

# Colorful bones – Can be histology useful for forensic anthropology in the digital era?

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## SUMMARY

Methods of forensic anthropology are typically used in the identification process of partially or fully skeletonized human remains. Usually, the first step is to determine whether the examined material is human or animal. It may be easy in case of intact bone due to macroscopic differences between human and animal bone but in case of fragmented or burned remains, it might not be that clear and morphognostic methods of forensic anthropology (examination of bone by the naked eye) cannot be used. The same problem might arise in age at death estimation whereas the post-mortem modifications might change the appearance of bone or diminish the changes related to aging. The solution to these challenging situations could be a histomorphological examination of bone, which can be also very helpful in obtaining the medical history or history of trauma.

**Keywords:** bone microstructure – histological examination of bone – forensic anthropology – the age-at-death determination from the bone – identification from bone fragments.

## Môže byť použitie histologických metód vo forenznej antropológii prínosné v digitálnej dobe?

### SÚHRN

Metódy forenznej antropológie sa v praxi najčastejšie využívajú pri identifikácii pozostatkov, ktoré sú čiastočne alebo úplne skeletizované. Prvým nevyhnutným krokom je spravidla určenie, či je vyšetrovaný materiál ľudského pôvodu. Určenie druhovej príslušnosti môže byť vzhľadom na anatomicke odlišnosti jednoduché, avšak pri zlomkovom alebo inak poškodenom materiáli nemusí byť vyšetrenie voľným okom postačujúce. Obmedzené použitie morfognostických metód sa tiež vyskytuje pri určovaní veku, nakoľko veku primerané degeneratívne zmeny sa rozkladným procesom môžu stierať. Uľahčenie riešenia týchto komplikovaných situácií sa ponúka v histologickom vyšetrení kostného tkaniva.

**Kľúčové slová:** vnútorná stavba kosti – histologické vyšetrenie kostí – forezná antropológia – určovanie veku v čase smrti z kostí – identifikácia z úlomkov kostí.

*Soud Lek 2019; 64(3): 28–30*

Human skeleton usually consists of 206 bones, including the patellæ and auditory ossicles (1). Bone tissue is one of the hardest tissues in the human body and is the second most resistant tissue (following the cartilage). Bones represent the framework for locomotive apparatus, protect soft tissues and internal organs within the cranial, thoracic and abdominal cavity. Bone tissue is also a storage of calcium, phosphates and other ions inevitable for maintaining the hemostasis (2). Bones of human skeleton consist of lamellar bone. Another type of bone, fibrillar (or woven) bone, is the first bone tissue in embryonic development, in adults it appears in the fracture healing process and in the tendon insertion sites (2). In some cases, the woven bone might indicate neoplasm or infectious disease (3). Woven bone has different histological features, for example, there are no layering nor Haversian systems. The intercellular non-mineralized matrix consists of type I collagen bundles with branched osteocytes with numerous processes (4). Plexiform bone is typically found in medium-sized animals (non-human mammals) com-

mon in our area (for example pig or sheep) (5). It can occasionally occur in children during a rapid growth spurt (6).

### Lamellar bone

Microscopic structure of bone is framed by periosteum and endosteum. Periosteum forms an osteogenic layer on the bone surface containing collagen fibers, fibroblasts, and blood vessels. Endosteum located inside the bone consists of osteoprogenitor cells, osteoblasts, and collagen fibers. Periosteum and endosteum are connected together by perforating (Sharpey) fibers (2).

In the cross-section of human lamellar bone, two main types of lamellar bone are visible – cortical (compact) and trabecular (cancellous) bone. Trabecular bone is formed into a three-dimensional net comprised of trabeculae or spicules of various thickness and length. These are covered by endosteum. Trabecular bone is internal bone and it is located in flat and irregular bones and in the ends of long bones (2). Cortical bone is located beneath periosteum of bones, it creates a dense layer covering the spongy bone (7). Cortical bone comprises of osteons (also called Haversian canals or systems), cylindrically shaped units surrounding central canal (8). The central canal contains blood vessels, nerves and endosteum and communicates with one another via Volkmann canals (2). Osteon is complex of concentric lamellæ, which consist of an intercellular matrix with collagen fibers bind together with amorphous matter incrustated by mineral compounds. Mineral component refers to 65% of bone tissue in the form of apatite mineral salts (mostly hydroxyapatite), citrate and carbonate ions, magnesium, and sodium ions (4). Due to decalcification, mineral compound dissolves, the bone becomes soft but its microscopic structure remains well-pre-

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Received: October 25, 2018

Accepted: April 23, 2019