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A Comprehensive Case Report of University of Montana Forensic Collection Case #141

By

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Professional Paper

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A Comprehensive Case Report of University of Montana Forensic Collection Case #141

Chairperson: Dr. Randall Skelton

UMFC case #141 was acquired in spring, 2006, as a commercially prepared anatomical specimen, reportedly from the Peoples Republic of China. It is a nearly complete skeleton that exhibits severe trauma of the lower limbs. I reviewed the literature on methods of estimating age from the skeleton, because age is difficult to estimate for this case and presents an interesting challenge. I then proceeded to estimate sex, ancestry, age, stature, and weight. I conclude that UMFC #141 is a White male, 39 to 45 years old, 5'0" to 5'4" in height, 110 to 161 pounds in weight. Healed fractures of both tibiae and fibulae, and of ribs 8, 9, and 10 are present. Degenerative joint disease is widespread throughout the skeleton, and cribra orbitalia is present. Time since death is difficult to estimate due to the manner of preparation of the skeleton.

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INTRODUCTION

According to data compiled by the Federal Bureau of Investigation, as of December 31, 2006, there were 110,484 active missing person records in the National Crime Information Center (NCIC) database, and an estimated 16,692 persons were murdered nationwide in 2005 (http://www.fbi.gov). In some cases, missing and murdered people are found as skeletonized remains. Forensic anthrpology can help with identificaiton of these individuals.

In today's world, the word "forensic science" refers to "any scientific research aimed at the analysis and interpretation of evidence that is a part of legal investigation process" (Nafte, 2000:5). Within forensic science, the investigation of deaths is a multidisciplinary endeavor, which includes contributions by forensic anthropology, forensic medicine, forensic photography, forensic psychiatry, forensic entomology, and forensic odontology. The goal of forensic investigation is "the through collection and analysis of physical evidence (Nafte, 2000:9)" from an anthropology perspective.

> Forensic anthropology is that branch of physical anthropology which, for forensic purposes, deals with the identification of more or less skeletonized remains [from a] human (Stewart, 1979:ix).

From a biological perspective, "death" is a continuous process that occurs over a period of time. First *somatic death* occurs, in which cardiac activity, respiration, reflexes, movement, and brain activity all cease. Then, cellular death, called *autolysis* takes place, in which metabolism stops and all cells in the body die. The biochemical process of decomposition starts during and after this phase and progresses to the complete skeletonization of the body (Nafte, 2000). When human remains are discovered, they are first investigated by coroners and/or medical examiners, who primarily deal with fleshed remains. In cases where decay has proceeded to the point that investigators cannot obtain adequate information for identification of the individual, the remains are sent to a forensic anthropology laboratory where study of the skeleton takes place. The process of identification involves providing information regarding those characteristics that may lead to recognition of the person, such as sex, age, ancestry or population affinity, stature, pathology, and trauma. In some cases, through the observation of pathology and trauma, forensic anthropologists can provide information about cause and manner of death, along with information on forces that caused trauma. For instance, wound analysis involves estimation of characteristics of force, direction and energy of force, number of traumatic events, and sequence of events (Byers, 2002).

Forensic anthropology also contributes to identifying victims of natural disasters, mass disasters such as airplane crash, and civil wars. The application of forensic anthropology to the investigation of human rights violations has significantly increased over the last two decades throughout Latin America, Africa, the Middle East, and Eastern Europe (Nafte, 2000).

In this paper, I perform a comprehensive analysis of Case 141 from the forensic collection in the University of Montana. The analysis in the report include sex estimation, ancestry estimation, age at death estimation, stature estimation, weight estimation, trauma observation, pathology observation, informative facts and abnormities observation, and time since death estimation.

LITERATURE REVIEW: ESTIMATION OF AGE

T. Dwight was the pioneer in the field of human skeletal identification in the United States and has been credited as the “Father of Forensic Anthropology” (Stewart, 1979). During his lifetime, he contributed methods for age determination, stature estimation, and sex identification (Byers, 2002).

Gratiolet (1856) was the first person who demonstrated the correlation between suture ossification and chronological age. Through the late 19th century to the early 20th century, a number of authors examined suture closure from various aspects, which included attribution of sex and ancestry to the differences in suture ossification, and the order and variability of suture closure; most of them reported that suture closure was not an appropriate means for age estimation because of its irregularity. McKern and Stewart (1957) addressed the small sample sizes of those early studies which led to unreliable outcomes.

In the 1920s, reexamination of skeletal maturation in relation to age estimation with consideration of its variability started from an anthropological perspective. Until that time, the estimation of chronological age from age related changes of skeletal remains was mainly based on textbooks of anatomy, in which variation was minimized and the practical standards were simply a reflection of central tendencies (McKern and Stewart, 1957).

T.W. Todd had a collection of well-documented skeletal materials and these played a significant role in improving methods for determining the age from skeletal remains. He observed age-related changes on the pubis symphysis from a series of white male samples and established a ten-phase system for determining age (Todd, 1920). Also Todd and Lyon (1924, 1925) generated a scoring system of cranial suture closure that helps with age estimation, although some authors rejected the utility of those techniques for age determination (McKern and Stewart, 1957).

McKern and Stewart (1957) studied skeletal age changes on 450 skeletal remains of American solders repatriated from North Korea. At the site of the analyses, age estimation standards derived originally from Todd's methods were available. They tested these methods by comparing the estimated and actual ages for the first 200 identified cases of the samples and found that there was a tendency to overestimate the age in the standards.

Todd and Lyon (1924, 1925) conducted extensive studies on cranial sutures, both ectocranial and endocranial, from samples that consisted of 307 "male Whites" and 120 "male Negroes", on which age, sex and ancestry were documented. They applied Broca's suture subdivisions and Frederic's scoring system and documented a definite age progression in closure. In their study, they tried to minimize individual differences by using 10 age intervals of three years length rather than actual ages; they eliminated all cases with abnormal suture closure; and they also removed skulls when the postcranial skeleton exhibited growth deviations.

McKern and Stewart (1957) noted that the main interest of Todd and Lyon's study was "biological generalizations" and not the application to age determination. Todd and Lyon stated:

> I propose to present the facts concerning suture closure and its relation to the racial form and individual contour of the braincase … our work does not justify the uncontrolled use of suture closure in estimation of age … our results are of distinct value however when taken in conjunction with identifications given by other parts of the skeleton (Todd and Lyon, 1924:326, 379-380).

As a method for determining age, their techniques have been reviewed and criticized.

Stinger (1953) observed the vault sutures of 100 Cape Colouredes, 190 Bantu, 20 White Germans, 60 North American Indians and 30 Eskimos and concluded that "… the age of the individual at death cannot be estimated from the degree of closure of the various cranial sutures, whether taken individually or collectively or whether observed exocranially or endocranially" (1953:56). Cobb (1955) studied the vault and facial sutures of 2,351 adult skulls of White and American Negro stock, which included those which used by Todd and Lyon, and found limitation of age estimation from suture closure due to its variability.

Brooks (1955) examined 194 male and 177 female California Indian skeletons and a sample of 103 males and 82 females from the Western Reserve collection, which was used by Todd, and concluded that the value of cranial suture closure as an age indicator is only in confirmatory level to other indicators of adult age. She also tested Todd's system of age estimation from the pubic symphysis on the same specimens used by Todd and found a consistent tendency to overage for all ages over 20 years. Hanihara (1952) also applied Todd's method to a series of 135 Japanese male cadavers, ranging ages of 17 to 54 years, although Hanihara demonstrated a "slightly different interpretation" on the description of symphyseal metamorphosis (McKern and Stewart, 1957). He concluded that Todd's system tended to overage his specimens; however, he did not determine whether the inclination attributed to ancestral difference or to subjective differences caused by observers.

Stevenson (1924) studied a series of approximately 110 "White" and American "Negro" skeletons of both sexes with an age range of 15 to 28 years old and provided a detailed description of the epiphyseal unions of the iliac crest, ischial tuberosity and ramus. However, his research met with criticisms because of his sample, in which their ages were obtained from the death certificates, which represented "both antemortem subjective estimate(s) as well as, in lesser degree, postmortem object guess(es)" Cobb (1952:799). Also, the uneven age distribution of the sample was mentioned by McKern and Stewart (1957).

After the Western Reserve collection was formed in 1920s, analysis on epiphyseal maturation of the scapulae became available in statistically satisfactory number. Graves (1922) observed the age-related changes in 139 pairs of scapulae from the collection, aging from 18 to 88 and found that the union of epiphyses of the scapula was completed by around 22 years old. Stevenson (1924) studied a sample of 110 pairs of scapulae with an age range of 15 to 28 years old and concluded that the epiphyses of the scapula fused at between 19 to 22 years of age (McKern and Stewart, 1957).

Saunders *et al*. (1992) conducted a study of methods for estimating age at death from skeletal remains. A population sample was taken from part of a cemetery of St. Thomas Anglican Church, which was in use during 1821 through 1874. In order to avoid initial bias, some regulations and working rules were applied. First, this study was carried out in the manner of blind tests. Therefore, the identity of the specimen, which was available from documented materials, was not provided to the investigator. Second, sex determinations and age estimations were made independently. Furthermore, double examinations, to obtain a measure of intra and inter observer error were applied. Morphological features used as age indicators in this investigation were the pubic symphysis, the auricular surface, cranial suture cloture, and the sternal rib ends. Saunders *et al*. (1992) also applied different indicators for males and females, and for Black and White.

Saunders *et al*. (1992) then applied “multifactorial determination” developed by Lovejoy and colleagues (1985) to the results collected from the four methods, expecting that the attributions of each method would show through the procedure. It turned out that the pubic symphysis method tended to underage except in the younger age categories and that the degree of bias increased 22.4 years for individuals over sixty. The auricular surface method also showed a tendency to underage, especially after the mid-thirties. The bias was almost twice that of the original study. It was found that the ectocranial suture closure method could not predict ages younger than 30 nor older than 50; and that the highest accuracy that could be achieved by this technique was 74%. The Accuracy of individual suture sites varied as well. The least accurate site was the lambdoidal, which showed 45% inaccuracy. Throughout the examination, the vault system presented higher consistency than did the lateral-anterior. The coefficient of determination generated from the sternal rib ends method was 0.50. This means that only 50% of the variability in estimated age is accounted for by variation in age estimation indicators on the sternal rib ends. This technique worked best for individuals of age under 30 and, between 40 and

49; however, it was not effective for individuals over 60. Saunders *et al*. (1992) noted that the outcome obtained from the multifactorial age determination was just a summary average and did not provide increased reliability. Overall, their study showed that each method found it difficult to obtain accurate age estimate, especially towards older ages. Possible bias in sampling itself was mentioned as well, considering the fact that large portions of the population represented individuals of age of over 50 (Saunders *et al*., 1992). Also, it should be noted that the known ages of the individuals in the sample were obtained from tomb stones which do not always provide accurate representation of chronological ages.

Aykroyd *et al*. (1999) reports that skeletal and dental indicators, as methods of providing estimated age, are distinct approaches; however, both show a tendency to underestimate the age of old individuals and to overestimate the age of younger specimens. One explanation for the over-aging of younger individuals is that the methods applied to them were developed for estimation of age in adult skeletal remains. Therefore if appropriate techniques for juveniles are developed and employed, this bias could be reduced. The greater concern is for the under-aging of the older specimens. Aykroyd *et al*. (1999) believe that it was systematically introduced by the technique of linear regression analysis, which can not provide an adequate model of the possibly non-linear aging process (Aykroyd *et al*., 1999).

Regression-based methods employ the equation of a regression line for estimation of unknown values. As long as they are used under a system of broad age categories, they would not be as affected by bias; however, under a narrower category system, bias might be introduced and lead to misinterpretation. As the bias is reflected in the correlation between age indicators and age, the smaller the correlation, the greater the bias. Age estimation methods are considered to be effective only when the correlation coefficient is around 0.9, which is unlikely to be obtained from real samples (Aykroyd *et al*., 1999).

Aykroyd *et al*. (1999) suggests that classical calibration is a solution to the bias which is generated from the regression analysis. In this method, the independent value and response value used in the regression analysis are treated in reverse ways. That is, the independent value is applied in the y-axis and response value in the x-axis. By the utilization of this analysis, systematic bias is eliminated, though it brings increased rates of error over all the age categories.

According to Aykroyd *et al*. (1999), the Bayesian approach is a radial alternative to the methods described above and does not use parameters for evaluation of age indicator variables. Instead, the probability distribution is presented with application of these values: prior probability, likelihood, and posterior probability. This analysis is not a manifestation of a generic aging model, rather a representation of actual knowledge on the aging of an individual. Therefore it does not represent a simple line of predicted age; it provides the information about the confidence level in the data set. This approach would be useful for the estimation of individuals in modern populations, in such a forensic situation, even though the technique requires a large reference population sample with distributions of all age categories (Aykroyd *et al*., 1999).

Hoppa (2000:186) stated that "a fundamental assumption made by skeletal biologists is that both the pattern and rate of age-related morphological changes observed in modern reference populations are not significantly different than in past populations." He selected two independent samples of known ages and compared them to the reference distribution for the Suchey-Brooks (Suchey *et al*., 1988) method of age estimation from the pubic symphysis. The first target sample was a 20^{th} century forensic sample, and the second sample was taken from the 18^{th}-19^{th} century Spitalfields archaeological remains. He found significant differences in the occurrence of age-progressive changes for osteological criteria between the reference and the target samples, especially in females, and cautioned that other current aging methods using the pubic symphysis were derived from Todd's original system which was established in 1920. He also addressed the inherent inaccuracy and unreliability of all age estimation techniques due to the low correlation between skeletal age and chronological age.

Since the time that the concept of forensic anthropology was introduced, various methods for determining age have been developed, reviewed, and revised. Each system seems to have a tendency due to either a systematic bias caused by the referral sample itself or to discrepancies caused by the secular changes since the establishment of the original method. Therefore, investigators should understand those issues and pay attention to the nature of methods they apply.

BACKGROUND

The Anthropology department of the University of Montana purchased this specimen from Skulls International Unlimited in spring of 2006, and it is currently curated in the forensic collection. The information on this individual is not available, although Skulls International Unlimited has told the department that it was imported from the Peoples Republic of China.

SKELETAL INVENTORY

This specimen consists of an almost complete skeleton. The only parts missing are the coccyx, 4th intermediate foot phalanges of both left and right feet, and hyoid, which is typically absent in commercial skeletal specimens. The lists for the skeletal inventory are attached as Appendix 1 and 2. The remains are well preserved and their condition is relatively good. Except for a couple of postmortem breakages observed on the ribs, every bone is intact.

SEX ESTIMATION

"In general the sex differences in the adult long bones are a matter of size –typical male bones being longer and larger (more massive) than typical female bones. To simplify observation of size, measurements of the maximum diameter of the head of humerus and of the femur are especially useful in sex estimation (Krogman 1962:143)." The tables that follow present the comparison of these measurements for University of Montana Forensic Collection (UMFC) 141 to the standards of a variety of metric sex estimation methods based on measurements of the femur, humerus, and tibia.

Sex estimation from Measurements of the Femur, Humerus, and Tibia

Pearson (1917-19) Method (Bass, 2005:19)

Maximum diameter of the head of the femur (mm)

X - 41.5 = Female

41.5 - 43.5 = Probably female

43.5 - 44.5 = Sex intermediate

44.5 - 45.5 = Probably male

45.6 - X = Male

Case 141: 45 mm = Probably Male

Dwight (1905:22) Method (Bass, 2005:19, 21)

The average maximum diameter of the femur head (mm)

49.68 for males

43.84 for females

Case 141: 45 = closer to Female

The diameter of the humeral head (mm)

Vertical: Male = 48.76, Female = 42.67

Transverse: Male = 44.66, Female = 36.98

Case 141

45 mm (Vertical) = closer to Male

44 mm (Transverse) = closer to Male

Stewart (1979) Method (Bass, 2005:231)

The greatest diameter of the femoral head (mm)

Stewart (1979:120) examined specimens from the Terry Collection and provided the following figures for sexing the femoral head of American White.

Female < 42.5

42.5 - 43.5 = Females (ambiguous)

43.5 - 46.5 = Sex intermediate

46.5 - 47.5 = Male (ambiguous)

Male > 47.5

Case 141: 45 mm = Sex intermediate

Symes and Jantz (1983) Method (Bass, 2005:251)

Univariate discriminant function sectioning points for whites, blacks, and Arikara Indian Tibiae

The data was collected from the Terry Collection and a post-contact burial sample of northern Plain Indians for this analysis.

Whites

Proximal breadth (precision 88.75%)

Case 141: 72 mm = closer to Female (Sectioning Point = 75.11)

Distal breadth (precision 86.25%)

Case 141: 51 mm = closer to Male (Sectioning Point = 49.24)

Blacks

Proximal breadth (precision 91.36%)

Case 141: 72 mm = <u>closer to Female</u> (Sectioning Point = 74.82)

Distal breath (precision 87.65%)

Case 141: 51 mm = <u>closer to Male</u> (Sectioning Point = 48.08)

Arikara Indians

Proximal breadth (precision 96.15%)

Case 141: 72mm = <u>closer to Female</u> (Sectioning Point = 74.56)

Distal breath (precision 92.31%)

Case 141: 51 mm = <u>closer to Male</u> (Sectioning Point = 50.88)

For Case 141, measurements of the tibiae may not be appropriate due to the impact caused by the injury traumas on them.

The results of sex estimation from measurements of the femur, humerus, and tibia are almost evenly mixed, therefore I conclude that the sex is indeterminate, based on these criteria.

Sex Estimation from the Skull

Giles (1964) mentions that the skull is most useful portion of the skeleton for sex estimation besides the pelvis. Bass (2005:81) states the general principles for sexing the skull, "estimation of sex is based on the generalization that the male is more robust, rugged, and muscle marked than the female; though, absolute differences seldom exist, and many intermediate forms are found."

<u>Sex Estimation List (Bass, 2005)</u>

<u>Face</u>

1. Superorbital ridges are more prominent in males than females:

Case 141 = <u>Intermediate</u>

2. Upper edges of the eye orbits are sharp in females, blunt in males:

Case 141 = Intermediate

3. The palate is larger in males:

Case 141 = Intermediate

4. Teeth are larger in males:

Case 141 = Male

Mandible

1. The chin is squarer in males and rounded with a point in the midline in females:

Case 141 = Male

2. Teeth are larger in males:

Case 141 = Male

Vault

1. The female skull is smaller, smoother, and more gracile. The female skull retains the childhood characteristics of frontal and parietal bossing into adulthood (Keen 1950):

Case 141 = Male

2. Muscle ridges, especially on the occipital bone, are larger in males (nuchal crests):

Case 141 = Male

3. The posterior end of the zygomatic process extends as a crest farther in males, often past the external auditory meatus:

Case 141 = Male

4. Mastoid processes are larger in males:

Case 141 = Male

5. Frontal sinuses are larger in males:

Case 141 = NA (not observable)

Overall, Case 141 was classified as a Male based on characteristics of the skull.

Sex estimation from the Sternum, Scapula, and Clavicle

Sternum (Bass, 2005)

According to the description presented by Bass (2005:112) "… the body of the sternum in males in more than twice the length of the manubrium. In females the body is less than twice the length of the manubrium".

Based on Bass' observations, I placed Case 141 as a Male.

Sternum (Jit *et al*., 1980)

Jit *et al*. have developed a formula for sex determination based on these sternal measurements: length of the manubrium, length of the mesosternum, and width of the sternebra. They examined 400 Indian sterna, including 312 males and 88 females, and found that "if the combined length of the manubrium and mesosternum was more than 140 mm the sternum was male, if less than 131 mm it was female" (1980:217)

Case 141: 145 mm = Male

Sternal foramina of the sternum (McCormick, 1981)

McCormick (1981:249-52) examined 324 cadavers and stated, "[sternal foramina] were about twice as common in men as in women, occurring in 9.6% and 4.3% respectively." The percentage of occurrence of this phenomenon is too low (7.7% among the cadavers McCormick studied) to utilize reliably for sex determination. Since males exhibit this condition at more than twice of the rate in females, it could be said that an individual with sternal foramina is possibly male; however, this cannot be used for positive identification of sex.

Case 141: Sternal foramina is absent

Dwight (1894) Method (Bass, 2005:123-4)

Measurements of the scapula (mm)

Scapula length

129 > Female

140 – 159 = Intermediate

160 < Males

Case 141: 150 mm = Intermediate

Glenoid cavity length

34 > Females

34 – 36 = Intermediate

37 < Males

Case 141: 37 mm = Male

Scapula (Bass, 2005)

Bass describes characteristic of the male and female scapulas, "the female scapula is typically broader than the male scapula. The female glenoid fossa is typically deeper than that of the male, and is set more nearly at a right angle to the axis of the body of the scapula, whereas the male glenoid fossa is typically broader and shallower, and tends to point more superiorly."

Case 141 exhibited a closer match to the descriptions of the Male scapula.

Septal aperture (supra-condyloid foramen) of the humerus

Occasionally, a foramen extending through into the olecranon fossa occurs at the distal end of humerus above the trochlea. In 1932 Hrdlicka referred it as a septal aperture and mentioned that this phenomenon was seen in females more frequently than in males. Based on his observation, it could be said that an individual with a septal aperture is probably female; however, the reverse may not be true since the majority of people, either male or female, lack the septal aperture (Bass, 2005).

Case 141: absent = Sex undetermined

Thieme (1957)

Measurements of the clavicle (mm)

Thieme (1957) took eight measurements of the clavicle and examined the applicability for determining sex from the “Negro” skeleton. The length of the clavicle was the most reliable of the eight measurements. However, Bass (2005) notes that this measurement by itself is not very helpful for estimating sex.

Clavicle length

Male = 158.24 +/- 10.06

Female = 140.28 +/- 7.99

Case 141: 134 mm = Female

The techniques for determining sex from the sacrum, scapula, and clavicle tend to provide less significant power for the purpose; however, the results obtained form those applicable methods seem to indicate the sex of Case 141 as a Male.

Sex Estimation from the Pelvis

Sexing the pelvis using three general rules (Bass, 2005:208)

“As in the living, the best area to determine the sex of a skeleton is the pelvis. The highest accuracy has been achieved using this bone” (Bass, 2005:207).

Pubic portion (longer in females)

Case 141= Male

Subpubic angle (greater in females)

Case 141 = Male

Subpubic concavity (present in females)

Case 141 = Male

Phenice (1969) Method

Sexing the os pubis

"Preliminary investigation has indicated that the use of the ventral arc, subpubic concavity, and medial aspect of the ischio-pubic ramus as sexing criteria allows one to sex the os pubis with an accuracy in excess of 95% "(Phenice, 1969:297). According to Bass (2005), ventral arc is the most reliable criterion among these three characteristics.

Ventral arc (a slightly elevated ridge in females)

Case 141 = Male

Subpubic concavity (a lateral curvature in females)

Case 141 = Male

Medical aspect of the ischiopubic ramus (a ridge or a narrow surface immediately below the symphyseal surface in females)

Case 141 = Male

Ilium (Bass, 2005:210-212)

Bass (2005) points out that postauricular region is most reliable for visual assessment of sex from the ilium.

Sciatic notch of the pubis (wide in females)

Case 141 = Male

Sacroiliac articulation (raised in females)

Case 141: flat = Male

Pre-auricular sulcus (found in females)

Case 141 = Male

Postauricular sulcus (found in females)

Case 141: absent = Male

Sacrum

Bass (2005:109) provides observations of the sacrum that help in determining sex, "the sacrum generally is more curved in males and flatter in females ".

Based on the observation given in Bass (2005), Case 141 was classified as a Male.

Additional morphological observations (Bass, 2005:212-213)

These observations can help in sex estimation; however, they generally hold minor value (Bass, 2005).

- In general the male pelvis is more robust and muscle marked

  Case 141 = possibly Male
- The obturator foramen is larger and oval shaped in males, whereas it is smaller and more triangular in females

  Case 141 = possibly Female
- Since the female pelvis is adapted for childbirth, the pelvic basin is more spacious and less funnel shaped

  Case 141 = possibly Male
- The acetabulum is larger in males to accommodate the larger femoral head

  Case 141 = Intermediate

From the morphological characteristics of the pelvis, it is fairly clear that Case 141 is a Male.

Estimation of Sex by Discriminant Functions and Other Advanced Metric Methods

Falsetti (1995) Method

Measurements of metacarpals

He took five measurements on five metacarpals from the Terry Collection that consists of 212 individuals (109 males, 103 females) of known sex and population affinity and established discriminant functions. He then found significant metric differences attributed to race on digit 1 and 3 and suggested to apply the equations for metacarpals 2, 4, and 5 to metacarpals of unknown ancestry. I used the equation for digit 5 since it showed the highest accuracy (85%) in correct classification when it was applied to the forensic collection.

Articular Length (52)	x -0.004	= -0.208
A-P Breadth (7)	x 0.848	= 5.936
M-L Breadth (8)	x 0.17	= 1.36
Proximal Breadth (14)	x 1.22	= 17.08
Distal Breadth (13)	x 0.787	= 10.231
Constant:		-30.68

Score for Case 141: 3.719 = Male (Sectioning Point = 0)

Measurements of the Innominate (Bass, 2005:194-7)

Ischium-Pubic Index = pubis length x 100/ ischium length

= 62.5 x 100/ 75.5

= 82.78 (Index Score for Case 141)

for Whites: Male (Sectioning Point = 95)

for Negroes: Male (Sectioning Point = 88)

Giles and Elliot (1962)

Discriminant function based on Craniometric Measurements

This method is probably more suitable for 19th century and early 20th century case due to the nature of their study sample

Measurements of UMFC 141 used (mm)

1. Basion-Prosthion Ht. (= BPL)	97
2. Glabello-Occipital Ln. (= GOL)	177
3. Maximum Width (= XCB)	132
4. Basion-Bregma Ht. (= BBH)	133
5. Basion-Nasion Ht. (= BNL)	120
6. Max. Diam. Bi-zyg. (= ZYB)	132
7. Prosthion-Nasion Ht. (= UFHT)	70

8. Nasal Width (= NLB) 38

Sex discriminant function

1 x (-1.00) = -97.0

2 x (+1.16) = 205.32

5 x (+1.66) = 199.2

6 x (3.98) = 525.36

7 x (1.54) = 107.8

Total = 940.68 Case 141 = Male (Sectioning Point = 891.12)

FORDISC2.0

FORDISC2.0 is a computer program that was created by Ousley and Jantz (1993) and operates analyses on estimation of sex and ancestry based on skeletal measurements. FORDISC2.0 is a program that takes measurements of skulls and computes custom discriminant functions for whatever measurements are supplied and whatever populations in its database are chosen. FORDISC2.0 holds two data sets: the University of Tennessee, Knoxville forensic data base, which consists of approximately two thousand modern forensic cases, and W.W. Howell's worldwide crania data set. FORDISC enables uses to control the number of variables employed in the analysis. The Forensic Database in FORDISC consists of modern forensic cases; thereby FORDISC would be proper for modern cases (Skelton, 2006).

The first two analyses were obtained under the "Sex Only" function which pools the White and Black samples according to sex. Posterior Probabilities calculate "the probability of group membership under the assumption that the unknown belongs to one of the groups in the function," and the typicality probabilities represent "how likely the unknown belongs to any particular group, based on the average variability of all the groups in an analysis" (Ousley and Jantz, 1993).

Two group distance function analysis (Mahalanobis Distance) 1

Measurements included: Cranial and mandible measurements

Number of variable used: 31 variables

Case 141 = classified into <u>Female</u>

Distance from male = 839.2, Distance from female = 673.8

Posterior probability = 1.000, Typicality = 0.000

<u>Two group distance function analysis (Mahalanobis Distance) 2</u>

Measurements included: Cranial measurements

Number of variable used: 24 variables

Case 141 = classified into <u>Male</u>

Distant from male = 163.3, Distance from female = 174.7

Posterior probability = 0.997, Typicality = 0.000

<u>Two group distance function analysis (Mahalanobis Distance) 3</u>

Measurements included: Postcranial measurements

Number of variable used: 39 variables

Case 141 = classified into White <u>Male</u>

Distance from WM = 118.6, Distance from WF = 169.0

Posterior probability = 1.000, Typicality = 0.000

Throughout all the three analyses, posterior probabilities reached 1.0 or very close to it; however, typicality probabilities were all zero. It is especially interesting that the first two even came back with typicality of zero when posterior probabilities were almost 1.0, considering the fact that they were under the Sex Only function and that there were no choices other than male or female. Also it should be noted that the results of analysis 1 and 2 were totally reversed, which attributes to the inclusion or exclusion of mandible measurements.

<u>Gill (1984)</u>

The Gill's method was not available due to inaccessibility of a simometer that is required for this technique.

Overall, discriminant functions and other advanced metric methods classified Case 141 as a Male.

Conclusions for Sex Estimation

Although there are numerous methods available for determining the sex of an individual, it is safe to say that the employment of the os coxae is most reliable for this purpose, followed by the assessment of the skull. For Case 141, significant criteria in these areas consistently indicated that this individual is male. Therefore, I would call Case 141 a male.

ANCESTRY ESTIMATION

Depending on the literature examined, the meaning and range of inclusion for a certain population group name vary significantly. Personally I prefer, regardless of technical issues, to employ terminologies, White, Black, and Asian, simply for practical reasons. I believe that there is some advantage in using those terminologies because they are both broad enough and narrow enough, while remaining neutral in connotation. However, when performing ancestry estimation based on the methods developed by individual researchers, I decided to adopt the terminologies they originally used.

Kennedy (1995:797) addresses “the paradox of the scientific rejection of the race concept and its survival in medical-legal contexts.” Identification of the ancestral background of an individual in forensic anthropology requires knowledge of the geographical distributions and frequencies of phenotypic traits in modern populations.

> … classifications of populations on the basis of arbitrarily selected phenotypic characters do not reveal natural biotic entities below the level of species. Rather, all sub-specific populations are open genetics system with full potentiality for gene flow. Nonconcordance of genetically discrete traits means that clinal patterns are distinctive for each genetic character when plotted geographically by their frequencies. (Kennedy, 1995:797)

Phenotypic traits observed in certain population would not remain the same over long time period as long as there is “continuous operation of selective and random processes which, if adaptive, enhance survival and lead to morphological and physiological changes” (Kennedy, 1995:797). Kennedy then emphasizes that the aspect of the protocol of methodology for ancestral identification in the forensic anthropology is not engaged in a racial classification of human subjects. He suggests that ranges of phenotypic variation and the geographical diffusion of specific phenotypic characters as separate clinal patterns are demonstrated to students by observation of human skeletal collections from different parts of the world.

Ancestry Estimation form the Skull

"The skull is the only area of the skeleton from which an accurate estimation of racial origin may be obtained" (Bass, 2005:83).

Race Estimation List (Bass, 2005:83-88)

Morphological and anatomical variations

- Nasal sill
  Case 141: intermediate = White/ Asian
- Zygomatics
  Case 141: retreating = White
- Orthognathous (flat; opposite of prognathism)
  Case 141: present = White
- Frontal facial profile
  Case 141: long and narrow = White
- Nasal opening
  Case 141: intermediate = White/ Asian
- Shovel-shaped incisors
  Case 141: present in the upper central incisors; also they are rotated slightly toward the midline = Asian
- Nasal root depression at nasion
  Case 141: not prominent = unidentified race
- Nasal bridge
  Case 141: not prominent = unidentified race

Gill (1995) Method (Burns, 1999:38)

Nonmetric Cranial Traits

Palate shape

Case 141: parabolic = European Origin

Palatine suture

Case 141: straight/ z-shaped = American Indians/ European Origin

Zygomaticofacial suture

Case 141: curved/ S-shaped = African Origin

Cranial sutures

Case 141: complex with a Wormian bone = American Indians

Occlusion of maxillary and mandibular teeth

"*Caucasoids* most frequently display a slight overbite" (Bass, 2005:299).

Case 141: an overbite observed = White

Shovel-shaped teeth

The tables of percentage frequency of shovel-shaped incisors presented in Bass (2005:195-196) indicates that among various population groups, Native Americans generally exhibits the highest frequencies of the phenomena.

Case 141 has shovel-shaped median and lateral incisors = Native Americans

Dahlberg (1951)

Molar cusp pattern

"It should be noted that frequently cusp patterns appear intermediate in configuration and therefore are difficult to classify. Also, the genetically unstable third molar frequently presents an irregular cusp pattern that does not resemble any particular type" (Bass, 2005:290-293).

Besides, in my opinion, populations are highly specialized regionally, and I feel that molar cusp patters are therefore not very suitable for the purpose of ancestry estimation in forensic case analysis. The population groups used in the study are Chinese, Mongol, Alaska Eskimo, E.G. Eskimo, Texas Indian, Pecos Indian, Pima Indian, Ancient European white, European white male, Chicago white, Australian Aborigine, and African Negro (Bass, 2005:292-293).

Lower first molars

Case 141: +5 pattern = closest to Texas Indian (precision 30.6%)

Lower second molar

Case 141: +4 pattern = European white (precision 94.0%)

Lower third molars: NA

*(The third molars are too variable to establish standards.)

Overall, morphological characteristics observed from the skull of Case 141 exhibited features of mixed population affinities, with White characteristics holding the highest frequency.

Ancestry Estimation from the Measurements of the Femur, Scapula, and Sacrum

Baker *et al*. (1990) Method (Bass, 2005:234-237)

Again, available ancestral categories were White and Black.

Maximum notch height of the femur

Male: Black =/> 34 (accuracy 79.2%)

White =/< 32 (accuracy 76.9%)

Case 141: 21 mm = White

Measurements of the femur (Bass, 2005:223-5, 235)

Bass (2005) establish a section for this subject in the newest version of his laboratory manual; however, when Stewart (1962) originally studied the measurements of the femur, he actually concluded that "the metrical expression of the femoral curvature employed will not, as a rule, differentiate most of the skeletal remains of Whites, American Negroes, and South Dakota Indians" (1962: 58).

Stewart's primal motive for his study was to examine Hrdlicka's comment, "*skeletons of Negroes are always to be distinguished from those of other races by the straightness of their long bones*" (Stewart, 1962:49) since he was "unable to recall anything in the literature besides [the] joint surface alternation that is similarly helpful in identifying the race of postcranial bones".

Intercondylar shelf angle

Craig (1995) reported on population variation in the intercondylar shelf angel. She states, "variations in this angle are not dependent on the size of the femur, nor is the angle affected by arthritis in the notch or by trauma to the auricular surfaces. Even fragmentary femora can be measured" (Craig, 1995:777). Unfortunately, this criterion is only visible in an X-ray, and I was unable to conduct this analysis due to inaccessibility of X-ray equipment.

Scapula (Bass, 2005:121-122)

Bass (2005) attributes the correlation of scapular indices and ranges of variation to the analysis of Hrdlicka (1942:399), in which four population groups were used: All whites, North American Indian, Alaskan Eskimo, and American Negro. Even though there is not strictly "Asian" category, fundamentally those categories seem sound and reasonable enough.

Measurements of UMFC 141 used (mm)

Length of spine	125/121
Length of supraspinous line	52/ 55
Length of infraspinous line	115/ 110

Scapula Index = max breadth x 100/ max length

= 92 x 100/ 147

= 62.59 (Scapula Index for Case 141)

Case 141 = closest to Alaska/ Eskimo

Wilder (1920) Method (Bass, 2005:107-108)

Bass (2005) attributes the estimation of population by the sacral index to the analysis of Wilder (1920:118), in which six population groups were employed: Negroes, Egyptians, Andamanese, Australians, Japanese, and Europeans. It seems that they were evenly selected in terms of geography; however, they do not represent the level of ancestral affinity required in the context of forensic case study.

Measurements of the Sacrum

Sacral Index = maximum anterior breadth x 100/ maximum anterior height

= 108 x 100/ 119

= 90.76 (Index Score for Case 141)

Populations holding closest sacral index to Case 141

Negroes Males: 91.4

Egyptians Males: 94.3

Andamanese Males: 94.8

The measurements of the femur, scapula, and sacrum are not strong ancestral indicators due to the nature of the studies and their referral populations. The results from those techniques placed Case 141 as a race indeterminate.

Ancestry Estimation from the Vertebral Columns

Duray et al (1999) Method (Bass, 2005: 100)

Bifidity of the cervical spinous processes

Duray *et al*. (1999) examined a sample from the Hammon-Todd collection (359 Americans of African (black) and European (white) descent and noted that C (cervical) 3 through C6 exhibited highly differentiated frequency of bifidity that attributed to ancestry and sex: whites compared to blacks, and males compare females carried a higher frequency of bifidity.

Case 141: bifidity found on C3-C6 = White, Male

Ancestry Estimation from Discriminant Function Analyses

Giles and Elliot (1962)

Discriminant function based on anthropometric Measurements

“The cranium provides more identification of race than any other skeletal part …” (Giles and Elliot, 1961:147). They established a method for ancestry identification from cranial measurements. As the first step, the following eight measurements were taken: Glabello-occipital length, Maximum width, Basion-bregma height, Maximum diameter bi-zygomatic, Prosthion-nasion height, Basion-nasion, Basion-prosthion, and Nasal breadth. Then they selected the linear functions of the eight measurements for white - “Negro” separation and for white - Indian separation. Two pairs of discriminant function formulas were presented for each sex as well. They tested the formulae on a sample of 551 males and 471 females, and 82.6% in male and 88.1% in female were assigned into the proper category.

There were some problems with their sample: their definition of “Negro” and paucity of the American Indian sample. They classified any person who showed any phenotypic evidence of “Negroid” admixture into “Negro.” Also, they used the Indian Knoll sample, which is well-preserved and which C.E. Snow (1948) has published a full report on, for their American Indian sample. However, as mentioned by themselves, their sample was not statistically sufficient, and they took the measurements from Snow’s report.

Also, Angel (1982) reported significant influence of nutrition and health conditions and secular change on the skull base height (prosion-basion), which was over six times greater than that on the general skull size change. This factor may have an affect on craniometric analyses for determination of population affinity at both the individual and population levels.

Measurements of UMFC 141 used (mm)

1. Basion-Prosthion Ht. (= BPL)	97
2. Glabello-Occipital Ln. (= GOL)	177
3. Maximum Width (= XCB)	132
4. Basion-Bregma Ht. (= BBH)	133
5. Basion-Nasion Ht. (= BNL)	120
6. Max. Diam. Bi-zyg. (= ZYB)	132

7. Prosthion-Nasion Ht. (= UFHT) 70

8. Nasal Width (= NLB) 38

White/ American Indian discriminant function

1 x (+0.10) = 9.7

2 x (-0.25) = -44.25

3 x (-1.56) = -205.92

4 x (+0.73) = 97.09

5 x (-0.29) = -34.8

6 x (+1.75) = 231

7 x (-0.16) = -11.2

8 x (-0.84) = -31.92

Total = 9.7 Case 141 = White (Sectioning Point = 22.28)

White/ Negro discriminant function

1 x (+3.06) = 296.82

2 x (+1.60) = 283.2

3 x (-1.90) = -250.8

4 x (-1.79) = -238.07

5 x (-4.41) = -529.2

6 x (-0.10) = -13.2

7 x (+2.59) = 181.3

8 x (+10.56) = 401.28

Total = 131.33 Case 141 = Negro (Sectioning Point = 89.27)

FORDISC2.0

Based on the result obtained from sex estimation, I assumed that Case 141 is a male and excluded all female options here. The general rule in using FORDISC is that the fewer groups you select, the greater the chance the result is more successful and meaningful. Skelton (2006) addresses the concept that approximately 85% of human variation is variation within groups, and about 15% is variation between groups, which means that variability between members of the same population is much higher than the variation that separates different populations. It is fairly rare that an individual exhibits all and only the features of the population group to which he/she belongs.

> Alleles, and the characteristics that they code for … vary clinally. That is there are areas of low frequency and areas of high frequency, with relatively gradual transitions between them. There are no sharp boundaries between groups (Skelton, 2006).

The Ischium-Pubis Index that is currently applied for sex determination under the designated ancestral category was originally proposed by Schultz (1930) for differentiating two species or genera of the higher primates in studies of primate taxonomy. Interestingly enough, Schultz was facing the same subject matter as we are in identification of population affinity, that is, the individual variability.

> It had been found that the higher primates vary individually to such a degree that numerous specimens are indispensable for reliable definitions of the typical and average conditions of most skeletal characters. It seems particularly important to determine the ranges of individual variations within a species or genus and the degree to which these ranges approach one another or even overlap (Schultz, 1930:404).

The eleven population samples used in FORDISC 2.0 are of individuals who were born in the 20th century, except for most of American Indians, which are mid to late 19th century Amerindian remains (Ousley and Jantz, 1993). For this time discrepancy issue and for its small sample size (50 males, 29 females), I excluded American Indian population in the analysis. Also, I dismissed Hispanic and Vietnamese population groups due to the small sample size (39 and 51, respectively). "*Hispanic* has been the most problematic as far as "race" is concerned, and includes individuals born in the U.S. Mexico, and Central America. There are no Caribbean individuals, who more often classify as Black. Most of those come from New Mexico" (Ousley and Jantz, 1993).

Probabilities exhibited the same tendency observed in sex estimation analyses. Although all three analyses classified Case 141 into a white male with high posterior probability, the typicality probabilities were all zero again. The selection process of the population groups was well organized through the procedure, and, therefore, I believe that there was no factor causing bias except the nature of Case 141 itself.

Two group discriminant function

Measurements used: Postcranial measurements
Number of variable used: 39 variables
Population groups included (available): WM (White Male) and BM (Black Male)

Case 141 = classified into a White Male
Distance form WM = 91.8, Distance from BM = 118.1
Posterior probability = 1.000, Typicality = 0.000

Analysis of discriminant function 1

Measurements used: Cranial measurements (mandible measurements dismissed)
Number of variable used: 17 variables (variables excluded from Chinese Males and Japanese in FORDISC2.0* were excluded as well in here for standardization purpose)
Population groups included: WM (White Male), AM (American Indian Male), JM (Japanese Male), HM (Hispanic Male), and CHM (Chinese Male)

Case 141 = classified into a White Male (81.9% accuracy)
Distance from WM = 125.4
Posterior probability = 0.995, Typicality = 0.000

* Excluded measurements in Chinese Males are UFBR, FOB, and all mandibular measurements; excluded measurements in Japanese are MAL, UFBR, EKB, DKB, FOL, MDH, HMF, XRB, XRH, MNL, and MAN (Ousley and Jantz, 1993).

Analysis of discriminant function 2

Measurements used: Cranial measurements (mandible measurements dismissed)
Number of variable used: 17 variables

Population groups included: WM (White Male), JM (Japanese Male), and CHM (Chinese Male)

Case 141 = classified into a White Male (92.8% accuracy)
Distance form WM = 122.2
Posterior probability = 0.999, Typicality = 0.000

Discriminant function analyses consistently classified Case 141 as a White.

Conclusions on Ancestry Estimation

Identification of ancestry is difficult especially in modern cases due to the increasing rate of admixture among populations; as gene flow increases between populations, genetic distances between them diminishes. The results obtained from FORDISC2.0 on Case 141, zero typicality probabilities, may be reflecting the possibility of admixture. Despite the fact that Case 141 was purchased from China, majority of assessments performed here indicated that this individual was a White. Therefore, as a part of procedure, I would claim Case 141 is most likely a White.

AGE AT DEATH ESTIMATION

"The biological age of a skeleton can be determined with varying degrees of success, depending on the period of life reached. At the stage when the teeth are erupting and the epiphyses uniting, age often can be judged quite precisely. After growth has stopped and the permanent dentition has erupted – that is onwards from about 25 to 30 years - the estimation of age depends almost entirely on degenerative changes (Bass, 2005:12)".

Growth Processes: Epiphyseal Union of Long Bones, Iliac Crest, and Clavicle

McKern and Stewart (1957)

The age distribution for stages of union for the long-bone epiphyses

McKern and Stewart (1957:41-52) examined a series of skeletal remains of the American soldiers repatriated from North Korea and reported the age distribution for stages of union for the long-bone epiphyses.

Completely united or fused: 24 years old (completion 100%) for proximal humerus
23 years old (completion 100%) for distal radius
23 years old (completion 100%) for distal ulna
22 years old (completion 100%) for distal femur
23 years old (completion 100%) for proximal tibia
22 years old (completion 100%) for proximal fibula

Case 141

All the epiphyses were completely fused = over 24 years of age

The sample studied in McKern and Stewart (1957) consists of males. In general, the union of the epiphyses in females occur slightly earlier than in males; however, this issue can be disregard here since Case 141 was identified as a male.

Johnston (1962) (Bass, 2005:247, 257)

Johnston (1962) studied skeletal data from Indian Knoll and reported age of the epiphyseal fusion of the tibia and the fibula.

The relation of age to length of the subadult tibia

Male

Distal epiphysis: complete union = 20 years old

Proximal epiphysis: complete union = 23 years old

Case 141

Both end of epiphyses were completely fused = over 23 years of age

The relation of age to length of the subadult fibula

Male

Distal epiphysis: complete union = 20 years old

Proximal epiphysis: complete union = 22 yeas old

Case 141

Both end of epiphyses were completely fused = over 22 years of age

McKern and Stewart (1957)

Epiphysis on the iliac crest: age distribution of stages of union

As mentioned earlier, a sample used in this project was the U.S. war dead received from North Korea.

Completely united or fused = 23 yeas old

(precision 100%)

Case 141: completely fused = over 23 years of age

Epiphyseal Fusion of the Medial Clavicle Burns (1999)

"In the human body, the medial claviclar epiphysis is the last epiphysis to fuse" (Burns, 1999:51). Generally this epiphyseal fusion takes place in the mid-twenties; however, the latest age of the fusion documented is 32 years.

Case 141 = over 25 years old

Suchey (1985) (Bass, 2005:129)

Suchey (1985) studied epiphyseal union of the medial clavicle from a sample of modern Americans, aged from 11 to 40, that consisted of American whites, American blacks, Latin Americans, and Oriental with a breakdown of 605 males and 254 females.

Case 141: Stage 4 (complete union) = 31-40 years old (accuracy 100%)

Workshop of European Anthropologist (1980:523)

The workshop presented a method for age estimation using long bone length. However, this system were not applicable to Case 141 since this method is for age estimation of children of ages up to around 12 years old (Krogman and Iscan, 1986).

Epiphyseal Union of Long Bones, Iliac Crest, and Clavicle indicated that Case 141 was over 31 years of age at death, at least.

Growth Processes: Formation and Eruption of Teeth

Stewart (1963) (Bass, 2005:14)

Variations in tooth formation

Generally tooth formation occurs in the order of calcification, crown completion, and apical closure, and it will complete by around the age of 18 years old (Bass, 2005).

The teeth of Case 141 had passed these stages, which indicates that this individual was well over 18 years old.

Ubelaker (1978) (Bass, 2005:301-302)

According to Bass (2005:301), the chart compiled by Ubelaker is "one of the best documented and current charts;" however, the sample population that Ubelaker's observations were based on was American Indians.

The sequence of formation and eruption of teeth

Case 141 = over 35 years old

Formation and eruption of teeth indicated that Case 141 was over 35 years of age at death, at least.

Age-related Changes: Cranial Suture Closure

Methods using cranial suture closure (Skelton, 2006)

The basilar suture

McKern and Stewart (1957:34) reported that in the age groups of 19 to 20, activity at the site practically ceased and the basilar suture closed by the age of 21 years. The basilar suture is said to be the only suture that is fairly reliable (Skelton, 2006).

Case 141: closed = over 21 years

General age indication based on the maxillary sutures

Mann *et al*. (1987) reported that the four maxillary sutures (incisive, interpalatine, intermaxillary, and palatomaxillary) are helpful in estimating age. "At birth the maxillary sutures are well defined with gaps existing along their margins. The sutures of the maxilla in young individuals exhibit a rough, bumpy appearance. Increasing age results in a progressively smoother as the bumps and sutures slowly disappear" (Bass, 2005:48). Based on the stage of transition on the sutures, an individual is classified into one of the three categories: Subadult, Adult (18+), and Old adult (50+).

Case 141 = Adult (18 - 50 years old)

Todd and Lyon (1925) Method

- Ectocranial suture closure

Case 141

Sagital: Commenced = 21-28
Coronal: Commenced = 27-49
Lambdoidal: Commenced = 27-30 = 21-49 years old
Masto-occipital: Commenced = 29-31
Spheno-temporal: Commenced = 37+

Todd and Lyon (1924) Method

- Endocranial suture closure

Case 141

Sagital: Commenced = 23-34
Coronal: Commenced = 25-40
Lambdoidal: Commenced = 27-46 = 23-80 years old
Masto-occipital: Commenced = 31-80
Spheno-temporal: Commenced = 31-66

The Baker (1984) Method

- Application of both ectocranial and endocranial suture closure

Case 141

Sagital Endocranial suture: Commenced = 19-79
Sagital Ectocranial suture: Commenced =19-83
Lambdoid Endocranial suture: Commenced = 19-74 = 19-89 years old
Lambdoid Ectocranial suture: Commenced = 24-84
Coronal Endocranial suture: Commenced = 22-79
Coronal Ectocranial suture: Commenced = 24-89

Meindl and Lovejoy (1985)

Ectocranial suture closure

Meindl and Lovejoy (1985) developed a method for determining age based on the degree of suture closure from a sample of 236 crania from the Hamann-Todd Collection. Age estimates obtained from this method found to be independent of population affinity and sex.

The lateral-anterior sutures are superior to the vault sutures for determining age. Meindl and Lovejoy (1985:57) note that this method "can provide valuable estimates of age-at-death in … forensic contexts when used in conjunction with other skeletal age indicators".

Case 141

Ectocranial lateral-anterior sutures: Score 1.1 = 19-48 years old

[Mean age = 32.0 years old]

Ectocranial vault sutures: Score 1.2 = 18-45 years old

[Mean age = 30.5 years old]

The age ranges acquired from the observations of cranial suture closure, in general, were overwhelmingly wide for the purpose of age identification. If I only employ the core range of age at death, the criteria provided a range of 23 to 45 years.

Age-related Changes: the Rib

Iscan *et al*. (1985)

Phase analysis of the sternal end of the right 4^{th} rib

Iscan *et al*. (1985:1094) observed a sample consisted of 118 white male ribs of identified age, sex, and population affinity and concluded that "the sternal rib end may yield a similar degree of accuracy to the pubic symphysis and perhaps better than that for cranial suture closure."

Case 141

Phase 5 = 34.4-42.3 years old/ Phase 6 = 44.3-55.7 years old

Age-related Changes: Pubic Symphysis

Pubic Symphysis

“The innominate is probably the most important bone in age estimation because the changes occurring in the development of subadult bone to adult bone in the pubic symphysis are very distinct” (Bass, 2005:197).

Todd (1920) System

Todd (1920) observed the age changes in pubic symphysis that occur after puberty from 306 skeletons, which consisted of all white male, and established a ten-phase system for estimating age from that area.

Phase 1. Age 18-19: Typical adolescent ridge and furrow formation with no sigh of margins and no ventral beveling.
Phase 2. Age 20-21: Foreshadowing of ventral beveling with alight indication of dorsal margin.
Phase 3. Age 22-24: Progressive obliteration of ridge and furrow system with increasing definition of dorsal margin and commencement of ventral rarefaction (beveling).
Phase 4. Age 25-26: Completion of definite dorsal margin, rapid increase of ventral rarefaction and commencing delimitation of lower extremity.
Phase 5. Age 27-30: Commencing formation of upper extremity with increasing definition of lower extremity and possibly sporadic attempts at formation of ventral rampart.
Phase 6. Age 30-35: Development and practical completion of ventral rampart with increasing definition of extremities.
Phase 7. Age 35-39: Changes in *symphysial* face and ventral aspect of pubis consequent upon diminishing activity, accompanied by bony outgrowths into pelvic attachments of tendons and ligaments.
Phase 8. Age 39-44: Smoothness and inactivity of *symphysial* face and ventral aspect of pubis. Oval outline and extremities clearly defined but no “rim” formation or lipping.

Phase 9. Age 45-50: Development of "rim" on *symphysial* face with lipping of dorsal and ventral margins.

Phase 10. Age 50 and upward: Erosion of and erratic, possibly pathological osteophytic growth on *symphysial* face with breaking down of ventral margin.

(Todd, 1920:313-314)

Case 141: Phase 8 = 39-44 years of age

McKern and Stewart (1957) Method

McKern and Stewart (1957) reevaluated Todd's (1920) nine features, which were: 1. Ridges and furrows; 2 Dorsal margin; 3. Ventral beveling; 4. Lower extremity; 5. Superior ossific nodule; 6. Upper extremity; 7. Ventral rampart; 8. Dorsal plateau; and 9. Symphyseal rim, and proposed a method for age estimation by observing symphyseal metamorphosis in terms of combinations of its component parts. They stated, "In comparison to Todd's system, the symphyseal formula expresses the true nature of symphyseal variability and does not confine the observer to the narrow limits of typical phases" (1957:88).

The Symphyseal Component

Case 141

1. Dorsal plateau: score = 5
2. Ventral rampart: score = 5
3. Symphyseal rim: score = 3

Total Score = 13

Age range in years: 23-39 years of age

Meindl *et al*. (1985) Method

Meindl *at al*. (1985) assessed all current standardized methods of age estimation using the os coxae and presented revised standards for age determination based on the Todd method which found to be most reliable among all techniques. The modification was made based on the fact that the original system tended to underage.

Case 141

Maturing stage: Stage 8 under Todd's system

= 40-44 years of age (modified result)

Katz and Suchey (1986) Method (Suchey-Brooks methods)

Katz and Suchey (1986) examined a sample (n =739) of well-documented male os coxae and recommended a modified Todd six-phase system. They addressed that "Todd's system was found to over-age and both the Todd and the McKern-Stewart systems did not account for age variability seen in advance pubic bone patterns" (1986:427).

Case 141: Phase 5 = 27-66 years of age [Mean = 45.6]

The results from the observations of pubic symphysis overlap around ages between 39 and 44.

Age-related Changes: the Ilium

Lovejoy *et al*. (1985)

Age from auricular surface

Lovejoy et al. (1985) presented a method for determining adult age based on chronological changes in the auricular surface of the ilium. They observed over 250 well-preserved auricular surfaces from the Libben population, approximately 500 samples from the Todd Collection, and 14 forensic cases of confirmed identity with age.

Case 141

Age Mode 5 = 40-44 years old/ Mode 6 = 45-49 years old

Degenerative Changes: Vertebral Columns and Osteoarthritis

The Vertebral Column

Bass (2005:18-21)

Stewart (1958) studied distribution of five categories of osteophytosis in 306 lumbar, thoracic, and cervical vertebrae of white American males with the age range of 21 to 84 years olds and stated that lipping develops slowly between the age of 20 and 30; intensifies between 30 and 50; and becomes fairly pronounced over the age of 50.

Case 141

Average stage of lumbers: Stage 5 = age range of 51 to 84 years olds

Average stage of thoracics: Stage 3 = age range of 31 to 84 years olds

Average stage of cervicals: Stage 3 = age range of 28 to 84 years olds

The intensity of osteophytosis in lumber vertebrae, compared to thoracic and cervical vertebrae, was severe. This could be simply due to the aging process or affected by the injury trauma on the lower limbs.

Burns (1999:64-67)

- Age changes in vertebral body

  Child (under 16 years)

  Late teenager (16-20 years)

  Young adult (20-29 years)

  Older adult (over 30 years)

Case 141 = over 30 years old

- Osteoarthritis in the lower back

Burns (1999:66) gives a description of “An elderly or Hard Working Back”, in which osteoarthritic “lipping” and osteophytes are observed on the vertebral bodies, and the “auricular surface of the sacrum is rough and porous with sharply defined edges.”

Based on the observation given in Burns (1999), Case 141 was identified as an elderly person or a person with history of heavy labor.

Overall, the observations of the vertebral columns indicated that Case 141 was over 30 years of age at death, at least.

Degenerative Changes: Dental Attrition

Lovejoy (1985)

Dental wear age determination:

Lovejoy (1985) studies a sample of 332 adult dentitions selected from the Libben population and established functional attritional stages of the maxillary the mandibular dentition. He found no significant sexual differences in wear pattern.

Case 141

The Maxillary dentition: Phase G = 35-40 years of age

The Mandibular dentition: Phase G = 35-40 years of age

Dental attrition scoring system

Dental attrition aging methods are presented in Skelton (2006); however, the techniques are population-specific and only apply to Prehistoric California Central Valley Native Americans and Montanans, neither of which were relevant to Case 141.

Degenerative changes in teeth (Burns, 1999)

Burns (1999:126) addresses the complication of degenerative changes, "… degenerative changes are influenced by diet, nutrition, and general health. In the present would of processed food and long lifetime, teeth are also influenced by behavior and professional dental care". Attrition, secondary dentin, periodontosis, root transparency, cementum, and root resorption are listed as the changes occur due to degeneration or aging of teeth. Unfortunately, dental radiographs or ground sagittal sectioning, which I did not have access to, are required to see those changes. Burns (1999:126) comments on this matter, "the method would probably be in more general use if the equipment *were* more easily obtained and the techniques were more accessible".

Brothwell (1965) (Bass, 2005:299)

Correlation of age at death with molar wear in premedieval British skulls

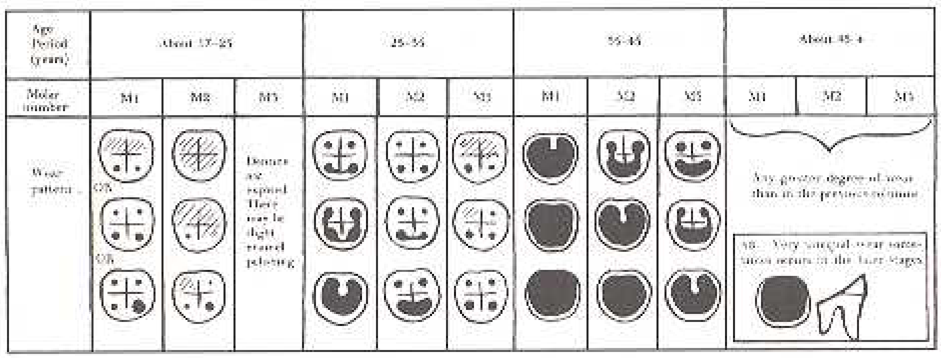

Figure 4–18. Correlation of age at death with molar wear in premedieval British skulls (after Brothwell 1965:69). Permission for reproduction granted by D. R. Brothwell and the Trustees of the British Museum of Natural History.

Base on the occlusal wear patterns, age classification of Case 141 was determined as <u>25 to 35 years of age</u>

Dental attrition of Case 141 exhibited a age range between 30 and 40 at death.

<u>**Other Age-related Features**</u>

<u>Atrophic spots (Graves, 1922) (Bass, 2005:118-120)</u>

Atrophic spots are defined as localized, discrete, or coalescing areas of bone atrophy that appear on the scapula (Bass, 2005:118). Graves (1922) reported that the frequency and size of the atrophic spots increase for the scapulae from individuals over 45 years of age. Differentiation of atrophic spots from other translucent areas in the body of the scapula can be made by the fact that they are smaller in size and that there is no alternations in vascularity and bone structure.

Case 14

Atrophic spots: Absent = indicated age estimate is <u>under age of 45</u>

<u>Rhomboid fossae</u> (Bass, 2005:128)

The frequency that rhomboid fossae are observed on the medial end of the clavicle is higher in younger individuals than in older individuals; the largest fossae were most common in males 20-30 years of age.

Case 141

Rhomboid fossae: no trace = <u>probably over 30 years old</u>

These age-related features gave Case 141 a age range of 30 to 45 at death.

<u>Conclusions on Age Estimation</u>

Utilization of the numerous techniques available does not necessarily generate a specified, narrower range of age estimate. I had to deal with this issue for determining age at death of Case 141; however, after consideration of the apparent reliability of each method and the nature of the methods, the analyses revealed a certain degree of consistency with core age range of 39-44 years. In general, aging of the os coxae, which mainly includes analyses of pubic symphysis and auricular surface, is fairly reliable for age estimation. Although the McKern and Stewart method gave me younger age range compared to other methods, I believe it was partially due to my unfamiliarity to the technique. Overall, I assigned Case 141 into an age range of 35 to 49 years old.

STATURE ESTIMATION

"Estimating statute is complicated by racial differences among population samples. The racial affiliation of the sample must be known, and the appropriate formulae or tables for that racial group must be used to estimate stature" (Ousley and Jantz, 1993).

Genoves (1967) Method

The Geneves formulae for stature calculation are not applicable here because his referral population was of Mesoamericans, which is not the population this specimen is from.

Stature Estimation from the Upper long Bones

Trotter and Gleser (1958) Methods

They noted that "it can be stated as a general rule that in no case should lengths of upper limb bones be used in the estimation of stature unless no lower limb bone is available."

Stature formula for the humerus (for Male)

White: 2.89 humerus + 78.10 +/- 4.57 = 161.3 +/- 4.57

Mongoloid: 2.68 humerus +83.19 +/- 4.16 = 160.4 +/- 4.16

Stature formula for the radius (for Male)

White: 3.79 radius + 79.42 +/- 4.66 = 163.2 +/- 4.66

Mongoloid: 3.54 radius + 82.00 +/- 4.60 = 160.2 +/- 4.60

Stature formula for the ulna (Male)

White: 3.76 ulna + 75.55 +/- 4.72 = 167 +/- 4.72

Mongoloid: 3.48 ulna + 77.45 +/- 4.66 = 162.7 +/- 4.66

Meadows and Jantz (1992) Method

Stature formula for the metacarpal (for White Males)

Stature = (bone in mm) (slope) + intercept +/- SE

Left M1: (47) x 1.67 + 91.89 +/- 5.57 = 170.4 +/- 5.57

M2: (64) x 1.311 + 81.96 +/- 5.10 = 165.8 +/- 5.10

M3: (63.5) x 1.298 + 84.90 +/- 5.19 = 167.3 +/- 5.19

M4: (55.5) x 1.355 + 90.41 +/- 5.27 = 165.6 +/- 5.27

M5: (53) x 1.468 + 90.64 +/- 5.47 = 168.4 +/- 5.47

Right M1: (48) x 1.659 + 91.77 +/- 5.52 = 171.4 +/- 5.52

M2: (64) x 1.261 + 85.51 +/- 5.15 = 166.2 +/- 5.15

M3: (63) x 1.279 + 85.98 +/- 5.36 = 166.6 +/- 5.36

M4: (54) x 1.375 + 89.54 +/- 5.33 = 163.8 +/- 5.33

M5: (52.5) x 1.433 + 93.16 +/- 5.67 = 168.4 +/- 5.67

Stature Estimation form the Lower Long Bones

Stature formula for the femur (for Male)

White: 2.32 femur + 65.53 +/- 3.94 = 157.6 +/- 3.94

Mongoloid: 2.15 femur + 72.57 +/- 3.80 = 157.9 +/- 3.80

Stature formula for the tibia (for Male)

White: 2.42 tibia + 81.93 +/- 4.00 = 163 +/- 4.00

Mongoloid: 2.39 tibia + 81.45 +/- 3.27 = 161.5 +/- 3.27

Jantz *et al.* (1995) noted the problem with using the Trotter's stature formulae for the tibia and suggested to modify the measuring system.

> Using Trotter's original measurements, we discovered that she consistently *mismeasured* the tibia. Trotter's measurements of the tibia are 10 to 12 mm shorter than they should have been, resulting in stature estimations averaging 2.5 to 3.0 cm too great when the formulae are used with properly measured tibia … Estimation of stature from Trotter and Gleser's tibia formulae is to be avoided if possible. If necessary, the 1952 formulae could be used with tibia measured in the same manner that Trotter measured, excluding the malleolus. (Jantz *et al*., 1995:758)

The stature estimate derived from stature formula for tibia, using the measurement system suggested by Jantz et al. (1995) is as follow:

2.42 tibia + 81.93 +/- 4.00 = 158.6 +/- 4.00

This is more consistent with stature estimates obtained by other methods and, therefore, more sound than the result obtained via the original method.

more sound than originally reached result.

Stature formula for fibula (for Male)

White: 2.60 fibula + 75.50 +/- 3.86 = 158.2 +/- 3.86

Mongoloid: 2.40 fibula +80.56 +/- 3.24 = 156.9 +/- 3.24

Holland (1995) Method

Holland took maximum length and posterior length of the calcaneus, and the maximum length of the talus to predict adult stature. He concludes, "the equations … have some utility in providing stature estimates in cases where other methods are not applicable" (Holland, 1995:319).

	Right	Left
1. Maximum length of the calcaneus (MCAL)	76	76.5
2. Posterior length of the calcaneus (PCAL)	57	57
3. Maximum length of the talus (MTAL)	57.5	59

White Male (mean age 48 years, SD 13 years)

1.003 (PCAL) + 112.42 +/- 5.55 = 169.6 +/- 5.55

0.674 (MCAL) + 116.24 +/- 5.75 = 167.6 +/- 5.75

White or Black Male (mean age 42 years, SD 17 years)

1.05 (MTAL) + 109.66 +/- 6.07 = 170.8 +/- 6.07

1.039 (PCAL) + 0.489 (MTAL) + 82.14 +/- 5.33 = 169.8 +/- 5.33

FORDISC2.0

It is rational to use FORDISC for stature estimation since long bone epiphyses of this individual have fused. "The PI should get larger as a bone measurement gets further from the mean bone length due to the error terms of the regression slope and intercept. FORDICS does not adjust the PI according to bone length because the vast majority of adult bone measurements are within 3 standard deviations of the mean, which minimally affect the PI" (Ousley and Jantz, 1993). Also, Ousley (1995) mentions that "prediction Intervals are more appropriate than standard errors for quantifying precision… It also reflects a more realistic picture of the relationship of stature to long bone lengths" (1995:277-8).

According to Ousley (1995), generally Trotter and Gleser stature estimation is slightly more precise than forensic stature estimation. He mentions that "Prediction Intervals are more appropriate than standard errors for quantifying precision… Informing the police [with PIs] may not significantly narrow down possible identifications, but it will also avoid excluding other possible identifications. It also reflects a more realistic picture of the relationship of stature to long bone lengths."

Group = WM
Data source = Forensic
PI (Prediction Interval) = 95%
Equation selected= FEMXLN + TIBXLN (maximum length of the femur and the tibia) (The femur is a good indication used for stature estimation. In this case the individual exhibits injury trauma on tibias and fibulas; measurements of those bones should be included in the equation since the stature would have been affected as such in the person's life time.)
Prediction Equation = 0.05592 (FEMXLN + TIBXLN) + 21.4
Prediction Stature = 62.3 in +/- 3.2 = 158.2 cm + /- 8
Prediction Interval = 59.1 – 65.5 in = 150.2 – 166.4 cm

PI = 90%

Predicted Stature = 62.3 in +/- 2.7 = 158.2 cm +/- 6.59

Prediction Interval = 59.6 – 65 in = 151.6 – 164.8 cm

Group = WM

Data source = Forensic

PI = 95%

Equation selected = FEMXLN + FIBXLN (maximum length of the femur and the fibula)

(Considering the incorrect measuring issue on tibia mentioned by Jantz et al. (1995), the fibula was employed here, instead of the tibia.)

Prediction Equation = 0.05684 (FEMXLN + FIBXLN) + 20.8

Prediction Stature = 61.4 +/- 3.3 in = 156.0 cm +/- 8.4

Prediction Interval = 58.1 – 64.7 in = 147.6 – 164.3 cm

PI = 90%

Predicted Stature = 61.4 in +/- 2.7 = 156.0 cm +/- 6.9

Prediction Interval = 58.7 - 64.1 in = 149.0 – 162.8 cm

*FSTAT estimates are applicable to all adults with no need to compensate for age.

Group = WM

Data source = Trotter

PI = 95%

Equation selected = FEMXLN + FIBXLN

(The incorrect measuring issue on tibia was considered again.)

Prediction Equation = 0.0937 (FEMXLN + FIBXLN) + 28.3

Prediction Stature = 62 in +/- 2.5 = 157.5 cm +/- 6.4

Prediction Interval = 59.5 – 64.5 in (= 5’0” – 5’4” in) = 151.1 – 163.8 cm

PI = 90%

Predicted Stature = 62 in +/- 2.1 = 157.5 cm +/- 5.3

Prediction Interval = 59.9 – 64.1 in = 152.1 162.8 cm

Discussion on Stature

Overall the stature of this individual is estimated to be in the range of 5’0” to 5’4” (151.1to 163.8 cm). The Lower limbs are more reliable for stature estimation than the upper limbs. I believe that in this case it is crucial to include measurement of either the tibia or fibula in addition to the femur, considering the fact that there is healed injury trauma on those bones which could have influenced the stature of the person. Because of possible problems with Trotter’s measurements of the tibia, I relied most heavily on the stature estimate obtained from FORDISC2.0 using Trotter stature estimation with an equation of FEMXLN + FIBXLN. As mentioned by Ousley (1995), a large interval of estimate may not be informative for positive identification of individuals for police; but, it would avoid excluding other possible identifications, especially when stature has an issue of population specificity. Therefore, I applied a 95% prediction interval.

WEIGHT ESTIMATION

Weight estimate was calculated from the stature estimate of this individual using the Metropolitan Life Insurance Company charts given in Skelton (2006). There are three categories under robusticity in the charts: gracile, medium, and robust. The only way to determine robusticity is to visually assess muscularity of the skeleton, particularly the long bones and the skull. Since Case 141 exhibited prominent marks of muscle attachments on the long bones, I assigned this individual to the "robust" category. According to the height/weight tables, the weight estimate of Case 141 is 110 - 161 pounds.

The Utility of weight estimation in this context is often criticized due to its high difficulty and uncertainty of the source. Skelton (2006) mentions issues with height/weight tables themselves that those charts are "designed to show what people should weigh" and not reflections of reality. Also, age is not considered in those charts either (Skelton, 2006). However, since the purpose of this project is to perform all possible aspects of a skeletal analysis, I provided this estimate as well.

TRAUMA

Healed fracture of the tibiae and the fibulae

Healed fractures were noticeable on the midshafts of tibiae and fibulas. They were simple fractures, obviously happened antemortem, and the direction of force was downward in the medial to lateral plane. Even though they were healed back together, the way they healed suggests that treatment was not administered under current best medical practices.

Healed fractures of the ribs

Healed fractures were observable on the bodies of right ribs 8 through 10. Steele and Bramblett (1988) mention that ribs 3 through 10 show high frequencies of injury. The highly vascular structure of the ribs enables them to form a callus and heal fast. Also, injury that takes place during adolescence would not remain since bones are flexible around this time (Steele and Bramblett, 1988). Considering those facts, it seems that the injuries on the area occurred not long before the time of death. Steele and Bramblett (1988) also point out the possible causes of rib fractures include activities related to muscle action, such as coughing, childbirth, or heavy lifting; however, those causes would not apply to Case 141, considering the fact that fractures were seen only on one side of the rib cage.

Breaks on the ribs that were glued together must have taken place postmortem.

PATHOLOGY

Caries

Minor carious lesions were found on the distobuccal surfaces of the lower first left molar and of the lower second right molar. The distolingual surface of the upper right second molar exhibited a severe carious lesion.

Possible cribra orbitalia

Steele and Branblett (1988:63) describes that cribra orbitalia is a particular form of bone growth associated with a hematologic disorder and that "pneumatization" of the orbital plate of the frontal occurs in this pathological condition. Porosity is the structural characteristic of this condition which is usually observable in the lateral area of the orbital plate.

Case 141 exhibited porous, reactive bone on the orbital plates, with the porotic type of vascularization. This phenomenon is frequently observed in dry skeletal material; however, its cause is difficult to determine (Steele and Bramblett, 1988).

DJD (Degenerative joint disease)

"Articular surfaces between the vertebrae are true synovial joints and exhibit the same arthritic changes seen in all such joints. The joints between a vertebral body and disc do not have a synovial membrane, a distinction made to recognize vertebral osteophytosis as a specific degenerative condition of these superior and inferior body surfaces. Stresses and damages to fibers of fibrocartilage provoke bone deposition along ventral and lateral margins of vertebral bodies" (Steele and Bramblett, 1988:135-136).

Case 141

Severe arthritis and osteophytes were noticeable on the lumber and thoracic vertebrae. Osteophytes grew to extreme size, especially between L1 and T12, and fused the vertebral bodies together. These arthritic changes occur as a part of the aging process; however, in Case 141, they may have been enhanced by the injury to the lower limbs.

Polishing on joint surfaces

The medial condyle of both femurs and medial condyle of both tibiae were severely polished at the point of their articulation due to intense use of the regions. This could be simply the process of aging or associated with the injury.

Informative Facts and Abnormity

Handedness (Burns, 1999:157-8)

In most cases, human skeletons are asymmetrical; the relationship between bilateral asymmetry of long bones and handedness in human skeletons is reported by Steele and Mays (1995) that the dominant arm is longer than the other, which is now a general rule accepted amongst anthropologists (Burns, 1999). Thereby, the scapula and the humerus are the main indicators of handedness. In case 141 the right arm is longer than the left and that the left leg is longer than the right.

Humerus

The muscle attachment areas, especially around the deltoid tuberosity, of the right and left humeri should show differences; the dominant side would exhibit slightly larger muscle attachments.

Case 141

The muscle attachments on the right humerus were slightly larger than that on the left humerus.

= Right handed

Scapula

The glenoid fossa on the dominant side tends to display a dorsal bevel as a result of repeated reaching and wearing of the glenoid rim. The non-dominant side should simply display an osteoarthritic rim on the dorsal margin of the area.

Case 141

The glenoid fossa of the right scapula exhibited a dorsal bevel.

= Right handed

Overall, I conclude that this individual was right handed.

Muscle attachment

Case 141 showed prominent marks of muscle attachments on the long bones, which indicates intense muscle use in those areas. Actually, it is interesting to think that high muscle activity had have been performed in the life time of the person even in the lower limbs, since this individual suffered from severe injuries to the lower limbs at one time. Considering that proper treatment was not administered, it would be safe to say that this person had been engaged in intense muscle activities, at least until the injury.

Possible misplacement of the upper second left molar (postmortem)

Burns (1999:118) provides characteristic descriptions on the cusps of the upper molar, "the cusps of the maxillary molar are not in a symmetrical relationship… the mesiolingual cusp predominates on the maxillary molar… the distolingual cusp of the maxillary molars is separated from the other three by the diagonal distolingual groove". Also Bass (2005:285) illustrate that the lingual root of the upper second molar is largest but not widely divergent and that its contact facets are located mesially and distally.

Based on the observations given above, it seems that the tooth placed in the position of the upper second left molar most fits the pattern of the upper second right molar instead; it was 180 degree flipped over from the proper positioning. Its occlusal surface does not fit to the pattern of tooth arrangement of the mandibular molars either. If this is really the case, I am not quite sure where this tooth came from or how this happened, since the other teeth seem to be in the right locations.

Dental variations (Bass, 2005)

- Supernumerary teeth = Absent
- Congenital absence of teeth = Absent
- Crowding of teeth = Present on the mandible:

"Frequently the adult dentition will appear to be crowded, with one or more teeth pushed out of their normal position … This condition usually is a consequence of a reduction in the size of the mandible without a corresponding reduction in the size of the teeth. The space in the alveolus is not large enough to permit the teeth to erupt in their normal positions, so consequently they must erupt in altered positions … Crowding frequently accompanies impacted third molars and the rotated condition of teeth (Bass, 2005: 290)

- Rotation of teeth = Present partially on the left lower second premolar due crowding of the teeth in the mandible
- Extra or missing roots = NA
- Taurodontism = NA

It is "a condition found in the molars, in which the pulp cavity is enlarged and the roots are reduced" (Bass, 2005:297).

- Peg-shaped teeth = Absent
- Enamel extensions and enamel pearls = NA
- Artificial deformation = Absent

TIME SINCE DEATH

In order to determine the time since death of an individual, the amount of decomposition of human remains, the amount of animal scavenging, the life cycles of insects found on decomposing remains and their succession, plant growth found in association with human remains, and the amount of deterioration observed in material items associated with human remains can be estimated (Byers, 2002). None of the above factors applies to the Case 141. Although the fact that these remains were in a condition of complete skeletonization would provide me rough estimates, time consumed in the process of decomposition and skeletonization would significantly vary under different environmental conditions as reported by Galloway *et al*. (1989). Under hot, arid climates, skeletonization would take three months to over three years (Galloway *et al*., 1989). However, under cold, dry climates, it would take 2 months to eight years (Komar, 1998). The climates found in the People's Republic of China severely diverge, depending on the part of the county, which we do not have information of where the remains came from. Therefore, time since death of the Case 141 is undetermined.

CONCLUSIONS

The skeletal remains of Case 141 are most consistent with a white male, 35-49 years of age at death, 5’0”-5’4” in height and 110-161 pounds in weight. The tibiae and the fibulae exhibits healed fractures which also could have caused accelerated arthritis on the vertebrae and polishing on articular surfaces of the tibiae and the fibulae.

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Appendix A. List of the skeletal remains present in this case

The skull: the cranium
the mandible
Vertebrae: 7 cervical vertebrae including the atlas and the axis
12 thoracic vertebrae
5 lumber vertebrae
Thorax: the sternum (the manubrium, the corpus sterni plus the xiphoid process)
12 ribs
Shoulder girdles (left and right): clavicles, scapulas
Arms (left and right): humeri
radii
ulnae
Hands (left and right): the carpals (trapeziums, trapezoids, capitates, hamates, scaphoids, triquetrals, pisiforms, lunates)
5 metacarpals
14 hand phalanges
Pelvic girdles: the sacrum
the os coxae
Legs (left and right): femora
patellae
tibias
fibulas
Feet: (left and right): the tarsals (tali, calcaneuses, cuboids, naviculars, laterals cuneiforms, intermediate cuneiforms, medial cuneiforms)
five metatarsals
12 foot phalanges

Appendix B. List of the skeletal remains absent in this case

Hyoid
Coccyx
Left and right 4th middle/ intermediate foot phalanges

Appendix C. Cranial measurements taken (mm)

Maximum Cranial Length (GOL)	177
Maximum Cranial Breadth (XCB)	132
Byzygomatic Breadth (ZYB)	132
Basion-Bregma Heigth (BBH)	133
Cranial Base Length (BNL)	120
Basion-Prosthion Length (BPL)	97
Maxillo-Alveolar Breadth (MAB)	62
Maxillo-Alveolar Length (MAL)	49
Biauricular Breadth (AUB)	120
Upper Facial Height (UFHT)	70
Minimum Frontal Breadth (WFB)	89
Upper Facial Breadth (UFBR)	99
Nasal Height (NLH)	55
Nasal Breadth (NLB)	23
Orbital Breadth (OBB)	38
Orbital Height (OBH)	36
Biorbital Breadth (EKB)	91
Interorbital Breadth (DKB)	22
Frontal Chord (FRC)	110
Parietal Chord (PAC)	129
Occipital Chord (OCC)	96
Foramen Magnum Length (FOL)	38
Foramen Magnum Breadth (FOB)	32
Mastoid Length (MDH)	30
Chin Height (GNI)	34
Height of the Mandibular Body (HMF)	32
Breadth of the Mandibular Body (TMF)	11
Bigonial Width (GOG)	103
Bicondylar Breadth (CDL)	112
Minimum Ramus Breadth (WRB)	30
Maximum Ramus Breadth (XRB)	46

Appendix D. Postcranial measurements taken (mm)

		Left	Right	Average
Clavicle	Max. Length	136	131	134
Scapula	Height	151	148	150
	Breadth	93	92	93
Humerus	Max. Length	285	290	288
	Epic. Breadth	60	60	60
	Max. Vert. Diam. Head	45	45	45
	Max. Diam. Mid.	21	21	21
	Min. Diam. Mid.	17	19	18
Radius	Max. Length	221	221	221
	A-P Diam. Mid.	12	12	12
	Transv. Diam. Mid.	13	15	14
Ulna	Max. Length	244	246	245
	Dorso-Volar Diam.	13	15	14
	Transv. Diam.	15	17	16
	Phys. Length	216	217	217
Innominate	Height	201	196	199
	Iliac Br.	151	153	152
	Pubic Length	81	77	79
	Ischium Length	67	67	67
Femur	Max. Length	399	395	397
	Bicondylar Ln.	398	394	396
	Epicondylar Br.	75	75	75
	Max. Diam. Head	45	45	45
	A-P Subtroch. Diam.	29	29	29
	Trans. Subt. Diam.	28	28	28
	A-P Diam. Mid.	26	28	27
	Transv. Daim. Mid.	26	27	27
Tibia	Con.-Malleo. Ln.	335	335	335
	Max. Prox. Epip. Br.	71	72	72
	Max. Dist. Epip. Br.	51	51	51
	Max. Diam. Nut. For.	35	37	36
	Trans. Diam. Nt. For.	25	28	27
Fibula	Max. Length	322	314	318
	Max. Diam. Mid.	19	19	19
Calcaneus	Max. Length	77	76	77
	Middle Breadth	41	41	41
Sacrum	Ant. Height	NA	NA	115
	Ant. Surface Br.	NA	NA	108
	Max. Breadth S1	NA	NA	48