BEYOND TUBERCULOSIS: IDENTIFYING OTHER PATHOLOGICAL SPINAL CONDITIONS IN ANCIENT CHACHAPOYA HUMAN REMAINS*

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Abstract. While tuberculosis was likely endemic in pre-Columbian populations in Peru, new case studies identify other skeletal vertebral lesions not consistent with TB. Two individuals were interred within a cliff-tomb at the site of Diablo Wasi in the Chachapoyas region (~1350–1450 AD). Both are adult males approximately 25 to 40 years of age. Individual A presents with significant kyphosis at T12 with medium to large coalescing focal lesions on the anterior bodies of T6-T12. Differential diagnosis suggests paracoccidioidomycosis. Individual B demonstrates systemic osteopenia and osteoporosis. Bone surfaces demonstrate a proliferation of smooth-edged macroporosity and reticulating perforations especially of the ribs and vertebra. Incompleteness and complex etiology limited diagnosis, but an endocrine disorder, or neoplastic/hyperproliferative condition like leukemia are suggested. These mummified remains advance our understanding of the range of conditions present and support the need for paleopathological rigor as tuberculosis may not always be the cause of spinal osteomyelitic lesions.

Keywords. Spinal pathology. Kyphosis. Paleopathology. Chachapoyas. South America.

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1. INTRODUCTION

Mummified human remains provide many opportunities to identify evidence for different disease processes affecting past populations (Cockburn *et al*., 1998; Dageförde *et al*., 2014). However, not all diseases manifest in skeletal tissues and we are more likely to recognize lesions when we have well-preserved remains with more advance stages of disease progression. The value of case studies and detailed differential diagnosis cannot be understated especially when archaeological discovery is based on random events and rare preservation; what we find and the condition in which it is preserved is not consistent, nor are all disease processes (Buikstra *et al*., 2017). It becomes essential to describe the *osseous impact* in order to establish clear differential diagnoses (Hershkovitz *et al*., 1998).

Hyperkyphosis of the spine is a strong indication of abnormal body posture and can be the result of various processes, including congenital factors, traumatic injury, and destructive disease processes that maybe either chronic or acute, infectious or inflammatory (Dick, 1997). Pathological collapse due to fracture in vertebral bodies results from both focal and diffuse diseases that weaken osseous architectural integrity. Destruction and collapse at one or a few contiguous levels points to more acute processes, more likely infectious or neoplastic, and diffuse disease affecting the entire spine points to more chronic and systemic disease. Involvement or preservation of the disc spaces vs primarily bone modification provide other clues, as does the impact location as primarily posterior vs anterior on the vertebral element. While such bone manifestations are rare in the archaeological record, tuberculosis is one such disease that has been identified (Strouhal, 1991). Individuals can develop "classic Pott's disease" with a pronounced curvature of the spine resulting from the collapse of the lower thoracic and upper lumbar vertebral bodies due to expanding lytic lesions across the endplates.

In this paper we describe and define two cases of vertebral kyphosis caused by rarer pathological conditions, identifying that various distinct disease processes affected this population in ancient Peru other than tuberculosis.

2. ARCHAEOLOGICAL CONTEXT

In the Central Andes of South America, mummified humans remains have provided opportunities to identify the presence of distinct disease processes affecting past populations (e.g., Guillén, 2004; Lombardi & García Cáceres, 2000; Panzer *et* *al*., 2017). The northeastern montane region, while that of a high altitude subtropical cloud forest with high precipitation and humidity, has paradoxically yielded an extensive collection of well-preserved human remains from cliff tombs perched on the walls of vertical escarpments. These date to the Chachapoya culture that flourished between AD 900–1470 and whom were later incorporated into the Inca Empire from ~AD 1470–1532.

There is a long history of archaeological interest in the Chachapoyas region (Bandelier, 1907; Langlois, 1940), but generally few intensive field excavations (Guengerich, 2015; Narváez, 2013). Our research at the necropolis of Diablo Wasi is part of a broader exploration of mortuary practices in Chachapoyas linked with questions of population health and social organization. Spectacular, complex mortuary structures suggest that variation in ideological design and social investment in funerary architecture was linked to social stratification (Nystrom *et al*., 2010). But, early ethnohistorical documents, based on Inca and local testimony, suggest that politically the Chachapoya were not a single, united polity (Schjellerup, 2008). Therefore, mortuary complexity and these elaborate and highly visible tombs may have signaled ethnic identities and may have been lineage-based investments for collective interments rather than being limited to social elites (Crandall, 2012; Kauffmann Doig & Ligabue, 2003). Perhaps forthcoming analysis of aDNA could test if individuals within tombs are more closely related than among neighboring tomb structures (Guevara *et al*., 2017).

Chachapoya mortuary sites have generated significant attention due to their prominent placement high on exposed cliff walls (Kauffmann Doig & Ligabue, 2003). However, this visibility has led to damage by looters who remove contents and destroy bodies looking for cultural materials to sell on the black market. Two decades ago the discovery of an almost untouched site at Laguna de los Condores produced hundreds of unopened mummy bundles (Guillén, 2002). With this exceptional preservation of textiles and soft tissues, there is a great opportunity to explore the past health and disease prevalence of individuals buried in the tombs as well as compared to other regional sites.

2.1. Diablo Wasi

The mortuary complex of Diablo Wasi (Huasi) is located ~16 km south of the modern community of Leymebamba (Fig. 1). The site includes over 40 tombs placed across the almost vertical surface of four exposed limestone rock escarpments. Most of these structures are extremely challenging to reach, which has re-

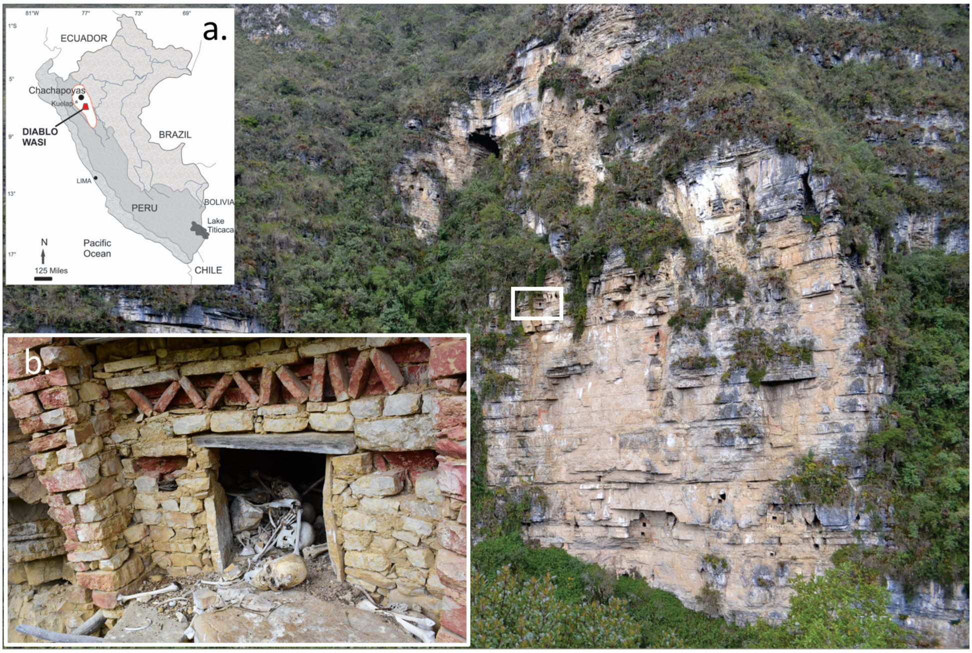

Fig. 1. Photo of Diablo Wasi mortuary complex with inset (a) of map of Peru with location of archaeological site within Chachapoya region and (b) photo detail of EF-01 tomb where remains of Individual A and B were recovered.

sulted in better preservation of remains, although looters have still caused significant damage. Natural and geological processes also have negatively impacted preservation. As archaeologists, we employed specialized rope access techniques to safely reach a selection of the tombs in order to document architecture and analyze materials identified (Toyne *et al*., 2018). Unfortunately, access was limited and we could only recover a small amount of materials.

Tomb "Estructura Funeraria", EF01, is the focus of this paper and even for its location in the center of the Central sector of the cliff wall was still disturbed and the bodies unwrapped from their textiles with some of the bodies partially dismembered in the search for treasures. The tomb was created by filling in a natural crack to create a flat floor surface within a natural triangular shaped rock grotto (3m wide by approximately 5m deep). The space was then enclosed by a wall constructed of masonry layers of smaller cut stones and two shorter buttress side walls. There is a small access point shaped by two large flat stones and a wooden plank lintel, as well as a narrow (~40cm) platform of thin rocks in front of the entrance. There are decorations of zig-zag friezes above the entrance, small box niches across the base, as well as red and white paint on the façade. There are other tombs in this and adjacent sectors with similar types of decorative elaboration reflecting great effort in the creation of these mortuary spaces.

Notably tomb construction materials produced a radiocarbon date of the 9–10th century (918+/– 33 years AD calibrated) yet the two individuals date to the 14th century (Ind A: 1383+/– 36 years; Ind B: 1357+/– 83 years AD calibrated). This suggests that the tomb was used for at least 400 years after it had been constructed and there was successive re-uses of the space (Epstein & Toyne, 2015). Both of the mummified bodies are contemporaneous with the Chachapoya occupation. The soft tissue desiccation and mummification within textile wrappings suggests that this type of body preservation was present prior to the Inca arrival in AD 1470, but whether it was intentionally enhanced to create artificially mummified corpses or a natural process is not clear.

There were a least 10–12 mostly mummified individuals identified within the tomb. Logistics of hanging ropes made traditional archaeological practice and documentation of location difficult and dangerous, and it was challenging to see all of the remains piled and distributed across the tomb floor. We were only able to 'sample' and recover these two individuals and other isolated skeletal materials scattered across the entranceway.

3. METHODS AND MATERIALS

Osteological analysis followed standard observations recommended by Buikstra and Ubelaker (1994) and others (Allison & Gerszten, 1975). Demographic estimate of age was based on epiphyseal closure, dental attrition, and ectocranial suture closure. Sex was estimated based on the morphology of the os coxa and cranium as well as overall size and robusticity. Individuals were photographed, photogrammetry was applied, and standard radiographs were taken of binary views.

4. RESULTS

4.1. DWEF-01 Individual A. This articulated, partially mummified individual (young adult male, 30–39 years) is moderately complete (Fig. 2) with evidence of

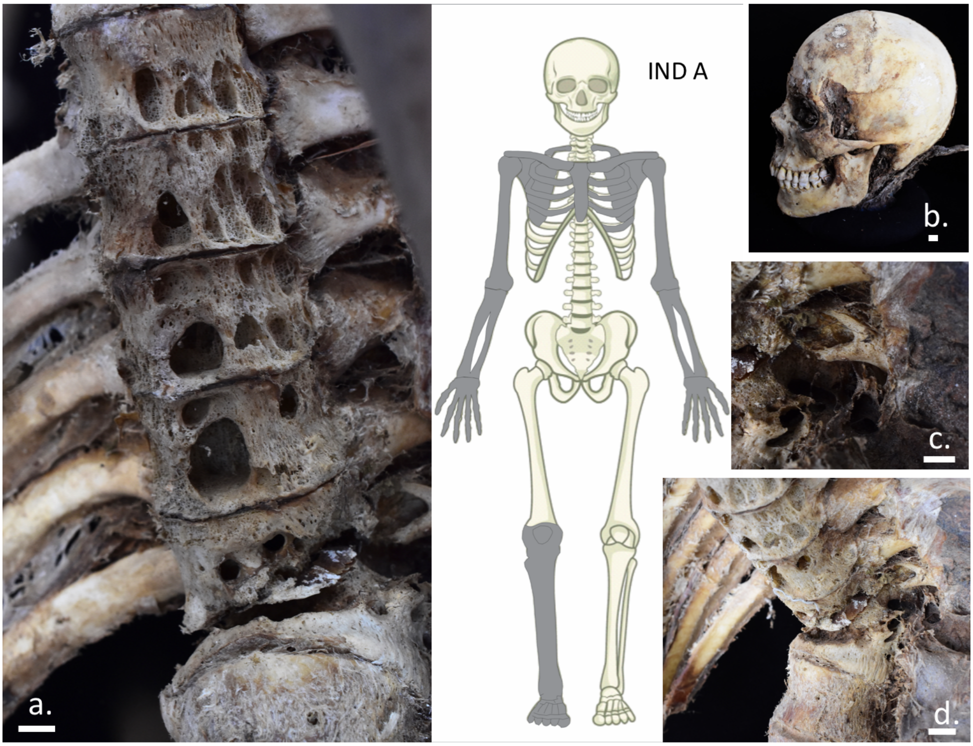

Fig. 2. Composite of Individual A skeletal pathology, including inventory of skeletal remains present (missing elements in grey). Inset details of pathological bone lytic lesions: a) thoracic vertebral column; b) cranium with dental calculus; c) left R11 with large focal lesion; d) T11 and T12 wedge shape. (white bar = scale of 1 cm).

postmortem damage including rodent chewing on the sternal ends of the ribs. The cranium is present but disarticulated postmortem at the level of C3/C4. The skeletal remains are covered by limited soft tissue skin and muscle, and articulated by desiccated ligamentous structures demonstrating that the individual was placed in a tightly flexed and seated body position.

The significant pathological lesions are located in the spinal column with focal lytic lesions starting at T7 through T12 with well-defined smooth oval margins generally on the anterior aspect of the vertebral bodies. These are consistent with abscess formation or "a space occupying-lesion character, as if the excavated area had been occupied by a mass" (Hershkovitz *et al.*, 1998:51). There is no evidence

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for involvement of the posterior vertebral cortical bone of the neural arch, transverse processes, or epiphyses. The thoracic involvement increases caudally among these contiguous vertebrae where T7 has small (~5 mm) lesions, and T9 and T10 retain normal body height but have larger (up to 15 mm by 20 mm) overlapping erosive lesions located on the anterior bodies (endplates are not affected). T11 is mostly complete and demonstrates a wedge-shaped deformation with reduction in the anterior body height, due to significant lytic lesions of the inferior portion of the body. T12 is reduced in height due to concavity and missing the superior ½ of the vertebral body due to lytic lesions. It is not clear if there was a fracture due to the osteopenia of the vertebral body, but the upper surface of the vertebral body appears to have developed a pseudo-facet with T11 as though there was a moveable joint surface between them (intervertebral disc may have been absent) allowing a small amount of anterior and posterior flexion of the spine. The reduced body height of T12 creates an enhanced kyphotic angle (hyperkyphosis) or Gibbous deformity of the spinal column. From a linear base, the angle of kyphosis approximates almost 45 degrees anteriorly, a moderate kyphosis. Classification: Whole Kyphosis type 4 (Wang *et al*., 2012). Lesions appear active and slowly progressive, but there is also evidence of bone remodeling to suggest some healing over the long term.

There is also involvement of the lower ribs with a large lytic lesion on the neck of the left R11 and the right R11 has initial signs of lesion development with a large smoothly lipped circular depression in a similar location. The transverse processes are not visible under soft tissue, but since T12 is partially destroyed, it appears that the lateral and posterior aspects of the articular areas may also be damaged including the head of the left R12. The adhering soft tissue also obscures observations of modification of posterior surfaces of the ribs, os coxa, and hip joint. The superior endocranial surface of the skull presents extensive unhealed macroporosity. Radiographs did not elucidate other internal bone erosion, including within the endocranium.

The differential diagnosis is presented in Table 1. Based on the location and morphology of the granulomatous-like lesions on the vertebrae, tuberculosis, brucellosis, and mycocceal (fungal) infections are possible diagnoses. Lesion distribution and progression suggests a hematological spread rather than metastic malignancies. This pattern is atypical of common causes of osteodiskitis. Tuberculosis is unlikely, as is brucellosis, for the lack of periosteal reactive bone around lesions, the absence of lesions affecting the body margins, as well as lack of coalescing lesions.

Table 1. DIABLO WASI - EF01 - INDIVIDUAL A. Differential diagnosis.

DISEASE	PATHO-GENESIS	DISTRIBUTION	TYPE OF LESION	EPIDEMIOLOGY	DIFFERENTIAL +	DIFFERENTIAL –	REFERENCES
Chronic Osteomyelisis	Infection	Any bone	Large focal lytic lesions, external or internal origin	Geography: Any Demography: both sexes and all ages	+ large cloaca; discrete focal lesions in vertebral elements + kyphosis	- consistent appearance across multiple elements without continuity between (epiphyses not affected)	Barreto *et al.*, 2011
Metastatic Carcinoma	Neoplastic	Vertebral column but also acrum, ribs, sternum, skull, and proximal metaphysis and epiphysis of femur and Vertebrae: Compression fractures and kyphosis are common	Large focal lytic lesions, with sclerotic margins. Also destruction of cancellous bone.	Geography: Any Demographay: Age and gender vary with the source of the carcinomaln adults, 80% metastasize from the breast, prostate, lung, thyroid, and kidney	+ Involvement of vertebral column, ribs, humerus + Vertebral compression fractures; kyphosis + Lytic lesions + Sparing of cranial vault	- Sparing of mandible, and glenoid fossa - Large lesions - sclerotic margins; well defined margins	Marks and Hamilton, 2007; Ortner, 2003:532; Resnick, 2002; Rothschild *et al.*, 1998
Lymphoma	Neoplastic	Femur, tibia, fibula; HL - spine, pelvis, ribs, femur and sternum (descending order of most common to least common)	Hodgkins and NHL both tend to cause multiple osteolytic lesions with a 'moth-eaten' appearance. Lesions can be lytic, sclerotic, or both.	Geography: Any Demographay: Age and sex vary with the source of the carcinoma; increase with age males > females	+ Involvement of spine, and ribs + Lytic lesions + Sex	- sclerotic margins	Mulleman *et al.*, 2004; Ortner, 2003:376
Tuberculosis	Infection Bacterial	Vertebrae most common but also extra vertebral elements; femur, tibia, clavicle, elbow, sacrum, skull Vertebrae: Compression fractures and kyphosis are common; posterior segments only rarely affected + Reactive bone formation Ankylosis and ossification of interspinous ligaments	Large destructive foci in the cancellous bone, osteoporosis, perforation of lytic lesions in cortex with In vertebrae, paravertebral abscesses form and ankylosis between joints of vertebrae involved in kyphosis	Wide geographical variance and demographic prevalence	+ Involvement of vertebrae + Osteoporosis + Vertebral compression fractures; kyphosis + Reactive bone formation	- smooth resorptive lesions in cancellous bone - lack of new bone formation - Involvement of adjacent bones	Dass *et al.*, 2002; Lombardi & García, 2000; Ortner, 2003
Mycoses	Infection Fungal	**Blastomycosis** – any bone; but especially vertebrae, ribs, skull, tibia, metatarsals, metacarpals	lytic lesions with well-defined borders and sclerotic margins and periosteal reaction. Vertebral body erosion; kyphosis	Geography: Ohio and Mississippi valleys and North Carolina , also S Am, more moist enviro. Age: Highest incidence 30-50 Sex: Males > Females	+ Involvement of vertebrae, and ribs + lytic lesions with sclerotic margins + Vertebral body erosion + Vertebral compression fractions; kyphosis + Sex	- no periosteal reaction - inconsistent geography	Hershcovitz *et al.*, 1998; Sorenson, *et al.* 1999
		Paracoccidioidomycosis (Paracoccidioides brasiliensis. South American blastomycosis)– any bone may be affected, especially vertebrae, clavicles, ribs, and extremities	smooth-edged round lytic lesions (single or multiple), with no periosteal reaction or sclerotic margins.	Geography: South America Age: More common adults Sex: Males > Females; 12:1	+ Involvement of clavicles, ribs, and vertebrae + Lytic lesions + Vertebral body erosion + Vertebral compression fractions; kyphosis + Sex + Geography	- sclerotic margins - only vertebrae and ribs affected	Amstalden *et al.*, 1996; Angulo & Pollack, 1971; Ortner, 2003:326
		Cryptococcosis (European blasomycosis) – any bone may be affected, especially	well circumscribed lytic lesions; no sclerotic margins	Geography: World-wide, European origin Demography: both sexes and all ages	+ Involvement of vertebrae + Typically causes focal lytic lesions	- sclerotic margins - inconsistent geography	Ortner 2003:326; Sorenson *et al.*, 1999; Zhou *et al.*
		Coccidioidomycosis – Axial skeleton: acromion, coracoid processes, styloid processes of radius and ulna, condyles of the humerus, ends of clavicles, ribs, skull (limited to the outer table) and vertebra	Lesions are lytic and there may be periosteal reactive bone formation. Marginal sclerosis is uncommon; fistula rare; usually non-coalescent lesions in vertebrae.	Geography: Southwest United States, Central America, Venezuela, Bolivia, and Argentina Demography: both sexes and all ages	+ Involvement of vertebra (but no extra-vertetebral soft-tissue attachments) + Lytic lesions	- involves contiguous vertebrae - inconsistent geography; more drier environment - no involvement of pedicles - sclerotic margins	Dalinka & Greendyke, 1971; Sorenson *et al*,. 1999
Brucellosis	Infection Bacterial	Vertebrae most common, but may also appear on skull	small destructive lytic focus on superior, anterior surface of the vertebral body with sclerotic margins. Does not result in collapse of vertebral bodies.	Geography: Mediterranean basin, Persian Gulf, the Indian subcontinent, and parts of Mexico and Central and South America Demography: both sexes and all ages Males>females	+ Involvement of vertebrae	- vertebral compression fractions after extensive lesions - Lesions localized to superior, anterior surface affecting the intervertebral disc tissues and vertebral body margins; can cause spondylitis in the lumbar and thoracic spine - inconsistent geography; restricted to Old World - no involvement of lumbar	Anastopoulou, *et al.*, 2017; Ortner, 2003; Namiduru *et al.*, 2004

Table II. DIABLO WASI - EF01 - INDIVIDUAL B. Differential diagnosis.

DISEASE	PATHO-GENESIS	PATTERN OF LESIONS	DESCRIPTION	EPIDEMIOLOGY	DIFFERENTIAL		REFERENCES
					+	–	
Cushing's Syndrome	Endocrine	Axial skeleton; especially vertebral bodies (lumbar and thoracic) and ribs; Skull is typically spared.	Severe osteoporosis which may result in focal lytic lesions similar to those seen in multiple myeloma as well as reticulated perforations. Trabecular bone is more affected than cortical bone. Pathological fractures common.	Geography: not restricted Age: Any age but is most frequently affects young adults Sex: Women > men 4:1	+ axial skeleton involvement + osteoporosis + lytic lesions similar to those seen in MM (no sclerotic margins) + vertebral compression fractures; kyphosis + age + reticulated perforations	- sex less likely - osteoporosis too severe - clinical does not identify perforating lesions - normal sella turcica	Mancini *et al.*, 2004; Ortner, 2003:367
Multiple Myeloma	Neoplastic	Vertebral column, ribs, cranium, pelvis, femur, clavicle, and scapula	Small and round 'punched out' lytic bone lesions in affected bone sized 5mm-2cm in diameter. Spongiosa of vertebral bodies destroyed. Often results in collapse and kyphosis	Geography: not restricted Age: Older adults; peak age of incidence is 65-70 years Sex: Men > women 1.4:1	+ involvement of vertebral column, ribs, clavicles, and scapulae + lytic lesions + vertebral compression fractures; kyphosis	- age too young - size of lesions (<5mm) small - lesion margins not punched out	Ortner, 2003:359, 377; Rothschild *et al.*, 1998
Metastatic Carcinoma	Neoplastic	vertebral column (especially lower thoracic), sacrum, ribs, sternum, skull, and proximal metaphysis and epiphysis of femur and humerus Vertebral compression fractures and kyphosis are common	Large focal lytic lesions, with irregular-shaped sclerotic margins.	Geography: not restricted Age and gender vary	+ involvement of vertebral column, ribs, humerus + vertebral compression fractures; kyphosis + lytic lesions + sparing of cranial vault	- sparing of mandible and glenoid fossa - no large lesions - margins circular and not sclerotic margins	Marks and Hamilton, 2007; Ortner, 2003:532; Rothschild *et al.*, 1998
Leukemia	Neoplastic	Any bone	Discrete, small osteolytic lesions without sclerotic margins. Lesions are found in both trabecular and cortical bone Osteoporosis is another common feature and can result in vertebral body collapse and kyphosis	Geography: not restricted Age: All ages; there is a small peak of incidence in children under 5 and then incidence increases with age. Sex: Males > Females	+ small lytic lesions without sclerotic margins + osteoporosis + vertebral compression fractures; kyphosis + sex		Auferheide & Rodríguez-Martín, 1998:355; Klaus, 2016; Rothschild *et al.*, 1997
Lymphoma (Hodgkins and Non-Hodgkins)	Neoplastic	NHL -Femur, tibia, fibula; HL - spine, pelvis, ribs, femur and sternum	Both tend to cause multiple osteolytic lesions with a 'moth-eaten' appearance . Lesions can be lytic, sclerotic, or both.	Geography: not restricted Age: Any but incidence increases with age Sex: Males > Females	+ involvement of spine, and ribs + lytic lesions + sex	- no sclerotic lesions	Ortner, 2003:376; Resnick and Haghighi, 1995
Hyperparathy-roidism	Endocrine	Axial skeleton, facial bones, pelvis, ribs, short tubular bones, and femora	Osteoporosis may result in focal lytic lesions Scalloped depressions on cortical surfaces of phalanges Biconcave vertebrae, 'codfishing,' are common	Geography: not restricted Primary hyperparathyroidism: Usually adults Sex: Females > males; 4:1 Secondary hyperparathyroidism: Age and sex varies with etiology	+ osteoporosis + involvement of axial skeleton, facial bones, and ribs + lytic lesions similar to those seen in MM (no sclerotic margins) + resorption of dental alveoli	- no evidence brown tumors - sex - no biconcave vertebrae	Delling, 1987; Foldes *et al.*, 1995; Resnick, 2002
Tuberculosis	Infection Bacterial	Vertebrae most common but also extra vertebral elements; femur, tibia, clavicle, elbow, sacrum, skull Vertebrae: Compression fractures and kyphosis are common; posterior segments only rarely affected Ankylosis and ossification of interspinous ligaments	Large destructive foci in the cancellous bone, osteoporosis, perforation of lytic lesions in cortex with smooth margins due to abscess formation, reactive bone formation around lesion. Paravertebral abscesses form and ankylosis between joints of vertebrae involved in kyphosis	Wide geographical variance and demographic prevalence	+ Involvement of vertebrae + Osteoporosis + Vertebral compression fractures; kyphosis	- small, smooth resorptive lesions in cancellous bone - lack of new bone formation - Involvement of adjacent bones - no involvement of paravertebral region	Dass *et al.*, 2002; Lombardi & García, 2000; Ortner, 2003
Mycoses	Infection Fungal	**Blastomycosis** – any bone; but especially vertebrae, ribs, skull, tibia, metatarsals, metacarpals	Lytic lesions with well-defined borders and sclerotic margins and periosteal reaction. Vertebral body erosion; kyphosis	Geography: Ohio and Mississippi valleys and North Carolina Age: Highest incidence 30-50 Sex: Males > Females	+ involvement of vertebrae, and ribs + vertebral compression fractions; kyphosis + sex	- diffuse focal resportion - no periosteal reaction - inconsistent geography	Sorenson *et al.*. 1999; Hershcovitz *et al.*, 1998
		Paracoccidioidomycosis (Paracoccidioides brasiliensis. South American blastomycosis)– any bone may be affected, especially vertebrae, clavicles, ribs, and extremities	Smooth-edged round lytic lesions (single or multiple), with no periosteal reaction or sclerotic margins.	Geography: South America Age: More common adults Sex: Males > Females; 12:1	+ involvement of clavicles, ribs, and vertebrae + vertebral compression fractions; kyphosis + sex + geography	- diffuse, small focal lesions - only vertebrae and ribs affected	Amstalden *et al.*, 1996; Angulo & Pollack, 1971; Ortner, 2003:326
		Cryptococcosis (European blasomycosis) – any bone may be affected, especially vertebrae, os coxa, ribs, and cranial bones.	Well circumscribed lytic lesions; no sclerotic margins	Geography: World-wide, European origin Demography: both sexes and all ages	+ involvement of vertebrae + typically causes focal lytic lesions + no sclerotic margins	- diffuse focal resportion - inconsistent geography	Ortner 2003:326; Sorenson *et al.*, 1999; Zhou *et al.*, 2015
		Coccidioidomycosis – Axial skeleton: styloid processes of radius and ulna, condyles of the humerus, ends of clavicles, ribs, skull (limited to the outer table) and vertebra focus on soft tissue attachment sites	Lesions are lytic and there may be periosteal reactive bone formation. Marginal sclerosis is uncommon; fistula rare; usually non-coalescent lesions in vertebrae	Geography: Southwest United States, Central America, Venezuela, Bolivia, and Argentina Demography: both sexes and all ages	+ Involvement of vertebra (but no extra-vertetebral soft-tissue attachments) + Lytic lesions	- involves contiguous vertebrae - inconsistent geography; more drier environment	Dalinka & Greendyke, 1971; Sorenson *et al.*, 1999

The most probable diagnosis is consistent with a mycotic infection such as coccidioidomycosis, where the smooth zones of resorption can be present in the spinal column. However, coccidioidomycosis does not usually produce lesions in contiguous vertebrae or result in Gibbus deformities (Szeyko *et al*., 2012). The case identified here is advanced compared to most modern clinical cases and therefore it is surprising that there was no other extra-vertebral involvement observed. While there are some similarities to other granulomatous fungal infections, these can also be ruled out due to geography except for paracoccidioidomycosis, which is endemic to South America, but it has no modern clinical support for similar vertebral lesions (Amstalden *et al*., 1996). Unfortunately, radiographic imaging did not provide additional diagnostic features as the osteolytic lesions usually have indistinct margins and cannot be radiologically distinguished from other forms of osteomyelitis (Barreto *et al*., 2011). Paracoccidioidomycosis is commonly found in similar environments today as Chachapoyas with tropical or subtropical climates ranging from 18º to 23ºC with forest cover and rainfall over 500 mm, but at lower elevations (900 to 2,000 masl) than Diablo Wasi (Allison *et al*., 1979), whereas coccidioidomycosis is endemic to drier environments (Temple, 2006). Both infections result from pulmonary inoculation (Restrepo *et al*., 1970), but rarely involve the bones and joints (Amstalden *et al*., 1996). The previously reported case of paracoccidioidomycosis from ancient South America (northern Chile, 290 AD) was identified via an autopsy and histological analysis of lung tissue with "yeast-like organisms" (Allison *et al*., 1979:675), but the antiquity, prevalence, and distribution of this disease is little known. This diagnosis could also be stymied due to co-morbidity complicating the skeletal features, individual health predispositions, and issues with comparisons to limited modern clinical cases.

4.2. DWEF-01 Individual B This individual (estimated as a middle-aged adult male, 30 to 44 years) was only partially preserved although similarly articulated by soft tissue structures. The skeleton was missing the inferior portion of the body below T11, and portions of the arms (Fig. 3). There is soft tissue of skin and thin muscle layers adhering to the posterior aspect of the cranium, the neck and across the upper body.

Pathological lesions were evident across almost all bone surfaces of the ribs and vertebrae, but also the scapula, mandibular ramus, basilar portion and sphenoid of the cranium. These were small (2–4 mm), well-circumscribed focal resorption of the cortical bone, but with no periosteal reaction. Especially across the sternal ends of the ribs, there were dense areas of perforation reticulation, but no coa-

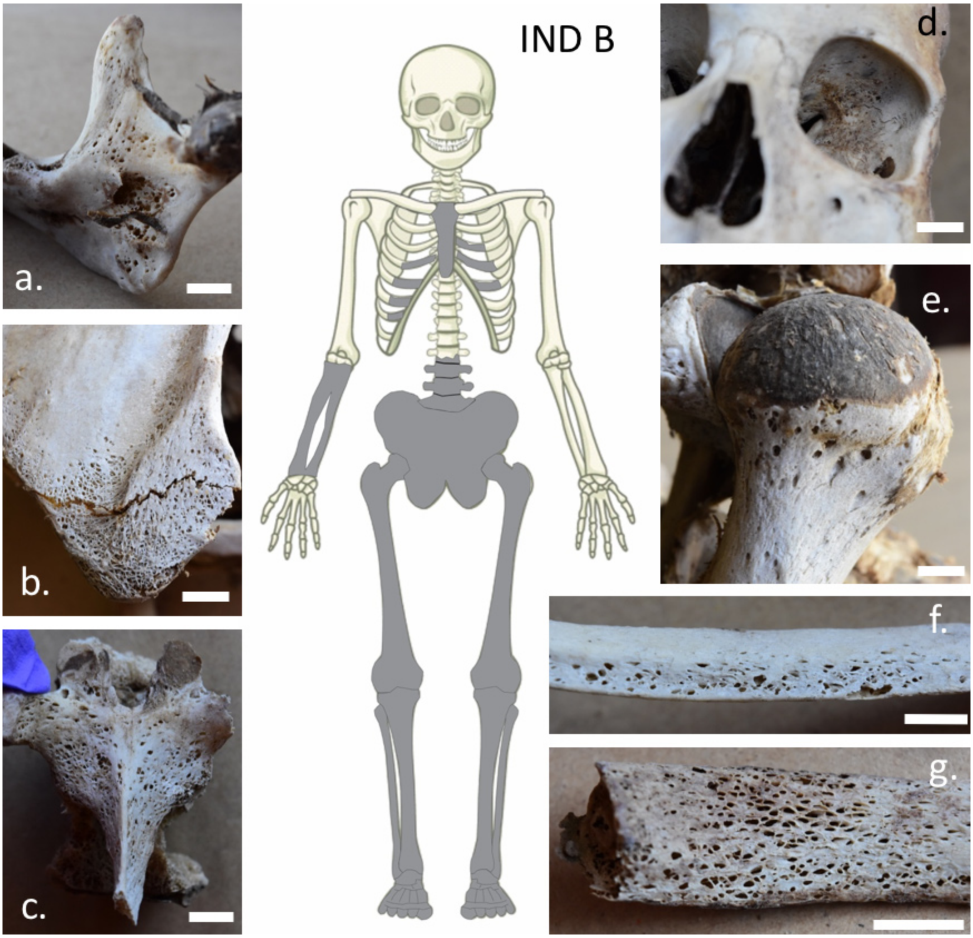

Fig. 3. Composite of Individual A skeletal pathology, including inventory of skeletal remains present (missing elements in grey). Inset details of pathological bone focal resorption: a) right ascending mandibular ramus; b) inferior aspect of right scapula; c) posterior aspect of thoracic vertebra; d) orbital porosity; e) metaphysis of left humerus; f) inferior aspect of rib; g) ventral surface of sternal end of rib. (white bar = scale of 1 cm).

lescence of lesions. There is also porosity along the metaphysis of the proximal humerus. Most of the surfaces of the anterior thoracic vertebral bodies appear damaged by taphonomic processes, but remaining surfaces show focal resorption as well as the posterior neural arches and transverse processes. T4 demonstrates

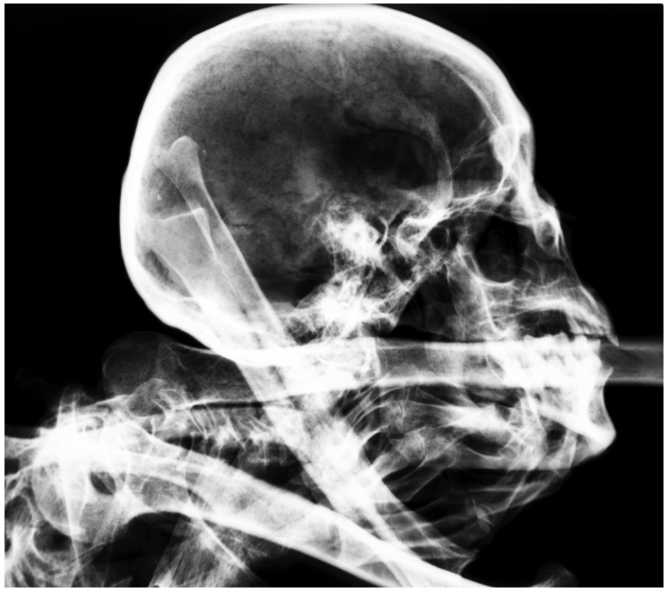

Fig. 4. Radiograph in lateral view of Diablo Wasi EF-01 Individual B.

angular wedging of the anterior body but no modification of the endplates suggesting the vertebral collapse was the result of loss of internal structural integrity. The angle of kyphosis approximates more than 45 degrees anteriorly, a moderate kyphosis, classified as "hollow round back", type 3 (Wang *et al*., 2012). Diffuse osteoporosis is suggested by light weight of bones, and confirmed by radiographs. The superior ectocranial vault also shows crenulations of cranial surface and porosity of the superior orbits.

Table 2 presents the full differential diagnosis for the lesions observed. While a complete skeleton is better for a confident diagnosis, we feel that the evidence for skeletal lesions in this case are consistent with a diffuse destructive bone disease such as a metabolic disorder or myeloproliferative neoplasm. The radiographic presence of a normal sella turcica argues against endocrinopathy-induced osteopenia from Cushing's disease. However, it is difficult to rule out hyperparathyroidism (Foldes *et al*., 1995). We considered multiple myeloma, but there were no cranial lesions and the margins of focal resorption were much smaller than 2-5 mm nor can these be characterized as 'punched out' (Ortner, 2003:378). Rothschild *et al*. (1997) presented two cases of acute leukemia from anatomical collections in the US, whose patho-morphology and distribution are quite similar to this case (focal resorption and cranial crenulations), and so we propose a possible diagnosis of leukemia. One other case has been identified in the Andean region, but on the coast in juvenile remains (Klaus, 2016).

5. TUBERCULOSIS LESIONS

Kuelap is a nearby settlement with a large skeletal series, but no mummified individuals. There are 13 individuals with focal skeletal lesions consistent with TB, both vertebral lesions and appendicular skeletal lesions (Toyne & Esplin, 2016). Both males and females demonstrate lesions including young and middle-aged adults. At least four of the cases demonstrate large cloaca and coalescing vertebral body lesions, which led to complete destruction of the vertebral body or fracture, vertebral collapse and whole kyphosis (Lombardi & García Cáceres, 2000; Wang *et al*. 2012). Most compromised vertebrae are lower thoracic (T10-12) and 1st lumbar, but there is little evidence of generalized osteoporosis. Fig. 5 illustrates the vertebral pathology associated with extensive lesions and destruction of L1 resulting in Gibbus deformity in a middle-aged adult female (PAC ENT1C) from Kuelap. The number of individuals and evidence from other sites suggest that TB was likely endemic in the region (Friedrich *et al*., 2010).

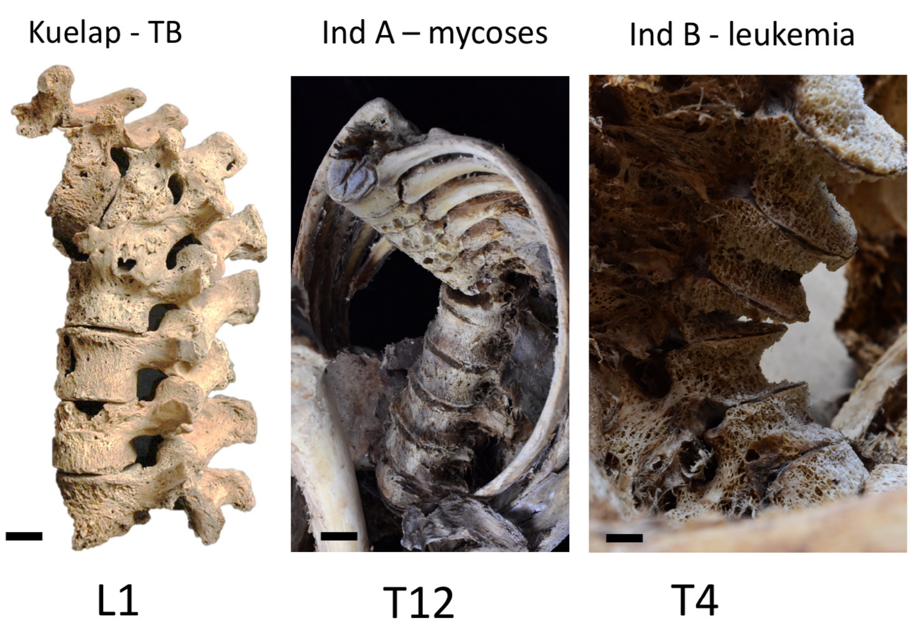

Fig. 5. Imagine comparing individuals from Kuelap with tuberculosis, PAC Ent1c (a), and from Diablo Wasi EF-01: Individual A (b) and Individual B (c), showing location and pattern of kyphosis.

6. DISCUSSION: COMPARISON OF KUELAP TB, DIABLO WASI IND A AND IND B

Each case demonstrates distinct osteological and pathological conditions, yet all three individuals present with pronounced kyphosis of the spinal column. Vertebral collapse and fusion is uncommon in the archaeological record and may be due to various etiologies (Dass *et al*., 2002). In general, collapse of the anterior structures of the vertebral body can be due to damage caused by either by infection or neoplasms, usually metastatic, or to a more generalized process that advances osteopenia, e.g. endocrine or inflamatory disorders. With these conditions, vertebral fractures may be precipitated by minor trauma (Dick, 1997). The position of collapse depends on the vertebral unit and the type of structural compromise (internal or endplate involvement). Diffuse disease processes result in relatively uniform collapse whereas more metastatic disease, hematogenous seeding of infection, and congenitally deficient vertebral endplates lead to more focal weakening or asymmetrical collapse (Sartoris *et al*., 1986). These distinctions can be seen between these cases and other examples of individuals with TB.

In these cases, with TB and the possible fungal infection (IND A), this is lower thoracic vertebral collapse due to extensive erosion of the infectious lesions resulting in irregular focal concavity near the endplates. A clinical case of paracoccioidomycosis was mistaken for TB (Benoldi *et al*., 1985). In IND A, lesions eroded the superior surface of T12 creating anterior wedging. IND B has vertebral collapse due to diffuse osteoporosis resulting from probable myeloproliferative neoplasm (leukemia) higher up in the thoracic spine resulting in angular deformation of the T4 vertebral body but no damage to the endplates. Radiographically these osteological features can be distinguished, but often it is difficult to diagnose whether it is benign or malignant causes (Sartoris *et al*., 1986). If these bodies had been completely wrapped in textiles or disarticulated skeletal elements, it would be more challenging to make these observations and identify possible differential diagnoses. At the same time, radiographs of complete mummy bundles alone may not have been able to clearly describe the morphology of the osseous lesions to be useful for comparative research (Rothschild & Rothschild, 1995). Computed topography may further elucidate these factors in the future.

From an anthropological perspective, these conditions would have impacted the daily lives of these individuals. All three individuals likely spent their final days (if not months or years) with a significant deformation of the spinal column. The

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kyphosis was located at different vertebral levels due to distinct underlying disease processes.

7. CONCLUSION

Here we present two cases identifying rare pathological conditions not previous described for the Chachapoyas region. They add to the increasing list of pathological conditions identified across the Andes. Ideally, we would like to retrieve the remaining individuals from the same mortuary context to explore questions of local identities and responses to these types of disease processes (Tilley, 2015). There are other examples of surgical interventions and medical care in the region to suggest local knowledge of treatment for advanced disease states (Toyne, 2015). If these are social elites at Diablo Wasi, then this context contains two male adults with significant pathology and spinal malformations that would have impacted the functional mobility and quality of life for these individuals. Living in such a harsh, mountainous environment, we can also consider that some type of social assistance was necessary.

DNA studies are currently underway to complement osteological and radiological observations; however, unfortunately histology is not permitted (Weinstein *et al*., 1981), it is not permitted. It is important to report potential and variable cases of bone pathology in order to improve current understanding of the appearance and distribution of lesions resulting from various diseases in archaeological specimens. We also recognize that incomplete remains can frustrate confident differential diagnoses, but partially skeletonized individuals provide important opportunities to observe contiguous lesions morphology. These cases are invaluable to identify and make comparisons to other known skeletal and mummified collections in the region and beyond to be able to broaden our understanding of the disease burdens in these past populations.

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