A SKELETON IN THE CUPBOARD

An Osteological Study

JESUS COLLEGE

CAMBRIDGE

a skeletal analysis

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Acknowledgements

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Introduction

Phoenix Exhumation Ltd were commissioned by Dr Frances Wilmoth, Librarian, Jesus College, Cambridge to examine a skeleton. The skeleton, nicknamed 'Esmerelda,' was believed to be that of a female but and to be made from the skeletons of three individuals.

The skeleton was examined during February 2011, particular aims being to establish gender and number of individuals the skeleton was composed of.

The full skeletal record is held by Phoenix Exhumation Ltd.

Material

The skeleton was used as an anatomy teaching skeleton during the mid 1900s. The skeleton reflects the need within medical institutions during the 18^{th} century onwards to be provided with cadavers on which students could learn anatomy and practice dissection. In 1752 the Company of Surgeons was granted the corpses of all executed felons (Boyle *et al*, 2005) and in 1832 the Anatomy Act was passed in which the medical profession could take for dissection all unclaimed bodies of those dying without family, in the workhouse or hospitals. In addition, skeletons were brought to Europe from other parts of the world.

The skeleton was presented for examination in a wooden display case, strung with the original nineteenth century wiring and pins and with a circular hanging loop inserted into the skull. The spine was layered with paper or parchment to replace the intervertebral discs.

On removal from the case, it was decided to divide the skeleton into three main parts and to detach the wiring of the right mandibular joint to enable a more comprehensive examination.

Bone and tooth condition and preservation are excellent, the cortices are intact, a portion of the left humeral head was detached and the second medial and distal (mp2 and mp3) phalanges of the right hand are missing. Several repairs had been made: the medial and distal third and fifth phalanges (mf3, df3, mf5 and df5) of the left foot had been glued together, as had the head of the left radius. The bones had been cleaned from accumulated dust by the conservator and needed no further work.

Due to the necessity to remove minimal wiring, some surfaces of the skeleton were rendered inaccessible; it was not possible therefore to inspect completely the joint surfaces of the spine, pelvis, hands and feet.

Methods

Methods used are primarily those of, or referred to in, Bass, Brothwell, Cho *et al*, Iscan Stewart, Ubelaker (Bass 1987, Brothwell 1971; Cho *et al.* 1996; Iscan & Kennedy 1994; Stewart 1979; Ubelaker 1989). For simplicity and clarity a pro-forma record sheet of Gone to Earth, supplemented with Phoenix Exhumation Ltd recording sheets, was used. Photographs of the skeleton were taken using a digital Nikon P80.

Bone inventory

The initial process of investigation was to establish the number of complete and partial bones present. The ear ossicles, hyoid and thyroid were missing. The spinal column had four instead of five lumbar vertebrae (see Epigenetic traits, below). The manubrium of the sternum appeared to have a damaged jugular notch. The left radius was broken at the proximal articular surface. The right hand was missing the second medial phalange (mp2), and the second distal phalange (dp2).

The right patella does not match the left because of size, colour, texture and rugosity and is that of a different skeleton.

The maxillary teeth were all present except for the left first incisor and canine, the right first and second incisors and the second premolar (i.e. left 1, 3; right 1, 2, and 4), All are complete apart from the left second incisor, which had the crown missing, and chipping on the right second premolar (i.e. left 2; right 5). The mandibular teeth are all present and complete apart from chipping of the right first and second incisors (i.e. right 1 and 2).

Determination of ethnicity

Morphological methods to estimate ethnicity use the standard “three groups” system. Some features pertain only to Caucasoid type skulls, some to Negroid or Mongoloid, other features are present in more than one group.

It can be seen from Table 1 that features of Caucasoid and Negroid type are equal in number or could equally apply to either group. It is therefore suggested that it could be of mixed Caucasoid-Negroid origin.

Table 1: ethnicity determination by morphology

	Caucasoid	Negroid	Mongoloid
Vault	ovoid	flat bregmatic depression	
Orbits	Sloping		
nasal root		quonsett hut	
Nasals		Wide	
nasal aperture	narrow	inf border guttered (slight)	
Malars	retreating ↔ ttriangular ↔	retreating triangular	
zyg suture	curved ↔	curved	
zyg arch	narrower than vault ↔	narrow than vault	
Maxilla	canine fossa		
Alveolus		prognathism	
Mandible	rami pinched undulating	rami straight straight	
Bite	edge to edge (South Asian) ↔	edge to edge ↔	edge to edge
Molars	Carabelli’s cusps		
Femora	Curved		
total indicators	**13**	**13**	**1**

Determination of sex

Recording methods were based on the 'five sexes' classification (F, ?F, ?, ?M, M), and were morphology of certain areas of skull and pelvis measurement and were both used to assess sex. Limitations to sexing can arise whereby measurements and shape may overlap in the ranges found between the two sexes, but the completeness of this skeleton has allowed assessment of 15 out of 17 sex-determination features; It was not possible to assess the conformation of the pre-auricular and auricular surfaces as they were wired together and inaccessible. The principle areas of the pelvis can give 90-95% accuracy and this can be increased when the skull is also present.

For this skeleton, twelve features indicated male (♂) and one feature possible female. Overall, therefore, the skeleton is shown to be that of a male.

Table 2: sex determination using bone morphology

skull	♂+	♂	♂	♂	♂	♂	♂
	brow	orbit	mastoid process	nuchal crest	zygomatic arch	mental foramen	gonial angle

pelvis	♂	/	/	♂	♂	♀?	♂	♂
	sciatic notch	pre-auricular surface	auricular surface	sub-pubic angle	sub-pubic concavity	ischio-pubic ramus	ventral arch	Sacrum

Table 3: sex determination using bone measurements

bone	humeral head	femoral head
dia (cm)	46.5	47.5
sex	indeterminate	male

Determination of age

The main methods used to determine the age of the skeleton were from comparisons with standards of the pubic symphysis, sternal rib ends and cranial sutures (Brooks & Suchey 1990, Iscan *et al* 1984, 1985 and Meindl *et al*. 1985). The non-weight bearing rib ends give the most reliable estimate so the individual was in his late 20s to early 40s, and this is not significantly contradicted by the other methods. Dental attrition was assessed as an experiment, but iis known to severely underage post-medieval dentitions as shown here.

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Table 4: ageing methods (Caucasoid)

ageing method	*stage*	*age range*	*mean age*
sternal rib end 1	stage 4	22-35	28.2
sternal rib end 2	stage 5	29-52	38.8
pubic symphysis		23-57	35.2
auricular area	N/A		
cranial sutures		28-52	41.1
dental attrition		17-25	

Table 5: ageing methods (Negroid, wear systems distinct from Caucasoid)

ageing method	*stage*	*age range*	*mean age*
sternal rib end 1	stage 4	23-32	28.5
sternal rib end 2	stage 5	26-51	38.9
auricular area	N/A		

Stature

Stature has been calculated from the regression formulae of Trotter & Gleser (Trotter & Gleser 1952), using the right femur. The stature range for the skeleton is, if Caucasoid 176.1 cm +/- 3.27 cm (5' 9" +/- 1 3/4"), and, if Negroid 172.1 cm +/- 3.94 cm (5' 7" +/- 1 3/4").

Pathological conditions

Identification of pathology is based mainly on the works of Iscan & Kennedy, Ortner & Putschar and Steinbock (Iscan & Kennedy 1994; Ortner & Putschar 1985; Steinbock 1976). Congenital/developmental and epigenetic (non-metric) variants of the axial skeleton are from Barnes and Hauser & De Stefano (Barnes 1994; Hauser & De Stefano 1989) and teeth from Hillson (Hillson 1990).

Dental disease

On examination of the dentition it was apparent that no ante-mortem tooth loss had occurred. The maxillary right first and second incisors, right canine and left first incisor were lost post-mortem: the left maxillary second incisor only has the root present. There had been no dental caries and no abscessing.

Descriptions of the aetiologies of the dental diseases follows mainly Hillson (Hillson 1979), although for reasons of time and cost only macroscopic methods have been used, contrary to his practice.

Calculus

Dental plaque often mineralises to calculus (or tartar) which modern experience shows can be resistant to regular tooth-cleaning. Calculus was present in this dentition, on the maxillary left first and second premolars and first to third molars, right canine, second premolar and first to third molars, and on the mandibular left first premolar, the first and third molar, and the right second and third molars (i.e. max: L4-8, R3, 5-8, mand: L4, 6-7, R7-8).

Fig. 1a shows the calculus on the outsides of the teeth (labial/buccal surfaces); Fig. 1b shows the greater amount of calculus on the interior (lingual surfaces) overhanging the gum in life. This is usual, as the salivary glands open onto the interior and tend toincrease plaque deposits there.

Fig. 1a calculus on the maxillary teeth, 1b calculus on the mandibular teeth

Periodontal disease

In life, periodontal disease manifests as inflammation in the soft and hard tissues of the jaws, with pitting, recession or new-bone formation on the bones (Roberts, 1995, 56). The causes include factors such as unclean mouths, irritation by calculus deposits, attrition and lowered tissue resistance through diets rich in refined carbohydrate.

In this skeleton the alveolar bone (which forms the tooth sockets) has receded from the roots of the maxillary left second premolar and first to third molars, and maxillary right canine, second premolar and first to third molars (i.e. max: L5-8, R3, 5-8)

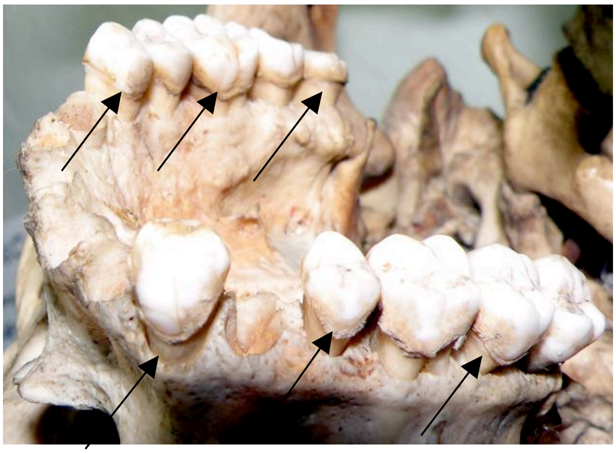


Fig. 2 alveolar recession on the maxillary teeth (basal view)

Alveolar recession is also present on the mandibular teeth as can be seen from Figure 3.

Fig. 3a alveolar recession on the mandibular teeth, 3b alveolar recession (enlarged)

Arthropathies

Vertebral arthritis

The spine of the skeleton shows osteophytes (nodules of new bone) on the edges of the bodies of thoracic vertebrae 4 to 10. These changes indicate osteoarthritis (often, and more appropriately, called degenerative arthritis) of the spine, a condition almost universally prevalent in those over 35 years of age.

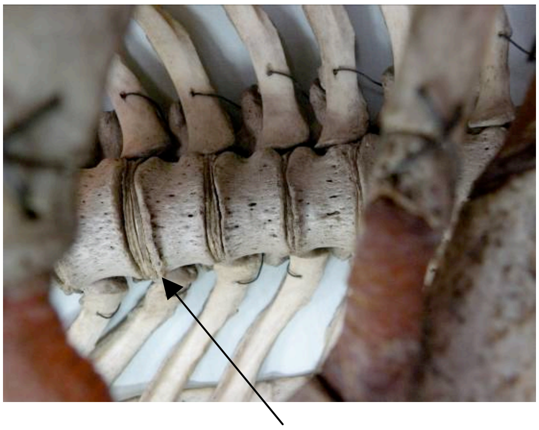


Fig. 4 osteophytic lipping on the thoracic vertebrae

Neoplasia

Ivory osteoma

The skull has a small ivory osteoma on the occipital bone of the skull c 2.5cm down the left hand fork of the lambdoid suture. This is a dense but benign bony outgrowth, which is relatively common in middle-aged and older adults and predilects the skull.

Fig. 5a ivory osteoma present on the occipital bone of the skull ivory osteoma (enlarged)

Epigenetic/non-metric traits

Epigenetic/non-metric traits, small developmental variants in the skeleton of no clinical significance, can be indicators of relatedness of individuals, although the relative contribution of multiple-genetic and environmental components is unclear for many traits.

Bilateral maxillary tori

A torus consists of a ridge ofcompact bony tissue, generally of non-clinical significance, which appears to have some heritable tendency (Hauser, 1950 p 176, 180, plate XXVII f & g). The skeleton has maxillary tori situated medial to the seventh and eighth molars and slightly protruding into the lingual margin of the second premolars. It is unusual to find a maxillary torus extending as far as the premolars (Woo, 1950 in Hauser & DeStefano 1989, p 180).

Fig. 6a bilateral maxillary tori, left side 6b bilateral maxillary tori, right side

Carabelli's and posterior cusps

Carabelli's cusps are present on the maxillary first molars: these are extra lingual cusps. Frequency varies widely between 35% and 85% the higher frequencies being amongst Africans and the highest Europeans (Hillson, 1990 p 264).

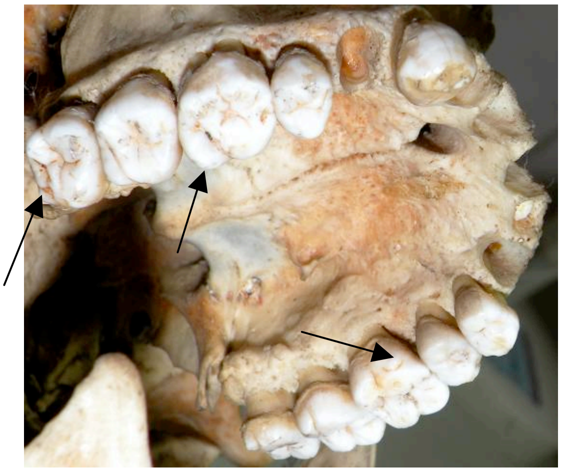


Fig. 7 carabelli's cusps on the maxillary first molars and posterior cusps on the third molars

Supraorbital notch

The orbits of the skull show bilateral large acute medial supraorbital notches with a large nutrient foramen present on the right (Hauser & DeStefano, 1989 p 53, P1. VIII, Fig. 10).

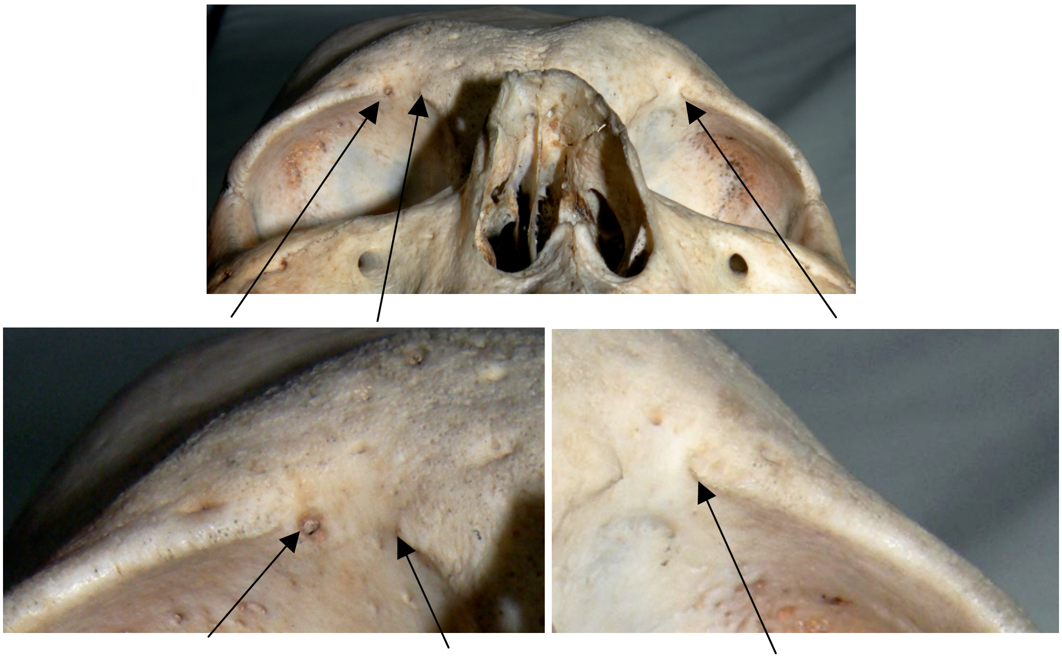


Fig. 8a orbits of the skull showing bilateral supraorbital notches and nutrient foramen 8b supraorbital notch, left orbit 8c supraorbital notch and nutrient foramen, right orbit

Wormian bones (extra sutural bones)

Wormian bones are extra bones found along the suture lines of the skull. There are a number of views as to the reason for the development of these bones but a genetic tendency requiring environmental factors for the manifestation of the trait seems likely; they are moderately heritable (Hauser & Destafano, 1989, p 88-93). On the skull of this a skeleton, there is one principal and several minor ossicles on the right hand fork of the lambdoid suture.

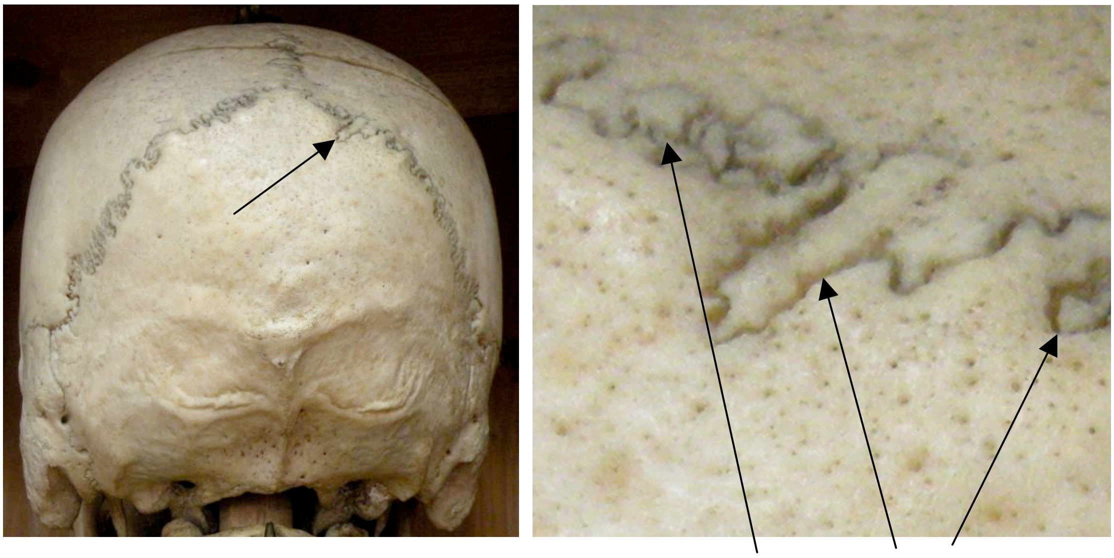


Fig. 9a Wormian bones present on the lambdoid suture, 9b wormian bones (enlarged)

Wrinkled enamel

Wrinkled enamel is present on the mandibular lower first molars.

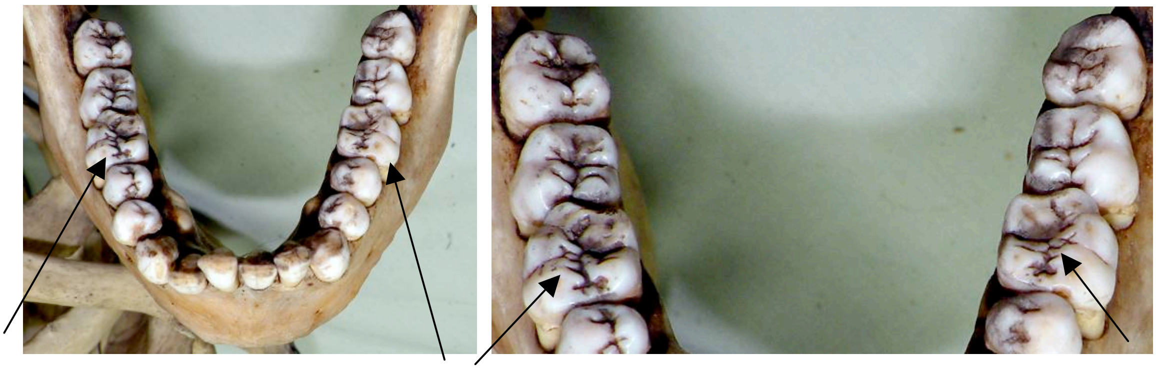


Fig. 10a wrinkled enamel present on the mandibular first molars, 10b wrinkled enamel (enlarged)

Vertebral errors of segmentation

Lumbarisation of the first sacral (S1)

The first sacral vertebra shows a trace of lumbarisation. This is where a vertebra takes on some of the appearances and physical characteristics of another type of vertebra. Barnes states that

> … the change is produced by caudal shifting at the lumbosacral border whereby the first sacral segment attempts to move up into the presacral vertebral column. The segment then becomes partially or completely independent from the sacral body and takes on the characteristics of the lumber spine. (Barnes 1994 p 110, Figs. 3.36 f-g and 3.38)

In the case of this skeleton the first sacral is not fully fused to the sacrum and has the appearance of a lumbar vertebra.

Fig. 11a lumbarised first sacral, location diagram 11b sacrum showing the lumbarised first sacral

Lumbarised twelfth thoracic vertebra

The spine is one vertebra short in total. The first sacral vertebra is lumbarised. The twelfth thoracic vertebra also appears to be lumbarised, with rib facets for the vestigial ribs, but otherwise in lumbar form. At the thora-columbar border, according to Barnes

> … the superior facets of the twelfth thoracic vertebra are flat thoracic type and the inferior facets are cupped lumbar type. Cranial shifting moves the transitional set of facets up to the next vertebra it can also reduce the size of the last thoracic rib, sometimes an extra transitional vertebral segment at the thoracolumbar border takes on the appearance of the last thoracic vertebra with transitional facets and a small pair of thoracic-shaped ribs (Barnes, 1994, p 104 - 105) Fig. 3.34a & c)

The small thoracic-shaped ribs can be seen in Fig. 13.

Fig. 12a lumbarised twelfth thoracic vertebra, location diagram, 12b spinal column showing the lumbarised twelfth thoracic vertebra, 12c lumbarised twelfth thoracic vertebra (enlarged)

Stress indicators

Cribra orbitalia

Episodes of physiological stress, such as dietary deficiencies or disease can leave permanment changes on bones or teeth, thereby allowing for an identification of the cause and, sometimes, when it occurred. *Cribra orbitalia*, a spongy or sieve-like formation of bone in the eye orbits caused by iron-deficiency anaemia (Stuart-Macadam 1982; 1994). The central marrow-filled layer of the skull bones produces red blood cells and if they are in short supply or defective, this layer will thicken to increase production, eventually breaking through the outer layers, hence the spongy appearance. The skeleton has advanced stage 3 *cribra orbitalia* present in the left orbit and stage 3 present on the right orbit. This is represented by large and small scattered foramina.

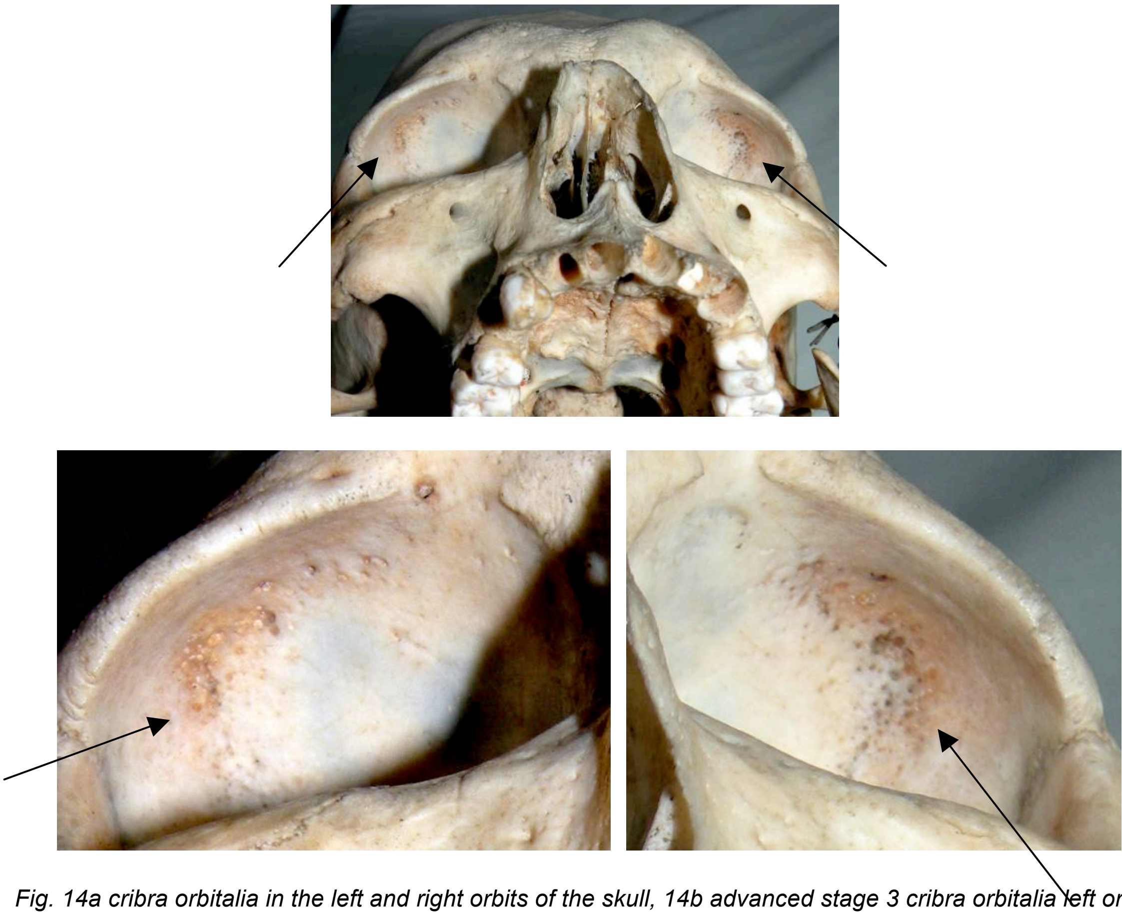


Fig. 14a cribra orbitalia in the left and right orbits of the skull, 14b advanced stage 3 cribra orbitalia left orbit, 14c stage 3 cribra orbitalia right orbit

Enamel hypoplasia

The skeleton has dental enamel hypoplasias, in which physiological stresses, such as severe malnutrition or feverish illness, have inhibited both development and produced stripes of inadequately mineralised enamel (Brothwell, 1972, Dobney & Goodman 1991; Goodman & Armelagos 1985; Goodman *et al.* 1980; Hillson 1990; Karhu 1990; Sweeney *et al.* 1971; Van Gerven *et al.* 1990). The teeth affected are the maxillary right canine, the mandibular left incisors and the first premolar, right incisors, canine, premolars and first molars. The skeleton has at least four bands of defective enamel on the upper right canine, indicating at least four episodes of stress.

Measurements from the cemento-enamel junction to the hypoplastic line, compared with the ageing charts of Rose *et al* (1985) indicate that the individual suffered episodes of stress between the ages of 1.48 and 4.75 years. Two to three bands of defective enamel are also present on the mandibular left incisors and canine, and right incisors, canine and premolars.

Fig. 13a enamel hypoplasias on the maxillary right canine, 13b enamel hypoplasias (enlarged)

<u>*Infection and trauma*</u>

Infection/inflammation of, and trauma to, of bone are usually easy to observe on skeletonised material. Most infection, however only affects soft tissue and therefore some of the most common causes of death are unidentifiable in the skeleton. In this skeleton, there are examples of extra-cortical new bone (disorganised bone produced on the surface in response to inflammation or other increased vascularity) on tibiae and fibulae. Disorders known to cause such new bone production include localised traumas, and infection although the changes in this case appear to be too widespread, and systemic infection such as syphilis – the latter, however, tending to have associated changes in the skull which are absent here. A series of x-rays were taken of the left leg to investigate further possible causes of these changes, but no diagnosis could be made (Fig. 25).

left tibia

- anterior surface, *c.*10cm from the proximal end the cnemial crest is raised for *c*.10cm by 0.05-0.4cm from the distal to proximal ends (Fig. 17)

- medial side, *c*.11cm from the proximal end, striated partly remodelled new bone blends downwards to plaques of fine grained extra cortical new bone (ECNB), until *c*.8.5cm from distal end where remodelled new bone with porosities extends to the medial malleolus. The medial malleolus is covered in coarse grained slightly remodelled new bone (Fig. 18)

- posterior surface, *c*.5.5cm from the proximal end, interleaved patches of coarse and fine new bone extends distally to meet the fibula in a florid like form (Fig. 20)

left fibula

- lateral side shaft length especially on the interosseus crest are patches of partly remodelled spiculated bone, which increase until reaching the distal tibio-fibula joint (Fig. 21).

right tibia (anterior surface)

- medial side *c*.17cm from proximal end *c*.4cm of heavily remodelled extra cortical new bone (ECNB), striated and slightly raised.

- lateral side c6cm from distal end *c*.3cm of possible ECNB. c17cm heavily remodelled new bone and major vascular channels (Fig. 23)

- posterior surface *c*.11.5cm from distal end *c*.5cm patch of ECNB across surface as striated new bone. *C*.5cm from distal end patches of striated ECNB up to distal end. Note ECNB actually lies on the surface.

right fibula (anterior surface)

- c5cm from proximal end *c*.13cm of remodelled new bone. Some raised c4cm by *c*.2cm. *C*.13cm from distal end *c*.5.5cm of remodelled new bone (Fig. 24)

Left tibia and fibula

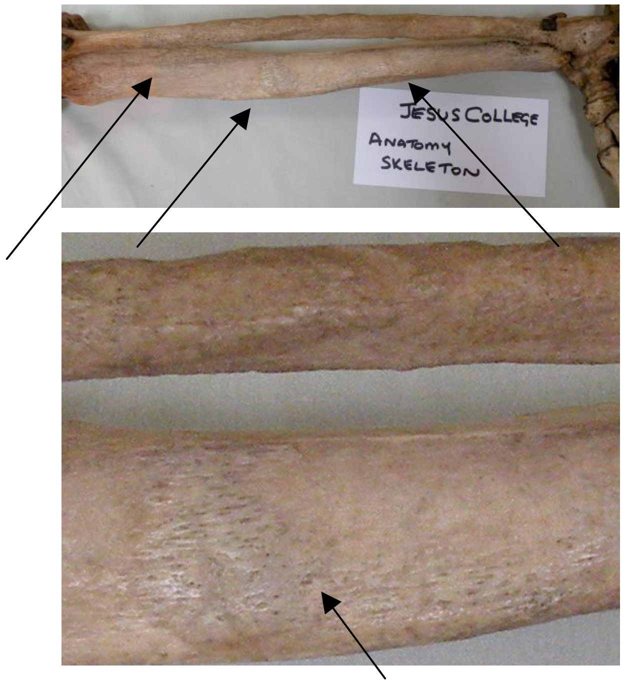


Fig. 15a left tibia (lateral surface) and fibula showing locations of extra-cortical new bone, 15b patch of extra-cortical new bone (enlarged)

Fig. 16a left tibia and fibula anterior surface showing location of partly-remodelled new bone 16b partly remodelled new bone (enlarged)

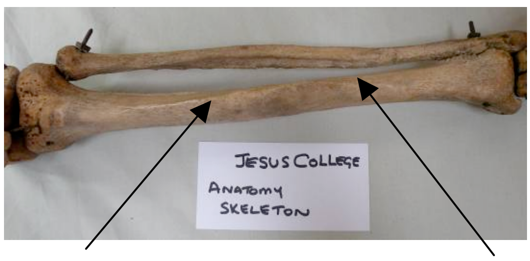


Fig. 17 left tibia anterior surface raised cnemial crest

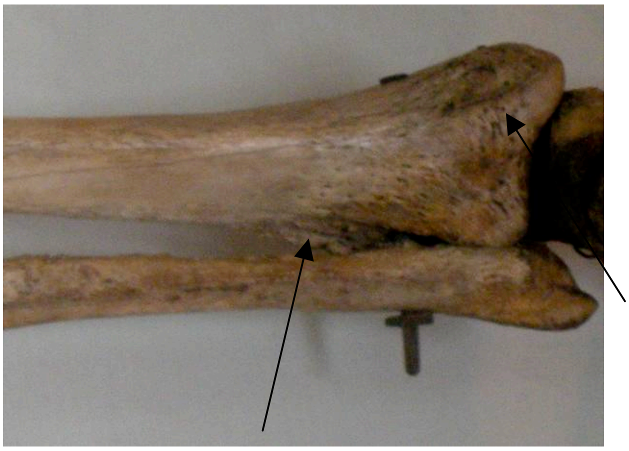
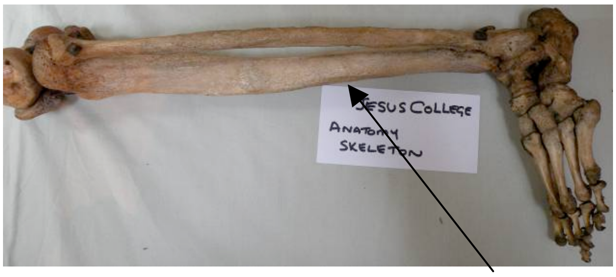


Fig. 18a left tibia medial side remodelled new bone, 18b remodelled new bone (enlarged)



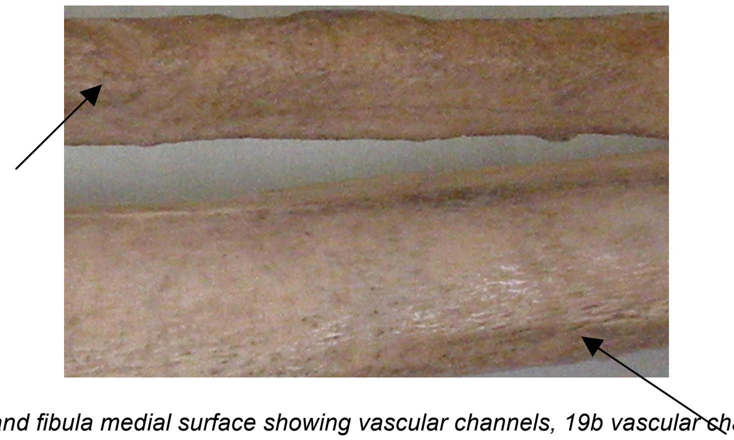


Fig. 19a left tibia and fibula medial surface showing vascular channels, 19b vascular channels (enlarged)

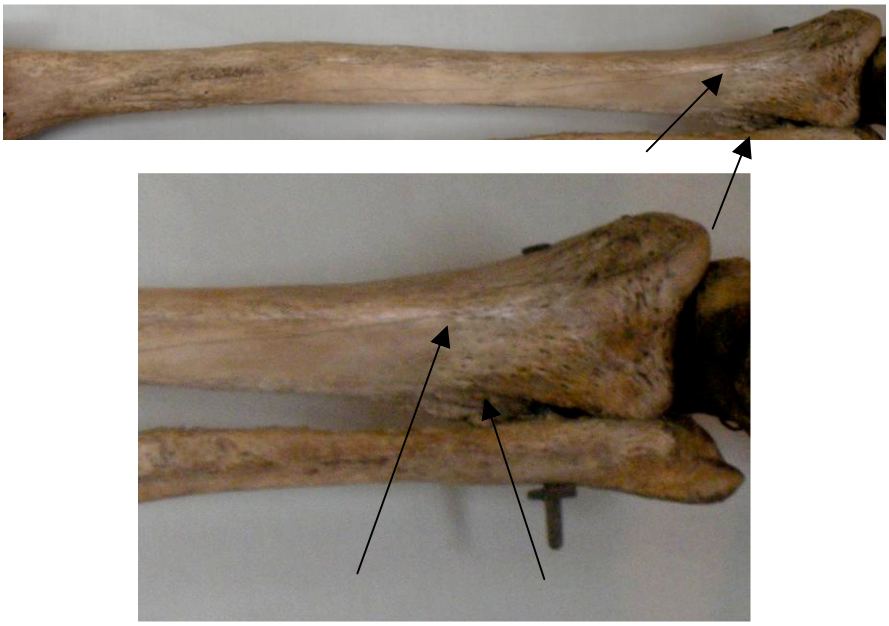


Fig. 20a left tibia posterior surface showing coarse and fine new bone, 20b new bone (enlarged)

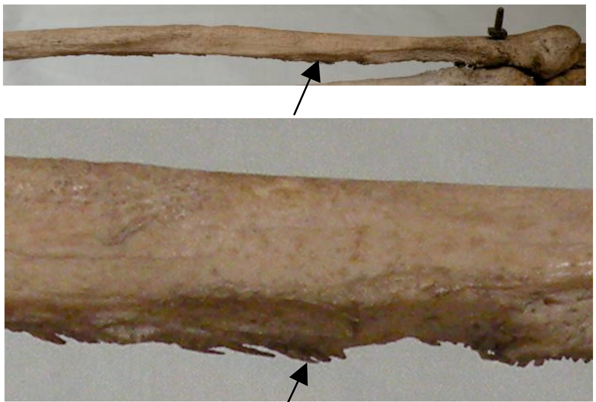


Fig. 21a left fibula lateral side, showing partly remodelled spiculated new bone, 21b partly remodelled spiculated new bone (enlarged)

Fig. 22a left fibula anterior surface showing vascular channels, 22b vascular channels (enlarged)

Right tibia and fibula

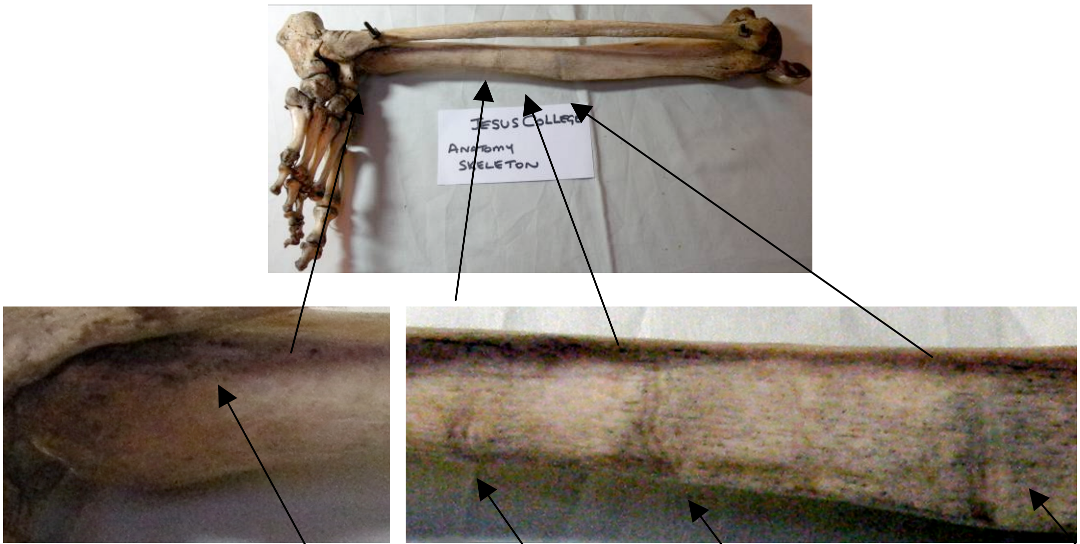


Fig. 23a right tibia lateral side distal end heavily remodelled new bone and mid shaft vascular channels, 23b heavily remodelled new bone (enlarged), 23c vascular channels (enlarged)

Fig. 24a right fibula anterior surface c13cm of remodelled new bone, 24b remodelled new bone (enlarged)

Fig. 25a x-rayed left and right tibia and fibula, showing remodelled new bone, 25b proximal end of shaft (enlarged), 25c distal end of shaft (enlarged)

Habitual activity ('occupational change')

Para-functional wear

Parafunctional wear describes wear on teeth due to activities not connected with mastication. It can be produced by habitual activities such as holding or pulling objects between the teeth (e.g. hairdressers holding hairgrips, spinning by pulling linen thread through the mouth). On the skeleton, curved wear is visible on the lower left canine and second incisor. Were these teeth to be replaced at their correct heights in the jaw (they have been glued in irregularly), a semi-circular shape could be seen which resembles that of 'pipe-wear', produced by the habit of clamping a clay pipe between the teeth and relatively common in the eighteenth and nineteeth centuries.

Fig. 26a parafunctional wear resembling 'pipe-wear' on the mandibular teeth, 26b occlusal surface showing parafunctional wear

Other conditions

Certain changes fall outside the general range of classifications, while others are impossible to diagnose:

The skeleton has the medial and distal phalanges of the third and fifth toes (mf3/df3, and mf5/df5) of the left foot fused together. This is a very common occurrence and is not regarded as pathological.

Fig. 27a fused third and fifth medial and distal phalanges, 27b fused phalanges (enlarged)

The manubrium of the sternum is (Barnes, p 215; delayed cranial cohesion of sternal bands). This developmental condition is not of clinical significance, unlike its more severe manifestation in which the whole sternum is bifid. It also has a notch on the superior aspect probably due to the previously-named condition but emphasised by some man-made damage.

Fig. 28 wide and notched manubrium of the sternum

There is an unidentifiable bone formation present on the left femur: a curved ridge of bone on the femoral neck (*c.* 5.0 x 0.5 cm) and a "netted" patch of bone distal to it (1.0 x 2.0 cm).

Fig. 29a left femur showing unidentifiable bone formation, 29b unidentifiable bone formation (enlarged)

Post-mortem changes to the skeleton

The skeleton has two post-mortem cuts through the skull, traversing the posterior parietals, and meeting to form a wedge-shaped removable section. The purpose might have been for autopsy or to insert the hook on which to hang the skeleton in for display and teaching.

Fig. 30a post-mortem cuts across the parietal bones of the skull, posterior view, 30b post-mortem cut, superior view, 30c post-mortem cut, right lateral view

The rib cage has also been cut post-mortem. The cuts are typical of autopsy practice to remove the thoracic organs from the rib cage. Given the way in which the skull was prepared, however, it is equally possible that these cuts relate to the preparation of the skeleton.

Fig. 31a post-mortem cuts into the rib cage, 31b post-mortem cuts (enlarged)

Conclusion

The Jesus College skeleton was initially suspected of being a female, made up from three different skeletons. The examination has shown that mainly one individual is represented, but with the right patella from another individual. The skeleton is male, with both Caucasoid and Negroid features, suggesting a mixed race ancestry, of medium height and aged at death in the late 20's to late 30's.

General health was relatively good, there was an ivory osteoma (a common benign bone tumour), a trace of vertebral arthritis, evidence of childhood anaemia and some slight dental disease resulting from poor dental hygiene. Infection was evident on both the lower left and right limbs in the form of new bone, the cause of which has not been possible to diagnose. There were several epigenetic/developmental traits of no clinical significance. Parafunctional wear on the mandibular teeth was probably caused by habitual smoking of a clay pipe.

Several post-mortem cuts into the skull and rib cage were present, indicative of the preparation of the skeleton for anatomical purposes.

References

Barnes, E., *Developmental defects of the axial skeleton in paleopathology*, University Press, Colorado, 1994

Bass, W. M., 1987. *Human Osteology: A laboratory and field manual, 3rd edition, Columbia*

Bergman, P., 1993. 'The occurrence of selected non-metrical traits of the skull in relation to cribra orbitalia and grave equipment'. *Variability and Evolution, Vol 2/3 p 63-75*

Boyle, A. *et al*. *The archaeological experience at St Luke's Church, Old Street, Islington,* Oxford Archaeology 2005

Brooks, S. & Suchey, J. M., 1990. Skeletal age determination based on the os pubis: a comparison of the Acsadi-Nemeskeri and Suchey-Brooks methods. *Human Evolution, Vol 5 p 227-238*

Brothwell, D. R. 1981. *Digging up bones*. 3rd edition. Oxford: Oxford University Press and British Museum (Natural History)

Cho, H., A. B. Falsetti, J. McIlwaine, C. Roberts, P. S. Sledzik & A. W. Willcox. Editors. 1996. *Handbook of the Forensic Anthropology Course of the Department of Archaeological Sciences, University of Bradford and the NMHM/AFIP, Washington, D.C*

Dobney, K. & A. H. Goodman. 1991. 'Epidemiological studies of dental enamel hypoplasias in Mexico and Bradford: their relevance to archaeological skeletal studies,' in *Health in past societies*, (BAR International Series No. 567). Edited by H. Bush & M. Zvelebil. Oxford: Tempus Reparatum

Goodman, A. H. & G. J. Armelagos. 1985. 'The chronological distribution of enamel hypoplasia in human permaenet incisor and canine teeth' *Archs Oral Biology Vol 30 no 6 p 503-506*

Goodman, A. H. & G. J. Armelagos. 1985. Factors affecting the distribution of enamel hypoplasias within the human permanent dentition. *American Journal of Physical Anthropology* 68: 479–93

Goodman, A. H., G. J. Armelagos & J. C. Rose. 1980. Enamel hypoplasias as indicators of stress in three prehistoric populations from Illinois. *Human Biology* 52: 515–28.

Hauser, G. & G. F. De Stefano. 1989. *Epigenetic variants of the human skull*. Stuttgart: Schweizerbart

Hillson, S. 1990. *Teeth*. (Cambridge Manuals in Archaeology). Cambridge: Cambridge University Press

Iscan, M. Y. & K. A. R. Kennedy. Editors. 1994. *Reconstruction of life from the skeleton*. 2nd edition. New York: Wiley-Liss

Iscan, M. Y., S. R. Loth & R. K. Wright. 1984. Metamorphosis at the sternal rib end: a new method to estimate age at death in white males. *American Journal of Physical Anthropology* 65 (2): 147–56

Iscan, M. Y., S. R. Loth & R. K. Wright. 1984. Age Estimation from the Rib by Phase Analysis White Males. *Journal of Forensic Sciences Vol 29, p 1094-1104*

Iscan, M. Y., S. R. Loth & R. K. Wright. 1985. Age Estimation from the Rib by Phase Analysis White Females. *Journal of Forensic Sciences Vol 30, p 853-863*

Karhu, S. L. 1990. *Inter-tooth distribution of dental enamel hypoplasias among Medieval Christian Nubians from Kulubnarti*. American Journal of Physical Anthropology 81: 247

Kennedy, K. A. R. 1994. 'Skeletal markers of occupational stress,' in *Reconstruction of life from the skeleton*, 2nd edition. Edited by M. Y. Iscan & K. A. R. Kennedy. New York: Wiley-Liss

Meindel, R. S., & Lovejoy C. O., Ectocranial suture closure: a revised method for the determination of skeletal age at death based on the lateral-anterior sutures. *American Journal of Physical Anthropology Vol 68, Issue 1 pp 57-66*

Ortner, D. J. & W. G. J. Putschar. 1985. *Identification of pathological conditions in human skeletal remains*. Vol. 28. (Smithsonian Contributions to Anthropology). Washington & London: Smithsonian Institution Press

Roberts, C. & Manchester, K. 1995, *'The Archaeology of Disease'* Alan Sutton Publishing Ltd, New York. 2nd ed.

Rogers, J. & T. Waldron. 1995. *A field guide to joint disease in archaeology*. New York: John Wiley & Sons

Rogers, J., T. Waldron, P. Dieppe & I. Watt. 1987. Arthropathies in palaeopathology: the basis of classification according to most probable cause. *Journal of Archaeological Science* 14: 179–93

Rose, J. C., Condon, K., and Goodman, A. H., 1985 Diet and developmental disturbances: dental defects. In: *The Analysis of Prehistoric Diets* (Edited by Gilbert R. and Mielke J.) pp. *281-305.* Academic Press, New York

Steinbock, R. T. 1976. *Paleopathological diagnosis and identification*. Springfield, Ill.: Charles C. Thomas

Stewart, T. D. 1979. *Essentials of forensic anthropology*. Springfield, Ill.: Charles C. Thomas

Stuart-Macadam, P. 1982. *A correlative study of a palaeopathology of the skull*. Ph.D. dissertation, University of Cambridge

Stuart-Macadam, P. 1994. 'Nutritional deficiency diseases: a survey of scurvy, rickets and iron-deficiency anemia,' in *Reconstruction of life from the skeleton*, 2nd edition. Edited by M. Y. Iscan & K. A. R. Kennedy, pp. 201–22. New York: A.R. Liss

Sweeney, E. A., A. J. Saffir & R. de Leon. 1971. Linear hypoplasia of deciduous incisor teeth in malnourished children. *American Journal of Clinical Nutrition* 24: 29–31

Trotter, M. & G. Gleser. 1952. Estimation of stature from the long bones of American whites and negroes. *American Journal of Physical Anthropology* 10(4): 463–514

Ubelaker, D. H. 1989. *Human skeletal remains: excavation, analysis, interpretation*. (Manuals on Archeology 2). Washington: Taraxacum for Smithsonian Institution.

Van Gerven, D. P., R. Beck & J. R. Hummert. 1990. Enamel hypoplasia in two Medieval populations from Nubia's Batn el Hajar. *American Journal of Physical Anthropology* 82: 413–20