“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 microstructural 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 teeth samples to compare the information for researchers in various fields, or digital data that can be shared with other researchers on the collection is done 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.”

“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 19 and 80; top row men, bottom row women.”

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 19 and 80; top row men, bottom row women.
tal volumetric scans of lower limbs. All that the specimens were collected with informed consent from the next of kin, with expert help from transplant coordinators and mortuary staff and the support of the Victorian Institute of Forensic Medicine. This means that the specimens are of recently living persons from the state of Victoria in Australia who died suddenly and unexpectedly.

“The ultimate aim is to maintain people’s bone health throughout life.”

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 decomposi-
tion and record a great deal of in-
formation about people’s lives. Given that you have all the infor-
mation about the bone donors in the collection, have you ever con-
sidered doing cross-research with teeth samples to compare the teeth and bone findings?

Prof. Clement: The ethical con-
straints of this collection mean that we cannot do this for spec-
mens we have collected so far. Besides that, removing teeth re-
sults in significant disfigure-
tment—something we as research-
ers are reluctant to do unless ab-
солutely necessary. Teeth are also able to be studied in living indi-
viduals, reducing the need to study extracted cadaveric teeth.

Lastly, teeth are exposed to a va-
riety of very different environ-
mental factors, such as diet and
habitual wear, thus not easily correlated with the changes in bone due to mechanical influ-
ences. Researchers at the Mel-
bourne Dental School do have a keen interest in determining life histories through mineralised tissue, though, so it 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 find-
gs?

Dr Hardiman: The key findings of research on this collection broadly relate to the ability to study features in recently de-
ceased individuals from a pros-
perous urban environment that are impossible to study in the liv-
ing. An example of a really inter-
esting finding is that of the level of porosity in the cortical bone being a function of the size of indi-
vidual pores, rather than pore density in the bone. More recently, researchers on the collection have been able to reconstruct the os-
teocyte lacunar network and the 3-D structure of Haversian sys-
tems. All these findings help us to understand much more about the 3-D form of bone tissue in the femur and how this might change throughout the human life span.

One of the major findings was that there is a high degree of variation regarding the femur bone between individuals of the same chronological age. Can you explain why?

Dr Hardiman: Bone is very re-
sponsive to mechanical forces. If one considers a number of people within a community, some are active in their daily lives than others, and there is a broad spec-
trum of activity types. For example, some people have a more sedentary lifestyle, while others have physically demanding work and extracurricular activities.

All these physical lifestyle factors have a remodelling effect on limb bones, at different rates and with different morphologi-
cal outcomes. Genetic effects also come into play. The Melbourne Femur Collection includes blood samples that were collected to-
gether 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 individu-
als were alive in the state of Victo-
rin, 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 dif-
ficult to make a precise age deter-
mination after the permanent den-
tition has erupted because there is a great deal of variation as well. For age determination, which is neces-
sary, for example, owing to the re-
cent influx of refugees into Europe, would it be more precise to com-
bine data from teeth and bones?

Prof. Clement: In theory, this might be a good addition to cur-
rent 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 at age determination using cra-
unial 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 accu-
ately within a reasonable range. The second is that any investiga-
tive technique that can be used on living individuals would not be sensitive enough. The third is that there are inevitably popula-
tion differences in rates of change of bone features, and environ-
mental effects that would proba-
ably 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 fur-
ther 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 physi-
cal changes on bone tissue. We now have the capability to work effectively with big data to pre-
dict changes in bone by input-
ting very detailed information about its morphological struc-
ture and the bone tissue’s physi-
ological composition. Perhaps soon we will be able to watch a skele-
ton ageing virtually and test the effects of preventative therapies on the structure of bone. The ul-
timate aim is to maintain peo-
ple’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 inter-
view.