

Foot Amputation by the Moche of Ancient Peru: Osteological Evidence and Archaeological Context

JOHN W. VERANO^{a,*}, LAUREL S. ANDERSON^a AND RÉGULO FRANCO^b

^a *Department of Anthropology, Tulane University, 1021 Audubon St., New Orleans, LA 70118, USA*

^b *Fundación Augusto N. Wiese, Jiron Carabaya No. 501, Lima, Peru*

ABSTRACT Three probable cases of foot amputation, with healing, in skeletal remains associated with the Moche culture (AD 100–750) of northern coastal Peru are described. Each case exhibits non-functional tibio-talar joints with proliferative bone occupying the normal joint space. The robusticity of the tibiae and fibulae suggest renewed weight-bearing and mobility following recovery. The osteological evidence is consistent with details shown in Moche ceramic depictions of footless individuals. A footless Moche skeleton with wooden prostheses, described in 1913 by Peruvian physician Vélez López, appears to represent a fourth example of this procedure. The Moche surgical approach was similar to a technique that would be pioneered in western medicine by the Scottish surgeon Sir James Syme some 1500 years later. Copyright © 2000 John Wiley & Sons, Ltd.

Key words: amputation; Moche; palaeopathology; Peru; surgery; Syme amputation

Introduction

Amputation and trephination are the two most common forms of ancient surgery described in the palaeopathological literature (Steinbock, 1976; Ortner and Putschar, 1981). Trephined skulls are known from many parts of the world, and there is no question that the practice has considerable antiquity in both the Old World and the Americas (Aufderheide and Rodríguez-Martin, 1998). Evidence for the practice of amputation in prehistoric times is less convincing. Bloom *et al.* (1995), Mays (1996), and Aufderheide and Rodríguez-Martin (1998) provide recent reviews of possible cases of amputation in the archaeological record, emphasizing some of the problems in diagnosis. In the Old World, written descriptions of amputation date back as early as the sixth century BC, and the practice is well-described by Celsus and

other Roman physicians of the first century AD (Meade, 1968). Evidence that amputations were performed in the pre-contact New World is more illusory, as it is based strictly on archaeological evidence. Possible examples of amputation have been reported in skeletal remains from North, Central, and South America (Morse, 1969; Hurtado, 1970; Saul, 1972; Friedmann, 1973; Stewart, 1974; Merbs, 1989), although some of these probably represent non-union of fractures rather than amputation (Stewart, 1974). Pre-hispanic artistic depictions of individuals missing feet, hands, or entire limbs have also been used to suggest that amputations were performed in the Americas before European contact (Tello, 1924; Donnan, 1978; Urteaga-Ballon, 1991).

This report describes three recently-discovered cases of what appears to be surgical amputation of the foot by disarticulation of the ankle joint in skeletal remains associated with the Moche culture (AD 100–750) of northern coastal Peru. The remains were recovered in

* Correspondence to: Department of Anthropology, Tulane University, 1021 Audubon St., New Orleans, LA 70118, USA. Tel.: +1 504 8623049; fax: +1 504 8655338; e-mail: verano@mailhost.tcs.tulane.edu

1995 and 1998 at the archaeological sites of El Brujo and Mocollope in the lower Chicama river valley (Figure 1). The bony response in each case is remarkably similar, and seems to reflect a common pattern of healing followed by renewed adaptation to weight-bearing and locomotion.

Case descriptions

Cases I and II were excavated at the archaeological complex of El Brujo, which has been the focus of a major Peruvian archaeological project co-directed by archaeologists from the University of Trujillo, National Institute of Culture, and the Augusto N. Wiese Foundation of Peru since 1991 (Franco *et al.*, 1994, 1996). One of the authors (RFJ) is a co-director of the El Brujo project and supervises the field research. Another author (JWV) has been an affiliated researcher with the El Brujo Project since 1995, directing the analysis of human remains recovered from excavations. Case III was discovered

and collected by Thomas Wake, a zooarchaeologist for the Mocollope Archaeological Project, directed by Glenn Russell of the Institute of Archaeology, University of California, Los Angeles. Analyses of the human remains described in this report were conducted by JWV and the other author (LSA).

Case I

El Brujo Complex, West Sector

Tomb 4

Tomb 4, excavated in 1995 from a unit on the west side of one of the two major adobe platforms at El Brujo (Huaca Cao), contained the complete skeleton of an adult male, with the exception of the bones of the feet. The burial was one of four individuals—two adult and two adolescent males—found in simple graves

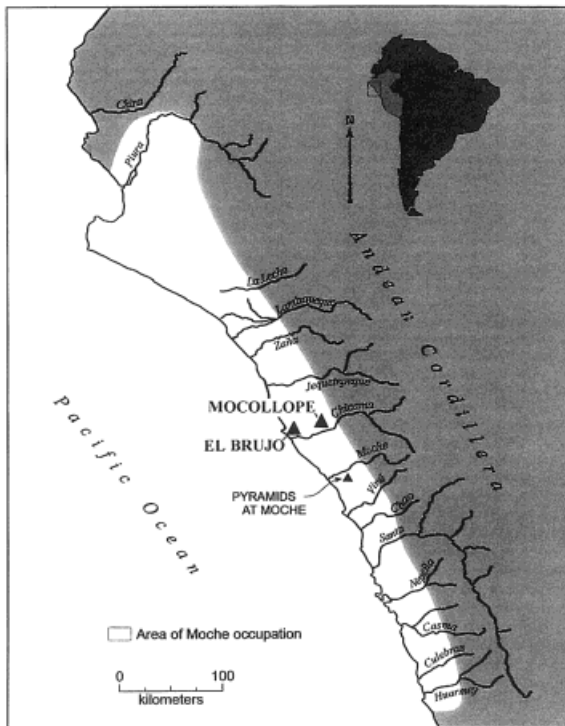


Figure 1. Map of the north coast of Peru.



Figure 2. Articulated leg bones of Case I (anterior view).



Figure 3. Distal ends of tibiae and fibulae, Case I (anterior oblique view).

placed in architectural fill below an intact layer of adobe bricks. Few grave offerings were found with these individuals, suggesting that they were of relatively low status, despite their location close to the platform. No offerings were found in Tomb 4 (Franco *et al.*, 1995).

Multiple skeletal age indicators, including morphology of the pubic symphysis and auricu-

lar surface, as well as cranial suture closure (following guidelines presented in Buikstra and Ubelaker, 1994) suggest an age at death of approximately 35–39 years. Male sex is indicated by the morphology of the os coxae and skull.

All foot bones are absent. The distal tibiae and fibulae show non-functional joint surfaces,



Figure 4. Radiograph of tibiae and fibulae, Case I.



Figure 5. Left tibia and fibula, Case II (posterior view).

with joint spaces filled with irregular growths of dense bone (Figures 2 and 3). The distal tibio-fibular articulations are normal in appearance, and there is no evidence of bony reaction, either lytic or proliferative, proximal to the ankle joints. Weight and robusticity of the tibiae and fibulae appear normal, as does cortical bone thickness in radiographs (Figure 4). The knee and hip joints appear normal as well. The anterior inferior iliac spines are strongly developed, suggesting strong hip flexors. Bones of the upper limb are robust, and both elbow and wrist joints show incipient degenerative changes (marginal lipping on the coronoid processes of both ulnae and on articular facets of the distal radii).

Case II

BRU M98-4

Huaca Cao, El Brujo Complex

This specimen consists of the associated left tibia and fibula of an adult male. The bones were recovered from the fill of a disturbed high status chamber tomb within the Huaca Cao



Figure 6. Distal ends of left tibia and fibula, Case II (anterior oblique view).

pyramid at El Brujo in 1998. Adult age is indicated by complete epiphyseal union; sex is estimated from the size and robusticity of the bones. While the proximal tibia is normal in appearance, the ankle joint is grossly pathological. The tibio-talar joint cavity is filled with dense bone, and both medial and lateral malleoli are abnormally flattened and bent inward (Figures 5 and 6). The distal tibia and fibula show bony ankylosis at the fibular notch. The bones are otherwise normal in gross appearance and size.

Case III

MOC98-1

Mocollope

Disturbed Burial

Case III is a largely complete skeleton of a young adult female. Her remains were found associated with a looted tomb examined in 1998. No artifacts were recovered with the remains, but the location and form of the tomb suggests it is associated with the Moche occupation of the site. The skeleton is approximately 85% complete, missing only the skull, some elements of the upper limbs and shoulder girdles, most bones of the hands and left foot and portions of the os coxae and left fibula. Young adult age (ca. 25–35 years) is estimated from epiphyseal closure and auricular surface morphology. Female sex is indicated by a wide greater sciatic notch, auricular surface elevation, and a pronounced preauricular sulcus (Figure 7). All synovial joints are normal in appearance, with the exception of the right ankle. It shows a pattern of bony reaction similar to Cases I and II, with in-filling of the normal joint space with new bone (Figures 8 and 9). The right fibula also shows an inward bending of the lateral malleolus similar to what was seen in Case II. The left ankle joint is normal in appearance. The left calcaneus, the only bone of the left foot recovered, appears normal (Figure 10).



Figure 7. Bones of the pelvic area of Case III, showing age and sex indicators.

Patterning of osseous reaction

The three cases described above show individual differences, but strong similarities in the overall patterning of bony reaction in the ankle joint(s). The reaction is one of bony proliferation limited to the tibio-talar joint space, with no involvement of the metaphyses or diaphyses of the tibia or fibula. The proliferative bone appears well organized and remodelled in all cases. In one example (Case I) both ankles are involved; in another (Case III) only one ankle is affected; laterality in Case II cannot be determined, as only an isolated tibia and fibula were recovered. In all three individuals, the relatively normal size, weight, and robusticity of the affected bones suggests that weight was placed on the distal ends of the affected limbs following healing. Weight bearing is further indicated by the plastic deformation of the medial and lateral malleoli seen in Cases II and III.

Differential diagnosis

The bilateral symmetry demonstrated by Case I and the lack of any indication of infection or inflammation of the long bone metaphyses or

diaphyses argues against loss of the feet as a direct result of infection—although surgical removal of a diseased or traumatized foot is a possibility. Congenital absence of the feet is unlikely, since this is not a reported congenital defect. Moreover, major developmental malformation of the foot or ankle would be expected to lead to changes in the robusticity and morphology of the tibia and fibula—something that is not seen in these cases. What best fits the observed pattern of bony changes, in our opinion, is intentional amputation of the foot through disarticulation of the ankle joint, followed by healing and renewed weight-bearing on the affected limb. This scenario draws support from details shown in representations of footless individuals in Moche art.

Amputation in Moche art

Moche art is well known for ceramic vessels depicting individuals with physical defects and pathological conditions (Donnan, 1978). Individuals with missing limbs, hands, and feet are commonly represented in this group (Weiss, 1984; Urteaga-Ballon, 1991). In a review of published collections we have found nearly 100



Figure 8. Right tibia and fibula compared with left tibia, Case III (anterior view).

ceramic vessels showing persons with missing limbs or extremities. The most common are individuals missing both feet (> 50%), followed by those missing a single foot (26%). Less common are those missing arms, arms distal to the elbow, and hands (Table 1). Figure 11 is a representative example of a Moche ceramic ves-

sel depicting a footless individual. Of particular interest is a readily visible median groove on the end of each leg stump. Such grooves are commonly shown in Moche depictions of footless individuals (see also Figure 12), and appear to mark a depressed area in between the lateral and medial malleoli. Such an anatomical feature would be expected if a foot were amputated by disarticulation at the ankle, leaving the malleoli as marginal protuberances.

Many individuals with missing feet are shown with cup-like objects placed over the terminal ends of leg stumps, or being held in the hand as if in the act of placing or removing the object (Figure 12). These appear to be prostheses designed to permit weight-bearing and locomotion following loss of the foot. Some Moche ceramics show individuals wearing the objects and standing upright (Urteaga-Ballon, 1991).

There has been much speculation about what the Moche were communicating in their depiction of amputees. Most scholars suggest that Moche amputations were a form of punishment rather than an attempt to treat infection or other disease (Vélez López, 1913; Tello, 1924; Urteaga-Ballon, 1991). Support for this argument comes from the observation that many Moche representations of individuals with missing limbs also show what appears to be intentional mutilation of the nose and lips. Indeed, in the ceramic sample we examined, nose and lip deformities are visible in 63% of amputees (Table 1; Figure 11). Not all cases of lip and nose deformities in Moche art can be attributed to intentional mutilation, however. Some appear to illustrate congenital defects like cleft lip, while others show lesions more suggestive of an infectious disease such as mucocutaneous leishmaniasis, which is endemic in portions of Peru today (Urteaga-Ballon, 1991). The relationship between missing limbs and facial deformities in Moche art thus is not a simple one. Leprosy, which can affect the oral and nasal mucosa directly, and the hands and feet secondarily (as a result of trauma and secondary infection), does not appear to have been present in the New World before European contact (Steinbock, 1976; Ortner and Putschar, 1981; Aufderheide and Rodríguez-Martin, 1998), and Leishmaniasis does not affect the hands or feet.



Figure 9. Comparison of right and left ankle joints, Case III (anterior oblique view).

Frostbite damage to the feet as a motive for amputation has been suggested to us, although this seems unlikely in a coastal Peruvian culture such as the Moche.

All Moche artistic representations of amputees that we have examined appear to be males, although identifying gender in Moche art is difficult in some cases (Lyon, 1978). Obvious Moche gender signifiers such as prominent breasts or braided hair were not observed, however. It is significant, therefore, that Case III is of female sex, indicating that amputations were performed on women as well as men.

Amputees in Moche art are commonly shown wearing a head cloth and a tunic; a few have ear spools or necklaces, but none wear elaborate headdresses or other signifiers of high rank. Most individuals are shown seated in a cross-legged position, kneeling, or lying prone; some are depicted standing (usually holding a long stick for support) or seated on the back of a camelid (probably a llama). Some individuals are shown playing a drum, while others have an outstretched hand as if begging (Figure 11).

Examples are also known in Moche art of skeletal figures wearing a prosthesis over a missing foot in scenes that appear to represent a procession or dance. One recent study of the iconography of Moche footless individuals hypothesizes that amputation may have been a

form of ritual mutilation that marked certain individuals as special attendants to the nobility in Moche society, and in the afterlife as well (Arsenault, 1993). Whatever the function or meaning of amputation in Moche society, until recently there was little skeletal evidence to suggest that surgical amputation was actually performed.



Figure 10. Right and left lower leg bones with left calcaneus, Case III.

Table 1. Frequency of missing feet, hands, and other body parts in a sample of 99 Moche ceramic vessels showing apparent amputation or mutilation

Body part missing	Number of cases
Single foot	26
Both feet	55
Arm	2
Both arms	6
Forearm and hand	6
Both forearms	5
One hand	0
Both hands	2
Both hands and both feet	1
Individuals with prostheses	24
Individuals with facial mutilation	62

Previous osteological evidence for amputation in pre-hispanic Peru

In 1913, Peruvian physician Vélez López published a description of a footless Moche skeleton found at the site of Mocollope in the Chicama River Valley (Vélez López, 1913). The skeleton was found with wooden prostheses over the distal ends of the tibiae and fibulae. Based on his examination of the material, he concluded that the skeleton was a double amputee who had used the prostheses for some period of time, as evidenced by wear on their inferior surfaces. He described these objects as



Figure 11. Moche ceramic vessel showing an individual with missing feet and mutilation of the nose and lips. Courtesy of the San Diego Museum of Man (Catalog # 1981-14-17).



Figure 12. Moche ceramic vessel showing an individual with a cup-like prosthesis. Courtesy of the American Museum of Natural History (Catalog # B4919).

simple wooden cups padded with wool. The tibiae were reported to be normal in appearance, with no evidence of swelling, infection, or other pathology. Vélez López concluded that the feet were not lost as a result of disease, but were intentionally amputated—probably as a form of punishment. Unfortunately, Vélez López did not publish photographs of the skeleton or prostheses. The material appears to have been in a private collection, and its present whereabouts are unknown. Nevertheless, the skeleton described by Vélez López is of great interest because it appears to present a case similar to those described in this report. Moreover, it was reportedly excavated at the archaeological site of Mocollope, where Case III (this report) was found in July of 1998.

While other possible cases of amputation in pre-hispanic Peruvian skeletal remains have been described, they are more problematic.

Hand and foot bones are notorious for being lost in archaeological excavations, as anyone who has worked with museum collections can attest. Cut marks (indicating perimortem removal) or bony reaction to antemortem trauma (as in Cases I–III described above) should be present if a hand or foot was in fact amputated. Several cases of Moche burials with either 'extra' parts or 'missing' parts illustrate the problem of confident identification. Christopher Donnan and Carol Mackey described an adult male Moche burial from Huanchaco in the Moche River Valley that included extra articulated hands as grave offerings (Donnan and Mackey, 1978). A female skeleton buried in a nearby tomb was missing both hands. Donnan and Mackey suggest that the hands may have been removed from the occupant of one tomb and placed with the other. Unfortunately, neither hand nor forearm bones were examined for cut marks, the presence of which might have resolved the question.

Several retainer burials recently excavated from royal Moche tombs at Sipán in the Lambayeque River Valley present similar problems. The skeletons of two young adult males, interpreted as 'guards' for the tombs (Alva and Donnan, 1993) lacked bones of the feet. One of us (JWV) examined these skeletons, but found that the preservation of the distal ends of tibiae and fibulae was too poor to identify cut marks or other features that might confirm amputation (Verano, 1997). Two articulated human feet were found in an adjacent room, however, indicating that some activity involving dismemberment was going on at the site (Alva and Donnan, 1993). If these feet belonged to one of the footless guards, this suggests some activity related to mortuary ritual, since both individuals were sacrificed to accompany a high status individual. Unfortunately, the ankle bones were fragmentary and cut marks were not identified.

Another example of a possible healed amputation from Peru is an isolated proximal humerus collected by Ales Hrdlicka in 1913 from a disturbed communal tomb near Huarochiri in the central highlands. The bone terminates at the proximal third of the diaphysis, and shows obvious healing in the form of closure of the medullary cavity and smoothing of the distal



Figure 13. Proximal third of left humerus collected by Hrdlicka near Huarochiri, Peru (posterior aspect). Courtesy of the San Diego Museum of Man (Catalog # 1915-2-668).

end (Figure 13). The specimen has been studied and described by several researchers (Rogers, 1973; Merbs, 1980), who agree that it may be an amputation, although a healed fracture with non-union is considered an alternative diagnosis. The lack of secure dating and associated

skeletal elements makes this case problematic, as does the issue of surgical technique. It is difficult for us to imagine sectioning a humerus through the diaphysis without using a saw, a tool that was unknown in Peru prior to European contact. While repeated grooving with a sharp knife could theoretically cut through a long bone diaphysis, the degree of angulation of the terminal end (visible in Figure 13) also seems inappropriate if the bone was intentionally sectioned. In our opinion, fracture with non-union seems a more likely explanation in this case.

Moche foot amputation: surgical approach

While metal saws date back to before the eighth century BC in the Old World (Symes *et al.*, 1998), they were unknown in the Americas prior to European contact. Thus, transdiaphyseal amputations of limbs would not be expected to be found in the New World prior to the European introduction of metal saws. The amputation of a hand or foot by disarticulation at the wrist or ankle joint, however, could be done with simple cutting tools. In 1842, Scottish surgeon Sir James Syme popularized a technique for amputating feet by disarticulation at the ankle joint, demonstrating that it provided superior results to traditional above-ankle trans-tibial amputations in terms of healing and patient mobility (Wagner, 1992; Wilson, 1992). While in the classic Syme procedure the medial and lateral malleoli are subsequently sawed off to provide a more stable support surface for the patient, the foot itself is removed by surgical disarticulation of the tibio-talar joint using a scalpel. Skeletal evidence from Cases I–III presented here, along with Moche artistic depictions of amputees showing the protruding malleoli of the tibia and fibula, suggests that the Moche developed a technique similar to the Syme method some 1500 years ago. Moreover, the degree of healing seen in Cases I–III indicates that they were able to perform this procedure successfully. The retention of the medial and lateral malleoli may have made standing

and walking difficult even with prostheses like those described by Vélez López, although recent clinical studies have demonstrated that in some cases a superior outcome can be achieved by performing a Syme ankle disarticulation without resection of the malleoli (Pavot, 1973).

Conclusions

We believe that the three cases presented here represent the first well-documented skeletal evidence that the Moche of ancient Peru performed successful amputations of the feet. Amputation by disarticulation of the ankle joint would have been a simple and logical approach, given the tools available at the time. Osteological evidence for amputations of hands or arms has not been found to date, but Moche art suggests that examples may exist. Why the Moche performed amputations will no doubt remain a subject of speculation. Artistic depictions of individuals with missing feet disappear along with the Moche culture in the late eighth century AD. A few ceramic vessels showing individuals with missing arms are known from the subsequent Lambayeque culture of northern Peru (ca. AD 900–1200), but these may simply represent continuities of Moche artistic themes. The actual practice of amputation may have disappeared with the Moche as well. Spanish chroniclers who observed Inca culture firsthand in the sixteenth century do not describe amputation, nor have any unequivocal examples of amputation been found in Inca period skeletal remains.

Acknowledgements

The authors are grateful to Thomas Wake and Glenn Russell of the Institute of Archaeology, University of California, Los Angeles, for permission to study the skeletal remains from Mocollope, and to Alana Cordy-Collins and Rose Tyson of the San Diego Museum of Man for permission to photograph the ceramics and osteological specimen in Figures 11–13. Figure 1 is courtesy of Donald McClelland of the Fowler Museum of Cultural History, Los Angeles. Fig-

ure 12 was photographed with permission of the American Museum of Natural History, New York. Project funding for the El Brujo excavations is generously provided by the Augusto N. Wiese Foundation. The authors are particularly grateful to the late Dr Guillermo Wiese de Osma, Chairman of the Wiese Foundation, for his dedication to Moche archaeology and for his friendship and wise counsel. The Wiese Foundation and the research staff of the El Brujo Archaeological Project provided generous logistical and research support for JWV and LSA during their fieldwork in Peru, for which they are most grateful. Travel and research support for this study was provided by grants from the Tulane University Committee on Research (JWV) and the Roger Thayer Stone Center for Latin American Studies at Tulane University (JWV, LSA).

References

- Alva W, Donnan CB. 1993. *Royal Tombs of Sipán*. Fowler Museum of Natural History: Los Angeles, CA.
- Arsenault D. 1993. El personaje del pie amputado en la cultura Mochica del Perú: un ensayo sobre la arqueología del poder. *Latin American Antiquity* 4: 225–245.
- Aufderheide AC, Rodríguez-Martin C. 1998. *The Cambridge Encyclopedia of Human Paleopathology*. Cambridge University Press: Cambridge.
- Bloom AI, Bloom RA, Kahila G, Eisenberg E, Smith P. 1995. Amputation of the hand in the 3600-year-old skeletal remains of an adult male: the first case reported from Israel. *International Journal of Osteoarchaeology* 5: 188–191.
- Buikstra JE, Ubelaker DH (eds). 1994. *Standards for Data Collection From Human Skeletal Remains*. Arkansas Archaeological Survey: Fayetteville.
- Donnan CB. 1978. *Moche Art of Peru: Pre-Columbian Symbolic Communication*. Museum of Cultural History: Los Angeles, CA.
- Donnan CB, Mackey CJ. 1978. *Ancient Burial Patterns of the Moche Valley, Peru*. University of Texas Press: Austin, TX.
- Franco R, Gálvez C, Vásquez S. 1994. Arquitectura y Decoración Mochica en La Huaca Cao Viejo, Complejo El Brujo: Resultados Preliminares. In *Moche: Propuestas y Perspectivas, Actas del Primer Coloquio Sobre la Cultura Moche*, Uceda S, Mujica E

- (eds). Universidad Nacional de La Libertad: Trujillo, Peru; 147–180.
- Franco R, Gálvez C, Vásquez S. 1995. *Programa Arqueológico Complejo 'El Brujo', Informe 1995*. Fundación A.N. Wiese: Lima.
- Franco R, Gálvez C, Vásquez S. 1996. Los Descubrimientos Arqueológicos en la Huaca Cao Viejo Complejo 'El Brujo'. *Arkinka* 1: 82–94.
- Friedmann LW. 1973. Amputation in Pre-Columbian America. *Archives of Physical Medicine and Rehabilitation* 54: 323–325.
- Hurtado ED. 1970. Pre-hispanic osteopathology. In *Handbook of Middle American Indians*, vol. 9, Stewart TD (ed.). University of Texas: Austin, TX; 68–81.
- Lyon PJ. 1978. Female supernaturals in ancient Peru. *Nawpa Pacha* 16: 95–140.
- Mays SA. 1996. Healed limb amputations in human osteology and their causes: a case study from Ipswich, UK. *International Journal of Osteoarchaeology* 6: 101–113.
- Meade RH. 1968. *An Introduction to the History of General Surgery*. W.B. Saunders: Philadelphia, PA.
- Merbs CF. 1980. *Pathologies from the Hrdlicka Collection, Slide Set II*. San Diego Museum of Man: San Diego.
- Merbs CF. 1989. Trauma. In *Reconstruction of Life from the Skeleton*, Iscan MY, Kennedy KAR (eds). Alan R. Liss: New York; 161–189.
- Morse DF. 1969. *Ancient Disease of the Midwest*. Illinois State Museum Reports of Investigations No. 15: Springfield.
- Ortner DJ, Putschar WGJ. 1981. *Identification of Pathological Conditions in Human Skeletal Remains*, Smithsonian Contributions to Anthropology, No. 28. Smithsonian Institution Press: Washington, DC.
- Pavot AP. 1973. Ankle-disarticulation: a definitive type of amputation in adults. *Archives of Physical Medicine and Rehabilitation* 54: 307–310.
- Rogers SL. 1973. A case of surgical amputation from aboriginal Peru. In *Ethnic Technology Notes* No. 11. San Diego Museum of Man: San Diego, CA.
- Saul FP. 1972. The human skeletal remains of Altar de Sacrificios: an osteobiographic analysis. *Papers of the Peabody Museum of American Archaeology and Ethnology, Harvard University* 63: 1–123.
- Steinbock RT. 1976. *Paleopathological Diagnosis and Interpretation*. Charles C. Thomas: Springfield.
- Stewart TD. 1974. Nonunion of fractures in antiquity, with descriptions of five cases from the New World involving the forearm. *Bulletin of the New York Academy of Medicine* 50: 875–891.
- Symes SA, Berryman HE, Smith OC. 1998. Saw marks in bone: introduction and examination of residual kerf contour. In *Forensic Osteology, Advances in the Identification of Human Remains* (2nd edn), Reichs KJ (ed.). Charles C. Thomas: Springfield; 389–409.
- Tello JC. 1924. Arte antiguo peruano. *Revista de Estudios Antropológicos, Lima*. vol. II. In *Catalogue of the Hrdlicka Paleopathology Collection*, Tyson RA, Alcauskas ESD (eds). San Diego Museum of Man: San Diego.
- Urteaga-Ballon O. 1991. Medical ceramic representation of nasal Leishmaniasis and surgical amputation in ancient Peruvian civilization. In *Human Paleopathology, Current Syntheses and Future Options*, Ortner DJ, Aufderheide AC Jr. (eds). Smithsonian Institution Press: Washington, DC; 95–101.
- Vélez López LR. 1913. Las mutilaciones en los vasos antropomorfos del antiguo Perú. XVIII Session of the International Congress of Americanists: London; 267–275.
- Verano JW. 1997. Human skeletal remains from Tomb I, Sipán (Lambayeque river valley, Peru); and their social implications. *Antiquity* 71: 670–682.
- Wagner FW Jr. 1992. The Syme ankle disarticulation. In *Atlas of Limb Prosthetics: Surgical, Prosthetic, and Rehabilitation Principles*, Bowker JH, Michael JW (eds). Mosby Year Book: St. Louis, MO; 413–430.
- Weiss P. 1984. Paleopatología Americana. *Boletín de Lima* 33: 17–52.
- Wilson AB. 1992. History of amputation surgery and prosthetics. In *Atlas of Limb Prosthetics: Surgical, Prosthetic, and Rehabilitation Principles*, Bowker JH, Michael JW (eds). Mosby Year Book: St. Louis, MO; 3–15.