“There are several barriers to using bones in useful age determination”

An interview with Prof. John Clement and Dr Rita Hardiman from the Melbourne Dental School at the University of Melbourne, Australia

By Kristin Hübner, DTI

With the Melbourne Femur Collection, the University of Melbourne holds a unique archive of human bone samples that has allowed for a multitude of interdisciplinary research projects in the past two decades. Dental Tribune spoke with Prof. John Clement, who has worked with the collection since its initiation, and Dr Rita Hardiman about its forensic and anthropological value and the experiences the dental profession brings to the methodological mix that help unlock the information recorded in the bone tissue.

The Femur Collection was initiated in 1991. Can you explain the initial purpose of the collection?

Prof. Clement: The initial purpose of the collection was to test the theory that femoral cortical bone microstructure could be used to establish age at death for an individual. This relied on being able to reliably measure the rate of turnover of bone during life, and age changes in the bone’s features. The aim was to collect samples of the midshaft of the femur covering the entirety of the human lifespan and both sexes. The femur was chosen because it is a durable part of the skeleton, likely to survive unscathed in cases in which deceased individuals are not discovered for a long time. These are also the cases in which an anthropological assessment of age at death is required.

Why is it located at the Melbourne Dental School?

Dr Hardiman: When the Femur Collection was initiated to try to determine a pattern of micro-structural change to establish age at death, Professor Clement was working at the Victorian Institute of Forensic Medicine as a consultant forensic odontologist, as well as fulfilling his academic role at the School of Dental Science—as it was then called—at the University of Melbourne. The collection was established to answer questions about unknown deceased individuals’ identity, in particular: how old was the person when he or she died? This is part of the work of a forensic odontologist.

I joined the collection at a later date, in 1998, to answer questions about sex differences and age changes in the cortex of the femoral midshaft.

Is there a similar collection elsewhere in the world that you know of?

Prof. Clement: Not such a well-documented, well-provenanced collection from recently living individuals, collected in accordance with national ethical guidelines and with explicit permission of the next of kin, for the express purpose of research into age-related changes.

How many individuals are represented in the collection today, and where were the specimens obtained?

Dr Hardiman: The collection represents over 600 individuals. Specimens are either physical samples of femoral bone or digital data from teeth and bones.

“The next big step in the collection’s future is to couple the results of genetic investigations with the morphological outcomes from the bones.”

Fig. 1: Cortical thickness mapping of the proximal femur in women of different ages. — Fig. 2: Two rows of microradiographs of the femoral midshaft cortex illustrating the wide variation in bone structure. All from individuals between the ages of 78 and 80, top row men, bottom row women.
The collection is a rich source of information for researchers in various fields. What methodologies and experiences does the dental profession contribute?

Prof. Clement: Dental academics and researchers have a long history of intrepid research into all five types of mineralised tissues that are important in the jaws and faces of people, using a number of methodologies at the forefront of scientific technology. All research conducted on the collection is done with expert knowledge of bone growth and development and of age changes. This field of knowledge is one with which the dental profession is closely linked.

Just as with the femur bone, teeth are very resistant to decomposition and record a great deal of information about people’s lives. Given that you have all the information about the bone donors in the collection, have you ever considered doing cross-research with teeth samples to compare the teeth and bone findings?

Prof. Clement: The ethical constraints of this collection mean that we cannot do this for specimens we have collected so far. Besides that, removing teeth results in significant disfigurement—something we as researchers are reluctant to do unless absolutely necessary. Teeth are also able to be studied in living individuals, reducing the need to study extracted cadaveric teeth. Lastly, teeth are exposed to a variety of very different environmental factors, such as diet and habitual wear, thus not easily correlated with the changes in bone due to mechanical influences. Researchers at the Melbourne Dental School do have a keen interest in determining life histories through mineralised tissue, though, so I think we would be a very interesting idea for the future.

To date, over 80 papers have been published based on the collection. Could you name a few key findings?

Dr Hardiman: The key findings of research on this collection broadly relate to the ability to study features in recently deceased individuals from a populous urban environment that are impossible to study in the living. An example of a really interesting finding is that of the level of porosity in the cortical bone being a function of the size of individual pores, rather than pore density in the bone. More recently, researchers on the collection have been able to reconstruct the osteocyte lacunar network and the 3-D structure of Haversian systems at age determination using cranial sutures. Unfortunately, there are several barriers to using bones in useful age determination. The first is that there is no reliable method to determine age accurately within a reasonable range. The second is that any investigative technique that can be used on living individuals would not be sensitive enough. The third is that there are inevitable population differences in rates of change of bone features, and environmental effects that would probably confound any results, such as malnutrition and diseases that affect bone metabolism.

With the emergence of new digital technology, the collection probably offers the potential for even further discoveries. In your opinion, what do you foresee in this regard for the future?

Prof. Clement: The insights for the future will probably come from more precise mathematical modelling of the effects of physical changes on bone tissue. We now have the capability to work effectively with big data to predict changes in bone by inputting very detailed information about its morphological structure and the bone tissue’s physical composition. Perhaps soon we will be able to watch a skeleton ageing virtually and test the effects of preventative therapies on the structure of bone. The ultimate aim is to maintain people’s bone health throughout life so that everyone can remain as active and have as enjoyable, productive and long a life as possible!

Thank you very much for the interview.

Esthetics in many colors
Perfect shade determination with VITA Easyslide®

All these physical lifestyle factors have a remodelling effect on limb bones, at different rates and with different morphological outcomes. Genetic effects also come into play. The Melbourne Femur Collection includes blood samples that were collected together with many of the bone samples. The next big step in the collection’s future is to couple the results of genetic investigations with the morphological outcomes from the bones. As for nutrition, in the time span that these individuals were alive in the state of Victoria, most of them would have had very good nutrition, so effects of malnutrition would most likely not be seen in these bone samples.

Looking at teeth only, it can be difficult to make a precise age determination after the permanent dentition has erupted because there is a great deal of variation as well. For age determination, which is necessary, for example, owing to the recent influx of refugees into Europe, would it be more precise to combine data from teeth and bones?

Prof. Clement: In theory, this might be a good addition to current methodologies. Of course, closure of epiphyses in the long bones is currently used as an age estimate—again, only in those who have not finished growing. And there have been some—as yet ultimately unsuccessful—attempts to date, over 80 papers have been published based on the collection. Could you name a few key findings?

Dr Hardiman: The key findings of research on this collection broadly relate to the ability to study features in recently deceased individuals from a populous urban environment that are impossible to study in the living. An example of a really interesting finding is that of the level of porosity in the cortical bone being a function of the size of individual pores, rather than pore density in the bone. More recently, researchers on the collection have been able to reconstruct the osteocyte lacunar network and the 3-D structure of Haversian systems at age determination using cranial sutures. Unfortunately, there are several barriers to using bones in useful age determination. The first is that there is no reliable method to determine age accurately within a reasonable range. The second is that any investigative technique that can be used on living individuals would not be sensitive enough. The third is that there are inevitable population differences in rates of change of bone features, and environmental effects that would probably confound any results, such as malnutrition and diseases that affect bone metabolism.

With the emergence of new digital technology, the collection probably offers the potential for even further discoveries. In your opinion, what do you foresee in this regard for the future?

Prof. Clement: The insights for the future will probably come from more precise mathematical modelling of the effects of physical changes on bone tissue. We now have the capability to work effectively with big data to predict changes in bone by inputting very detailed information about its morphological structure and the bone tissue’s physical composition. Perhaps soon we will be able to watch a skeleton ageing virtually and test the effects of preventative therapies on the structure of bone. The ultimate aim is to maintain people’s bone health throughout life so that everyone can remain as active and have as enjoyable, productive and long a life as possible!

Thank you very much for the interview.

Esthetics in many colors
Perfect shade determination with VITA Easyslide®

All these physical lifestyle factors have a remodelling effect on limb bones, at different rates and with different morphological outcomes. Genetic effects also come into play. The Melbourne Femur Collection includes blood samples that were collected together with many of the bone samples. The next big step in the collection’s future is to couple the results of genetic investigations with the morphological outcomes from the bones. As for nutrition, in the time span that these individuals were alive in the state of Victoria, most of them would have had very good nutrition, so effects of malnutrition would most likely not be seen in these bone samples.

Looking at teeth only, it can be difficult to make a precise age determination after the permanent dentition has erupted because there is a great deal of variation as well. For age determination, which is necessary, for example, owing to the recent influx of refugees into Europe, would it be more precise to combine data from teeth and bones?

Prof. Clement: In theory, this might be a good addition to current methodologies. Of course, closure of epiphyses in the long bones is currently used as an age estimate—again, only in those who have not finished growing. And there have been some—as yet ultimately unsuccessful—attempts...