Discuss the three following methods of ageing the skeleton, critically analysing each: dental attrition, rib ends and cranial suture closure.
Introduction

In archaeological studies using cemetery data there is a need to determine the age-at-death of skeletal material to enable the development of demographic profiles for populations, covering aspects such as population composition, community status, health, and disease. Such data also helps to consider if certain grave goods are associated with a particular age group. (Aykroyd, R.G. et al. p.57; Roberts, C & Manchester, K. p.23; Mays, S. 1998, p.66)

Most age determination techniques have been developed using sample collections of skeletons of known age and sex, for example, the Spitalfields collection, where data was collected using the results of excavations at Spitalfields Church, London, of individuals from the 18th and 19th centuries. Real age-at-death was known as many skeletal remains could be associated with grave plates and historical data. (Aykroyd, R.G. et al., p.57; Roberts, C. & Manchester. K., p.24) There are factors to consider when using standards developed from sample collections as they can be biased with regards to age, sex and ethnicity. To overcome these problems Aykroyd et al. (p.58) suggest that researchers should use a number of methods to cover biases in any one method. Roberts & Manchester (p.22) highlight that age assessment taken from modern collections may not be applicable to archaeological material as quality of diet can determine the rate at which people grow & age and with modern diets having changed from ancient ones, standards for one population may not match another.

Methods of ageing

There are a number of methods to choose from when trying to determine the age of unknown skeletal material. In general terms these cover (Mays 1998, p.50):

- Morphological changes at the joints in the body where movement between bone is limited or non-existent e.g. cranial suture closure or rib end morphology
- Examination of bone structure e.g. bone microstructure
- Examination of the teeth e.g. tooth wear or dental microstructure

The ageing of juveniles is considered to be relatively simple. Dental development, the calcification and eruption of teeth and the development of the skeleton are accepted as reliable methods, (Roberts, C. & Manchester, K. p.23) although the
issue of the degree of similarity between modern and ancient individuals must be taken into consideration. Assigning age to an adult skeleton is, instead, quite problematic as once the bones have developed and the teeth erupted the body begins to disintegrate. This process does not occur at the same rate for all as diet, disease, and physical activity will affect the rate of ageing. (Aykroyd, R.G. et al. p57)

For adults there are a number of methods that have been developed and it is recommended that a combination be used. Where the skeleton is well preserved the Workshop of European Anthropologists recommended the Nemeskeri, Harsany and Aesady method. Other methods which met the Workshop’s approval included:

- The Miles method which looks at the abrasion of molar teeth
- Spondylytic changes of the vertebrae
- Arthritic changes of large joints
- Gustafson’s method of tooth examination

(Ferembach, D. p.532)

Roberts and Manchester (p.23) suggested the following, while noting that debate as to accuracy in some of the methods still continues:

- Examination of tooth attrition (Brothwell)
- The closure of cranial sutures (Masset)
- Changes in the sacral/auricular surfaces of the pelvis (Lovejoy et al.)
- Changes in the sternal rib ends (Loth & Iscan)
- Use of radiography and histology with the bones (Ascadi & Nemeskeri)

The literature on the topic of age assessment often refers to systematic errors in the ageing of individuals. Boddington states:

“When archaeological data is compared to the historical evidence the skeletal population has consistently higher mortality rates and the suspicion of under-aging is hard to dispel”.

It seems that younger individuals are often given older ages and older individuals given younger ages. The best example of this is seen in the work from Spitalfields, where there were discrepancies of up to 30 years in both directions. (Aykroyd, R.G. et al., p.56)

This essay will continue by looking at three methods from those described above – dental attrition, rib ends and cranial suture closure.
Dental attrition

A number of age-at-death assessment techniques have been developed based on tooth attrition. Mays (2002, p.861) describes dental wear as “the gradual and regular loss of tooth substance as a result of natural mastication”. The modern diet of soft, processed food means that wear on our teeth is slight. Yet in antiquity humans had a coarser diet due to harder particles in food. Such particles caused increased dental wear and it would be expected that older people would show more teeth wear than younger people. Wear occurs more regularly on molar teeth therefore these are used in ageing studies. Wear begins at the enamel and eventually dentine is exposed. Even the entire enamel crown may eventually disappear. It is this process that has enabled the development of a number of schemes that aid in age determination. (Mays, 1998, p.57)

Researchers on the topic have included Broca, Gustafson, Bang & Ramm, Brothwell, Miles, Lovejoy et al. and Davies & Pederson (Miles, A.E.W., p.973-976). One study, by Constandse-Westermann, looked at dental wear in a group of 19th century skeletons of a known age-at-death from the Netherlands. The study aimed to investigate the relationship between molar wear/crown height and age. Results showed no evidence for sex differences, with the crown heights of mandibular molars showing a closer correlation with age at death than those of the maxillary molars. Tooth loss in the sample appeared to increase once individuals were past middle age. The suggestion was made that those showing a 50% loss should be assigned ages over 50. This study showed the dental wear method out-performed other methods (e.g. pubic symphyseal morphology and cranial suture closure) and supported the use of the method on archaeological populations. (Mays, 2002, p.861-869)

Miles noted that teeth wear methods failed to take account of the fact that individuals may survive into their 80s and so could underestimate age. His method aimed to estimate the rate of molar wear in relation to real time. For example, if the first permanent molar (M1) erupts at 6 years then by age 12 the M1 shows 6 years of wear. Therefore if an M1 shows 12 years of wear the individual is around 18 years old. This method assumes that the rate of wear continues throughout adult life at the same rate and that the diet remains the same. Miles acknowledged that loss of teeth during this time would speed up the rate of wear on the remaining teeth and made adjustments to the method. He felt his system could be reasonably accurate up to 35 years with accuracy decreasing
from there on. Others have used the Miles system, for example, Lovejoy et al., who compared different methods and found tooth wear to be the most accurate with the least bias in under ageing. (Miles, A.E.W., p.974-975)

Benazzi et al. (p. 2372-2376) studied tooth samples from the Sassari collection, from Italy, consisting of individuals who lived in the late 1800s and early 1900s. In contrast to Constandse-Westermann, and Mays, they found a higher correlation between crown height and age in the maxillary molars than the mandibular ones. They felt certain factors must be taken into consideration when using dental wear methods, for example, sexual dimorphism of some teeth, variability in general, individual constitutional differences, hardness of enamel and its predisposition to wear and variations of diet.

“Such factors constitute serious limitations when a method based on residual height of the dental crown is used to determine age at death.” Their results showed that molar crown height was unreliable in determining age-at-death and felt the wear patterns on the occlusal surface could provide more satisfying results.

Mays refers to standards derived from modern collections and states that they may not be applicable to archaeological material. He feels the dental wear method mostly overcomes this as coarse food is known to be responsible for tooth wear in archaeological remains so predictions can be made regarding what factors are likely to cause differences in wear rates between populations (Mays, S., 1998, p.57). In saying this Mays is aware of a limit on the method, as its success depends on the degree to which diets are uniform between individuals in a population (Mays, S., 2002, p.861).

Regardless of the differences of opinion as to which surface to measure, tooth attrition is seen to be a reliable ageing technique for archaeological material (Mays, 2002, p.869; Lucy, D., Pollard, A.M. and Roberts, C.A. p.425; Miles, A.E.W., p.980).

**Sternal rib ends**

In 1984 Iscan et al. published a study on the age estimation of white males by examination of the sternal end of the ribs. They noted that previous histological and radiographic studies had confirmed lifelong age related changes occurring in the rib. Their results supported the validity of these changes. They also stated the
need to consider certain facts when ageing a skeleton. They felt that the more experienced observer would give a better estimation of age than a novice and highlighted conditions known to affect bone and therefore change the expected pattern of ageing in the ribs. Such conditions include lung disease, gender, race, diet, degree of physical activity and any intercostal variations. (Iscan, M.Y., Loth S. R. & Wright, R.K. 1984, pp. 1101-1103)

The study developed a ‘phase analysis’ method to determine age at death with phases numbered from 0 to 8. Phase 0 is assigned when the “articular surface is flat or billowy with a regular rim and rounded edges” and “the bone itself is smooth, firm and very solid”. While phase 8 describes the pit as:

“Very deep and widely U shaped. In some cases the floor of the pit is absent or filled with bony projections. The walls are extremely thin, fragile and brittle with sharp, highly irregular edges and bony projections.”


Iscan and Loth followed this study with an examination of white female ribs. Previous researchers had noted sexual dimorphism in both the manifestations and rate of change in the rib. For example, male morphologic changes were not obvious until the age of 17 while females had pronounced changed by 16. (Iscan, M.Y., Loth S. R. & Wright, R.K. 1985, pp.853 -854). Pubic symphysis had been considered reliable for age determination yet there were concerns regarding accuracy due to bone changes resulting from pregnancy and parturition. An advantage of using the rib method on females is that the rib is not directly subjected to the traumas of childbirth and so becomes a more reliable age indicator. As a result of this study separate standards for female age assessment were developed. (Iscan, M.Y., Loth S. R. & Wright, R.K. 1985, pp.855-860)

In 1986 Iscan et al. focused on the various factors that need consideration when estimating a skeleton’s age. Results yielded no obvious connection between correct age assessment and occupation, cause of death or ante-mortem disease. They also found, unexpectedly, that accuracy of age determination was not seriously affected by the experience & academic background of those doing the assessment, in contrast to their previous statement (Iscan, M.Y & Loth S. R. 1986a, p.131).

The rib end method is seen to be a valuable tool when determining age-at-death. The problem archaeologically is the survival of the ribs but some feel the
advantage is that they are not subject to stresses placed on the pelvis and so an individual’s lifestyle is less of a factor in age related changes (Aykroyd, R.G. et al. p.59). In saying this it should be stated that Rosing et al. (p.85) disagree. They feel that use of rib ends for ageing should be treated with caution as the metamorphosis that occurs will greatly depend on an individual’s activity patterns. Whereas Yavuz et al. (p.50) considered this method to be the only one reliable for age determination of an adult skeleton, specifically after the age of 40. Miles (p.977) puts an age limit on the method at 65 years.

**Cranial suture closure**

Cranial suture closure as a technique for age-at-death assessment has been in use for a number of centuries yet its accuracy is still debated. Its use is based on the belief that closure is part of an age related physiological process. Studies have been based on macroscopic observation but they differ in choice of sutures observed and in the definition of stages. Cranial sutures are still used because the cranium is often well preserved and observation doesn’t require specific equipment. (Dorandeu, A. et al., p.47)

Mann et al. chose to examine the maxillary suture. They developed a method of estimating age based on the obliteration of the four maxillary sutures. Samples of 186 individuals of known age, race and sex were examined. During the early adult years suture obliteration was seen to progress at similar rates in both sexes but this changed with age. Results showed that males exhibited greater suture obliteration than females of the same age. Table 1 indicates the earliest complete closure of the sutures by sex.

<table>
<thead>
<tr>
<th>Suture</th>
<th>Male Age (N=110)</th>
<th>Female Age (N=76)</th>
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<tbody>
<tr>
<td>IN</td>
<td>20</td>
<td>20</td>
</tr>
<tr>
<td>PMP</td>
<td>26</td>
<td>27</td>
</tr>
<tr>
<td>TP</td>
<td>33</td>
<td>84</td>
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<tr>
<td>AMP</td>
<td>40</td>
<td>67</td>
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*Table 1: Earliest complete obliteration of the four sutures by sex.* *(Mann. R. et al., p.784)*

Mann et al. felt their method couldn’t be used for exact estimates, as the age of older individuals may be overestimated, but that it was valuable in estimating age
ranges, sorting commingled remains and estimating skeletal age when only the maxilla is available. (Mann. R. et al., p.781)

Key, Aiello and Molleson (p.193) chose to apply three different methods to the Spitalfields data. The methods were those of:

- Acsasdi & Nemeskeri: This looks at endocranial union. Age determination is stated as possible between wide age limits and as being and important method when combined with others
- Meindl & Lovejoy: This method uses ectocranial sutures. Results suggested the technique was accurate particularly in older ranges
- Perizonius: He proposed a system choosing endocranial and ectocranial sites according to the approximate age group

They demonstrated that suture closure can be used to predict age at death but that not all sutures are equally suitable for the task:

- Only broad age ranges can be inferred
- Endocranial sutures can be used for individuals up to about 50 years
- Ectocranial sutures can show different rates of closure in men and women
- An open ectocranial suture occurs at all ages with equal frequency and can’t be taken as an indicator of a young age

Criticism of cranial suture closure comes from a number of directions. Yavuz et al. (p.50) and Iscan et al. (1984, p.1095) feel the extreme variability seen in individuals and the lack of suture closure association with age has condemned it. Mays (1998, p.50) also feels the age association is weak in this method. While others believe the method can be put to use for individuals up to about 60 years of age (Miles, p.977).

**Conclusion**

It is clear that there are differences in opinion about which methods are most appropriate in obtaining an age-at-death assessment of skeletal remains, although it is generally agreed that the use of a combination of methods will give the best results. All methods have their advantages and disadvantages so most researchers tend to use several and “average them out based on experience” (Aykroyd, R.G. et al., p.60). With this in mind there are still considerations to make including, the issue of the degree of similarity between modern and ancient
individuals; problems of systematic under or over aging; the expertise and experience of the researchers and the age ranges for which a method is best suited. Maples is often quoted as saying that “age assessment will always be ultimately an art, not a precise science”. This is true because of the subjective nature of some of the ageing process and because of the “inherent individual variation in the rate at which biological processes proceed” (Miles, p.980).
References


