First European Exposure to Syphilis: The Dominican Republic at the Time of Columbian Contact

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Recognition of syphilis in Europe in the late 15th century and its prior absence suggest New World origin. Skeletal populations were examined from sites with documented Columbian contact in the Dominican Republic. Examination of 536 skeletal remains revealed periosteal reaction characteristic of treponemal disease in 6%–14% of the afflicted population. Findings were identical to that previously noted in confirmed syphilis-affected populations and distinctive from those associated with yaws and bejel: it was a low population frequency phenomenon, affecting an average of 1.7–2.6 bone groups, often asymmetric and sparing hands and feet, but associated with significant tibial remodeling. While findings diagnostic of syphilis have been reported in the New World, actual demonstration of syphilis in areas where Columbus actually had contact was missing, until now. The evidence is consistent with this site as the point of initial contact of syphilis and of its subsequent spread from the New World to the Old.

The impact of emerging diseases on current medicine and society suggests there is value to understanding a disease that arose in Europe in the late 15th and early 16th centuries. Understanding how syphilis emerged, spread, and was "contained" by society may provide insights to fighting diseases such as AIDS today. Interpretation of the historical record suggests that syphilis was first recognized in Europe sometime between the late 15th and early 16th centuries [1–3]. Although treponemal disease clearly was present in pre-Columbian Europe, it was clearly nonvenereal in nature [4]. Our own examination of several thousand Old World skeletons revealed no evidence of syphilis before the voyages of Columbus [5]. That assessment is compatible (on a time line basis) with the Columbian hypothesis [6, 7] of a New World origin for syphilis. Is there other evidence to support the contentions of Cockburn [1] and Cockburn [2]?

Kolman et al. [8] and Centurion-Lara et al. [9] documented that treponematoses are caused by genetically distinct organisms, thus validating previous evidence: reproducible differential animal sensitivity to the different treponemal agents of syphilis, yaws, and bejel [10–13]. Demonstration that the macroscopically recognizable skeletal manifestations of syphilis, yaws, and bejel are also quite disparate as population phenomena [14], and reproducible across population lines [4, 15, 16], allows a unique approach to assessment of the role of Columbus in syphilis transmission.

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Methods

The analyzed sample consists of excavated skeletal remains in the collections of The National Museum of Anthropology, Santo Domingo, Dominican Republic. Sites evaluated included those at El Soco, Juan Dolio, La Caleta, Atajadizo, Cueva Cabrera, Cueva Maria Sosa, and Cueva Roja. Cueva Roja is dated at 4560 years before the present (ybp), Cueva Maria Sosa is dated at 3200–3900 ybp, El Soco is dated at 1200 ybp, La Caleta, Cueva Cabrera, and Atajadizo are dated at 700–800 ybp, and Juan Dolio is dated at 600 ybp [17, 18]. Krieger [19] documented subsequent Columbian contact through pottery discovered at more recent sites at these locales.

The number of individuals at the various sites and the nature and extent of skeletal involvement were determined independently by at least 2 of the authors, with full concurrence. Because tibial changes are found in 99% of individuals with treponemal disease [15, 16], the tibia appears to be sentinel and critical to the diagnostic approach. The size of ossuary populations were therefore determined according to the number of tibiae present.

The skeletal remains were subjected to macroscopic visual examination to identify all occurrences of bony alteration throughout each skeleton, to specify the types of bony alterations at each occurrence, and to map the distribution of occurrences in each skeleton. Apparent lesions were examined at a stereoscopic magnification of ×40 to verify their status as lesions of antemortem pathological processes and not as artifacts of postmortem damage (e.g., mechanical or chemical erosion).

Treponemal disease was specifically recognized on the basis of the periosteal reaction and osteitis [14, 20–27]. The technique for distinguishing the periosteal reaction from taphonomic changes was validated through entropy studies [28], which allowed it to be clearly distinguished from postmortem damage.

The osseous reaction to treponemal infections, although reproducible for each variety, is not uniform among them [14]. Population parameters (frequency, demographics, characteristics, and skeletal distribution) for treponemal disease (table 1) provide clear, reproducible clues to the identity of the underlying treponemal infection [14–16, 29]. With the exception of the extent of saber shin remodeling, there is no difference in alteration in individual bones among the various treponematoses. It is the epidemiological approach, rather than an isolated bone approach, that actually allows discrimination among the treponematoses. The criteria allow identification of groups, with no overlap between the venereal (syphilis) and nonvenereal (yaws and bejel) forms.

The percentage of individuals with skeletal involvement and the extent of that skeletal involvement are key to distinguishing among the treponematoses [15, 16]. The extent of skeletal involvement is analyzed according to both the frequency of hand and foot involvement and how many body areas are affected. We have referred to the latter as "bone groups." The term "bone group" is an artificial construct utilized to quantitate the extent of skeletal involvement. For the purpose of that calculation, involvement of a skeletal component is treated as 1 bone group, whether that involvement is unilateral or bilateral. Carpal, tarsal, metacarpal, metatarsal, and phalangeal involvement are each considered single bone groups, whether ⩾1 are affected.

The variety of treponemal disease is assessed by comparison with osseous changes found in diagnosed populations (table 1). The comparison sample for syphilis comprises 135 individuals selected from the Hamann-Todd Collection (Cleveland) of 2906 skeletons on the basis of an autopsy diagnosis of syphilis [14]. These individuals died between 1913 and 1933. The comparison sample for yaws comprises 40 individuals from the Gognga Gun Beach locale (Guam) dated at 500 ybp [30]. The comparison sample for bejel comprises 40 bedouins who had individual burials [31]. These individuals, dated at 50–200 ybp, were from bedouin groups from the LeHav site (Israel) for whom the diagnosis was clinically confirmed.

Syphilis (table 1) is a pauciostotic (affecting few bone groups) disorder with a low population frequency. The rate of unilateral tibial involvement and the extent of saber shin–associated periosteal remodeling facilitate its recognition as a population phenomenon. Yaws is a polyostotic (median number of bone groups affected, 4) disorder with a high population frequency (21%–38%). It frequently affects the hands and feet and commonly produces

Table 1. Population parameters of treponemal disease of skeletal remains at 5 sites in the Dominican Republic contrasted with parameters of skeletal remains of individuals with confirmed disease.[a]

	Site in the Dominican Republic					Confirmed disease		
Parameter	El Soco	Juan Dolio	La Caleta	Atajadizo	Cueva Cabrera	Syphilis[b]	Yaws[b]	Bejel[b]
Date, years before present	1200	600	700–800	700–800	700–800	60–90	500	50–200
Adults								
No. evaluated	101	48	179	18	67	2906	214	40
No. (%) affected	8 (8)	3 (6)	11 (6)	2 (11)	9 (14)	145 (5)	71 (33)	10 (25)
Juveniles								
No. evaluated	5	19	3	0	0	50	60	10
No. (%) affected	0	0	0	0	0	0	8 (14)	1 (10)
>5% Affected	No	No	No	No	No	No	Yes	Yes
Unilateral tibial involvement	Yes	Yes	Yes	Yes	—[c]	Yes	No	No
Saber shin without surface reaction	Yes	—[d]	Yes	—[d]	Yes	Yes	No	No
Average no. of bone groups affected	2.1	1.7	2.6	2.0	2.3	1.9	4.0	2.0
Average no. of bone groups >3	No	No	No	No	No	No	Yes	No
Hands/feet >5%	No	No	No	No	No	No	Yes	No
Distribution, no. affected								
Tibia	8	3	10	2	9	96	35	14
Fibula	6	1	5	1	7	41	20	3
Femora	1	1	5	1	1	41	31	3
Humerus	0	0	2	0	0	0	16	10
Radius	1	0	1	0	2	8	13	1
Ulna	1	0	1	0	0	6	15	0
Hand bones	0	0	1	0	0	2	9	0
Foot Bones	0	0	0	0	0	0	12	0
Clavicle	0	0	1	0	2	4	3	0

NOTE. Bone group, artificial construct used to quantitate the extent of skeletal involvement.
[a] Skeletal remains from the Hamann-Todd Collection in Cleveland (syphilis), Gognga Gun Beach in Guam (yaws), and the LeHav site in Israel (bejel).
[b] Derived from [14].
[c] Not assessable, as ossuary.
[d] No saber shins available for assessment.

bone lesions in subadults. Bejel is a pauciostotic disorder with a high population frequency. It occurs in subadults as well as in adults. In contrast to the extent of saber shin remodeling in syphilis, that in yaws and bejel is invariably associated with persistent surface evidence of the periosteal reaction.

Results

Skeletal remains from 536 individuals were examined (table 1, plus the unaffected populations at Cueva Maria Sosa and Cueva Roja). Site preservation was good. Juan Dolio and Atajadizo were ossuaries, precluding assessment of bilaterality of disease involvement (table 1). The periosteal reaction characteristic of treponemal disease (figure 1) was recognized in 6%–14% (9/67 = .134328). of site skeletons from El Soco, Juan Dolio, La Caleta, Atajadizo, and Cueva Cabrera, as delineated in table 1. Findings were identical to those previously noted for confirmed syphilis-affected populations and distinctive from those associated with yaws and bejel. No subadults were affected. Unilateral disease was present. The average number of bone groups affected ranged from 1.7 to 2.6. Hands and feet were essentially spared. Saber shin remodeling often was so marked that it erased all surface indications of the periosteal reaction.

There was no evidence of the periosteal reaction in tibiae of 25 individuals from Cueva Maria Sosa or 98 from Cueva Roja. The findings precluded a diagnosis of treponemal disease.

Discussion

Skeletal remains from the El Soco, Juan Dolio, La Caleta, Atajadizo, and Cueva Cabrera sites in the Dominican Republic were compared with those of populations with confirmed syphilis (individuals from the Hamann-Todd Collection in Cleveland), yaws (individuals from the Gognga Gun Beach locale in Guam), and bejel (bedouin from the LeHav site in Israel) (table 1). Syphilitic periostitis was noted in 6%–14% of the skeletons from the sites examined in this study; this finding was indistinguishable from the rate of 5% noted for individuals with confirmed syphilis but was distinctive from the rate of 25%–33% reported for the populations with bejel and yaws [14–16, 29–31]. No subadults were affected; this finding was similar to observations for syphilis but contrasted with those noted for yaws and bejel [14–16, 30, 32].

The mean number of affected bone groups (e.g., tibiae were considered 1 bone group) ranged from 1.7 to 2.6 (table 1) for the skeletal remains from the Dominican Republic sites, comparable with that noted for syphilis. Tibial involvement was most common (and often unilateral), followed in frequency by fibular and femoral involvement. Saber shin deformity was often associated with such extensive surface remodeling that no residual surface periostitis could be detected [14]. The pauciostotic disease found in the skeletal remains from the Dominican Republic sites contrasts with the polyostotic nature of yaws. Population frequency, absence of disease in subadults, absence of significant hand and foot involvement, and presence of unilateral tibial disease all contrast to findings observed in populations with yaws [14–16, 29–31]. Population frequency, juvenile sparing, unilateral disease, and extent of tibial remodeling also allow comparison with bejel [31].

Differential diagnosis. Population analysis overcomes much of the confusion inherent in examination of isolated skeletons. Few disorders have the population frequency of the trepone-

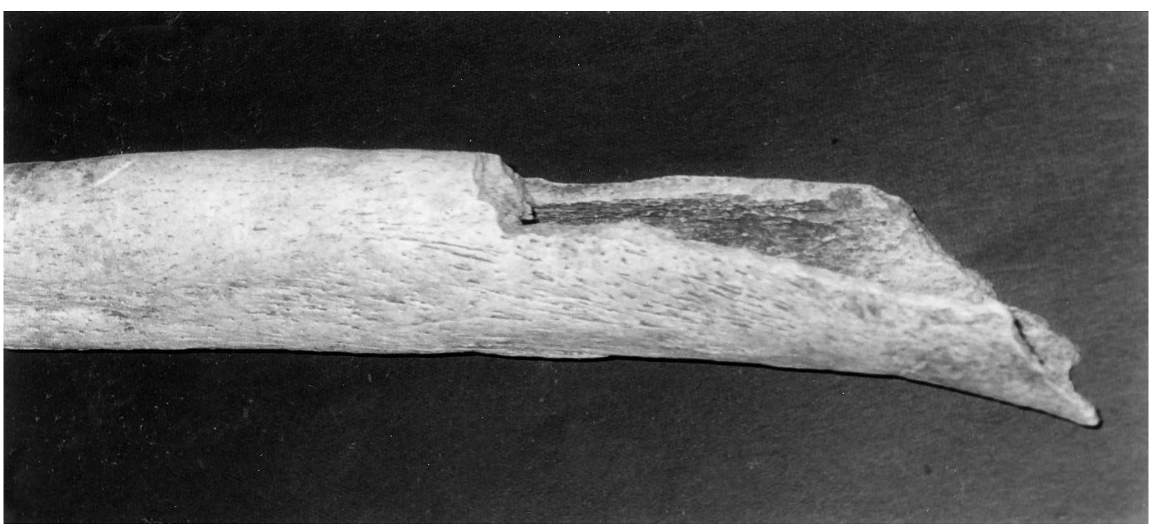

Figure 1. Anterior oblique view of an incomplete tibia from skeletal remains from a site in the Dominican Republic with Columbian contact. A postmortem break allows visualization of saber shin formation from bone accretion causing thickening at the anterior surface. The periosteal reaction of treponemal infection is also manifest as bone apposition that is most prominent along the left inferior border but is obscuring the normal bone surface (middle of the photograph).

matoses [31, 33], greatly reducing possible alternative diagnostic considerations. Although the differential diagnosis of treponematoses includes venous stasis, hypertrophic osteoarthropathy, thyroid acropachy, hypervitaminosis A, fluorosis, and infantile cortical hyperostosis [31, 33], the manifestations of these conditions are quite different from those of the treponematoses. None cause saber shin deformity. The distal diaphyseal distribution with epiphyseal extension in hypertrophic osteoarthropathy is easily distinguished from the general diaphyseal, but epiphysis-sparing, lesions of treponemal disease. The long bone distribution of the reaction in syphilis is at variance with the predominantly metacarpal, metatarsal, and phalangeal distribution of thyroid acropachy and the mandibular, clavicular, scapular, and rib involvement of infantile cortical hyperostosis. Absence of enthesis (sites of tendon, ligament, and capsular insertion) calcification and lack of internal bone architecture distortion help to distinguish these findings from those of hypervitaminosis A and fluorosis. Diseases that are uncommon in the population should not occur at a population frequency sufficient to compromise epidemiological studies. Thus, the relative rarity of infantile cortical hyperostosis and thyroid acropachy would allow those diagnoses to be excluded, even if their skeletal distribution were not sufficiently selective.

Confidence in diagnosis. How confident is the diagnosis of syphilis? Should the cultural context be the arbiter of diagnosis or should the pathology speak for itself? The cultural and/or geologic context is important to analyze the implications of disease recognition [34]. The "collective anthropological opinion" [6, 35, 36] had interpreted the various treponematoses as simply a climate-related modification of the clinical presentation of a single organism, suggesting the paradoxical concept that clinical manifestations are relatively unimportant to the differential diagnosis. However, predicating disease recognition on the basis of the cultural and/or geologic context appears to represent circular reasoning. Lockhart et al. [37] suggested that "ecologists and evolutionists have frequently raised the specter of disease as an important force in determining species abundance and distribution," noting that much of this has "remained largely in the realm of speculation." Paleopathology can transcend limitations of such circular reasoning.

Kolman et al. [8] and Centurion-Lara et al. [9] clearly demonstrated, with DNA evidence, the error of the "cultural" perspective. They documented that the treponematoses were caused by genetically distinct organisms. That documentation enables confident analysis of disease origin on both sides of the Atlantic. This work further validates previous evidence of the differential sensitivity of hamster strains and rabbits to the different treponemal agents of syphilis, yaws, and bejel [10, 11]. It substantiates data on repetitive passage: when the strains causing syphilis, yaws, and bejel were injected into rabbits and hamsters, the manifestations of these infections differed from each other through repetitive passage, while strains causing a given treponematosis produced identical findings [12, 13]. These new DNA studies [8, 9] and other data [10–13] sufficiently rebut the 1 treponeme theory, thereby allowing full attention to the important clinical and/or historical question.

Recognizing that causative organisms cannot be identified by macroscopic visual examination of isolated treponemal disease–afflicted bones and noting individual skeletal variation, a more powerful diagnostic tool was required. Although disease is quite variable among individuals, the spectrum of disease manifestations is actually quite reproducible as a population phenomenon. If all afflicted individuals in a population are examined, a pattern and/or frequency of manifestations can be recognized. Those characteristics seem to characterize the disease, allowing its recognition. Diagnoses predicated on recognition of individual classic cases, rather than the population spectrum of disease, will overlook many afflicted individuals and mistakenly include those with other disorders. It is the epidemiological approach that so powerfully allows disease recognition. Diagnosis should be predicated on comparison with populations diagnosed in life. Application of such a population approach to test the Columbian hypothesis [38–42] provides unique insights to ancient health.

Reproducibility of findings across population, and even species, lines has been repeatedly documented for rheumatoid arthritis, spondyloarthropathy and other forms of arthritis, hypertrophic osteoarthropathy, cancer, and treponemal disease by multiple groups of investigators [14, 15, 23, 38–46]. In each of these disorders, the frequency of bone and/or joint affliction and character of that affliction were indistinguishable among different afflicted populations.

Recognizing the reproducibility of macroscopic findings for the identification of syphilis [14–16, 29], skeletal populations from the Dominican Republic that dated from 1200 to 500 ybp clearly had the same disease that was present in the skeletal remains from the Hamann-Todd collection. Thus, the 15th century Dominican Republic clearly provided the opportunity for contraction of syphilis by Columbus's crew.

Dental and congenital sources of confusion in the search for syphilis. The approach of predicating recognition of syphilis on the presence of alleged congenital changes has not been productive. The search for dental stigmata of congenital syphilis has led anthropologists to lend the name "mulberry molars" to many unrelated forms of dental hypoplasia (e.g., Cook), none of which look anything like those rare entities described in standard textbooks of oral pathology [47]. The hypoplastic teeth represented by mulberry molars do not seem to survive in archaeological sites and therefore are not practical markers for syphilis in such sites.

Congenital syphilis is scarcely represented in the archaeological record [32]. The mythology of the frequent occurrence of bone damage in individuals who had congenital syphilis appears to be related to misreading of the original texts. There is only a narrow window of opportunity before complete resolution of remodeling occurs [32]. Unless the individual dies during that window of opportunity, it is unlikely that any osseous changes would be recognizable. Because osseous pathology is found in <5% (usually <1%) of subadults with syphilis, it would not be expected to be found unless there were close to 100 syphilis-afflicted individuals (which is uncommon in archaeological sites).

Prior "virgin" state. No treponemal disease, however, was present in the Dominican Republic 3200 years ago. Although the first documented population affliction was 1200 ybp, the 2000-year interval was not represented by skeletons.

Denouement. Findings diagnostic of syphilis have been reported in the New World [15, 16, 29]. No such diagnostic findings have been found in the Old World before the voyages of Columbus [4]. Although several investigators [7, 35, 36, 48–50] have variably attributed New World treponematosis to venereal and nonvenereal disease, that perspective has not been based upon criteria for distinguishing among the varieties. Now that there is unequivocal evidence that the treponematoses are actually caused by different organisms, the question of the origin of syphilis can be clarified.

It cannot be stated at this time which migration [51] was responsible for the introduction of syphilis to the Dominican Republic. The critical missing evidence has been demonstration of the presence of syphilis in areas with which Columbus actually had contact [13]. It is clear, however, that treponemal disease was present at the time of Columbian contact. The disease present was indeed syphilis. Columbus' crew clearly had the opportunity and means to contract and spread the venereal disease we now call syphilis.

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