

Treponematosi in a pre-Columbian hunter-gatherer male from Antofagasta (1830 ± 20 BP, Northern Coast of Chile)

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ARTICLE INFO

Keywords:

Caries sicca

Treponemal disease

Andean formative

Northern Chile

ABSTRACT

Objective: This paper reports a new case of treponemal disease in a pre-Columbian hunter-gatherer inhabiting the desert coast of South America.

Materials: A well-preserved adult male skeleton from the “Vertedero Municipal” archaeological cemetery, located near the city of Antofagasta (Northern Chile).

Methods: The skeleton was radiocarbon dated, and isotopic analyses were performed to assess diet and mobility. Lytic and proliferative lesions identified were evaluated macroscopically and radiologically.

Results: A radiocarbon date of 1830 ± 20 BP and isotopic values indicating a marine diet and coastal residence were obtained. The cranium shows reactive changes as focal superficial cavitation, radial scarring and nodular cavitation, while the ribs, sternum, clavicles, and scapulae exhibit multiple lytic and proliferative lesions. The right femur has a node while both tibiae show mild anterior cortical thickening with a narrowed medullary cavity.

Conclusions: Cranial lesions are pathognomonic for treponemal disease while postcranial changes are typical, and highly consistent with this pathology.

Significance: The type, morphology, and pattern of lesions make this case a good candidate for venereal syphilis. The case is relevant to the origin of venereal syphilis due to the lifestyle, temporal and ecological context of the individual.

Limitations: Diagnosis of venereal syphilis is based on skeletal lesions; thus, it must be confirmed by molecular analysis.

Suggestions for Further Research: A comprehensive review of cases of pre-Columbian treponemal disease in South America as well as molecular studies are needed to confirm the presence of venereal syphilis in the New World before European contact.

1. Introduction

Numerous studies have confirmed the presence of treponemal disease in pre-Columbian populations of North America (Baker and Armelagos, 1988; Powell and Cook, 2005; Harper et al., 2011; Betsinger and Smith, 2019), but evidence for South America is still scant (Verano and Lombardi, 1999; Standen and Arriaza, 2000; Rodríguez, 2006; García et al., 2009; Klaus and Ortner, 2014) and lacks a comprehensive

review of the cases reported (García et al., 2015). From Chile, most of the evidence reported comes from Northern locations, particularly from the coast of Arica. In 1982, Allison et al. report a Chinchorro adult female with lesions affecting the cranial vault, tibiae (saber shin), and ulna. Two years later, Standen et al. (1984) described another nine probable Chinchorro cases (5000 – 3700 BP), six of them showing incipient tibial and fibular periostitis, and three having gummatous tibial periostitis with saber shin deformity. Standen and Arriaza (2000)

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<https://doi.org/10.1016/j.ijpp.2020.01.004>

Received 5 August 2019; Received in revised form 14 January 2020; Accepted 20 January 2020

Available online 05 March 2020

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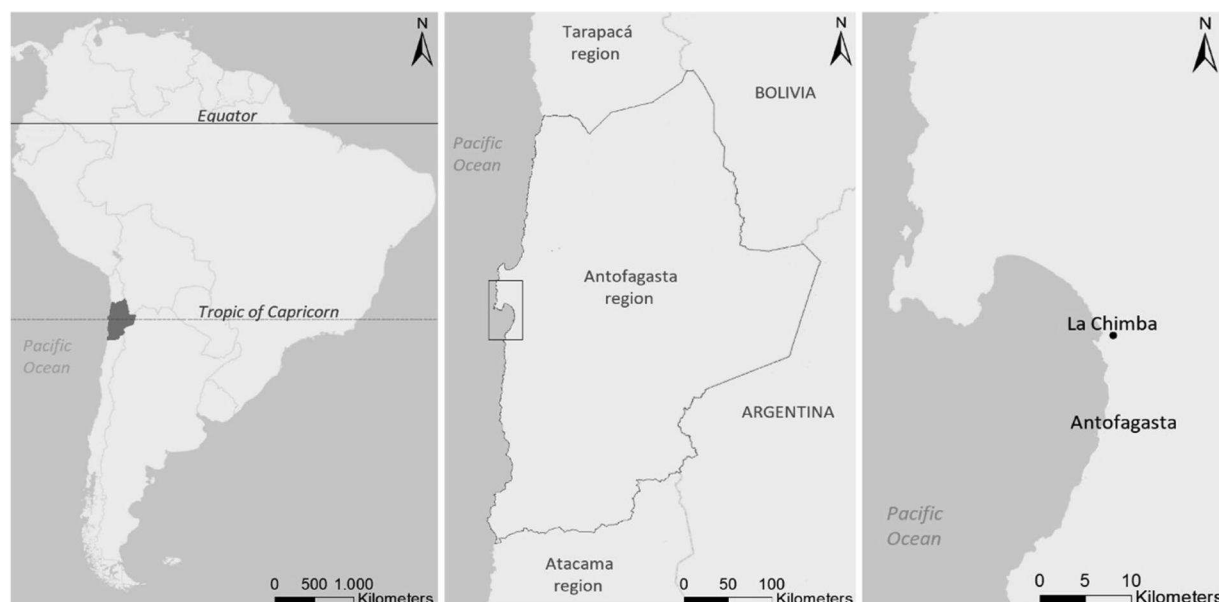


Fig. 1. Location of the Vertedero Municipal cemetery near the city of Antofagasta (23°38'S 70°24'W).

examined skeletal human remains of 636 individuals from different pre-Columbian populations of the Arica area spanning from 5000 to 800 BP (including those previously reported), and suggested that 8 % of them show lesions attributable to treponemal disease. Case reports from non-coastal settings in Northern Chile include an adult of indeterminate sex from the highlands (Allison et al., 1982), and an adult male dated 2160 + 100 BP from the Chiu Chiu 273 site, located near Calama at 2525 m above sea level (Castro et al., 2016).

This report presents a new probable case of treponematosi in a pre-Columbian individual from the coast of Antofagasta, Northern Chile. The type, morphology and pattern of the bone lesions identified are proposed as possible evidence of venereal syphilis. Finally, the temporal and ecological context of the case presented is discussed in relation to other treponemal cases reported in order to address the question of the type(s) of pre-Columbian treponematosi present in Northern Chile.

2. Materials and methods

The Pre-Columbian cemetery “Vertedero Municipal” (VMAnt) was discovered in 2000, in the sand dunes of the district of “La Chimba” at the northeast end of the city of Antofagasta (Fig. 1). The excavation recovered the skeletal remains of nine individuals (Table 1), together with their associated cultural goods (see Appendix A). Among the

Table 1

Bioanthropological and isotopic data of the human remains recovered from the pre-Columbian “Vertedero Municipal” cemetery of Antofagasta (VMAnt).

Burial	Ind	Rep	Sex	Age	C/N	$\delta^{13}C_{col}$	$\delta^{15}N$	$\delta^{13}C_{ap}$	$\delta^{18}O_{ap}$
VMAnt 1	E1	C	M	YA	3.3	-12.28*	24.97*	-8.47*	-1.56*
and 2	E2	P	M	YA					
	E3	P	F	YA					
VMAnt 3	E3	Ic	F	YA					
VMAnt 4	E4	C	F	YA	3.2	-12.55*	23.55*	-9.52*	-1.72*
VMAnt 5	E5a	C	M	MA	3.3	-12.69	24.38	-10.36	-0.46
	E5b	P	I	A					
VMAnt 6	E6	Ic	I	Ch	3.2	-12.94*	23.62*	-9.52*	-0.87*
VMAnt 7	E7	C	M	YA					

Ind: individual. **Rep:** Representation: C, complete (> 75 %); Ic, incomplete (50 % to 25 %); P, poor (< 25 %). **Sex:** M: Male; F: Female; I: Indeterminate. **Age:** Ch, Child; A, adult; YA, young adult (20–35 years); MA, middle adult (35–50 years). *Data from Ballester and Clarot (2014: 93).

adults, one probable case of treponemal infection was identified: individual 5a (Castro and Aspillaga, 2002). The skeleton of individual 5a, determined to be a middle adult male, is in a very good state of preservation and almost complete (inventory and methods detailed in Appendix A). The lesions were examined macroscopically, with magnification (10x) and radiologically following the protocols of Chhem and Brothwell (2008), and Beckett and Conlogue (2010). Radiographs were produced using portable devices (Ecotron EPX-F2800, and Carestream 35 × 43 cm image receptors). The scans were taken with 55 Kv and 2.5 mAs, at a source-object distance (SOD) and source-image receptor distance (SID) of 100 cm. The radiographs were generated by a Computed Radiography (CR) reader (Vita Flex CR System 45 PPH) and processed with IMAGE SUITE medical software. Bones with lesions were 3D modelled by stereophotogrammetry using a Canon Eos Rebel 650D camera for captures, the Agisoft software for 3D reconstruction, and the Meshmixer software for editing. Lesions were recorded following standard criteria (Buikstra and Ubelaker, 1994; Lovell, 2000), the guidelines established by Hackett (1976), observations of Powell and Cook (2005), and Harper et al. (2011). Diagnosis of general lesions was based on criteria from Ortner (2003) and Aufderheide and Rodriguez-Martin, 1998, while the diagnosis of treponemal disease was specifically based upon Hackett, 1975, 1976, 1981 and Harper et al. (2011). Lesions were ascribed to one of the following categories: ‘not consistent with’, ‘consistent with’, ‘highly consistent with’, ‘typical of’, and ‘diagnostic of’ treponemal infection (Appleby et al., 2015). Radiocarbon and stable isotopic analysis were performed from a fragment of the 9th right rib (without lesions) at the Center for Applied Isotope Studies of the University of Georgia.

3. Results

The radiocarbon date obtained from individual 5a was 1830 ± 20 BP (UGAMS#35762, bone, $\delta^{13}C = -12.69\%$), while its $\delta^{13}C$, $\delta^{15}N$, and $\delta^{18}O$ values (Table 1), indicating a marine diet and coastal residence, are similar to those obtained from the other three individuals from the same site (Ballester and Clarot, 2014). Regarding possible reservoir age effect due to the diet of individual 5a, Table 2 shows the calibrated age range using four calculation methods based on OxCal 4.3.2 (Ramsey, 2009), from which the more accurate (but less precise) date is the last one.

Lesions and anomalies ‘not consistent with’ and therefore not directly related to treponemal disease were identified in the cranium, mandible,

Table 2

Calibrated age ranges for the radiocarbon date of 1830 ± 20 BP obtained from Individual 5a.

Curve employed	Method of calculation	Calibrated age range at 95.4 %
SHCal13	–	cal AD 140-338
SHCal13	Subtracting 400 years	cal AD 634-677
Marine13	–	cal AD 507-655
Marine13	Using ΔR of 226 ± 98 (Ortlieb et al., 2011)	cal AD 615-1011

vertebrae, and feet. These include exostosis of the external acoustic meatus on the right side (Fig. 2.a), medium horizontal alveolar bone loss in both maxillae and mandible, and a periapical lesion associated with the right mandibular central incisor (Fig. 2.b). Regarding the vertebrae, C4 shows eburnation on the superior aspect of the body (Fig. 2.c), C5 and C6 show incipient articular degeneration on the anterior margin of the body (Fig. 2.d), and several lumbar vertebrae display mild lipping and small osteophytes. A circular pit on the base of the phalanx of the left first toe was identified in the feet (Fig. 2e), circular pits of about 5 mm in diameter with exposure of trabecular bone on the inferior aspect of the distal surface of both lateral cuneiforms and proximal surface of both third metatarsals, (Fig. 2f), in addition to mild lipping in several articular surfaces.

3.1. Lesions probably related to treponemal disease

Cranium: The cranial vault shows different stages of the *caries sicca* sequence (Hackett, 1975, 1976, 1981). Lesions in the frontal bone are transitional between phase 3 (focal superficial cavitation) and phase 4 (circumvallate cavitation); those located in the left parietal are in phase 5 (radial scars), and those identified in the right parietal are in phase 7 (nodular cavitation) (Fig. 3, and 3D model in Appendix Fig. A.1). This set of lesions fulfils the criteria of Harper et al. (2011: Table 2) considered ‘*diagnostic of*’ treponemal disease since they correspond with pathognomonic expressions of the disease.

Vertebral column (Fig. 4): Fusion of C2-C3 with active bone reaction on the anterior surfaces of their bodies (3D model in Appendix Fig. A.2), and circular and irregular proliferative lytic lesions on the body of C4 could be considered as ‘*highly consistent*’ with treponemal infection. The anterior surface of the body of T1 exhibits two circular lytic lesions and periosteal reaction resembling “*nodes with superficial cavitations*” and therefore could be considered ‘*typical of*’ treponemal infection.

Thorax and shoulder girdle (Fig. 5): the ribs show lytic and proliferative lesions in the ventral surfaces of the bodies following a bilateral and scattered pattern; the sternum shows multiple lytic and proliferative lesions (3D model in Appendix Fig. A.3), the right clavicle shows a lytic lesion and proliferative reaction in the sternal end (3D

model in Appendix Fig. A.4) while the left scapula shows lytic lesions in the medial border, lytic and proliferative lesions in the inferior angle, and proliferation in the scapular neck and acromial process (3D models in Appendices Fig. A.5 and A.6). Lesions in the ribs and sternum are ‘*typical*’ and ‘*highly consistent with*’, while lesions in the clavicle and scapula are ‘*highly consistent with*’ treponemal infection.

Lower limbs (Fig. 6): The posteromedial surface of the proximal diaphysis of the right femur shows a node of 9 cm in length (3D model in Appendix Fig. A.7). The lesion has a rugose surface pattern but without superficial pits, hence it is not diagnostic but ‘*highly consistent with*’ or “*strongly suggestive*” of treponemal disease (Hackett, 1975, 1976). The tibiae show periostitis at their distal thirds and mild anterior cortical thickening with a narrowed medullary cavity, features which are ‘*highly consistent with*’ treponemal infection.

4. Discussion

The “Vertedero Municipal” cemetery of Antofagasta is attributed to marine hunter-gatherers (Ballester and Gallardo, 2011; Carrasco et al., 2015; Knudson et al., 2012; Pestle et al., 2015; Pimentel et al., 2011; Torres-Rouff et al., 2012). This lifestyle provides a plausible explanation for lesions such as the exostosis of the external acoustic meatus (Standen et al., 1985, 1997; Castro et al., 2017), periodontitis, and foot lesions. This observation is reinforced by the absence of caries and the severe occlusal dental wear, suggesting that the periodontitis is more related to masticatory stress rather than infection. The circular pit on the base of the proximal phalanx of the first toe can be considered *osteochondritis dissecans* (Wells, 1974; Aufderheide and Rodriguez-Martin, 1998; Anderson, 2001), whereas the pits on the inferior aspect of the distal surface of the lateral cuneiforms and proximal surface of the third metatarsals can be considered a nonmetric trait in the form of an anomalous interosseous plantar ligament (Tenney, 1991; Wilbur, 1998), or a non-ossseus tarsal coalition (fibrous or cartilaginous), a developmental asymptomatic anomaly which results from failure of a joint space to form properly during foetal growth and which does not cause dysfunction (Regan et al., 1999). In this case, the most probable cause is nonossseus tarsal coalition since both articular facets are affected, and osteochondral fractures usually occur in convex bone surfaces (Regan et al., 1999).

Skeletal lesions caused by treponemal infection are not specific to this family of diseases (Ortner, 2003; Harper et al., 2011), and therefore discriminating between treponematosi and other diseases is difficult. Differential diagnosis has to consider pyogenic osteomyelitis, mycotic infection, tuberculosis and metastatic carcinoma (Steinbock, 1976). Nonetheless, a diagnosis of treponemal disease is supported by the numerous lytic and proliferative lesions in individual 5a. These include ‘*diagnostic*’ cranial lesions, ‘*typical*’ lesions in vertebrae, ribs and sternum, and ‘*highly consistent*’ lesions in a vertebra, right clavicle, left scapula, right femur, and tibiae. According to Hackett, 1975, 1976 the

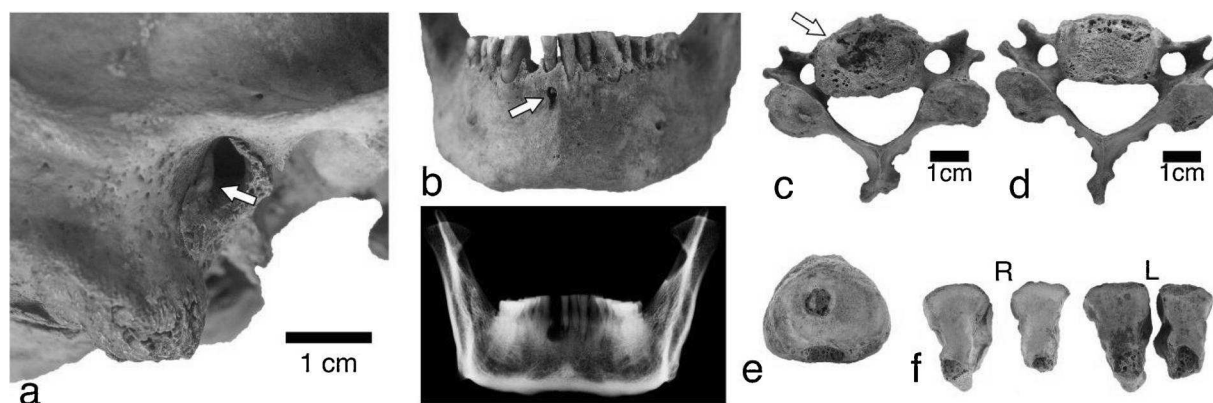


Fig. 2. Lesions and anomalies in individual 5a. From left to right: a) Exostosis of the external acoustic meatus; b) Periapical lesion in mandible; c) Eburnation on C4; d) Articular degeneration in C5; e) Circular pit on proximal aspect of first phalanx of left toe; f) Circular pits in cuneiforms and metatarsals (R, right; L, left).

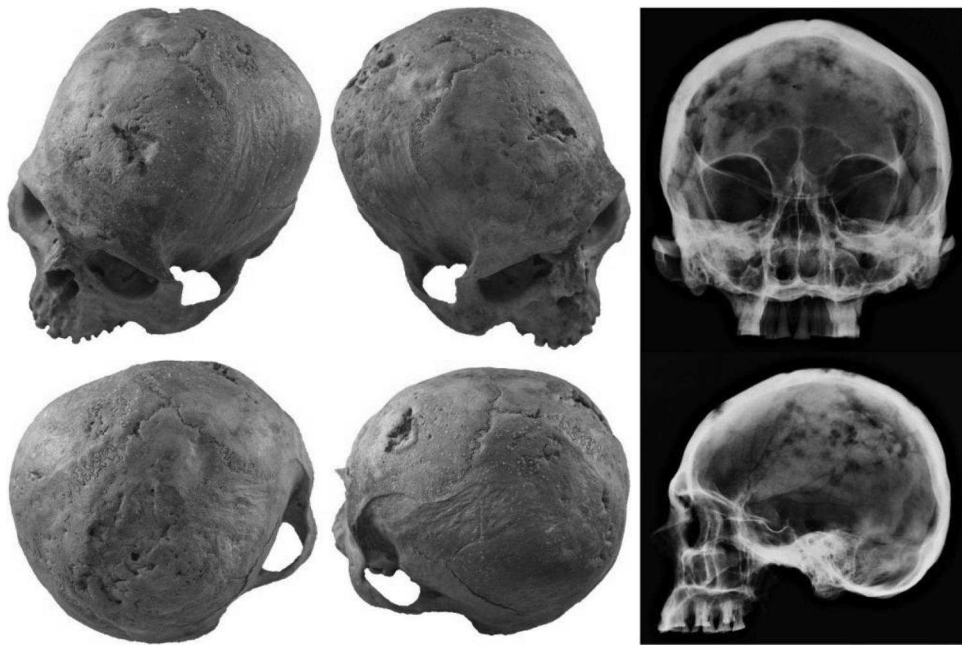


Fig. 3. Cranial reactive changes in individual 5a: Lesions in the frontal bone are transitional between focal superficial cavitation and circumvallate cavitation; the left parietal shows radial scars while the right parietal shows nodular cavitation.

pathognomonic criteria for treponemal disease are the last three stages of the *caries sicca* sequence and the combination of osseous expansions and nodes with superficial cavitation on long bone surfaces (Harper et al., 2011). The case presented fulfils the first criterion, but not completely the latter. Although the lesion in the right femur of individual 5a corresponds to an expansion, it does not show the superficial cavitation, hence, according to Hackett's criteria the lesion is "on trial" (strongly suggestive). Although the periosteal reactions, osteitis,

and osteomyelitis identified in vertebrae, ribs, and sternum could be the result of different processes, their morphology and bilateral and disseminated pattern permits consideration of them as 'typical' and 'highly consistent with' treponemal infection (Steinbock, 1976; Aufderheide and Rodriguez-Martin, 1998; Harper et al., 2011). If the postcranial lesions identified were actually caused by the disease, involvement of multiple skeletal segments could indicate the interrelationship between a haematogenous spread and the response of a compromised lymphatic

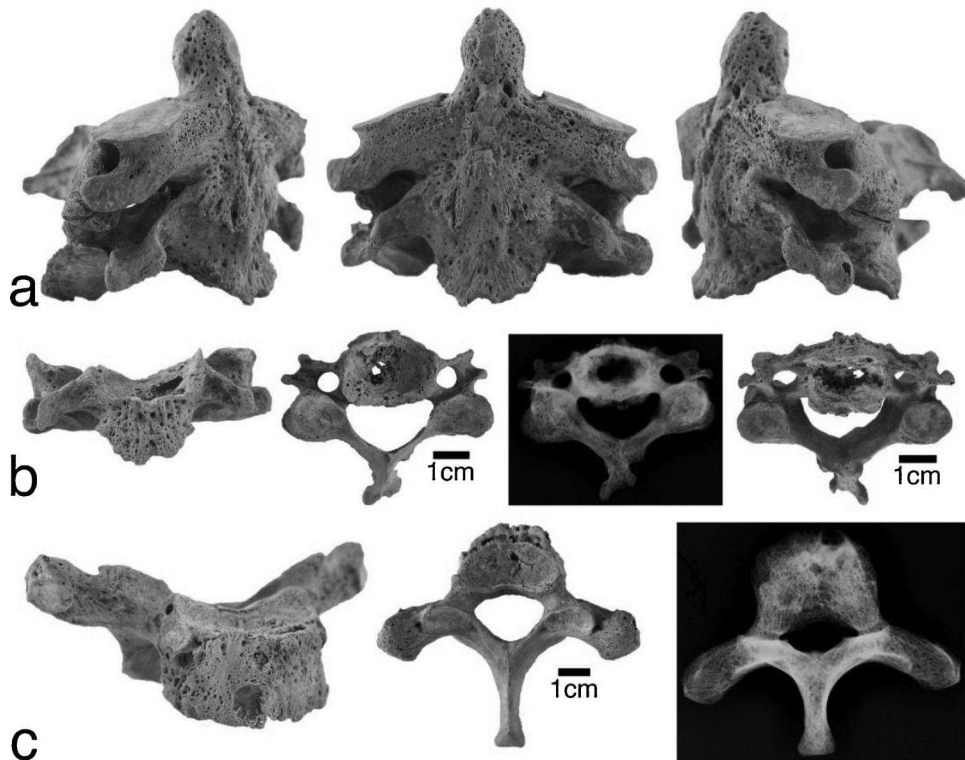


Fig. 4. Vertebral lesions in individual 5a: a) Fusion of C2-C3 with active bone reaction; b) Irregular lytic lesions in the body of C4; c) Lytic lesions and periosteal reaction in T1.

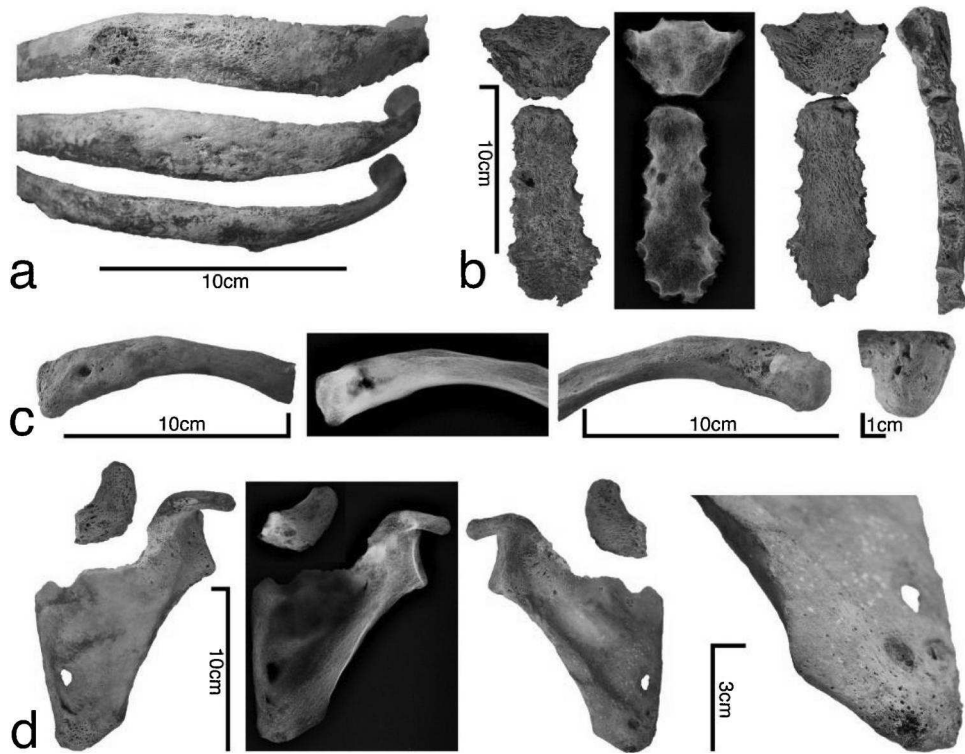


Fig. 5. Thoracic and shoulder girdle lesions in individual 5a: a) Proliferative and lytic changes in the left ribs (9–11); b) Proliferative lesion in the sternum; c) Lytic lesion in the right clavicle; d) Lytic lesions in the left scapula.

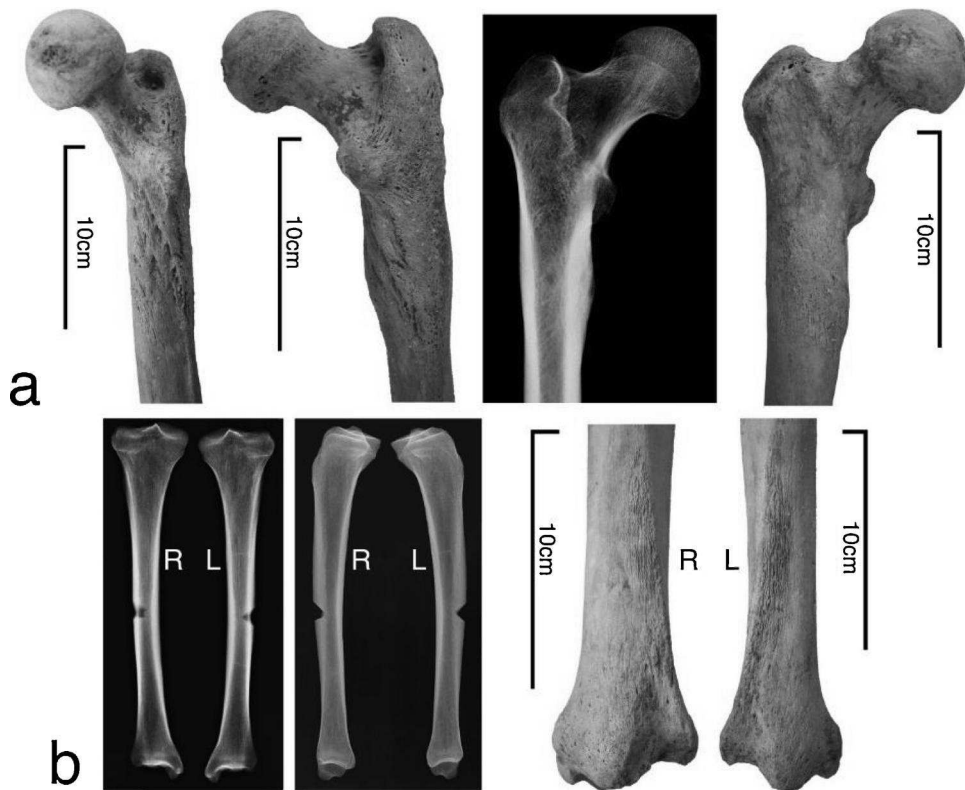


Fig. 6. Lower limb lesions in individual 5a: a) Rugose node in the right femur; b) Periostitis and mild anterior cortical thickening in both tibiae (R, right; L, left).

system (Buckley and Dias, 2002). Thus, lesions in bones of the neck, shoulders, and chest could be explained by lymphatic dissemination (Buckley and Dias, 2002). Regarding the diagnosis proposed, it must be noted that Individual 5a does not show the typical tibial lesions

(although they are highly consistent), together with the absence of lesions in bones distal to the knee and elbow.

Admitting that discrimination between yaws, bejel, and venereal syphilis in bone is still very challenging (Aufderheide and Rodriguez-

Martin, 1998; Ortner, 2003; Harper et al., 2011; Cook and Powell, 2012; Klaus and Ortner, 2014), it is possible to point out that the features and skeletal distribution of the lesions identified in individual 5a are suggestive of venereal syphilis. This is because the cranial vault lesions are ‘diagnostic’ (pathognomonic), whereas the type, morphology and pattern of the multiple postcranial lesions can be considered as typical, and highly consistent. The absence of bone lesions in the hands and feet, which are common in yaws and bejel but rare in venereal syphilis (Mitja et al., 2013; Giacani and Lukehart, 2014; Marks et al., 2014, 2015), also support this diagnosis. A molecular analysis will be performed in order to confirm the presence of the venereal form of treponematoses in the case described. In this regard, Kolman et al. (1999) used molecular methods to identify *Treponema pallidum* ssp. *pallidum* in an archaeological skeletal specimen from Easter Island, Chile (240 ± 50 BP). However, this claim was subsequently discredited owing to a lack of preservation of the treponemal pathogen (Bouwman and Brown, 2005; Von Hunnius et al., 2007). Recently, this line of research has received renewed interest with the results obtained from bones of a perinate and three infants from colonial Mexico (Schuenemann et al., 2018), which demonstrate not only the feasibility of retrieving ancient *T. pallidum* genomes from archaeological material but also the possibility of differentiating between *T. pallidum* ssp. *pallidum* (venereal syphilis) and *T. pallidum* ssp. *pertenue* (yaws).

The evidence for pre-Columbian treponemal disease in Northern Chile has received different interpretations, and there is no consensus regarding the causative pathogen. Allison et al. (1982) suggest venereal syphilis for two cases: a Chinchorro (Archaic coastal group, about 5000 BP) and an Atacameño (highlands, no date), while Standen et al. (1984) propose bejel as the causative agent for the nine Chinchorro cases they report, considering the arid and warm climate of the coast of Arica. In 2000, Standen and Arriaza (2000) following Rothschild and Rothschild (1995), modified their previous conclusion and attributed a yaws pattern to the lesions they identified in 51/636 individuals from different pre-Columbian populations of the Arica-Azapa area spanning from 5000 to 800 BP (including the nine Chinchorro cases studied previously by Standen et al., 1984). However, Rogan and Lentz (1994) analysed ribosomal DNA of *Treponema* extracts of four of the 51 individuals examined by Standen and Arriaza and proposed the possible presence of venereal syphilis after finding *Treponema pallidum* as the closest genetic match of the spirochete sequence, hence suggesting that “ancient treponematoses in Chile may have been due to a spirochete similar, but not identical, to *T. pallidum*” (p., 172). Recently, the presence of venereal syphilis in Northern Chile has been re-assessed after the report of an adult male dated to 2160 ± 100 BP recovered from a site near the city of Calama (Chiu Chiu 273), which has sternal and vertebral lesions compatible with the development of a thoracic aortic aneurysm of (venereal) syphilitic origin (Castro et al., 2016). It must be noted that the distance between Chiu Chiu and Antofagasta, where the case described here was recovered, is about 250 km, and several archaeological studies have demonstrated exchanges between coastal and highland groups in the Antofagasta area (Pimentel et al., 2011; Pestle et al., 2015) (see Appendix A). Taking into account that both cases are relatively contemporary, the remaining question is about the origin: coastal or interior? A working hypothesis is to consider that the pathology most probably emerged in coastal populations during Archaic times and then evolved and moved inland due to mobility and exchange between populations (Allison et al., 1982; Standen et al., 1984; Standen and Arriaza, 2000).

5. Conclusions

The outstanding preservation and completeness of the skeletal remains of a marine hunter-gatherer adult male, contemporary with the Formative Period of Northern Chile permitted the identification of a developmental anomaly (nonosseous tarsal coalition), lifestyle-related lesions (exostosis of the external acoustic meatus, periodontitis, mild

degenerative changes in the vertebral column and feet), and lesions related to treponemal disease. The type, morphology, pattern and severity of the bone lesions identified suggest this individual presents evidence of pre-Columbian venereal syphilis, a diagnosis supported by evidence from other cases reported for Northern Chile, but intriguing given the temporal, ecological context and lifestyle. The origin and dispersion of venereal syphilis is one of the most controversial topics in palaeopathology. The case presented here expands the knowledge about this disease in Chile and South America, but a comprehensive review of all the cases reported (and the report of new cases) is needed in order to have a clearer picture of its origin and dispersal within the subcontinent.

Acknowledgments

The authors thank the Museo de Antofagasta for allowing us access to the skeletal remains and the *Consejo de Monumentos Nacionales de Chile* for the authorization to export the samples analysed (Doc. 2193, dated May 10, 2018). We are also grateful to Iván Arregui and Mariela Torres for their help with Figure 1. The radiological and photographic equipment used belongs to OSTeam Ltd. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:<https://doi.org/10.1016/j.ijpp.2020.01.004>.

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