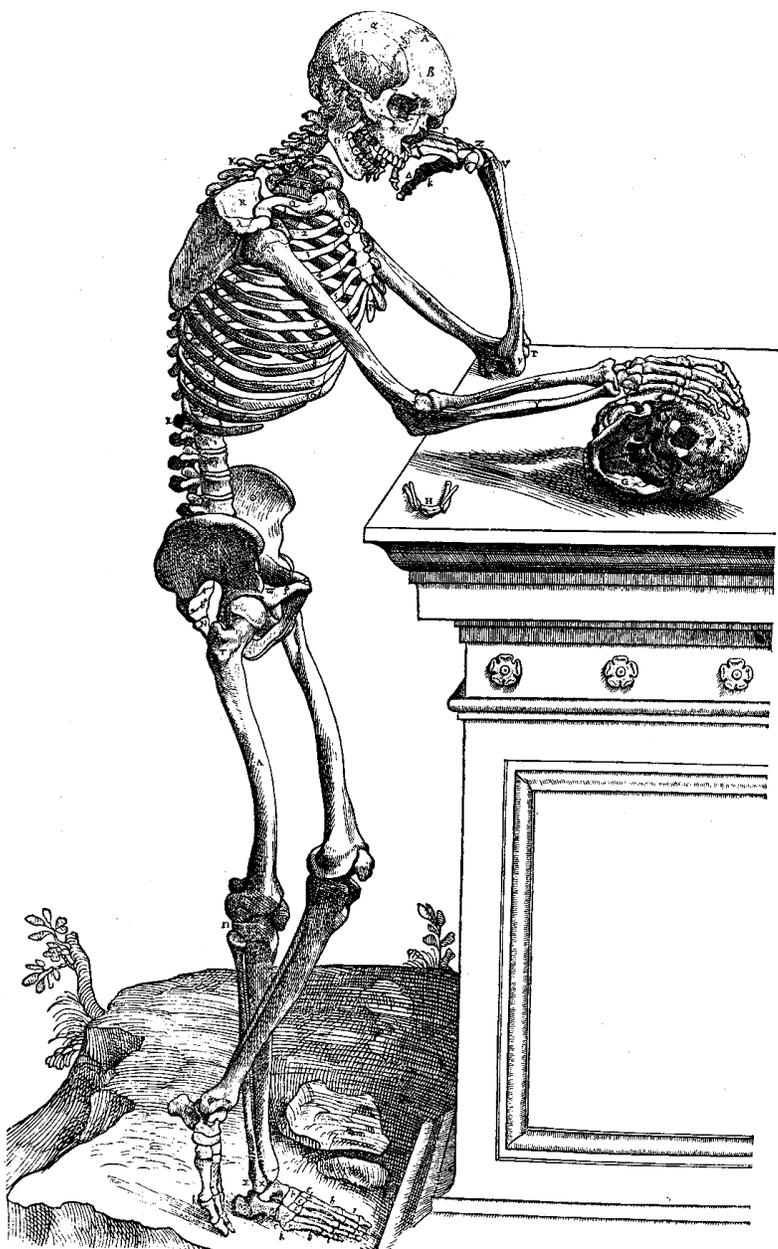


# TRANSITION ANALYSIS AGE ESTIMATION: SKELETAL SCORING MANUAL



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## Abbreviated Scoring Formats

### Pubic Symphysis

#### *Symphyseal Relief*

##### Location

Entire surface

##### Characteristics

1. Sharp billowing
2. Soft, deep billowing
3. Soft, shallow billowing
4. Residual billowing
5. Flat
6. Irregular

#### *Symphyseal Texture*

##### Location

Dorsal demiface

##### Characteristics

1. Smooth (fine grained)
2. Coarse grained
3. Microporosity
4. Macroporosity

#### *Superior Apex*

##### Location

Superior end of the symphyseal face

##### Characteristics

1. No protuberance
2. Early protuberance
3. Late protuberance
4. Integrated

#### *Ventral Symphyseal Margin*

##### Location

Ventral demiface

##### Characteristics

1. Serrated
2. Beveling
3. Rampart formation
4. Rampart completion I
5. Rampart completion II
6. Rim
7. Breakdown

#### *Dorsal Symphyseal Margin*

##### Location

Dorsal demiface

##### Characteristics

1. Serrated
2. Flattening incomplete
3. Flattening complete
4. Rim
5. Breakdown

### Iliac Auricular Surface

#### *Superior demiface topography*

##### Location

Superior demiface

##### Characteristics

1. Undulating
2. Median elevation
3. Flat to irregular

#### *Inferior demiface topography*

##### Location

Inferior demiface

##### Characteristics

1. Undulating
2. Median elevation
3. Flat to irregular

#### *Superior surface morphology*

##### Location

Superior part of the auricular surface

##### Characteristics

1.  $>2/3$  covered by billows
2.  $1/3-2/3$  covered by billows
3.  $<1/3$  covered by billows
4. Flat (no billows)
5. Bumps

#### *Apical (Middle) surface morphology*

##### Location

Apical (middle) part of the auricular surface

##### Characteristics

1.  $>2/3$  covered by billows
2.  $1/3-2/3$  covered by billows
3.  $<1/3$  covered by billows
4. Flat (no billows)
5. Bumps

#### *Inferior surface morphology*

##### Location

Inferior part of the auricular surface

##### Characteristics

1.  $>2/3$  covered by billows
2.  $1/3-2/3$  covered by billows
3.  $<1/3$  covered by billows
4. Flat (no billows)
5. Bumps

#### *Inferior surface texture*

##### Location

Inferior angle

##### Characteristics

1. Smooth

- 2. Microporosity
- 3. Macroporosity

*Superior posterior iliac exostoses*

Location

Superior part of the posterior ilium

Characteristics

- 1. Smooth
- 2. Rounded bony elevations
- 3. Pointed exostoses
- 4. Jagged exostoses
- 5. Touching exostoses
- 6. Fusion

*Inferior posterior iliac exostoses*

Location

Inferior part of the posterior ilium

Characteristics

- 1. Smooth
- 2. Rounded bony elevations
- 3. Pointed exostoses
- 4. Jagged exostoses
- 5. Touching exostoses
- 6. Fusion

*Posterior exostoses (or spicules)*

Location

Posterior to the sacroiliac joint

Characteristics

- 1. Smooth (no exostoses or spicules)
- 2. Rounded exostoses
- 3. Pointed exostoses

## Cranial Sutures

*Coronal Pterica (left)*

Characteristics

- 1. Open
- 2. Juxtaposed
- 3. Partially obliterated
- 4. Punctuated
- 5. Obliterated

*Sagittal Obelica*

Characteristics

- 1. Open
- 2. Juxtaposed
- 3. Partially obliterated
- 4. Punctuated
- 5. Obliterated

*Lambdoidal Asterica (left)*

Characteristics

- 1. Open
- 2. Juxtaposed
- 3. Partially obliterated
- 4. Punctuated
- 5. Obliterated

*Zygomaticomaxillary suture (left)*

Characteristics

- 1. Open
- 2. Juxtaposed
- 3. Partially obliterated
- 4. Punctuated
- 5. Obliterated

*Interpalatine (median palatine, posterior portion)*

Characteristics

- 1. Open (open and juxtaposed)
- 3. Partially obliterated
- 4. Punctuated
- 5. Obliterated

## Introduction

This manual covers how to record three skeletal features – the pubic symphysis, the iliac auricular area, and cranial sutures – used to estimate the ages of adults with the Transition Analysis computer program. When developing the procedure, beginning in 1996, we designed new scoring systems for age-progressive changes in bony morphology and examined two known age-at-death skeletal collections (Terry and Coimbra) to estimate the age distribution associated with each of the various stages that were defined. The program calculates an estimated age (maximum likelihood) and confidence intervals for archaeological or forensic skeletons. Further explanation of the procedure can be found in Boldsen et al. (2002).

One does not have to observe all skeletal traits to generate an age estimate. That is, the procedure was designed to accommodate the possibility – in many archaeological or forensic settings, bordering on a certainty – that only a partial skeleton is available.

### *Ambiguous skeletal features*

Occasionally it is difficult or impossible to distinguish between sequential stages in one or more components. Skeletal features might be altered by pathological processes or eroded after burial. There is still information, however, in such characters.

Osteologists should record whatever is observable, using a two or more stage designation as appropriate (e.g., Stages 3-4). Doing so allows one to take full advantage of the meager information that might be available in the bony structure that is being scored.

When a particular component cannot be observed it should be coded as unscorable. Usually such situations arise when there is postmortem damage. But sometimes that can happen as a result of antemortem alterations to normal skeletal structures. For example, large parity pits can eat deeply into the dorsal demiface of the pubic symphysis of females, eliminating features that otherwise could be scored.

There is no substitute for becoming thoroughly familiar with age-related changes in the skeleton before scoring unknown-age individuals.

That is especially true of the pubic symphysis and sacroiliac joint, as the procedures used here are not the same as those of conventional methods.

## Pubic Symphysis

Five separate components are examined for the pubic symphysis. The various features are based on previous descriptions of bony changes in the pubic bone, especially those of Todd (1920) and McKern and Stewart (1957), supplemented by observations of numerous North American and Danish archaeological skeletons. Many terms used here are derived from this earlier work.

Users of Transition Analysis can gain experience with the changes that take place in the pubic symphysis by closely examining the excellent casts in the McKern-Stewart and Suchey-Brooks pubic bone sets. For sake of convenience, the several parts of the roughly oval symphyseal face are described as superior, inferior, ventral (anterior), and dorsal (posterior), even though such terms are not entirely accurate when the bone is oriented in proper anatomical position.

Left and right sides are scored separately in Transition Analysis, using the codes associated with the stage descriptions (1, 2, 3, etc.). Opposing pubic bones generally resemble one another, although they often differ in some respects. The Transition Analysis program accommodates such variation as each pubic symphysis is scored separately.

## Symphyseal Relief

### *Location*

The entire face is of interest, and the terms generally follow those of McKern and Stewart (1957). Often the features distinguished here, especially billowing, are most clearly seen in the dorsal half of the symphyseal face. In fact, low ridges of bone, the billowing, can be entirely absent from the ventral symphyseal face, beginning as early as the ventral beveling stage.

### *Characteristics*

1. Sharp billowing
2. Soft, deep billowing
3. Soft, shallow billowing
4. Residual billowing
5. Flat

## 6. Irregular

### *Definitions*

1. *Sharp billowing*: Sharply crested ridges of bone cover at least half of the surface. Deep furrows that extend completely across the symphyseal face separate distinct ridges. The deepest furrows cut into the ventral and dorsal margins of the symphyseal face, interrupting the edge of the bone and giving it a jagged appearance. The distance between the high and low points of adjacent ridges and furrows can often be 3 mm or more. Occasionally, round instead of sharp crests occur on the high ridges in specimens that otherwise have deep furrows exceeding 3 mm. Such specimens are also considered examples of Sharp Billowing. Sharp Billowing has only been seen in teenagers.

2. *Soft, deep billowing*: Softly crested to low billows separated by deep furrows extend across at least half of the surface, typically the dorsal demiface. The furrows do not appear as if they have been filled in with bone. The distance between high and low points of adjacent ridges and furrows is 3 mm or less.

3. *Soft, shallow billowing*: Low but clearly visible and discrete billows separated by shallow furrows are present on at least half of the dorsal demiface. The remnants of an earlier ridge and furrow system dominate the dorsal demiface, and the furrows look as if they were partially filled with bone. Billows extend most or all of the way across the dorsal demiface, and in some individuals they reach the ventral margin.

4. *Residual billowing*: Billows are barely elevated above the symphyseal face, and they blend into one another to form low and indistinct raised areas that lack clearly defined furrows between them. The slightly raised areas, however, are still an important element of the surface, and they almost invariably occur on the inferior half of the face, often in the dorsal demiface. Individual billows usually cross only part of the symphyseal face, typically less than one-half its width. There must be two or more adjacent raised areas corresponding to billows to qualify as Residual Billowing. A single isolated bony elevation is not sufficient to be classified as Residual Billowing; instead, such specimens are considered Flat.

5. *Flat*: More than one-half of the symphyseal face within well-defined margins is flat or slightly

recessed, especially if surrounded by a well-developed Rim (see below). Occasionally small, flat, pillows of bone give the surface a pebbly appearance. The remainder of the symphyseal face does not conform to Residual Billowing (i.e., there is no more than one discrete low raised area). Sometimes there is a gap where the ventral rampart has failed to extend along the entire ventral edge of the pubis (see below); when that occurs, the surface within the gap does not receive a score.

6. *Irregular*: Pitting, which can be deep, covers more than one-half of the symphyseal face, giving it an irregular and disfigured appearance. The pits can be accompanied by small, sharp exostoses scattered across the face. Occasionally, in old people an otherwise flat face is thickly covered by rounded sharp exostoses of bone. Pitting in such specimens might be minor, but the bone is still classified as Irregular. Similar to the Flat category, the scored part of the symphyseal face does not include the ventral gap, if present. In Irregular specimens, the margins of the symphyseal face are typically defined by the Rim and Breakdown stages of the Ventral and Dorsal Margin components.

## Symphyseal Texture

### *Location*

The dorsal demiface surface is examined<sup>1</sup>. The ventral part of the bone, when ventral beveling is present, is often pitted, giving it the appearance of microporosity. A porous appearing ventral demiface should not be confused with whatever is happening in the dorsal demiface.

### *Characteristics*

1. Smooth (fine grained)
2. Coarse grained
3. Microporosity
4. Macroporosity

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<sup>1</sup> It is our impression that prehistoric Native American skeletons have microporosity more often and at an earlier age than medieval Scandinavians. More importantly, they differ from modern people in the Terry and Coimbra collections used to generate the transition curves used to estimate age. Therefore, it is best not to rely heavily on this component when examining Native American skeletons. In fact, it is prudent to record Symphyseal Texture stages for Native Americans, but treat them as missing data.

## Definitions

1. *Smooth (fine grained)*: Smooth to fine-grained bone extends across most, or all, of the dorsal demiface.

2. *Coarse grained (little net)*: Coarse-textured bone covers over one-third of the dorsal demiface. The surface looks like packed fine sand, similar to fine-grained sandpaper.

3. *Microporosity*: Porous bone covers over one-third of the dorsal demiface. It looks as if the surface was pierced by closely packed pin pricks.

4. *Macroporosity*: Deep pits cover over one-third of the dorsal demiface, giving it an irregular appearance. The pits are at least 0.5 mm in diameter, and are generally spaced close together. Sometimes the symphyseal surface is so irregular from pitting that it resembles the edge of a sponge.

## Superior Apex

### Location

A distinct knob of bone or, later, an elevated area is visible on the superior part of some pubic symphyses. Otherwise, this part of the symphyseal face resembles the rest of it.

### Characteristics

1. No protuberance
2. Early protuberance
3. Late protuberance
4. Integrated

### Definitions

1. *No protuberance*: Deep to shallow billowing is present in the superior part of the symphyseal face. There are no signs of a bony protuberance. In young individuals, this part of the symphyseal face can be poorly differentiated from the non-articular portion of the pubis immediately lateral to the joint.

2. *Early protuberance*: A distinct bony knob of variable dimensions with well-defined margins is visible in the superior part of the symphyseal face. It projects above the plane(s) defined by the immediately adjacent symphyseal face (i.e., the superior portions of the dorsal and ventral demifaces, where the latter can be characterized by ventral beveling). The surface of the bony

protuberance is typically smooth to fine grained. The bony knob often reminds one of a lentil or pea stuck on the bone.

3. *Late protuberance*: The superior part of the symphyseal face is raised somewhat above the rest of the articulation surface. The elevated area is typically located on the ventral side of the midline.<sup>2</sup> The margins of the slightly raised area tend to be poorly defined. Thus the Late Protuberance is more completely integrated with the rest of the symphyseal face than the distinctly knob-like Early Protuberance. Integration is partly a result of ventral rampart formation. Late Protuberance should not be confused with a narrow raised rim that can border the cranial end of the symphyseal face in many specimens. For a Late Protuberance to be scored as present, the slightly raised area must extend onto the symphyseal face; that is, it is not restricted to the margin that can feature a pronounced rim. Occasionally, the superior part of the symphyseal face can be isolated by marked pitting of the middle symphyseal surface, but these specimens should not be considered as a Late Protuberance stage. For Late Protuberance to be present, the slightly raised area must be visible on a rather smooth symphyseal face.

4. *Integrated*: The symphyseal face's superior end displays no signs of a low bony elevation. The area where the protuberance was formerly present is fully integrated with the rest of the symphyseal face. That is, the smooth to irregular (usually pitted) symphyseal face is essentially flat.

## Ventral Symphyseal Margin

### Location

The ventral part of the pubic symphysis is scored separately from the rest of the bone.

### Characteristics

1. Serrated
2. Beveling
3. Rampart formation
4. Rampart completion I
5. Rampart completion II
6. Rim
7. Breakdown

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<sup>2</sup> Occasionally, a gap exists in the superior one-half of the ventral margin, but the ventral rampart is otherwise completely formed. In that case the presence of a protuberance is not scored as the appearance of the bone can be confusing.

## Definitions

1. *Serrated*: Ridges and furrows typical of Sharp or Soft Deep Billowing extend uninterrupted across the ventral part of the symphyseal face, producing a serrated or jagged ventral margin.

2. *Beveling*: Billows are flattened in the ventral demiface, a process that generally starts at the superior end. The flattening, or beveling, must extend along at least one-third of the ventral margin to be scored as present. There is generally a well-defined margin where the ventral surface of the pubis (the beveled part) meets the articular surface located immediately posterior to it.

3. *Rampart incomplete*: The ventral rampart, following McKern and Stewart (1957), refers to a distinct outgrowth of bone that ultimately forms the ventral aspect of the symphyseal face. The rampart extends from one or both ends of the symphysis, and it often resembles a roll of well-chewed gum stuck on the ventral edge of the symphyseal face. The rampart does not extend along the entire ventral edge, and often some elements of a youthful symphyseal surface can be followed uninterrupted to the ventral edge of the symphysis. In the superior part of the ventral margin, the rampart forms on the Beveled surface. In the inferior part of the margin, remnants of the original irregular surface can often be seen dipping below a partially formed rampart, which looks as if it was lying on a shallowly furrowed surface. An incomplete rampart frequently extends inferiorly from the bony protuberance defining the cranial end of the face, sometimes forming a bony elevation that resembles a comma, with the rampart being the tail.<sup>3</sup> A rampart can also extend superiorly from the inferior end of the symphysis. Bony extensions from the superior and inferior ends of the symphysis, if both are present, typically leave a gap in the middle one-third of the ventral margin. An early Rampart Incomplete stage can consist of one or more bony knobs, commonly located in the middle one-third of the ventral margin. The knobs can occur with, or without, the formation of a bony rampart extending from the superior and inferior ends of the symphysis. If the rampart is more than two-thirds complete but there

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<sup>3</sup> A well-developed bony protuberance at the cranial end of the face that lacks a distinct inferiorly projecting ventral rampart should not be coded as Ventral Rampart Formation; that is, the mere existence of a cranially located bony knob without bone being laid down along the ventral margin is not sufficient to score the ventral rampart as present.

is a gap in the superior part of it, you should consider the possibility that the specimen is in the Rampart Complete I or II stages. Occasionally a rampart never completely forms along the ventral margin (see below).

4. *Rampart complete I*: Here the ventral rampart is complete, but there is a shallow sulcus extending along much of the length of the ventral pubis immediately lateral to the symphysis (often more pronounced inferiorly). The groove is a residual feature related to rampart formation along the ventral margin. A reasonably flat symphyseal surface extends uninterrupted from the dorsal to ventral margins, so the face is unlike the somewhat furrowed appearance of many Rampart Incomplete specimens where there is a shallow groove just dorsal to an incomplete ventral rampart. Occasionally a gap exists in the ventral margin, usually in its superior half; the ventral rampart is otherwise completely formed.<sup>4</sup>

5. *Rampart complete II*: Here the ventral rampart is complete, and there is no shallow sulcus as described in Rampart Complete I. A reasonably flat symphyseal surface extends uninterrupted from its dorsal to ventral margins, so the face is unlike the somewhat furrowed appearance of many Rampart Incomplete specimens where there is also a shallow groove just dorsal to the incomplete ventral rampart. Occasionally there is a gap in the superior half of the ventral margin, but the ventral rampart is otherwise complete. These specimens should be classified as Rampart Complete. With regard to Rampart Complete I and II, most specimens are in the later (II) stage.<sup>5</sup>

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<sup>4</sup> The gap in the ventral margin that occurs in some individuals was noted by McKern and Stewart (1957: 77, Fig. 40), who called it the "ventral hiatus." Gaps, when present, usually occur in the superior half of the pubic symphysis. In most instances, they are readily distinguishable from incomplete rampart formation because the remainder of the ventral rampart appears complete. That is, the ventral margin elsewhere has a rounded to angular edge, an anterior sulcus is typically absent, and a rim might have developed on the part of the rampart that is present. In addition, the symphyseal surface extends uninterrupted from the dorsal to ventral margins, and it is often flat. The appearance of the symphyseal face contrasts sharply with what is present in the typical Rampart Incomplete stage. In the earlier Rampart Incomplete stage, a shallow depression is often present immediately dorsal to the newly formed and still rather narrow rampart, and much of the rest of the symphyseal face is marked by remnants of the original ridges and furrows.

<sup>5</sup> It is our impression that the Rampart Complete I variant – the one with the narrow ventrally located sulcus immediately lateral to the ventral symphyseal margin – is more commonly found on Native American skeletons than on medieval and modern Europeans. But even in Native American skeletons, it is not often encountered.

6. *Rim*: A narrow, bony rim defining the ventral margin of the symphysis, perched on top of the ventral rampart, demarcates a usually flat or irregular face. The rim does not have to be complete, but it must be at least 1 cm long and readily visible as a raised ridge adjacent to a slightly recessed symphyseal face. The rim can be either a continuous ridge of bone or several segments, as long as 1 cm of an elevated border is present. The rim's crest can be low and rounded, or narrow and sharp. A ventral rim is always formed on top of a ventral rampart. Odd rim-like bone formations on gaps in a rampart or formed with no rampart at all are *not* scored as a ventral rim.

7. *Breakdown*: The ventral margin of the symphyseal face has begun to break down, as indicated by pitting and an erosion of the Rim. The breakdown of the ventral margin must exceed 1 cm (either in one spot, or when two or more areas of erosion are combined) to be scored as present. Care must be taken to distinguish antemortem degeneration – that is, true Breakdown – from postmortem damage. The latter, of course, can render the bone unscorable if it is extensive enough.

## Dorsal Symphyseal Margin

### Location

The dorsal part of the pubic symphysis is scored separately from the ventral margin. In females, dorsally located characteristics can be partly or entirely obscured by large postpartum, or parity, pits. Occasionally, such specimens cannot be scored properly.

### Characteristics

1. Serrated
2. Flattening incomplete
3. Flattening complete
4. Rim
5. Breakdown

### Definitions

1. *Serrated*: The dorsal margin of the symphyseal face is irregular because ridges and furrows typical of pronounced billowing extend uninterrupted to the edge of the bone.

2. *Flattening incomplete*: A well-defined flattened area at least 1 cm long is present where

the symphyseal face meets the dorsal margin. Flattening usually starts in the superior part of the dorsal demiface. Billowing is also present on the dorsal demiface, and it typically produces an undulating edge to the pubic symphysis, although it is not as extreme as what is found in Serrated specimens. The undulating edge usually occurs in the inferior part of the symphyseal face.

3. *Flattening complete*: There is a rather obvious area of flattening that completely (or almost entirely) covers the symphyseal face where it meets the dorsal margin. This flattening seemingly occurs partly through a coalescence of billows. A small area at the inferior end of the dorsal margin occasionally retains an undulating appearance.

4. *Rim*: An elevated bony rim demarcates a flat or, infrequently, an irregular face. The rim projects slightly above the symphyseal face, and its crest can be blunt or sharp. The rim does not have to extend along the entire dorsal margin to be scored as present, but it must be at least 1 cm long. The 1 cm rule pertains to either a continuous rim or discontinuous segments that together sum to that length. A rim typically develops first along the superior part of the dorsal margin. It can, however, occur anywhere along the dorsal margin.

5. *Breakdown*: The dorsal margin where the Rim is located shows evidence of breakdown, specifically a pitting and erosion of the edge of the pubic symphysis. The breakdown must exceed 1 cm in length either in one spot or when two or more areas of erosion are combined. Care must be taken to differentiate antemortem degeneration of the margin from postmortem damage, which is of no concern. Antemortem destruction attributable to large parity pits in females that can undercut the dorsal margin is not considered breakdown in the sense of the term as used here. It might not be possible to score those specimens; when that occurs, the component is simply missing data.

## Sacroiliac Joint

Four aspects of the sacroiliac joint area on the ilium are examined: the entire surface topography; surface morphology; surface texture; and marginal bony proliferation (exostoses on the posterior ilium facing the sacrum). Anatomical features and terms follow those of Lovejoy and colleagues (1985) where possible. Different parts of the joint (auricular) surface are scored for the same

morphological features because bony changes do not change in lockstep in all places.

## **Superior Demiface Topography**

### *Location*

The superior demiface is examined. The two demifaces are divided by a line extending posteriorly from the most anterior point of the apex to the posterior joint margin.

### *Characteristics*

1. Undulating
2. Median elevation
3. Flat to Irregular

### *Definitions*

*1. Undulating:* The surface is undulating, particularly in a superior to inferior direction. There is no centrally located and linear area of elevated bone (Median Elevation). When the entire articulation surface is viewed in aggregate, the overall effect is of two or three low waves proceeding lengthwise along the joint.

*2. Median elevation:* In the middle to posterior part of the demiface there is a broad raised area where the joint surface is elevated slightly above the rest of the joint. The elevation is flanked anteriorly, posteriorly, or both by one or two long low areas. The elevated area takes the form of an elongated ridge with the long axis paralleling the main orientation of the demiface. Occasionally the elevated area is restricted to a noticeable raised area, especially in the inferior portion of the superior demiface. The elevated area occupies as much as one-third of the joint surface.

*3. Flat to irregular:* The surface is essentially flat or recessed, a result of marginal lipping, or it is irregular from degeneration of the joint or the formation of low pillow-like exostoses.

## **Inferior Demiface Topography**

### *Location*

The inferior demiface is examined. The superior and inferior demifaces are divided by a line extending posteriorly from the most anterior point of the apex to the posterior border of the joint.

### *Characteristics*

1. Undulating
2. Median elevation
3. Flat to Irregular

### *Definitions*

*1. Undulating:* The surface is undulating, particularly in a superior to inferior direction. There is no centrally located area of elevated bone (Median Elevation). When the entire articulation surface is viewed in aggregate, the overall effect is of two or three low waves proceeding lengthwise along the joint.

*2. Median elevation:* In the middle to posterior part of the demiface there is a broad raised area where the joint surface is elevated slightly above the rest of the joint. The elevation is flanked anteriorly, posteriorly, or both by one or two long low areas. The elevated area takes the form of an elongated ridge – it is particularly apparent in the inferior demiface, in contrast with the superior one – with the long axis paralleling the main orientation of the demiface. The ridge occupies as much as one-third of the joint surface.

*3. Flat to irregular:* The surface is essentially flat or recessed, a result of marginal lipping, or it is irregular, from degeneration of the joint or the formation of low pillow-like exostoses.

## **Superior Surface Morphology**

### *Location*

The superior part of the face is examined. The joint surface is divided into superior, apical (middle), and inferior segments.

### *Characteristics*

1.  $>2/3$  covered by billows
2.  $1/3-2/3$  covered by billows
3.  $<1/3$  covered by billows
4. Flat (no billows)
5. Bumps

### *Definitions*

*1. Billows cover  $>2/3$  of the surface:* Low rounded ridges separated by furrows, which have distinctly rounded bases, are clearly identifiable. The ridge surfaces are curved from the depths of

the furrows completely across their crests. Most or all of the billowing is oriented roughly anterior to posterior, and furrows generally run across much, or all, of the face. Billowing covers most ( $>2/3$ ) of the joint surface (i.e., it is a dominant element of the surface).

2. *Billows cover 1/3-2/3 of the surface*: About one-half of the surface is covered by billows.

3. *Billows cover  $<1/3$  of the surface*: Billows are a noticeable, but minor, component of the joint surface. The rest of the surface is flat or bumpy.

4. *Flat (no billows)*: The joint surface is flat.

5. *Bumps*: Most, or all, of the joint surface is covered by low, rounded bony exostoses, much like little irregular pillows. Part of the surface may be flat, but over one-half of it is bumpy.

*Unscorable*: If pitting is so extensive it obscures much of the face, the joint surface is considered unscorable.

### Apical Surface Morphology

#### Location

The apical (middle) part of the face is examined. The joint surface is divided into the superior, apical (middle), and inferior segments.

#### Characteristics

1.  $>2/3$  covered by billows
2.  $1/3$ - $2/3$  covered by billows
3.  $<1/3$  covered by billows
4. Flat (no billows)
5. Bumps

#### Definitions

1. *Billows cover  $>2/3$  of the surface*: Low rounded ridges separated by furrows, which have distinctly rounded bases, are clearly identifiable. The ridge surfaces are curved from the depths of the furrows completely across their crests. Most or all of the billowing is oriented roughly anterior to posterior, and furrows generally run across much, or all, of the face. Billowing covers most ( $>2/3$ ) of the joint surface (i.e., it is a dominant element of the surface).

2. *Billows cover 1/3-2/3 of the surface*: About one-half of the surface is covered by billows.

3. *Billows cover  $<1/3$  of the surface*: Billows are a noticeable, but minor, component of the joint surface. The rest of the surface is flat or bumpy.

4. *Flat (no billows)*: The joint surface is flat.

5. *Bumps*: Most, or all, of the joint surface is covered by low, rounded bony exostoses, much like little irregular pillows. Part of the surface may be flat, but over one-half of it is bumpy.

*Unscorable*: If pitting is so extensive it obscures much of the face, the joint surface is considered unscorable.

### Inferior Surface Morphology

#### Location

The inferior part of the face is examined. The joint surface is divided into the superior, apical (middle), and inferior segments.

#### Characteristics

1.  $>2/3$  covered by billows
2.  $1/3$ - $2/3$  covered by billows
3.  $<1/3$  covered by billows
4. Flat (no billows)
5. Bumps

#### Definitions

1. *Billows cover  $>2/3$  of the surface*: Low rounded ridges separated by furrows, which have distinctly rounded bases, are clearly identifiable. The ridge surfaces are curved from the depths of the furrows completely across their crests. Most or all of the billowing is oriented roughly anterior to posterior, and furrows generally run across much, or all, of the face. Billowing covers most ( $>2/3$ ) of the joint surface (i.e., it is a dominant element of the surface).

2. *Billows cover 1/3-2/3 of the surface*: About one-half of the surface is covered by billows.

3. *Billows cover  $<1/3$  of the surface*: Billows are a noticeable, but minor, component of the joint surface. The rest of the surface is flat or bumpy.

4. *Flat (no billows)*: The joint surface is flat.

5. *Bumps*: Most, or all, of the joint surface is covered by low, rounded bony exostoses, much

like little irregular pillows. Part of the surface may be flat, but over one-half of it is bumpy.

*Unscorable:* If pitting is so extensive it obscures much of the face, the joint surface is considered unscorable.

## **Inferior Surface Texture**

### *Location*

Only one part of the joint surface – the inferior area – is scored for texture. This part of the joint is 1 cm long, as measured in a superior to inferior direction. Its lowermost point is a line defined by the margin of the greater sciatic notch on either side of the joint surface. Do not score the part that can extend well beyond the margin of the notch as defined above. Elongated joint surfaces commonly occur in females, and they are often characterized by macroporosity and marginal lipping. The pitting and lipping in these skeletons frequently differs markedly from the appearance of the rest of the joint.

### *Characteristics*

1. Smooth
2. Microporosity
3. Macroporosity

### *Definitions*

1. *Smooth:* Most, or all, of the joint surface appears to be smooth to slightly granular.

2. *Microporosity:* At least one-half of the surface has a porous appearance with apertures less than 0.5 mm in diameter. The symphyseal face looks as if it is covered by many closely spaced pinpricks.

3. *Macroporosity:* At least one-half of the surface is porous, with most, or all, of the apertures exceeding 0.5 mm in diameter.

## **Superior Posterior Iliac Exostoses**

### *Location*

Superior posterior iliac exostoses are scored. This area refers to the superior part of the medial surface of the posterior ilium where ligaments attach. It is located superior to the sacroiliac joint surface; that is, to a line that passes from the anterior superior iliac spine, to the most superior

point of the joint surface (the superior angle), and on through the posterior part of the ilium. In some individuals, the bone is distinctly raised in this area. So care must be taken to differentiate jagged (or high) exostoses from rounded or pointed ones perched on top of a raised elevation of bone.

### *Characteristics*

1. Smooth
2. Rounded bony elevations
3. Pointed exostoses
4. Jagged exostoses
5. Touching exostoses
6. Fusion

### *Definitions*

1. *Smooth:* The surface is often elevated in this area, but shows no evidence of discrete bony elevations. At most there are a few isolated small exostoses projecting from the bone surface.

2. *Rounded bony elevations:* Definite raised areas of bone with rounded crests dominate the scoring area.

3. *Pointed exostoses:* Over one-half of the rough area where ligaments attach is dominated by sharply pointed elevations of bone.

4. *Jagged exostoses:* The raised areas of bone have a jagged appearance, and round or sharp exostoses dominate the rough area where ligaments attach in life.

5. *Touching exostoses:* There is a pronounced growth of bone with a relatively flat top, usually roughly oval, where exostoses touch the sacrum.

6. *Fusion:* The ilium and sacrum are fused by exostoses in this area.

## **Inferior Posterior Iliac Exostoses**

### *Location*

The inferior posterior iliac exostoses are scored. This area refers to the inferior part of the medial surface of the posterior ilium where ligaments attach. It is located inferior to a line that passes from the anterior superior iliac spine, to the most superior point of the sacroiliac joint surface (the superior angle), and on through the posterior part of the ilium. This area is located immediately posterior to the middle of the sacroiliac joint; that

is, it lies behind the most anteriorly projecting part of the posterior margin of the joint. In some individuals, the bone is distinctly raised in this area. So care must be taken to differentiate jagged (or high) exostoses from rounded or pointed ones perched on top of a raised elevation of bone.

#### *Characteristics*

1. Smooth
2. Rounded bony elevations
3. Pointed exostoses
4. Jagged exostoses
5. Touching exostoses
6. Fusion

#### *Definitions*

*1. Smooth:* The surface is often elevated in this area, but shows no evidence of discrete bony elevations. At most there are a few isolated small exostoses projecting from the bone surface.

*2. Rounded bony elevations:* Definite raised areas of bone with rounded crests dominate the scoring area.

*3. Pointed exostoses:* Over one-half of the rough area where ligaments attach is dominated by sharply pointed elevations of bone.

*4. Jagged exostoses:* The raised areas of bone have a jagged appearance, and round or sharp exostoses dominate the rough area where ligaments attach in life.

*5. Touching exostoses:* There is a pronounced growth of bone with a relatively flat top, usually roughly oval, where exostoses touch the sacrum.

*6. Fusion:* The ilium and sacrum are fused by exostoses in this area.

### **Posterior Exostoses**

#### *Location*

The posterior iliac area between the Superior and Inferior Posterior Iliac Exostoses, as defined above, are scored. The area where the exostoses occur is on the medial side of the ilium bordered posteriorly by the iliac crest, anteriorly by the sacroiliac joint surface, superiorly by a slightly raised area often surmounted by bony exostoses (Superior Posterior Iliac Exostoses), and inferiorly by a similar area (Inferior Posterior Iliac

Exostoses). Most individuals are Smooth as defined below. The feature is best considered an old-age trait.

#### *Characteristics*

1. Smooth (no exostoses)
2. Rounded exostoses
3. Pointed exostoses

#### *Definitions*

*1. Smooth:* The area posterior to the sacroiliac joint is smooth, except for the two areas scored separately as Superior and Inferior Posterior Iliac Exostoses.

*2. Rounded exostoses:* Low, rounded exostoses (or spicules) cover the *entire* bone surface posterior to the sacroiliac joint, except for a ca. 0.5 cm band of smooth bone immediately adjacent to the posterior edge of the joint. The exostoses are normally lower than the Superior and Inferior Posterior Iliac Exostoses. The low exostoses give the normally smooth iliac surface a rough appearance. It looks as if the surface is covered by coarse (construction) sand.

*3. Pointed exostoses:* Low, pointed exostoses (or spicules) cover the *entire* bone surface posterior to the sacroiliac joint, except for a ca. 0.5 cm band of smooth bone immediately adjacent to the posterior edge of the joint. The exostoses are normally lower than the Superior and Inferior Posterior Iliac Exostoses. The sharp exostoses give the normally smooth iliac surface a rough appearance. It looks as if the surface is covered by coarse (construction) sand.

### **Cranial Sutures**

The suture closure scores are similar to what osteologists have used for over a century. As far as the vault is concerned, ectocranial suture closure is recorded because it is often difficult to examine the interiors of archaeological crania, which can be dirty. Suture segment names conform to those commonly used by osteologists. Palatal sutures are included largely because they have been shown to be of some use in age estimation, even though they are often damaged (Mann et al. 1987).

For sake of completeness, it is a good practice to record closure of both the left and right coronal, lambdoidal, and zygomaticomaxillary sutures, if

present. When entering data, it is possible to list scores for both sides if they are different. Although Transition Analysis is based on the left side, the inclusion of scores for both bilateral sutures is conservative as it, in effect, increases the age interval. Because sutures are notoriously poor indicators of age, wider intervals are not a bad outcome.

The first stage, Open, is perhaps best seen in Lambdoidal Asterica. It is, in fact, a common score for that suture segment, especially in young adults. It even occurs in middle-aged adults. The Open category is distinguished from Juxtaposed by a noticeable gap between the two adjoining bones. The width of this gap varies from one suture to another, although it is generally greatest at Lambdoidal Asterica. While there is no bony bridging of the suture in the Juxtaposed category, the two adjacent bones are only separated by a narrow line, just as if a line was drawn on the bone by a pencil with a thin lead.

## Coronal Pterica

### Location

Score the most inferior section of the coronal suture, a relatively straight part without a meandering appearance.

### Characteristics

1. Open
2. Juxtaposed
3. Partially obliterated
4. Punctuated
5. Obliterated

### Definitions

*1. Open:* The suture is visible along its entire length, and there is a noticeable gap between the bones.

*2. Juxtaposed:* The suture is visible along its entire length, but the suture is narrow because the bones are tightly juxtaposed. If there are any bony bridges they are rare and small, sometimes with a trace of the original suture still evident.

*3. Partially obliterated:* The suture is partially obscured. There is no trace of the original suture in the bony bridges.

*4. Punctuated:* Only remnants of the suture are present. They appear as scattered small points or grooves each no more than two millimeters long.

*5. Obliterated:* There is no evidence of a suture.

## Sagittal Obelica

### Location

Score the relatively straight part of the posterior sagittal suture near the parietal foramina.

### Characteristics

1. Open
2. Juxtaposed
3. Partially obliterated
4. Punctuated
5. Obliterated

### Definitions

*1. Open:* The suture is visible along its entire length, and there is a noticeable gap between the bones.

*2. Juxtaposed:* The suture is visible along its entire length, but the suture is narrow because the bones are tightly juxtaposed. If there are any bony bridges they are rare and small, sometimes with a trace of the original suture still evident.

*3. Partially obliterated:* The suture is partially obscured. There is no trace of the original suture in the bony bridges.

*4. Punctuated:* Only remnants of the suture are present. They appear as scattered small points or grooves each no more than two millimeters long.

*5. Obliterated:* There is no evidence of a suture.

## Lambdoidal Asterica

### Location

The most inferior part of the lambdoidal suture is scored. It is adjacent to asterion, and extends about one-quarter of the way up to lambda.

### *Characteristics*

1. Open
2. Juxtaposed
3. Partially obliterated
4. Punctuated
5. Obliterated

### *Definitions*

1. *Open*: The suture is visible along its entire length, and there is a noticeable gap between the bones.

2. *Juxtaposed*: The suture is visible along its entire length, but the suture is narrow because the bones are tightly juxtaposed. If there are any bony bridges they are rare and small, sometimes with a trace of the original suture still evident.

3. *Partially obliterated*: The suture is partially obscured. There is no trace of the original suture in the bony bridges.

4. *Punctuated*: Only remnants of the suture are present. They appear as scattered small points or grooves each no more than two millimeters long.

5. *Obliterated*: There is no evidence of a suture.

## **Zygomaticomaxillary**

### *Location*

The facial, or anterior, part of the zygomaticomaxillary suture is scored.

### *Characteristics*

1. Open
2. Juxtaposed
3. Partially obliterated
4. Punctuated
5. Obliterated

### *Definitions*

1. *Open*: The suture is visible along its entire length, and there is a noticeable gap between the bones.

2. *Juxtaposed*: The suture is visible along its entire length, but the suture is narrow because the bones are tightly juxtaposed. If there are any bony

bridges they are rare and small, sometimes with a trace of the original suture still evident.

3. *Partially obliterated*: The suture is partially obscured. There is no trace of the original suture in the bony bridges.

4. *Punctuated*: Only remnants of the suture are present. They appear as scattered small points or grooves each no more than two millimeters long.

5. *Obliterated*: There is no evidence of a suture.

## **Interpalatine (Median Palatine, Posterior Portion)**

### *Location*

The suture located between the two opposing palatine bones is of interest. The Open (1) and Juxtaposed (2) distinction is not important here because it is difficult to impossible to differentiate the two categories consistently. Note that to keep scoring consistent across all sutures, the Juxtaposed (2) category is simply eliminated.

A small bony crest that often forms along the midline of the palate can make it difficult to record the extent of suture closure. In other specimens, the suture is barely visible in the depths of a deep and narrow groove. Both the ridge and groove make it hard or impossible to score the suture.

### *Characteristics*

1. Open (open and juxtaposed)
3. Partially obliterated
4. Punctuated
5. Obliterated

### *Definitions:*

1. *Open (and juxtaposed)*: The suture is visible along its entire length, and there is a noticeable gap between the bones.

3. *Partially obliterated*: The suture is partially obscured. There is no trace of the original suture in the bony bridges.

4. *Punctuated*: Only remnants of the suture are present. They appear as scattered small points or grooves each no more than two millimeters long.

5. *Obliterated*: There is no evidence of a suture.

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