the serious stage is trabecular (hyperostosis spongiosa). In the aetiology the primary and secondary diseases of the haematopoietic organs can be included (Marcsik and Kósa 1976; Marcsik et al. 1984).

The fractures on the bone findings from historical ages may indicate the living conditions, the treatments of injuries, the conditions of the occurrence and the effectiveness of treatments or even the cultic customs of peoples living those days.

The fractures of the limb, the nasal bone, the clavicle and the rib available in our collection heeled without any functional damage. These results can only be explained with the hypothesis that people already knew and successfully applied the prime principle of the fixing and splinting of the injured limbs (Marcsik and Kósa 1978, 1982).

From paleodemographic aspect the fetal bones may also play a role in the determination of infant mortality in the earlier historical ages. We could acquire valuable paleodemographic data if during historical anthropological excavations more emphasis were put on the examination of fetal bones and bones of newborn babies and infants. In this paper of ours we wished to draw attention to the importance of the thorough examination of fetal and infant bones (Marcsik and Kósa 1988).

We performed the paleoserological examination of 77 individual bone samples excavated from 105 graves originating from approximately the 9$^{th}$ century with inhibition-absorption and absorption-eluation methods (Kósa and Marcsik 1989). In the case of 67 skeletons we repeatedly got identical results whereas in 10 cases the serological results were uncertain. On the basis of the 67 "certain" determinations the received gene frequency value ($p = 0.2015$, $q = 0.3430$, $r = 0.4555$) differed significantly from the gene frequency value of the population in the region of the present-day Szeged and neighbourhood ($P<0.01$).

The individual personal identification on the basis of a photo and a skull (superimposition) always presents many difficulties and professional problems especially if the skull is fragmentary (Kósa and Kelemen 1983). We carried out the identification of an unknown corpse in an advanced state of decomposition with the superimposition method and the comparative analyses of two- X-ray photos of the skull and computer aided video-superimposition (Kósa 1994a; Kósa et al. 1995).

The individual developmental variations of the frontal cavity are identical with the previous X-ray photos, which makes a safe personal identification possible (Kósa and Kelemen 1983).

The results of my osteological and odontological research and forensic anthropological activities can be summarized as follows:

- With the examination of fetal bones we have developed a complex method that can successfully be applied in forensic medical and historical anthropological analyses that did not exist previously, and that is suitable for the determination of body length and age, sex and race on the basis of bone sizes as well as for the determination of individual age on the basis of the structural and chemical analyses of bones. These methods have been widely applied internationally in the fields of forensic medical practice and historical anthropological research.

- The results of our examinations aiming at the determination of the individual ages of adult bones and teeth by help of modern instrumental technology (atomicabsorption spectrophotometric, scanning electron microscopic, electron microprobe, micro radiographic analysis etc.) make individual age determination possible in a wider range even in cases when the fragmented bones do not allow other (e.g. anthropometric) methods.

During our examinations aiming at the determination of the absolute chronology of bones (the time spent lying in the ground) we developed new laboratory methods that can be applied in forensic medical and anthropological research with greater accuracy and success than it was possible with previous methods.

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