Bone Damage in the Antemortem, Perimortem, and Postmortem Periods: *Looking for Traumatic Indications on Bones for Assessing the Quality of Life of Skeletal Remains*

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Abstract: The analysis of damages and changes to skeletal remains may help relate to the circumstances of death and or individual identification. Those changes are, for example, the physical properties of bone. Meanwhile, trauma refers to physical disturbance of living tissue due to external forces. Trauma and skeletal damage analyzes include the approximate time of trauma compared to the time of death, the mechanism, and the kind of forces that have caused the trauma. The materials for this study were 1 individual from the Museum of Anthropology, and 9 individuals from the collection of human skeletal remains at the Department of Anatomy and Histology, Physical Anthropology Section, in Universitas Airlangga. We observed the shape, the colour, and the texture; and analyzed if there were any antemortem trauma and/or abnormality of bones that happened during the life of the individuals. The damage to the skeletons observed in this research were mostly postmortem damage. Most of the damages did not show any healing process and appeared brighter than the surrounding bone, and had a jagged—irregular—and sharp edges. However, we also found signs of abnormal bones that were caused by the poor condition during the life of some of the skeletal remains. Postmortem damage can be differentiated from the antemortem trauma. This finding is important for further study in assessing the quality of life of people in Indonesia in the past, and for giving aids during identification, through unique characteristics observed on the skeletons.

1 INTRODUCTION

Forensic anthropologists use the principles of bone biomechanics to support trauma to bones. Bone biomechanics is determined by the material and structural properties (intrinsic variables) and the nature of the load (extrinsic variable) imposed. The intrinsic variables consist of material properties such as bone microstructure, cortical thickness, and trabecular thickness, while structural properties include bone morphology (ie, size and shape). Extrinsic variables include the magnitude, direction, rate, extent of use, and the duration of load applied to the bone. Simply put, intrinsic variables are related to weapons or objects that cause injury (Tersigni-Tarrant & Natalie, 2013).

The analysis of trauma and other changes to the skeleton can help relate to the circumstances of death or the identification of individuals. This change is a change in the physical properties of bone, whereas trauma refers to the physical disturbance of living tissue due to external forces. The conclusions derived from the skeletal trauma analysis include the relative time spent on the event of death, and the mechanism or type of force that causes trauma. Time of trauma can be categorized as antemortem (occurring before death) or perimortem (occurring around the time of death). Postmortem changes are not considered traumatized (because they do not interfere the living tissue). The mechanism of trauma is categorized as a blunt force, sharp, high strength, thermal, or some combination of these categories (Christensen et al., 2014).

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2 MATERIAL AND METHOD

This research material were from 1 individual skeletal bone collection of Museum of Anthropology, Faculty of Social and Political Sciences, Universitas Airlangga and 9 individuals from Department of Anatomy and Histology, Physical Anthropology Section, in Universitas Airlangga. Observation was done by observing the shape, colour, and texture, as well as analyzing whether there were antemortem trauma and/or bone abnormalities that occur during individual life processes.

Figure 1: Zygomatic dextra bone

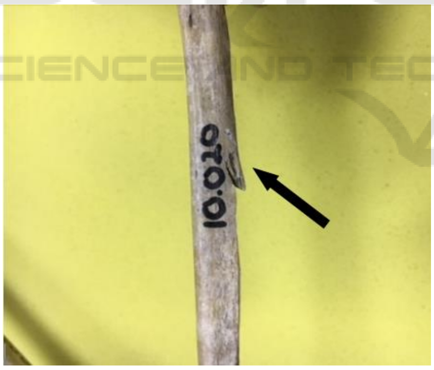

Figure 2: Ulna dextra bone

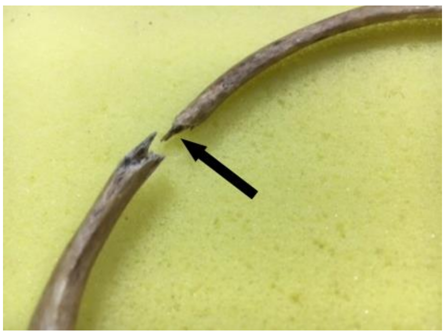

Figure 3: Costae sinistra bone

Figure 4: Tibia sinistra bone

Figure 5: Femur sinistra bone

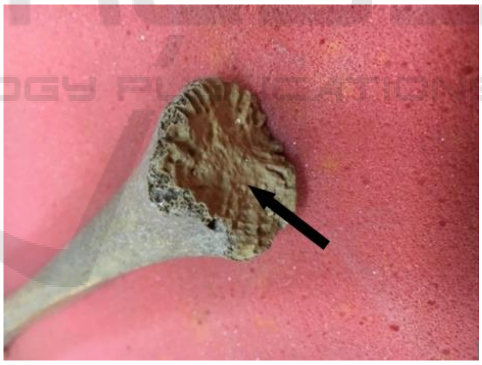

Figure 6: Tibia sinistra bone

Figure 7: Fibula dextra bone

Figure 8: Cranium bone

Figure 9: Pelvic bone

Figure 10: Sacrum bone

3 RESULTS

Table 1: Skeletons are observed with the type of period from its shape, colour, and texture.

No	Skeleton	Shape	Colour	Texture	Type
1.	Zygomatic dextra	Irregular	Brighter	Sharp	Postmortem
2.	Ulna dextra	Irregular	Brighter	Sharp	Postmortem
3.	Costae sinistra	Irregular	Brighter	Sharp	Postmortem
4.	Tibia sinistra	Irregular	Same	Rough	Antemortem
5.	Femur sinistra	Regular	Same	Smooth	Perimortem
6.	Tibia sinistra	Irregular	Same	Smooth	Antemortem
7.	Fibula dextra	Irregular	Brighter	Sharp	Postmortem
8.	Cranium	Irregular	Brighter	Sharp	Postmortem
9.	Pelvic	Irregular	Same	Rough	Antemortem
10	Sacrum	Regular	Same	Smooth	Antemortem

According to Table 1, the framework damage observed in this study was largely postmortem damage. The damage did not seem to be a healing process. Zygomatic, ulna, costae, fibula, and cranium bones fracture had a jagged (irregular) shape and sharp edge, also appeared to be brighter than the surrounding bone. Femur sinistra bone had a not jagged (regular) fracture and the colour was same with the surrounding bone. However, we also found abnormal bone marks caused by conditions during the life of some bones, such as on tibia sinistra, pelvic, and sacrum bones.

4 DISCUSSION

Antemortem trauma, occurring before the time of death, is characterized by an osteogenic reaction (new bone formation) of visible healing at the site of injury, since naturally the reaction occurs when the individual is alive. Fracture healing can be demonstrated with the tip of a rounded fracture or callus formation whereas an infection response is indicated by a proliferative or lytic lesion (Christensen et al., 2014).

The presence of antemortem trauma to unidentified skeletons serves as information that can be useful in the identification process. Thus, our ability to recognize, interpret, and know the antemortem fracture time is the key with accurate resolution in many death investigations. Most of the forensic anthropologists are familiar with the basic healing process of bone fracture, which involves inflammation, the development of soft callus and hard callus, as well as remodeling. Therefore, an understanding of the normal process of bone growth is necessary for basic anatomical considerations for bone healing (Boyd & Donna, 2018).

In the pelvic and sacrum bones (Figure 9 and 10), bone abnormalities occured during life. The pelvic bone was thought to be due to osteoporosis so that the bone appeared porous (small holes). The sacrum did not appear to blend between the two sides (there was a gap) so that it was assumed that the individual had a history of spina bifida abnormalities.

Pathology refers to the disease, and the pathological condition is an abnormal anatomy that is a manifestation of a disease process. The process of this disease can be due to infection, injury, or abnormalities. Not all diseases affect the skeleton, but can manifest as bone changes locally called lesions. Pathological lesions of bone can be proliferative, lytic, or deformative. Proliferative lesions (osteo proliferative) are characterized by excess bone deposition, while lytic (osteolytic) lesions involve bone loss (Christensen et al., 2014).

However, a more detailed temporal specification of antemortem time would be desirable, since a more precise “dating” would aid palaeopathologists and forensic anthropologists in interpreting facets such as medical status and medical care at the time of death (Boer et al., 2012).

Tibia sinistra bone (Figure 4) had an irreguler bulge shape, same colour with the surrounding bone, and rough texture was thought to be ostophytes. The tibia sinistra bone (Figure 6) appeared to be worn out (attrition) with smooth surface in the joint or the meeting of the two bones caused by excessive use during life.

Repeated mechanical stresses on the skeleton can cause the bones to adapt their morphology in response to these stresses. These adaptions are somestimes called ”markers of occupational stress” or “occupational markers”, in reference to their origins of often resulting from work-related physical activities (Christensen et al., 2014).

Trauma to the soft tissues that cause death often involves bones in deliberate attacks either sharp or blunt on the persecution, and the type of trauma around this time of death is called perimortem trauma (Indriati, 2010). Perimortem trauma refers to an injury that occurs relatively close to the time of death, but not necessarily “on” the death time. Trauma may occur immediately before, during, or after the death. Perimortem trauma to the bone is identified as an injury that occurs when the bones are in a fresh state biomechanically (Christensen et al., 2014).

In perimortem injury, the pattern of bone destruction is similar to that of antemortem trauma but does not indicate a cure or infection response. Because of the bones are still “green” or fresh when there is trauma, the fracture tips appear sharp and clean-not jagged and torn like broken ends of the shin bone. Compared with postmortem, fresh bone fractures are often more straight while dry bone fractures tend to appear jagged. As seen in the femur sinistra (Figure 5) which had a regular (not jagged) shape which was estimated to occur in the perimortem period. Perimortem trauma can provide valuable information about the cause and/or way of death (Burns & Karen, 2013; Christensen et al., 2014).

Perimortem trauma is traditionally denoted by wet or fresh fracture characteristics such as oblique fracture angles, a smooth fracture surface, and curved or V-shaped fracture outlines. Conversely, postmortem damage is denoted by dry

fracture characteristics such as right angles, a rough fracture surface, and a transverse or jagged fracture outline. In addition, a lighter coloration of the fracture surface is consistent with a recent postmortem fracture (Green & Schultz, 2016). In literature, there are already many characteristics known to make the distinction between perimortem and postmortem fractures like colour, smooth and rough edges (Scheirs et al., 2017).

The fracture of zygomatic, ulna, costae, fibula, and cranium bones (Figure 1, 2, 3, 7, and 8) had irreguler (jagged) shape with sharp edges. Trauma or postmortem damage is a damage that occurs long after death. The edges are sharp and the bone tends to be completely broken, not partially or with a bent tip like a greenstick fracture (Christensen et al., 2014).

Biomechanically, the reason for different postmortem fracture is because dry bones respond to different styles of fresh bone. The living bones contain moisture and collagen, which gives greater elasticity (Turner and Burr, 1993). Fresh bones contain water, which serves to absorb and remove some energy (called viscoelasticity). When the bones dry out, the bones no longer have the power to absorb energy, so the mechanical properties change and look like inorganic materials. This response is similar to a branch or twig that dries up its water content so that it gets easily broken (Christensen et al., 2014).

During the postmortem period, the loss of the organic content and moisture changes the viscoelastic composition of bone, which causes dry bone to be more brittle and stiff, rather than elastic and stiff. As a result, dry bone is less adept at resisting strain and fractures differently than wet bone during the perimortem period (Green & Schultz, 2016). Broken bone surfaces tend to be smooth in fresh bone, but tend to be grainy and powdery in dry bone (Jordana et al., 2013). Dry bone is much more brittle, causing fracture lines to run along or perpendicular to the grain of the bone causing jagged edges (Scheirs et al., 2017).

Forensic anthropologists (Maples, 1986, Sauer 1998) have determined that there is a difference between postmortem and perimortem fracture patterns. Both perimortem and postmortem trauma show no sign of healing, but postmortem damage is recognizable because it looks bright, unlike living bone, such as where the perimortem fracture is coloured by bleeding, decomposition fluid, soil or other materials. The bony ends of the bone damaged by the postmortem will appear brighter than the surrounding bone because these surfaces are exposed for longer periods by the environment. (Christensen et al., 2014). This is what causes postmortem trauma to have a brighter color than its surroundings, as seen in zygomatic, ulna, costae, fibula, and cranium bones.

However, colours can change again after alteration due to acquired patina through the years. This means that, if there is no colour difference, it does not necessarily mean that the fracture can only be perimortem (Scheirs et al., 2017).

It is important to distinguish between perimortem and postmortem, since perimortem events have much greater forensic involvement. Perimortem trauma may be caused by a murderer, whereas postmortem damage is more likely to be caused by animal excavation or inadvertent excavator use. Similarly, damage to the skeleton may occur during collection and transportation (Byers, 2010; Burns & Karen, 2013), as seen in the ulna bone (Figure 2) appeared to be caused by sharp object, which might occur during the excavation.

5 CONCLUSIONS

Postmortem damage can be differentiated from the antemortem and perimortem trauma. Postmortem damage can be recognized because it looks bright, unlike the living bone (still fresh). Fresh bones mainly consist of organic materials, collagen, and water. When the bone dries and the water component is lost, the bones become harder and stiffer, so the characteristics turn out to be more fragile and lose their elasticity. The edges are sharp and the bones tend to be completely broken. This finding is important for further study in assessing the quality of life of people in Indonesia in the past, and for giving aids during identification, through unique characteristics observed on the skeletons.

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