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A Comprehensive Case Report on University of Montana Forensic Case 66

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A COMPREHENSIVE CASE REPORT ON UNIVERSITY OF MONTANA FORENSIC CASE 66

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UMFC 66 is an anatomical specimen from the Physical Anthropology Lab at The University of Montana-Missoula. It is a nearly complete skeleton that exhibits no trauma. I examined the literature on suitable approaches to estimating age from the skeleton, because age is difficult to estimate for this case and presents an interesting challenge. I also estimated sex, ancestry, stature, and weight. I concluded that UMFC 66 is an American Indian, perhaps 20 to 28 years of age with a relatively short stature of about 1.56m (5'01"), weighing approximately 115 to 129 pounds. There is severe osteomyelitis throughout the left lower extremity. Time since death is within modern times, between World War II and the past few years.

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Tables and Figures

CHAPTER 1: INTRODUCTION

The skeleton of UMFC66 is curated in the Physical Anthropology Laboratory at the University of Montana-Missoula and classified as UMFC66. It is the skeletal remains of a previously buried individual. Because of the severe degree of osteomyelitis, it is possible that this was an impoverished, maybe homeless individual.

In the case of suspicious or unknown deaths, time of death is essential information necessary to determine the cause. Haglund and Sorg (1997) maintain that estimating the time interval since death can be extremely difficult. For the most part, this approximation is based on the amount and condition of soft tissue, such as skin, muscle, and ligaments remaining after decomposition, the preservation of the bones, extent of plant root growth, odor, and any carnivore and insect activities. In addition, many other variables must also be kept in mind, including the temperature at the time of death, open wounds, water retention, soil pH, and extent of dampness/dryness. The more time that has elapsed since death, the more challenging it is to determine the time interval since death.

Except for the severe osteomyelitis in the left lower extremities, this skeleton is in reasonably decent condition, showing little to no indication of deterioration. The bones are stained a brownish hue as a result of having been buried. Judging by the excellent quality of the bones and the lack of noninfectious deterioration, I would estimate this individual died in modern times, between the end of World War II and the last few years. Calculating the postmortem interval is a challenging process since there is no soft tissue to determine time since death. There is no information on the provenience of this skeleton and no way of knowing where it came from or how the University came into possession of it.

CHAPTER 2: SKELETAL INVENTORY AND DESCRIPTION

SKULL: The skull is small and somewhat gracile. Only about 45% of the maxillary dentition is present. The skull is of medium proportions with a cranial index of 75.0 to 79.9 (mesocranic). The skull of UMFC66 is of medium dimensions with a cranial index of 75.0. The cranial length-height index is 75.0, placing it in the hypsicranic range, reflecting the fact that this individual has a relatively high skull. Ignoring dentition, the skull is 100% complete, except that the hyoid bone is missing.

MANDIBLE: Like the skull, the mandible is somewhat gracile with a rounded mental region. The dentition is 75% complete with congenitally absent third molars. RM_1 was lost antemortem because of the presence of bone resorption; the other missing teeth were lost postmortem. Either this individual's third molars are missing congenitally or they were removed antemortem and accompanied by bone resorption. In the maxillary region, all of the teeth are present except for all of the incisors, both third premolars, and both third molars. In the mandible, all teeth are present as well, except for both central incisors, the right third premolar, the right first molar and, as mentioned above, both third molars; the dental inventory is illustrated in Appendix C. The left lower second molar has some broken enamel on the mesial side. Excluding the third molars, all other tooth loss is postmortem since there is no bone resorption.

CLAVICLES: The right clavicle is missing entirely. There are, however, two left clavicles. The bones are 100% complete and unbroken.

STERNUM: The manubrium and sternal body are unfused and the xiphoid process is missing.

RIBS: Except for ribs five and eight on the left side, there is a full compliment.

VERTEBRAE: Five of the cervical vertebrae are present, including C-1, C-2, as well as C-4 through C-6. Two of the vertebrae have partially fractured spinous processes. All but one of the thoracic vertebrae is present. All lumbar vertebrae are accounted for, as well as an additional one (this individual has six lumbar vertebrae). The thoracic and lumbar vertebrae are affixed together with some type of gray adhesive clay, and all the vertebrae are joined by a string running through the vertebral foramina.

SCAPULAE: Both scapulae show postmortem damage in the form of small (<16mm) slits on the infraspinous area. The left Scapula is wider and shorter than the right. Both are about 100% complete.

HUMERI: Both humeri are present and 100% complete.

RADII: Both radii are present and 100% complete.

ULNAE: Both ulnae are present and in good condition.

HANDS: The left trapezoid is present as well as one right and one left hamate. There are also two right 2nd metacarpals as well as two right 4th metacarpals and one 5th metacarpal from both the right and left sides. Five proximal phalanges and one middle phalanx are also present.

SACRUM: The sacrum is present and fully complete. The coccyx is fused to the sacrum and its tip is missing. There is also some evidence of infection.

OS COXAE: Both coxals are present. The right one shows evidence of osteomyelitis.

FEMORA: Both are present. The left femur is very badly deformed due to a severe bone infection.

TIBIAE: The left tibia is the only one present. The proximal end is, to some extent, affected by osteomyelitis.

FIBULAE: Both the right and left fibulae are present. They are 100% complete. The left fibula shows evidence of possible osteomyelitis on the proximal and distal ends.

FEET: Three of the tarsals (left calcaneus, left talus, and right navicular) are present along with the right second, third, and fourth metatarsals. The posterior aspect of the left calcaneus shows considerable deterioration and bone remodeling.

CHAPTER 3: MATERIALS AND METHODS

1. Age estimation
    - Işçan costosternal deterioration technique as presented by Burns (1999).
    - Vertebral osteophyte formation according to Albert and Maples (1995).
    - Used the McKern and Stewart, as cited by Bass (2005), method to determine median clavicular epiphysis closure.
    - Todd (1920) method of using the pubic symphyseal face as presented by Buikstra and Ubelaker (1994).
    - Additionally, I compared the Todd (1920) method to Gilbert and McKern (1978), Katz and Suchey (1986), and Brooks and Suchey (1990) pubic symphysis technique, each cited by Burns (1999).
    - Lovejoy et al. auricular surface method as referred to by Bass (2005).
    - Finally the Tromly (1996) method for determining degree of dental attrition.
2. Sex determination
    - Used the Ascádi and Nemeskéri method for sexually dimorphic cranial features presented by Buikstra and Ubelaker (1994).
    - Applied the Phenice (1969) method for pelvic morphology
    - Sacral morphology based on Anderson, as cited by Bass (2005).
    - Bass' (2005) discussion of femur sexing from Pearson.
3. Ancestry estimation
    - Applied the Bass (2005) technique from Giles and Elliot using discriminant functions.

- Made use of FORDISC 3.0, developed by Ousley and Jantz (2005), for osteometric analysis.

4. Stature

- Trotter and Gleser (1958) discriminant functions for determining stature from long bone length.

CHAPTER 4: AGE ESTIMATION

According to Bass (2005), age estimation is usually quite defined during the first stages of growth and development; epiphyseal plate closure, and bone ossification are the two key distinguishing features. On the other hand, when the growth process has finished and the permanent dentition has erupted, age assessment difficulty increases, and evaluation of the degenerative processes must be applied. As Burns (1999) points out the pubic symphysis of the pubic bone, the auricular surface of the ilium and the sternal end of the fourth rib are the most accurate indicators of age-at-death in adults. To a much lesser degree, the closure of cranial sutures can be utilized as well. Additionally, in older adults, processes of deterioration including arthritis, osteophyte formation, and osteoporosis can be used for common age estimates. Burns (1999) maintains that the stages of tooth eruption, fusion of epiphyses, and patterns of ossification in infants and children are very useful for estimating age. She goes on to state that bone development continues for repair of fractures and remodeling to deal with changes in lifestyle and stresses, even after adulthood is reached. Degenerative processes cause bone to go through continual remodeling and modification.

The true age of the individual is often disguised by environmental, nutritional, and disease pressure; however, the chronological age is often an estimate of the biological age which is based upon patterns of growth and deterioration. In addition, the accuracy with which age estimation can be performed becomes more difficult as the age approaches old age. In other words, the younger ages are estimated principally on the basis of developmental changes making more precise estimates possible, while in older individuals, estimates are often achieved by noting the degenerative changes, which are less accurate, as indicated by Bass (2005).

Since all bones are fully developed (i.e. all epiphyses are closed), it is apparent that UMFC66 is an adult. Using the epiphyseal closure for the humeral head, coronoid process of the scapula, distal humerus, humeral medial epicondyle distal radius, distal ulna, femoral head, greater trochanter, distal femur, distal/proximal tibia, distal/proximal fibula, and the sacrum, it is apparent from the complete fusion of these areas that this is an adult that may be as old as thirty years of age.

As illustrated by Albert and Maples (1995), osteophytes, or bone spurs, are a normal part of the aging process; the body creates them to better distribute weight across a joint that has been damaged by a condition such as arthritis. Osteophyte formation is a normal part of the aging process and is attributed to physical stress and deterioration.

There are no signs of vertebral osteophytes on the spinal column of UMFC66, and since the epiphyseal ring is fused to the vertebral body with no evidence of osteoarthritis, and a smooth and solid appearance it corresponds to an age range of twenty to twenty-nine.

Burns (1999) presents the method that Isçan et al. developed for age estimation based on changes at the sternal end of the fourth rib. Over time, the costosternal cartilage begins to ossify slightly due to the typical stresses placed on it, this appears with intensified degeneration, thinning and increased porosity at the ends of this surface. These changes are similar to those that occur on the symphyseal face of the pubic bone. Sex, pregnancy and activity patterns do not produce as much variation in the phases of sternal rib end as occurs on the pubic symphyseal face. There is a noticeable difference between ossification patterns in males and females.

In the case of UMFC66, the costosternal articulation appears to coincide with Stage 1/Stage 2: mid-teens to early twenties. The center takes on a dish shape and has little or no deterioration, while edges still retain an even rounded appearance. Ideally, the fourth rib should be used for analysis, but in this case, the sternal end is broken on both the right and left sides. In light of this, I used the sixth and seventh ribs to make my determination. The lack of deterioration leads me to conclude that this is a young adult, while the other ribs exhibit the same pattern supporting this conclusion.

As Bass (2005) states, according to McKern and Stewart, the medial (or sternal) clavicular epiphysis unites relatively slowly, usually beginning around 18 years of age. In the human skeleton, it is generally the last long bone epiphysis to fuse, usually fusing in the mid-twenties. This fusion is, therefore, useful when estimating age at death in post-adolescent individuals.

The sterno-clavicular epiphysis of UMFC66 is completely fused indicating this individual is older than twenty-five years old. The spheno-occipital synchondrosis, or basilar suture, is another commonly recognized suture closure. In the case of UMFC66, the suture is closed indicating this individual was no older than about twenty-five.

Variation in the face of the pubic symphysis is a region frequently analyzed for age estimation. Based on a large sample of male os coxae, as synthesized in Bass (2005), Todd outlined a 10-stage method for evaluating this pubic symphyseal surface. Changes in this surface over time continue in a predictable pattern from a heavily contoured face, to one bordered by a rim in the mid thirties, and to a surface marked by increasing porosity after forty years. According to Todd's method of pubic symphysis age estimation there are 10 phases ranging from ages 18 to 50 and over. The difficulty with this system is that the approximate ages from 20 to 40 have a tendency to be more reliable than ages over 50 years. In general, the phases can be categorized into the following groups: the post-adolescent stage (Phases I-III), increased growth (Phases IV-VI) and finally the degenerative process (Phases VII-X).

On examination of the pubic symphysis of UMFC66, it is reasonably apparent that the symphyseal faces can be categorized as Phase IV, corresponding to age 25-26. The billowing pattern is beginning to deteriorate with a slight appearance of granularity. There exhibits a large increase of ventral beveled area with equivalent reduction of ridge and furrow formation.

As presented by Burns (1999), the methods Todd used were reworked by several anthropologists: namely, Brooks, McKern and Stewart, Gilbert and McKern, Katz and Suchey, and Brooks and Suchey. Each tried to understand whether Todd's methods were really successful and if there was a way to enhance his techniques. It is my belief that after detailed study of the pubic symphysis it became evident that the Todd method was sufficient and there was in fact no satisfactory way of improving it. The Katz and Suchey and Brooks and Suchey methods took Todd's ten phases and narrowed them down to six phases. It is clear that the younger ages are more accurate with a lower range between ages, especially in the Katz and Suchey method. For example, Stage 1 has a range of eight years whereas Stage 6 has a fifty-one year range.

Using the Katz and Suchey method, as cited by Burns (1999), the pubic symphysis morphology of UMFC66 is categorized as Stage 2 (19 to 35 years of age), with obvious ossified nodules, a dorsal plateau, as well as the beginning of ventral slanting.

The site of articulation of the os coxa with the sacrum, known as the auricular surface, was the second pelvic age indicator employed. The method, cited by Bass (2005), was developed by Lovejoy et al., using a portion of the os coxa often better-preserved in context than the pubic symphysis. In a system similar to Todd's pubic symphysis method, the auricular surface technique compares changes in billowing, granulation, porosity, and transverse organization on the face of the os coxae's articulation with the sacrum. It also permits a bit more refinement at aging older individuals, with 50-60 year and older age categories.

Applying the technique illustrated in Burns (1999), developed by Meindl et al., and later refined by Meindl and Lovejoy, it becomes clear that UMFC66 exhibits a reduction of billowing with slight microporosity. The billowing has, to some extent, been replaced by striae, placing this individual into Phase 2, corresponding to an age range of 25-29, which is consistent with age ranges acquired by other methods.

Since all permanent dentition is not present and there are no third molars, it is not possible to determine age from dental eruption except to say that this is an adult. In his Master's Thesis, Tromly (1996) observed that the degree of dental attrition is a useful indicator of an individual's age at death. Attrition is the loss of enamel by forces from opposing teeth acting on each other. Attrition initially affects the enamel and, may proceed to the underlying dentin if left unchecked. Once the enamel has eroded away, attrition quickly damages the dentin beneath. Relatively minor amounts of force are placed on teeth from everyday behaviors such as mastication and swallowing. Occupational practices, such as holding items with the teeth, place greater amounts of forces on the opposing surfaces cause the teeth to wear much more quickly. Diet can also cause wear, especially when food has a high concentration of grit, such as sand or dirt. As expected, wear typically starts on the occlusal surfaces.

In the case of UMFC66, there is dentin exposure on all cusps of the first molar, one of which is pinpoint indicating that this individual was seventeen to thirty-five at time of death. The other teeth are missing, broken, or too worn to determine degree of dental attrition.

On the basis of these eight techniques applied to estimate age at death, I am able to deduce with reasonable certainty that this individual was between the ages of fifteen and thirty-five with a narrow range of twenty to twenty-eight. Using a technique of means, I devised a convenient and straightforward technique to achieve a narrow and wide age range from the data acquired. I used each age estimation method and placed the minimum age of each range in one column with the maximum age in the column next to it. Upon averaging these values the narrow age range differences are established, I then determine the minimum age in the minimum column and the maximum age in the maximum column to acquire the wide age range. Table 1 illustrates this method in practice.

	AGE RANGE	
TECHNIQUE	**Minimum**	**Maximum**
Sternal rib ends	15	20
Pubic symphysis: Todd	25	26
Pubic symphysis: Brooks and Suchey, Katz and Suchey	19	35
Dental attrition	17	35
medial clavicle	25	27
Vertebral epiphysis	20	29
Basilar Suture	17	25
Auricular surface	25	29
Narrow Age Range	**20**	**28**
Wide Range	**15**	**35**

Table 1: Age estimation applying means

CHAPTER 5: SEX DETERMINATION

Sex determination of an individual is an important step in identifying a skeleton. Although there is a good deal of variation within and between the sexes, there are several measurements that are accurate determinants of sex. Sex determination can be accurately assessed through examination of the pelvis and cranium, and to a lesser degree the long bones, especially the femur. As Falk (2004) states, it is only truly possible to determine sex with adolescent or adult skeletons since there is little to no sexual dimorphism in preadolescent children since changes in the skeleton do not appear until puberty. Using the size of the bones is one of the general ways to determine sex since males are inclined to have larger bones than females. This is known as sexual dimorphism. This does not apply in every instance. Occasionally males have gracile skeletons and females have robust skeletons. The os coxae are two of the most common bones to use if they are available. The subpubic angle is much wider in females, usually more than 90°, while in males it is typically less than 90°.

Specific measures of differences in sexual dimorphism have been developed. Particularly, according to Burns (1999), male crania tend to be larger and more robust than female crania. They typically have thicker supraorbital ridges, a more outstanding glabella, and very prominent temporal lines. In addition they have larger, broader palates, squarer orbits, larger mastoid processes, larger sinuses, and bigger occipital condyles than those of females on average. Male mandibles typically have squarer chins and thicker, rougher muscle attachments than female mandibles. Within human populations these features differ considerably, making it somewhat difficult to identify the sex of a skull without knowing which population it came from. On the whole, male skeletal features are bigger with stronger muscle attachments. Burns (1999) describes the adult female cranium as maintaining the gracile features of pre-adolescence. The male cranium, on the other hand, becomes more robust and noticeably rougher especially at the sites of muscle attachment. Major differences between the female and male skull include the occipital region, thickness of the supraorbital ridge, glabellar prominence, nuchal crest, mastoid process, temporal lines, and mandible. Essentially, the male cranium becomes thicker and more robust, as mentioned above. It takes a great deal of expertise and training to visually determine sex from just a cranium, which is why it is best to have one or both os coxae as well. The male cranium tends to have blunt supra-orbital margins and larger supra-orbital ridges. The female cranium tends to have sharp supra-orbital margins and no discernible supraorbital ridges according to Bass (2005). The occipital of males tend to have a well-defined nuchal crest. In some cases, the nuchal crest and nuchal line are very rugged and sharp. In very gracile females, there is almost no nuchal crest and the nuchal line is completely absent. There is a tendency for the mandible of a female to have a rounded chin. The gonial area is smooth and does not project. The mental eminence of the male mandible is inclined to be much more squarely shaped and the area around the gonial angle is broadened in some cases. In addition, male dentition is often larger. Finally, the temporal region in the female cranium is smoother and less rugged than that of the male cranium. In the female cranium the zygomatic arch normally does not extend, as a ridge, past the external auditory meatus. In male crania the zygomatic arch does typically extend past the external auditory meatus. In females the mastoid process is small and smooth while in males it is large and rugged.

As Bass (2005) states, sex determination is somewhat more straightforward than age estimation or ancestry determination since there are fewer categories. There are five categories into which an individual skeleton could possibly be placed: male, possible male, indeterminate, possible female, and female. In other words, sometimes males can have female traits and vice versa; and on occasion it is just too difficult to accurately determine.

Visual analysis of the cranium indicates that this is a female. There is little to no supraorbital ridge, a small mastoid process, and a single central boss on the frontal bone. The nuchal region shows a small muscle attachment. In addition to this, the zygomatic process ends before reaching the external auditory meatus. Interestingly, the mandibular ramus is wide and sharply angled, which is a male trait. However, the mental eminence is rounded/pointed indicating a female. Since, based on cranial traits, six of the seven (86%) traits match a female, I am fairly confident that this is a female. Further visual analysis of the cranium was done by assessing the morphology of five landmarks. Among these are the nuchal crest, mastoid process, supra-orbital margin, supra-orbital ridge, and the mental eminence. According to Buikstra & Ubelaker (1994), Ascádi's and Nemeskéri's cranial sex estimation shown in table 2 below illustrates the relative scores of each landmark.

1	Nuchal Crest	2
2	Mastoid Process	3
3	Supra-orbital Margin	1
4	Supra-orbital Ridge	2
5	Mental Eminence	2
$\bar{x}$	***MEAN***	***2***

Table 2: scores for sexually dimorphic cranial features

Taking the mean of the scores results in a number score of 2, this corresponds to a probable female.

As described by researchers at the University of Notre Dame (n.d.), bipedal locomotion and childbirth are the two main factors that control pelvic morphology. There is substantial sexual dimorphism in the pelvic region due to the need to facilitate childbirth. This difference is particularly useful for determining the sex of an individual. The pelvis is the only region of the skeleton that that shows such a difference between male and female members of the species. Morphology of the individual parts of the coxal bones, such as the pubis, auricular surface, and overall shape, are the most useful for determining sex. Features of the coxals such as shape of the pubic bone, elevation of the auricular surface, size/shape of the sciatic notch, size/shape of the acetabulum, presence of a preauricular sulcus, and curvature and width of sacrum, were useful in this analysis.

As described in Burns (1999), the greater sciatic notch is narrower for males and wider in females. In general the acetabulum is larger and deeper in males than in females. The sacrum is straighter in females and has more of a curvature in males, causing it to protrude slightly into the pelvic inlet; which is larger in women to allow the birthing process to occur. In addition to cranial morphology there are other useful bones, and other features to look for; however these are the most common ways of deciding the sex of a skeleton. Using a combination of features is the best way to determine an individual's sex. Due to variation, single traits may not always be representative of the sex of the individual. Therefore, it is best to use multiple features in determining sex however, with the limited amount of material that is often found, this is not always possible.

The best indicator of sex on the adult skeleton is the morphology of the pubic bone. The Phenice (1969) method is based on analysis of the following landmarks:

1. Ventral arc

2. Subpubic concavity

3. Medial portion of ischiopubic ramus

These three characteristics can distinguish male from female 95% of the time, according to Phenice (1969).

Applying the Phenice (1969) method to UMFC66, it is apparent that the ventral arc is a slightly elevated ridge of bone on the anterior (ventral) surface of female pubis, extending inferolaterally. The presence or absence of ventral arc is most determinative of the 3 Phenice (1969) characteristics. The subpubic concavity is a result of females having a longer pubic part of the coxal bone, the subpubic angle and hence the subpubic concavity has to be larger in females. Medial aspect of ischiopubic ramus in females is a ridge, sometimes a narrow surface, inferior to the symphyseal face.

As discussed by Bass (2005), Anderson states that the sacrum is prominently sexually dimorphic; in the female the sacrum is shorter and wider than in the male. The lower half of the sacrum develops a greater angle while the upper half is nearly straight, the lower half presenting the greatest amount of curvature. The direction is pointed more diagonally backward; this increases the size of the pelvic cavity and renders the sacrovertebral angle more prominent. The sacral curvature is more uniformly distributed over the whole length of the bone in males, and is greater overall than in the female. The sacrum is straighter in females, more curved in males in direct relation to childbirth. The sacral body to the two alae ratio is 1:1:1 in females, on the other hand, the body in males is greater than $^{1}/_{3}$. Sacral morphology reveals that UMFC66 is consistent with a female since it lies reasonably flat.

In the postcranial skeleton, measurements of the femur, sternum, scapula, and the humerus were taken. Two measurements of the scapula were taken- maximum scapular height, glenoid cavity height, and these measurements were subjected to discriminant function analysis.

The femur is the longest and strongest bone in the body, making it an ideal bone to determine robusticity as well as sexual dimorphism. Four measurements of the femur were taken to determine sex based on the Femur Sexing table devised by Pearson as cited by Bass (2005). The vertical head diameter is 41mm suggesting that this person is female. The trochanteric oblique length is 384mm also representing female. The bicondylar width is 65.5mm, also consistent with female. In addition to this, the circumference of the midshaft is 73mm, indicating female as well. The popliteal length is 129mm, which is consistent with an indeterminate sex. The subsequent table indicates that 75% of the femoral indicators are consistent with a female; while 25%, namely popliteal length is indeterminate. The difficulty with this method is that Pearson performed his research on seventeenth century Londoners, which are probably not compatible with the population to which UMFC66 belongs. If this population was characterized by a generally smaller body size than those examined by Pearson, the males will more often score as females.

MEASUREMENT	FEMALE	POSSIBLE FEMALE	INDETERMINATE	POSSIBLE MALE	MALE	UMFC66
Vertical diameter	<41.5	41.5-43.5	43.5-44.5	44.5-45.5	>45.5	40.6mm
Popliteal length	<106	106-114.5	114.5-132	132-145	>145	129mm
Bicondylar width	<72	72-74	74-76	76-78	>78	65.5mm
Trochanteric oblique length	<390	390-405	405-430	430-450	>450	384mm

Table 3: Sexing the Femur [after Pearson] - **UMFC66** (Bass, 2005)

Gutnam et al. (1980) used 400 Native American sterna to determine sex from the combined length of the manubrium and the corpus. They determined that if the combined measurement is greater than 140mm then the skeleton is male, and that it is female if the total is less than 131mm.

Interestingly, the length of the manubrium of UMFC66 is 54.5mm and the body measures 101.5mm with a combined length of this sternum is 156mm, indicating male. This is inconsistent with most of the other postcranial measurements.

In males, the body of sternum is greater than two times the length of the manubrium; in females, less than two times the length according to McCormick et al. (1983). The previous method is more of a guideline than a rule. Since the sternal body of UMFC66 is slightly less than twice as long as the manubrium, UMFC66 may possibly be a female.

The other bone not consistent with a female determination is the scapula. As put forth by Bass (2005), measurements by Dwight of the scapular length were taken from the superior border to the inferior border; the glenoid cavity height is measured as well. The scapular length, of 161mm, is consistent with a male while the glenoid cavity height, of 36.86mm, indicates an indeterminate sex. The maximum scapular length is 161 mm consistent with a male; the glenoid cavity height is 36.86 mm representative of an indeterminate sex.

Sex determination is normally examined by osteologists, according to Bass (2005). The only tibia present has distal and proximal deformations due to osteomyelitis and would reveal incorrect results if used.

According to Bass (2005), "the humerus is the second-best bone for sex estimation." Measurement of the humeral head of UMFC66 in the vertical and transverse orientations is 40.93mm and 32.53mm respectively, signifying a female. There is a possibility that small males could score as females with this technique.

Of the six postcranial bones analyzed, about 67%, or four of the six, indicate female. In addition to this, the cranium shows evidence that this individual was probably a female.

CHAPTER 6: BIOLOGICAL AFFINITY

As illustrated by Leakey (1994) since we all share common descent from Africa, the only differences we share are based solely on climatic adaptations. These differences are merely "skin deep" and do not reflect distinct races, only different biological affinities. Even though there may have been apparent geographic boundaries in the past making interbreeding nearly impossible, populations have become much more mobile in recent centuries greatly modifying genetic populations.

As stated by The American Association of Physical Anthropologists (1996) we all share the same ancestry as members of Homo *sapiens*. There is, however, a great deal of genetic variation due to several factors such as gene flow and mutation resulting from migration to all regions of the planet. Race is an illusory phenomenon; it is based mainly on what we perceive visually and on arbitrary definitions of customs as well as cultural practices. As far as forensic anthropologists such as Bass (2005) are concerned, the only area of the skeleton from which race can be determined is the cranium, and accuracy is fairly low. Race is only useful for identifying a population on a superficial level in order to distinguish them from other members of the group, narrowing down search parameters. Although at one time there may have been relative geographic separation of biological groups (due to boundaries impeding travel, such as mountains, deserts, rivers, and oceans). This implies that interbreeding was more difficult; migration and mobility and genetic changes within populations have changed this.

As illustrated by Burns (1999) in image 2, Europeans generally have the lowest degree of projection, or prognathism, of the alveolar ridge bones which contain the teeth, a notable size prominence of the cranium and forehead region, and a narrow, "ridged" nasal aperture. African traits are generalized to include a broader, more rounded nasal cavity, lower facial prognathism, and a dolichocephalic skull (proportionally longer from front to back). Individuals of American Indian descent sometimes are characterized, by relatively no prognathism, complex sutures, and a rounded cranium. It is important to note that many of these characteristics only have a higher frequency among particular population and the presence or absence of one or more does not automatically classify an individual into a racial group. Utilizing FORDISC can further assist in the interpretation of craniofacial measurements in regards to ancestry/race determination.

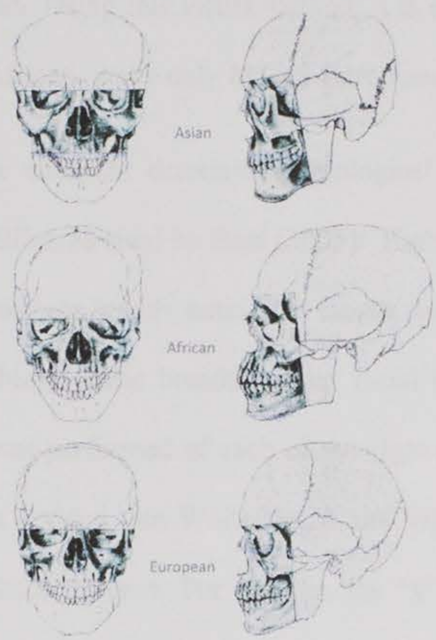

Image 2: Cranial ancestry traits

Non-metric cranial examination, based on the standards in Burns (1999) reveals UMFC66 to have traits of both American Indian, possibly including Asian and African descent, with mostly American Indian traits. The dentition is not crowded, the zygomas are small and retreating with curved or "S"-shaped zygomaxillary sutures as well as simple cranial sutures, all indicative of African ancestry. On the other hand, the palatal shape is elliptic with a straight palatal suture. The nasal bones are low with a "tented" morphology; there is a medium nasal aperture, and nasal spine. The mental eminence is blunt and the mandibular ramus is wide. Overall, the cranium is low and sloping, all consistent with American Indian ancestry. The degree of prognathism, which is little to none, is the only European trait, indicating possible distant European ancestry. There are eight traits consistent with American Indian ancestry and only four consistent with African. Using this visual method, it is evident that 67% of the traits are American Indian, 33% are African, while only 8% are European.

An additional technique used for determining biological affinity is the discriminant function analysis of Giles and Elliot, as cited by Bass (2005). Eight craniometric measurements are used consisting of basion-prosthion length, maximum length, maximum breadth, cranial base length, basion bregma height, bizygomatic breadth, upper facial height, and nasal breadth. A discriminant function analysis was performed of each of the eight measurements. Each column for male and female are further divided into White/Negro and White/Indian and a sum of the measurements is acquired for each column. For females the "y" axis (White-Negro) border between races is 92.2 whereas the "x" axis (White-Indian) racial border is 130.1.

UMFC66

			MALE		FEMALE		
		Measurement	WHT/NEG	WHT/IND	WHT/NEG	WHT/IND	SEX
1	Basion-Prosthion Ht. (ba-pr)	95	290.7	9.5	165.3	289.8	-95
2	Glabello-Occipital Ln. (g-op)	176	281.6	-44	225.3	-183	204.2
3	Maximum Width: (eu-eu)	132	-250.8	-205.9	-155.8	-714.1	
4	Basion-Bregma Ht.(ba-b)	132	-236.3	96.4	-18.5	566.3	
5	Basion-Nasion Ht. (ba-n)	100	-441	-29	-234	-402	211
6	Bizygomatic Breadth(zy-zy)	137	-13.7	239.8	-5.2	769.9	227.4
7	Prosthion-Nasion (n-pr)	65	168.4	-10.4	-1.7	-65	*258.7*
8	Nasal Width (al-al)	23	242.9	-19.3	56.4	-50.4	
			41.8	37	*31.8*	*211.4*	**806.3**
							FEMALE

Table 4: GILES & ELLIOT RACE WORKSHEET FROM BASS (2005)

performing two essential functions. Using standard cranial and postcranial measurements, it can classify unknown individuals into ancestry and sex groups by using multiple discriminant function analysis, and it can also derive stature estimations by the limit of a model so the best possible fit of the data can be achieved. Most of the data used in these analyses is taken from a large forensic database, the University of Tennessee Forensic Data Bank, which is comprised of individuals from around the country that are of known race and sex who were born after 1900.

FORDISC 3.0 utilizes as many as 33 cranial variables and a total of 76 postcranial variables in order to calculate ancestry based on a range of two to eleven classifications. Based on the results of my visual examination I selected American Indian, Japanese, African, and European females for this analysis. The study of UMFC66 is based on thirty cranial measurements and forty-one postcranial measurements (see Appendix B).

The first table of the results indicates that of the 24 total American Indian female samples, 21 fit into American Indian female while three correspond with Japanese female, whereas zero match African and European females. The second table (multigroup classification) indicates that of the four groups, American Indian is the closest to its centroid with a posterior probability value of 0.919 or 91.9% and a typicality of 0.946 or 94.6%. Next is Japanese with a typicality of 0.185 or 18.5%, while the African and European are farthest with values of 7.2% and 2.0% respectively. Based on the FORDISC 3.0 analysis as well as visual analysis, I am reasonably confident that this individual is of American Indian ancestry. I conclude that the ancestry of this individual is American Indian. The archaic term "Mongoloid" was used to describe Asians and American Indians for many years. In trying to avoid using this terminology, I chose to refer to this individual as American Indian, but this individual could have just as well been Asian. The methods used by forensic anthropologists are unable to reliably distinguish between people of Asian and American Indian descent.

Cranial morphology can be expressed using a number of cranial indices. These indices may be used to assist in determination of ancestry. For example, the nasal aperture is broad indicating African origin; the high cranial vault is a European trait. In addition to this, the broad elliptical shaped palate is consistent with American Indian descent. Table 5 below illustrates the cranial indices for this individual.

Element	Index	Description	
Cranial Index	75	mesochrany	medium
Cranial Module	146.7		
Length-Height Index	75	hypsicrany	medium
Breadth-Height Index	100	acrocrany	high
Fronto-Parietal Index	69	metriocrany	medium
Nasal Index	46	platyrrhiny	broad
Total Facial Index	38	hypereuryprosopy	very broad
Upper Facial Index	47	euryeny	broad
Palatal Index	122.9	brachystaphyline	broad
Orbital Index	94.7	hypsichoncy	narrow

Table 5: Cranial Morphology based on cranial indices from Bass (2005)

Cranial index is the relationship between the maximum breadth and the maximum length of the cranium. The formula is as follows:

$$\mathit{Cranial\ Index} = \frac{\text{maximum cranial breadth} * 100}{\text{maximum cranial length}}$$

These indices are displayed as a percentile number, providing the most straightforward description of the ratio of two proportions. The other indices follow the same format depending on the feature being evaluated.

CHAPTER 7: WEIGHT AND STATURE

As the University of Texas - Austin eForensic (n.d.) website states, stature is the normal height of a human in a standing position and is usually calculated from a regression formula based on the population and sex to which the case being analyzed belongs. Stature estimation is based on long bone measurement. The best bones to utilize are the humerus, femur, and tibia. However, the radius, ulna and fibula can also be used if these bones are not available. I was unable to use the tibial measurements since the only tibia present is partially deteriorated from osteomyelitis and is incomplete.

In order to obtain an accurate estimate of the stature using the six long bones, I calculated an average of all the Totter and Gleser (1958) discriminate function results which are shown in Table 6. In the case of UMFC66, I calculated the height to be in the range of 1.521m (5'00") to 1.595m (5'03") with a mean of approximately 1.558m (5'01").

AMERICAN INDIAN FEMALE

BONE	LENGTH	MINIMUM	MEAN	MAXIMUM
Humerus	315	159.36	163.81	168.26
Radius	249	168.72	172.96	177.2
Ulna	275	170.89	175.19	179.49
Femur	416	152.89	156.61	160.33
~~Tibia~~	----	----	----	----
Fibula	328	152.14	155.71	159.51
all measurements in mm				

Table 6: Stature based on discriminant function investigation of long bone length

There is no reliable way of estimating weight given of the lack of soft tissue. However, I employed the Halls (2003) Metropolitan Life tables of height and weight for a female with a height of 5'01" and a medium frame, corresponding to a weight between 115 to 129 pounds. This is the ideal weight of an individual of medium frame standing 1.56m (~5'01"); in my opinion the usefulness of weight estimation is extremely questionable.

CHAPTER 8: TRAUMA AND PATHOLOGY

Osteomyelitis, according to Babcock (2006), is a bone tissue infection that is usually the result of an infection elsewhere in the body. Osteomyelitis may occur for many different reasons and can affect both children and adults and is usually the result of a bacterial infection that spreads to the bone via the bloodstream.

As described by King (2006), when osteomyelitis affects adults, it often involves the vertebral bones and the pelvis, whereas in children the long bones are usually affected. *Staphylococcus aureus* is normally the source of the blood infection although it may be caused by a different type of bacteria or fungal organism such as syphilis, or tuberculosis. Syphilis is a curable sexually transmitted disease caused by the *Treponema pallidum pallidum* bacterium (http://www.mayoclinic.com/health/syphilis). Sexual contact is the primary transmission route, although sometimes transmission from mother to child during pregnancy can occur. Tuberculosis is caused by the *Mycobacterium tuberculosis* bacteria and usually affects the lungs, but it can also affect the bones and joints where it is spread from the lungs according to The Centers for Disease Control and Prevention (2007).

Researchers at the University of Virginia (2008) states that an infection caused by a traumatic injury, repeated injections, or a surgical procedure can be another cause of osteomyelitis. Additionally, individuals with diabetes who develop foot ulcers are more prone to contract the infection; the organism has direct entrance into the affected bone under these conditions. Individuals with a with a weakened immune system including those with sickle cell anemia, Human Immunodeficiency Virus (HIV), or individuals taking medications to suppress the immune system such as chemotherapy or steroids tend to be at greater risk for contracting osteomyelitis.

Babcock (2006) states that among children and teens, the long bones of the legs and arms are most frequently affected. This fact lends support to the impression that this individual was a late teen/young adult at death. In adults, osteomyelitis most often affects the vertebrae of the spine and/or the hips. According to The Cleveland Clinic (2008) osteomyelitis affects approximately one out of every 5,000 people (about 0.02%). If the infection is not treated, the disease can become chronic and the affected bone can experience a loss of blood supply, causing the bone to become necrotic. In children, osteomyelitis usually affects the adjoining ends of long bones. Based on the illustrations by Ortner and Putschar (1985) it is apparent from the degree of dead bone tissue; as well as the shape, condition and color of affected bone tissue, that this individual had osteomyelitis. There are also several small (<3mm) openings on the left distal femur. In addition to this, both coxals and the proximal tibia and fibula are affected.

The Cleveland Clinic (2008) also maintains that gender and ancestry have no relevance to the frequency or probability of contracting osteomyelitis. Some individuals are more at risk for developing the disease including diabetics, dialysis patients, and intravenous drug users.

Because of the severity of the osteomyelitis in the left lower extremity, particularly the femur, it appears that perhaps this person either was too underprivileged to afford, or did not have access to appropriate medical attention (i.e. antibiotics). I conclude that the cause of osteomyelitis was most likely not from syphilis since syphilis is also evident in the cranium, and there is no indication of a bone infection in this cranium. I also speculate that this individual may have had diabetes since, as mentioned above, it is one of the risk factors and there is an

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Appendix A: FORDISC 3.0 Analysis of UMFC66

Ousley & Jantz (2005).

DF using 17 variables:	OBH	OCC	PAC	UFHT	WFB	XCB	ZYB	AUB	BBH
	BPH	BNL	BPL	FRC	GOL	MAB	NLB	NLH	OBB
Variables removed:	UFBR	MDH	MAL	DKB	EKB	FOL	GNI	HMF	TMF

From Group	Total Number	Into Group				% Correct
		American Indian Female	Black Female	Japanese Female	White Female	
AF	24	21	0	3	0	87.5%
BF	74	3	58	10	3	78.4%
JF	100	11	13	69	7	69.0%
WF	130	2	6	5	17	90.0%

Total Correct: 265 out of 328 (80.79 % ****** CROSSVALIDATED ******

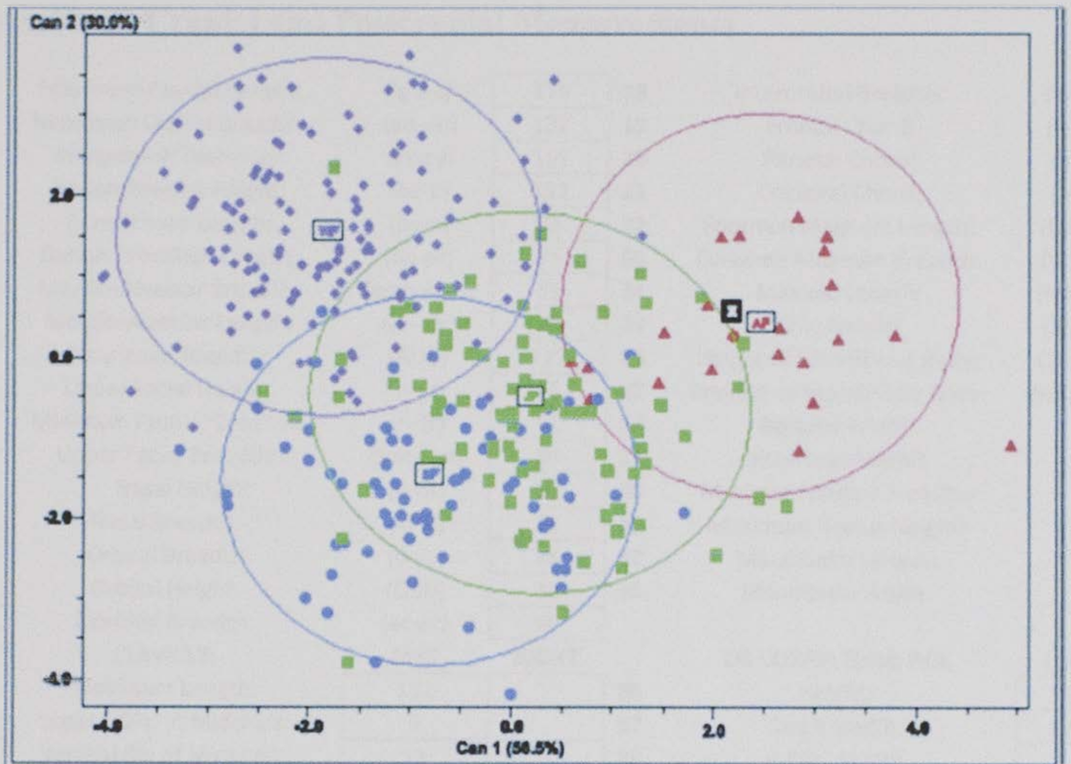
Multigroup Classification of UMFC66

Group	Classified into	Distance from	Posterior Probabilities	Typ F	Typ X	Typ R	
AF	**AF**	22.7	0.919	0.946	0.158	0.080	(23/25)
BF		37.2	0.001	0.072	0.003	0.000	(75/75)
JF		27.6	0.080	0.185	0.050	0.139	(87/101)
WF		38.3	0.000	0.020	0.002	0.008	(130/131)

UMFC66 is closest to *American Indian female (AFs)*

Current	Case	chk	AF	BF	JF	WF
AUB	127		127.0	116	118.6	116.5
BBH	132		128.5	129	131.7	134.3
BNL	100	+	99.8	97.3	95.5	99.1
BPL	95		96.7	98.4	94.3	91.2
FRC	115	++	107.0	107	106.4	109.5
GOL	176		177.2	179	131.7	178.3
MAB	59		62.9	63.3	61.5	57.7
NLB	23		25.5	25.0	24.8	22.3
NLH	50		52.0	47.9	48.7	49.2
OBB	38	-	41.2	38.3	38.1	39.2
OBH	36	+	35.5	34.3	34.2	33.2
OCC	96		93.0	95.5	97.4	97.1
PAC	105	-	107.0	113	108.7	113.2
UFHT	65	-	71.2	67.5	65.8	66.4
WFB	91		92.1	93.7	89.7	93.7

ln of Determinant=40.1225



classifies as American Indian female (posterior probability=0.919, typical probability=0.946)

Appendix B: Cranial and Postcranial Measurements

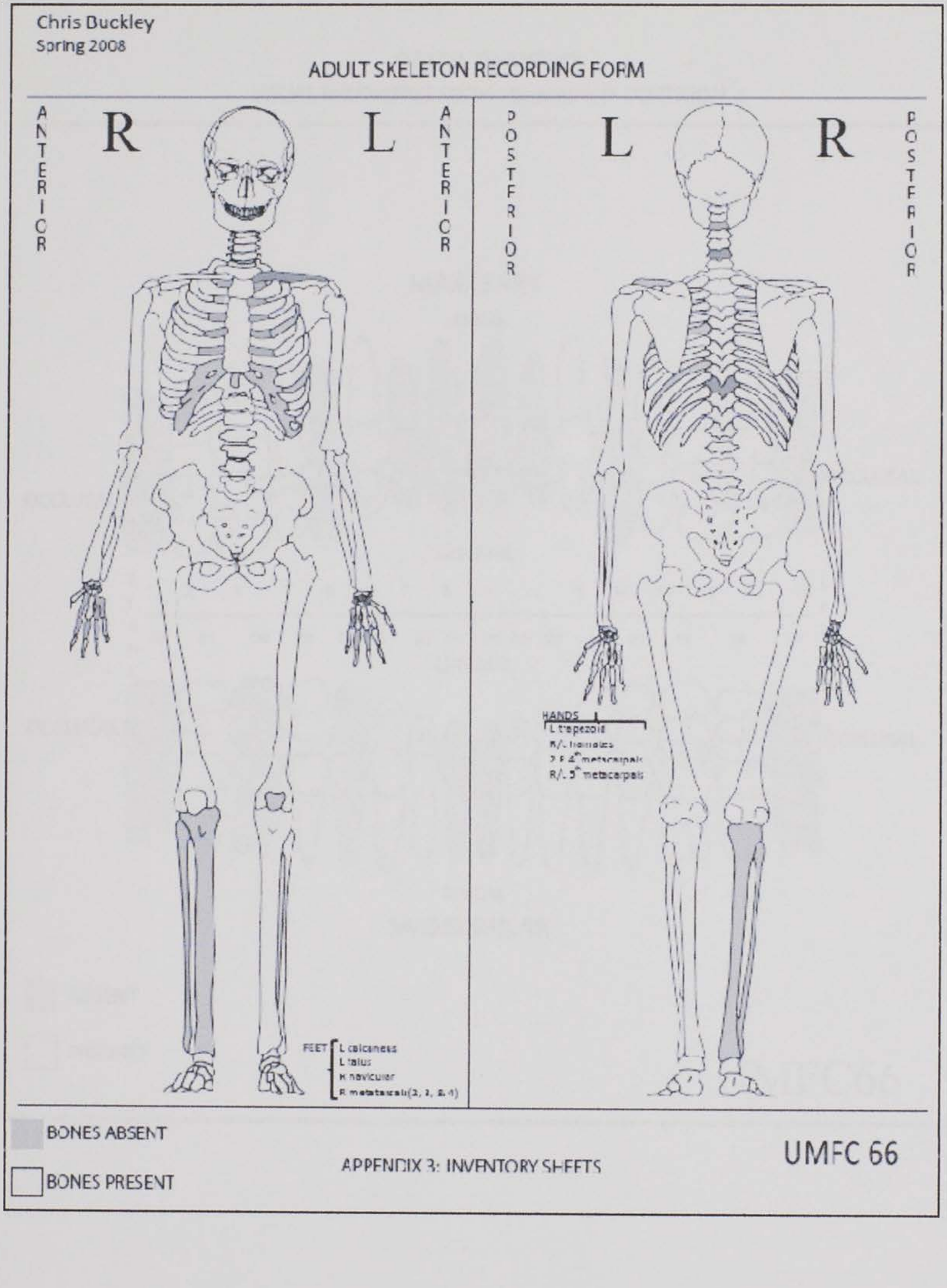
1	Maximum Cranial Length:	(g-op)	176
2	Maximum Cranial Breadth:	(eu-eu)	132
3	Bizygomatic Diameter:	(zy-zy)	137
4	Basion-Bregma Height:	(ba-b)	132
5	Cranial Base Length:	(ba-n)	100
6	Basion-Prosthion Length:	(ba-pr)	95
7	Maxillo-Alveolar Breadth:	(ecm-ecm)	59
8	Maxillo-Alveolar Length:	(pr-alv)	48
9	Biauricular Breadth:	(AUB)	127
10	Upper Facial Height:	(n-pr)	65
11	Minimum Frontal Breadth:	(ft-ft)	91
12	Upper Facial Breadth:	(fmt-fmt)	89
13	Nasal Height:	(n-ns)	50
14	Nasal Breadth:	(al-al)	23
15	Orbital Breadth	(d-ec)	38
16	Orbital Height:	(OBH)	36
17	Biorbital Breadth:	(ec-ec)	95
18	Interorbital Breadth:	(d-d)	27
19	Frontal Chord:	(n-b)	115
20	Parietal Chord:	(b-l)	105
21	Occipital Chord:	(l-o)	96
22	Foramen Magnum Length:	(ba-o)	33
59	Foramen Magnum Breadth:	(FOB)	28
24	Mastoid Length:	(MBH)	31
25	Chin Height:	(ASB)	32
26	Height of Mandibular Body:	(ZMB)	30
27	Breadth of Mandibular Body:	(MOW)	12
28	Bigonial Width:		107
29	Bicondylar Width:		123
30	Maximum Ramus Breadth:		41
31	Maximum Ramus Height:		
32	Mandibular Length:		
33	Mandibular Angle:		

		LEFT	RIGHT
	CLAVICLE:		
34	Maximum Length:	152	
35	Sagittal Dia. at Midshaft:	9	
36	Vertical Dia at Midshaft:	13	
	SCAPULA:		
37	Height:	150	162
38	Breadth:	102	98
	HUMERUS Epiph P/A:		
39	Maximum Length:	312	315
40	Epicondylar Breadth:	61	58
41	Max. Vert. Head Dia.:	45	41
42	Max. Dia. Of Midshaft:	22	23
43	Min Dia. Of Midshaft:	15	15
	RADIUS Epiph P/A:		
44	Maximum Length:		249
45	Sagittal Dia. Of Midshaft:		11
46	Transverse Dia. Of Midshaft:		16
	ULNA Epiph P/A:		
47	Maximum Length:		275
48	Dorso-Volar Diameter:		17
49	Transverse Diameter:		14
50	Physiological Length:		
51	Minimum Circumference:		
	SACRUM		
52	Number of Segments:	4	
53	Anterior Height:	126	
54	Anterior Surface Breadth:	109	
55	Maximum Breadth (S-1):	34	

		LEFT	RIGHT
	OS COXAE: Epiph P/A		
56	Height:	183	193
57	Iliac Breadth:	129	126
58	Pubis Length:		84
59	Ischium Length:		65
	FEMUR Epiph P/A:		
60	Maximum Length:		415
61	Bicondylar Breadth:		73
62	Epicondylar Breadth:		
63	Max. Dia. Of Head:		41
64	A-P Subtrochanteric Diameter:		
65	Transverse Subtrochanteric Dia.		
66	Circumference of Midshaft:		73
	TIBIA Epiph P/A:		
67	Condylo-Malleolar Length:		
68	Max. Prox. Epiphyseal Breadth		
69	Max. Distal Epiphyseal Breadth		
70	Max. Dia. Nutrient Foramen		
71	Circumference at Nutrient For.		
	FIBULA Epiph P/A:		
72	Maximum Length:	328	
73	Maximum Dia. At Midshaft:	13	
	CALCANEUS Epiph P/A:		
74	Maximum Length:		53
75	Middle Breadth:		50

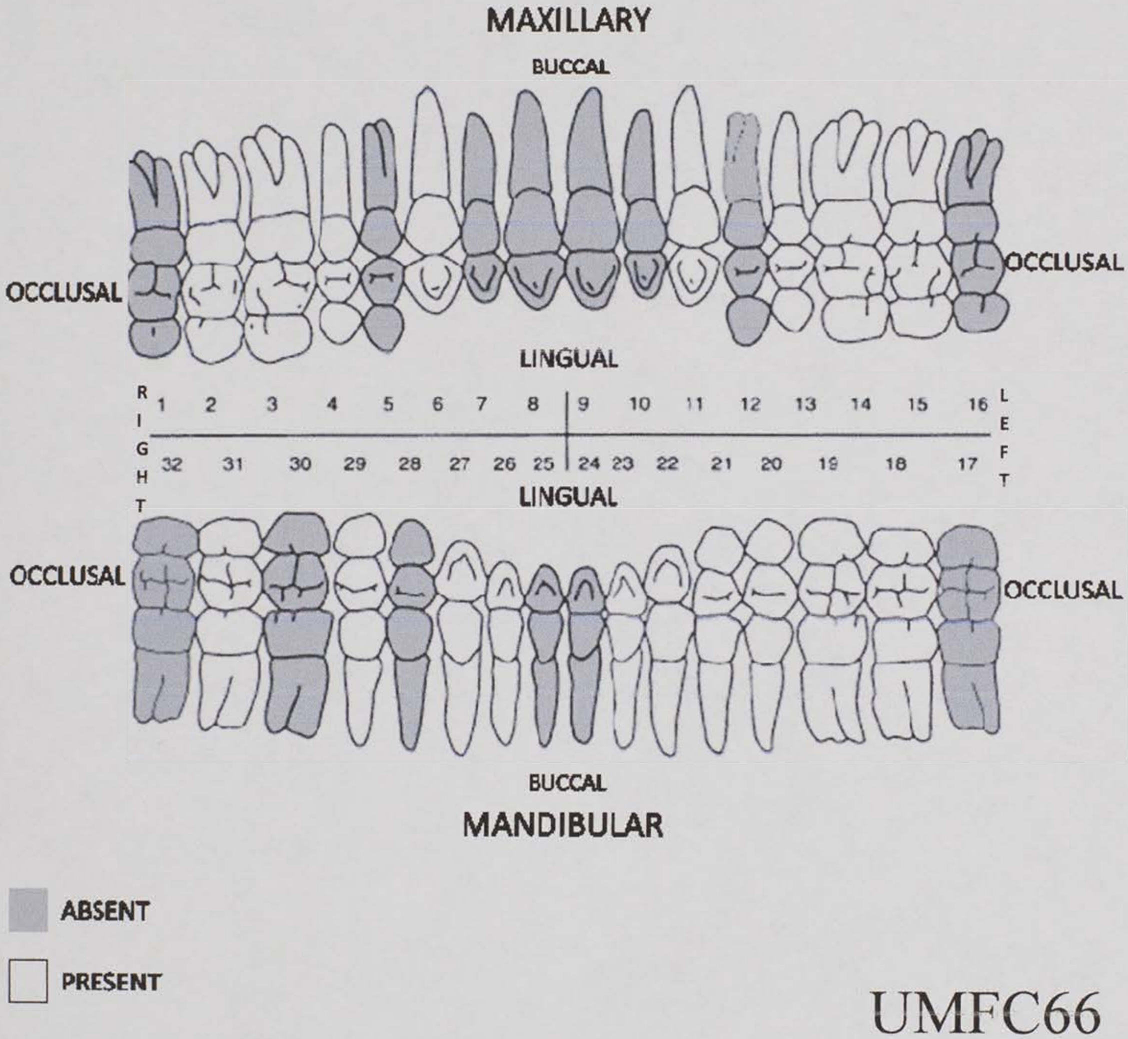
all measurements in mm

Appendix C: Inventory



DENTAL INVENTORY

VISUAL RECORDING FORM: PERMANENT DENTITION



UMFC66