

# A Differential Diagnosis of Diffuse Idiopathic Skeletal Hyperostosis (DISH) in a *Gorilla gorilla gorilla* Specimen

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## Introduction

- Diffuse Idiopathic Skeletal Hyperostosis (DISH) is a systemic and pathological condition that includes a tendency for ossification of ligaments particularly, though not limited to, the anterior longitudinal ligament (ALL), entheses and joints capsules with a predilection for the axial skeleton and ubiquitous vertebral column involvement<sup>1,2,3,4,5,6</sup>. DISH is prevalent in modern and past human populations, but has rarely been documented in other hominoids.
- The etiology of DISH is still under investigation. Clinically, the condition has been associated with the “metabolic syndrome” or “insulin resistance syndrome” characterized by abnormal insulin metabolism and glucose tolerance, obesity, increased abdominal fat distribution, hypertension and hyperlipidemia<sup>1</sup>. Captive lifestyle conditions for a non-human primate can be analogous to the clinically correlated behavioral risk factors.
- Differential clinical diagnostic criteria is presented in Table 1.
- Although its antiquity has been established, diagnostic standards based on clinical radiography are inconsistent, and only one case of DISH in a non-human primate has been reported in the literature<sup>7</sup>. This case provides the first postmortem differential diagnosis of the condition in a *Gorilla gorilla gorilla* specimen as a proxy for archaeological contexts.
- This study aims to: 1) further our understanding and interpretation of this disease process using 3D CT reconstructions and accompanying descriptions of histological features associated with ectopic growth and 2) increase our knowledge of the diagnostic signatures of DISH.

Site	DISH	Ankylosing Spondylitis (AS)
Vertebral bodies	“Candle wax” ossification and hyperostosis; large non-marginal osteophytes; Right thoracic spine; characteristic radiolucency between ALL and body	Thin, marginal syndesmophytes; ascending pattern of severity from sacroiliac joint; vertebral body “squaring;” “bamboo” appearance
Intervertebral disks	Normal or mild decrease in height	Normal or convex in shape
Apophyseal joints	Normal or mild sclerosis; occasional osteophytes	Erosions, sclerosis and bony ankylosis
Sacroiliac joints	Para-articular osteophytes	Erosions, sclerosis and bony ankylosis

Table 1: Clinical pathognomonic criteria for DISH and AS, a frequently confounding condition<sup>3</sup>.

## Materials & Methods

- The specimen was a 39 year old captive female Western Lowland gorilla euthanized in 2004 for inoperable obstetric cancer. At the time of death, she was 274 pounds with an ideal weight range of 235-255 pounds suggesting she was overweight. There was no evidence of diabetes or cardiovascular issues in her medical records.
- Antemortem radiographs, macroscopic diagnostic criteria, postmortem computed tomography (CT), and histomorphological observations are used to document DISH in a non-human primate.
- Figures 1 and 2 illustrate Mimics 3D CT reconstructions of the specimen prior to histological sampling.

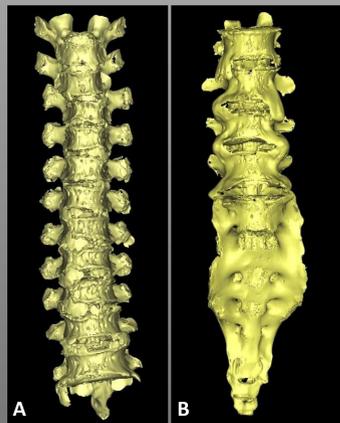


Figure 1: Gross appearance of thoracic (A) and lumbar (B) hyperostosis. Note the “candle wax” growth bilaterally in the lumbar spine and the potentially earlier stages of severity in the thoracic spine. Anterior views.

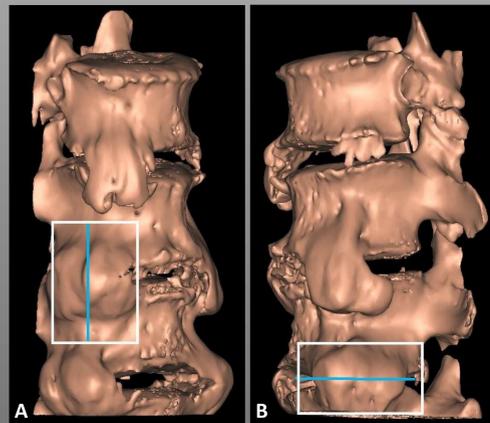


Figure 2: A) region of interest for longitudinal sectioning through the lesion between L3 and L4. Right anterior oblique view. B) region of interest for axial sectioning through the lesion between L4 and L5. Left posterior oblique view.

## Discussion

- Macroscopic differential diagnosis:** “Candle wax” ossification and complete ankylosis was observed bilaterally on at least four contiguous vertebrae (T12 through L4) with retention of intervertebral disc space (Figure 3). Hyperostosis appeared irregular and exuberant in contrast to the “fine, thin” syndesmophytes and “bamboo” spine characteristic of ankylosing spondylitis<sup>5</sup>. The pattern of affected vertebrae resembles ankylosing spondylitis with ascending severity; however, lack of sacroiliac involvement, zygapophyseal ankylosis, and the preservation of disc space are not consistent with AS.
- Progression of hyperostosis can be seen in antemortem radiographs (Figure 4).
- Postmortem CT:** The lumbar spine shows ascending severity of ossification which continues into the thoracic spine; the greatest lesion development is present at the L3-L4 level. Beginning “non marginally” and descending through L2, the severity of ossification increases and infiltrates the vertebral body just prior to reaching the intervertebral disc space destroying the characteristic separation between the ALL and vertebral body (Figure 5).

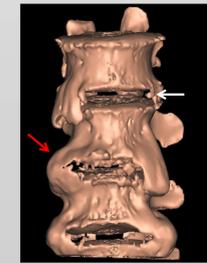


Figure 3: Characteristics consistent with diagnostic criteria for DISH. Note preservation of IV disk space (white arrow) and non-marginal ossifications (red arrow). Anterior view.

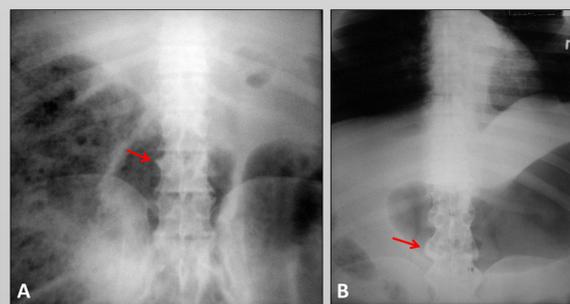


Figure 4: A) 10 years antemortem. Note multiple vertebral levels of early stages of non-marginal ectopic growth starting to bridge IV space (arrow). B) 1 year antemortem. Note extensive, irregular hyperostosis particularly on right side of the lower thoracic and bilateral lumbar spine (arrow). AP views.

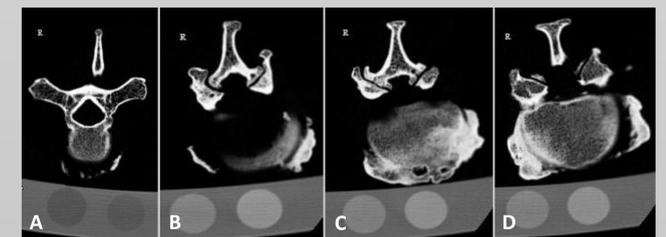


Figure 5: A) T#. Thoracic spine demonstrates right lateral ossification beginning at the midportion of the vertebral body and descending into the intervertebral disc space, extending anteriorly and left laterally indicative of the “non-marginal” nature of ALL ossification. B) L#. Characteristic radiolucency between ALL ossification and body. C) L#. Extensive sclerotic changes subjacent to ossified ligament obliterating separation. D) L4. Severe bilateral ossification of ALL.

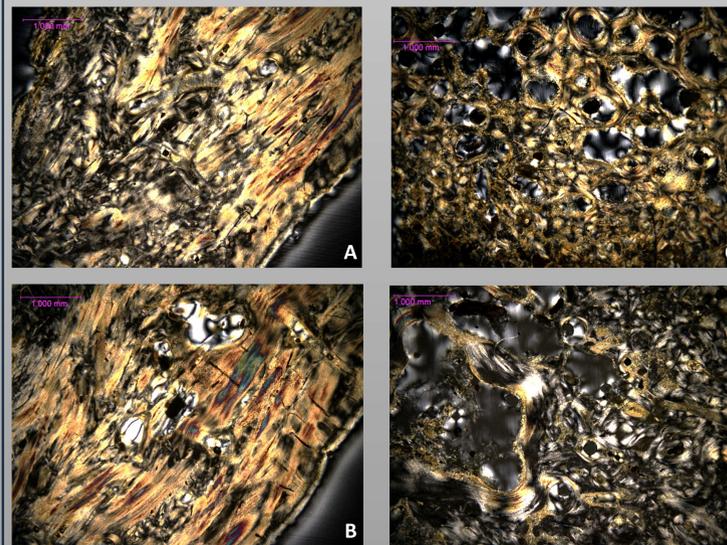


Figure 6: A and B are longitudinal, consecutive sections through the ectopic lesion. The lower right corner is the periosteal edge. Note the dense lamellar periosteal bone and excessive Volkmann's canals. A also demonstrates unorganized woven bone located medially. C and D are axial sections at the interface between lesion and vertebral body. C illustrates lamellar compaction near the bottom of the image, corresponding to the sclerotic changes seen on CT scans. The presence of Haversian systems is best seen in D.

- Histology:** Figure 6 details observed histomorphological features within the lesions. Both lamellar and woven bone are present. Longitudinally, periosteal lamellar apposition is seen along the outermost edge while what appears to be woven bone persists more medially. Ligamentous ossification is hypervascularized with extensive Volkmann's canals (Figure 6 A,B). In the axial (transverse) plane, vertebral body trabeculae shows infilling or compaction, a term introduced by Enlow<sup>8</sup>, near its interface with the ectopic bone. The lesion appears to extend into the vertebral endplates. Haversian systems are present in both planes of sectioning, though more prevalent in the axial, indicating remodeling (Figure 6 C,D). Identifiable features include Haversian systems either primary or secondary, at different stages, including possible resorption cavities. Additionally, there are areas of organized lamellar bone surrounding large cavities which were perhaps trabeculae experiencing varying stages of lamellar compaction.

## Conclusions

- Multiple avenues of evidence support the differential diagnosis of DISH in this specimen. Vertebral patterning and the histological presence of appositional bone growth vary from traditional diagnostic standards, suggesting a reconsideration of diagnostic criteria.
- The literature does not address the process of periosteal apposition in regards to spinal ligament ossification. In this specimen, there is histomorphological evidence of periosteal apposition contributing to the size and thickness of the lesion. The discussion of endochondral ossification as the primary and initial process associated with DISH<sup>3,7</sup> does not explain the appearance of advanced ossification of the ALL.
- It is suggested that diagnostic criteria for DISH in humans can be applied to non-human primates with the amount of flexibility exercised in human diagnosis. Captivity may provide analogous behavioral risk factors as those clinically associated with DISH.
- Future research:** Little is known of the appearance of early stages of the condition which may confound or even preclude correct identification of DISH in the bioarchaeological record. Future research on the histological progression of this condition and continued use of CT will help to flesh out the ambiguity of all stages of this disease process. Bioarchaeological research can provide insight to clinical understanding of DISH in modern human populations. Increasing awareness of DISH for physicians and bioarchaeologists will stimulate more accurate differential diagnoses in spinal pathology.

## Acknowledgements

This project was funded and supported by the Department of Anthropology at the Ohio State University. The authors would also like to thank Drs. Clark Spencer Larsen, Paul Sciulli, Sam Stout, and Scott McGraw.

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