ANTHROPOLOGIE • XLVII/3 • pp. 273–282 • 2009

DOUGLAS H. UBELAKER, ANN H. ROSS, KRISTINA M. ZARENKO

# DENTAL DISEASE IN NINETEENTH CENTURY, SPAIN

*ABSTRACT: Between 1884 and 1898 Dr. Frederico Oloriz Aguilera assembled a collection of crania from cadavers from geographically diverse regions within Spain. Examination of 75 males and 58 females from this collection revealed elevated levels of dental caries, antemortem tooth loss, and alveolar abscesses suggesting dietary preferences conducive to dental disease without sufficient dental hygiene. A low frequency of dental hypoplasia suggests low childhood morbidity. Comparative data from elsewhere in Europe and the Americas indicate that the dental disease in 19th century Spain was elevated but similar to that found in other regions at the time.*

*KEY WORDS: Dental Disease – 19th century Spain – Crania*

## INTRODUCTION

Dental disease represents a major source of morbidity in contemporary society. In particular, dental caries has become almost ubiquitous in modern populations. Combined with unusual attrition patterns and traumatic dental injury, dental caries can lead to alveolar abscess and other forms of chronic infection. Periodontal disease also represents a major contemporary dental health issue which combined with the problems discussed above can culminate in tooth loss and alveolar resorption. All of these factors represent significant health issues and affect the quality of life of people worldwide.

Historically, research has demonstrated the key role played by diet and dental hygiene in the development of dental disease. Prior to about 1930, interpretations prevailed that dental disease was rooted in the biological framework of populations and could be used as a "racial marker" (Campbell 1925, Ruffer 1920). Gradually research demonstrated the important role of diet as a contributing factor. As early as 1931 T. D. Stewart examined dental disease in archeologically recovered samples from Peru as well as in the clinical literature and suggested that diet played a key role (Stewart 1931). Many others have followed Stewart's lead in attempting to examine the complex factors involved (Johansson, Owsley 2002, Kelley *et al.* 1991, Larsen *et al.* 1991, Larsen *et al*. 2001, Sledzik, Moore-Jansen 1991, Hartnady, Rose 1991, Ubelaker, Newson 2002). Although considerable research has illuminated the complexity of dental disease using archeologically recovered samples, relatively little is known about these issues in populations of the recent past, especially the nineteenth century. Such context is needed to put modern dental health issues in proper historical perspective. The historical literature mostly does not contain the level of detail regarding dental health needed for that perspective. Such data only can be retrieved from documented samples from human remains. Unfortunately such samples dating from the nineteenth century are uncommon.

### The Oloriz Collection from Spain

During the latter half of the twentieth century the Spanish anatomist Federico Oloriz Aguilera recognized the need for a comparative cranial collection of Spanish origin. He initiated the collection in 1884 (Oloriz 1899). By 1898 Oloriz had assembled a collection of over 1900 crania mostly of Spanish origin and prepared from cadavers in the

anatomy departments in Granada and Madrid where he worked during a 14 year period. Since the collection originated largely from a cadaver sample, information was available about sex, age at death and region of origin. Following standard practice of the day, this information was not only retained in files but also marked on the parietals of the crania themselves.

By 1899, Oloriz had relocated to Madrid where his collection was recognized for its research potential (Oloriz 1899). Eventually, it was transferred to the Departamento de Anatomia y Embriologia Humana I of the Facultad de Medicina, Ciudad Universitaria in Madrid (Ocaña 1913).

## METHODS

In 2007 Ubelaker and Ross examined the Oloriz collection in Madrid where it was curated at Ciudad Universitaria. Skulls were selected which were reasonably complete and well preserved facilitating examination of the evidence for dental disease. For each such skull an inventory was completed of the presence or absence of all teeth following the format proposed by Buikstra and Ubelaker (1994). In addition, data were recorded for each tooth on the presence or absence of enamel defects, dental caries and alveolar abscess, again using the recommendations of Buikstra and Ubelaker (1994).

Dental data were collected from the dentitions of 58 females and 75 males from the Oloriz collection. These individuals originated from diverse regions within Spain, including Madrid and Granada. Ages at death of the 58 females ranged from 20 to 80 with a mean of 51. Ages at death of the 75 males ranged from 18 to 90 with a mean of 50. Since so many regions of Spain were represented, relatively few individuals originated from any one area. For this reason, regions were grouped together for purposes of analysis.

The dental inventory classified each tooth into one of the following six categories: 1) present, but not in occlusion, 2) present, fully developed in occlusion, 3) missing with no associated alveolar bone, 4) missing with alveolus resorbed indicating antemortem loss, 5) missing, with no alveolar resorption indicating post mortem loss, and 6) incompletely formed teeth, classified according to the system of Moorrees *et al*. (1963a, b), which allows an estimate of age at death (Ubelaker, Pap 1996, 1998).

Observations on dental caries were made for each tooth present according to the guidelines of Ubelaker and Pap (1996). Dental carious lesions were classified as 1) occlusal, 2) interproximal surface, 3) smooth surface, 4) cervical caries, 5) root caries, 6) large caries, and 7) non-carious pulp exposure. Dental carious lesions were recorded when they were at least one mm in diameter and presented clear evidence of disease and tissue collapse.

Enamel defects were classified as 1) linear horizontal grooves, 2) linear vertical grooves, 3) linear horizontal pits, 4) nonlinear arrays of pits, 5) single pits, 6) discrete boundary hypocalcification and 7) diffuse boundary hypocalcification. The colors of hypocalcifications were classified as 1) yellow, 2) cream/white, 3) orange or 4) brown. Defects were recorded only if they could clearly be distinguished from normal developmental variation and postmortem changes. (Ubelaker, Pap 1996)

Abscesses were classified in accordance with Ubelaker and Pap (1996) by their location in either the buccal or lingual bone side. In all cases, abscesses were noted in association with existing teeth or with those obviously missing postmortem. Observations on the presence or absence of abscess were not recorded in association with teeth missing antemortem when the alveolus was extensively resorbed.

## RESULTS

### Antemortem Loss

Antemortem tooth loss was relatively common in the Oloriz sample. Overall, of 4,544 observations for tooth presence or absence, 1648 or 36 percent of teeth had been lost antemortem. As shown in *Table 1*, tooth loss was more common in the maxilla (41.5%) than in the mandible (31.1%). Also tooth loss was more common in the mandible among females (34.9%) but more common in the maxilla in males (41.5%). Among tooth groups for both males and females, tooth loss was most common in molars, followed by premolars and incisors.

### Dental Caries

Of 346 observations of teeth present, 95 (27.5%) were carious. As shown in *Table 2*, carious lesions were relatively evenly distributed between maxillary (25.8%) and mandibular (28.4%) teeth, but more common in females (34.2%) than males (22.7%). In the mandible, carious teeth were more common in the molars (32.8%) followed by the canines (16.7%) and premolars (2.8%). In the maxilla, carious teeth were more common in molars (26.9%) followed by premolars (29.2%) and canines (20%).

Of the 95 carious teeth present, 25.3% are classified as root caries. Additionally 32.6% are classified as large caries and 17.9% as cervical caries. Smaller occurrences of occlusal (7.4%), distal (4.2%), and mesial caries (3.2%) are present. In both males and females, the most common caries classifications are root, large, and cervical caries. Males have a higher frequency of root caries (28%) than females (25%). Females have a higher frequency of both large caries (37.5%) and cervical caries (22.5%) than males (30% and 14% respectively). Occlusal, distal, and mesial caries are relatively evenly distributed between males and females.

### Alveolar Abscesses

4,544 observations were made for the presence of alveolar abscesses, as shown in *Table 3*. Of these, 516 (11.4%) revealed evidence of active abscess at the time of death (minimal remodeling). Overall, abscesses were more common in the maxilla (14.6%) than in the mandible (8.1%). Abscesses were slightly more common among females (9.4%) than males (7.4%) in the mandible but the

TABLE 1. Frequency of antemortem tooth loss for the Oloriz sample. Values for each tooth group represent the number of teeth lost antemortem compared with the number of observations for possible tooth loss.

| **Maxillary** | | | | | | |
|---|---|---|---|---|---|---|
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 66/300 | 23/150 | 130/300 | 279/450 | 498/1200 | 41.5 |
| Females | 46/232 | 23/116 | 101/232 | 206/348 | 376/928 | 40.5 |
| ? | 3/36 | 6/18 | 21/36 | 38/54 | 68/144 | 47.2 |
| Total | 115/568 | 52/284 | 252/568 | 523/852 | 942/2272 | 41.5 |
| Percent | 20.2 | 18.3 | 44.4 | 61.4 | | |

| **Mandibular** | | | | | | |
|---|---|---|---|---|---|---|
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 42/300 | 14/150 | 59/300 | 233/450 | 348/1200 | 29 |
| Females | 44/232 | 20/116 | 60/232 | 200/348 | 324/928 | 34.9 |
| ? | 0/36 | 0/18 | 3/36 | 31/54 | 34/144 | 23.6 |
| Total | 86/568 | 34/284 | 122/568 | 464/852 | 706/2272 | 31.1 |
| Percent | 15.1 | 12 | 21.5 | 54.5 | | |

TABLE 2. Frequency of carious teeth for the Oloriz sample. Values for each tooth group represent the number of carious teeth compared with the number of teeth examined.

| **Maxillary** | | | | | | |
|---|---|---|---|---|---|---|
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 0/3 | 1/4 | 5/16 | 12/59 | 18/82 | 21.9 |
| Females | 0/3 | 0/1 | 2/7 | 12/33 | 14/44 | 31.8 |
| ? | 0/0 | 0/0 | 0/1 | 1/1 | 1/2 | 50 |
| Total | 0/6 | 1/5 | 7/24 | 25/93 | 33/128 | 25.8 |
| Percent | 0 | 20 | 29.2 | 26.9 | | |

| **Mandibular** | | | | | | |
|---|---|---|---|---|---|---|
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 0/3 | 0/4 | 1/20 | 30/107 | 32/134 | 23.8 |
| Females | 0/0 | 0/1 | 2/13 | 24/59 | 26/73 | 35.6 |
| ? | 0/1 | 1/1 | 0/1 | 3/8 | 4/11 | 36.3 |
| Total | 0/4 | 1/6 | 3/34 | 57/174 | 62/218 | 28.4 |
| Percent | 0 | 16.7 | 2.8 | 32.8 | | |

TABLE 3. Frequency of alveolar abscesses for the Oloriz sample. Values for each tooth group represent the number of abscesses observed compared with the number of observations for abscesses.

| **Maxillary** | | | | | | |
|---|---|---|---|---|---|---|
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 27/300 | 24/150 | 56/300 | 77/450 | 184/1200 | 15.3 |
| Females | 21/232 | 17/116 | 32/232 | 62/348 | 132/928 | 14.2 |
| ? | 2/36 | 1/18 | 3/36 | 10/54 | 16/144 | 11.1 |
| Total | 50/568 | 42/284 | 91/568 | 149/852 | 332/2272 | 14.6 |
| Percent | 8.8 | 14.8 | 16 | 17.5 | | |

| **Mandibular** | | | | | | |
|---|---|---|---|---|---|---|
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 8/300 | 8/150 | 16/300 | 57/450 | 89/1200 | 7.4 |
| Females | 13/232 | 14/116 | 29/232 | 31/348 | 87/928 | 9.4 |
| ? | 1/36 | 2/18 | 2/36 | 3/54 | 8/144 | 5.6 |
| Total | 22/568 | 24/284 | 47/568 | 91/852 | 184/2272 | 8.1 |
| Percent | 3.9 | 8.5 | 8.3 | 10.7 | | |

reverse in the maxilla (males 15.3%, females 14.2%). Within mandibular teeth, abscesses were more common in molars (10.7%) followed by canines (8.5%) and premolars (8.3%). Within maxillary teeth, abscesses were most common in molars (17.5%) followed by premolars (16%) and canines (14.8%).

**Dental Hypoplasia**

As shown in *Table 4*, dental hypoplasia was relatively uncommon (2.3%) in the Oloriz sample, and slightly more common in females (4.5%) than males (1.2%) in the maxillary teeth. Hypoplasia was observed exclusively in molars within the maxillary teeth, but mostly in canines (33.3%) in the mandible.

**Calculus**

Detailed data on dental calculus are presented in *Table 5.* Observations on dental calculus were made on 333 teeth. Of these 243 (73.8%) displayed some evidence of dental calculus. 76.8% of teeth of males displayed calculus and 70.9% of teeth of females had calculus. Most deposits were recorded as slight and present in similar frequencies on the buccal and lingual sides of the teeth. Of the tooth groups, overall, deposits were most commonly found on the molars (79.5%), followed by the premolars (67.9%) and canines (50%).

**Comparative Data**

As a result of extensive research on skeletal samples from a variety of sources, comparative data are available to provide context for interpretation of dental disease in the Oloriz sample. *Table 6* presents information on dental samples that are utilized for comparison. These samples were selected because of their availability through published sources, excellent documentation in regard to provenience and date, reasonable sample size and data collection procedures that were compatible with those employed with the Oloriz sample. As noted in table 6, these samples range temporally from a site from ancient Ecuador dated to 8250 – 6600 BP to an ossuary in Ecuador dated from 1850 to 1940 AD. Geographically, the samples originate from the countries of Ecuador, Hungary, Chile, Brazil, and the US. These samples represent a broad range of time and geography and thus serve to place the Oloriz data in comparative context. Tables 7–10 reveal that in regards to antemortem tooth loss, carious lesions, and alveolar abscesses, the Oloriz sample ranks within the high end of the range of data presented. The frequency of dental hypoplasia is more moderately located. Table 11 compares the Oloriz sample to data from samples of similar time periods. The dates of these comparative samples range from 1600 to 1940 with the Oloriz sample (1884-1898) located on the later end of the range. As with the more comprehensive comparison, the Oloriz sample considered in the context of samples of similar time periods still ranks within the high end of the range of data for carious lesions and antemortem loss. The Oloriz sample has the highest value within the range of data presented for alveolar abscesses. The frequency of dental hypoplasia is more moderately located.

## DISCUSSION

The Oloriz sample originates from cadavers in 19th century Spain. As such, they depart demographically from the living population of Spain at that time. Nevertheless, this sample provides unique and important perspective of dental disease, demonstrating similarities with samples from other parts of the world from similar time periods. Like other world populations, people of 19th century Spain were acquiring dietary preferences that were conducive to dental disease and had not yet acquired effective dental hygiene. The result appears to have been elevated levels of antemortem tooth loss, alveolar abscess and dental caries. The moderate levels of dental hypoplasia suggest that childhood morbidity was less of a factor than diet in the progression of dental disease in 19th century Spain.

The Voegtly Cemetery sample dates from the mid-nineteenth century. The sample consists mostly of immigrants of Swiss-German ancestry who attended Voegtly Church (Ubelaker *et al.* 2003). Like the Oloriz collection,

TABLE 4. Frequency of dental hypoplasia for the Oloriz sample. Values for each tooth type are the number of teeth with hypoplasia compared with the number of teeth examined.

| **Maxillary** | | | | | | |
|---|---|---|---|---|---|---|
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 0/3 | 0/4 | 0/16 | 1/59 | 1/82 | 1.2 |
| Females | 0/3 | 0/1 | 0/7 | 2/33 | 2/44 | 4.5 |
| ? | 0/0 | 0/0 | 0/1 | 0/1 | 0/2 | 0 |
| Total | 0/6 | 0/5 | 0/24 | 3/93 | 3/128 | 2.3 |
| Percent | 0 | 0 | 0 | 3.2 | | |
| **Mandibular** | | | | | | |
| | Incisors | Canines | Premolars | Molars | Totals | Percent |
| Males | 0/3 | 0/4 | 2/20 | 0/107 | 2/134 | 1.5 |
| Females | 0/0 | 1/1 | 0/13 | 0/59 | 1/73 | 1.4 |
| ? | 0/1 | 1/1 | 0/1 | 0/8 | 1/11 | 9.1 |
| Total | 0/4 | 2/6 | 2/34 | 0/174 | 4/218 | 1.8 |
| Percent | 0 | 33.3 | 5.9 | 0 | | |

TABLE 5. Calculus Frequency for the Oloriz sample. Values for each tooth group represent the number of calculus teeth compared with the number of teeth present.

| | | | Buccal | | | | Lingual | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **S** | **M** | **L** | | **S** | **M** | **L** |
| | Male | Incisors | 1/3 | 0/3 | 0/3 | | 1/3 | 0/3 | 0/3 |
| | | Canines | 3/4 | 0/4 | 0/4 | | 3/4 | 0/4 | 0/4 |
| | | Premolars | 15/20 | 0/20 | 0/20 | | 13/20 | 1/20 | 0/20 |
| | | Molars | 87/107 | 0/107 | 0/107 | | 91/107 | 1/107 | 0/107 |
| | | Totals | 106/134 | 0/134 | 0/134 | | 108/134 | 2/134 | 0/134 |
| | | % | 79.1 | 0 | 0 | | 80.6 | 1.5 | 0 |
| | Female | Incisors | 0/0 | 0/0 | 0/0 | | 0/0 | 0/0 | 0/0 |
| | | Canines | 1/1 | 0/1 | 0/1 | | 1/1 | 0/1 | 0/1 |
| Maxillary | | Premolars | 8/13 | 0/13 | 0/13 | | 8/13 | 0/13 | 0/13 |
| | | Molars | 40/59 | 2/59 | 3/59 | | 36/59 | 4/59 | 0/59 |
| | | Totals | 49/73 | 2/73 | 3/73 | | 45/73 | 4/73 | 0/73 |
| | | % | 67.1 | 2.7 | 4.1 | | 61.6 | 5.5 | 0 |
| | ? | Incisors | 0/1 | 0/1 | 0/1 | | 0/1 | 0/1 | 0/1 |
| | | Canines | 0/1 | 0/1 | 0/1 | | 0/1 | 0/1 | 0/1 |
| | | Premolars | 1/1 | 0/1 | 0/1 | | 1/1 | 0/1 | 0/1 |
| | | Molars | 6/8 | 0/8 | 0/8 | | 7/8 | 0/8 | 0/8 |
| | | Totals | 7/11 | 0/11 | 0/11 | | 8/11 | 0/11 | 0/11 |
| | | % | 63.6 | 0 | 0 | | 72.7 | 0 | 0 |

the Voegtly sample exhibits high rates of dental caries and antemortem tooth loss. The prevalence of alveolar abscess is more moderately located. Unlike the Oloriz sample, the Voegtly sample presents a very high level of hypoplasia suggesting that episodes of stress were quite common during childhood. Disease and nutritional problems likely contributed to these episodes (Ubelaker, Jones, Landers 2003).

Data on dental health in comparative U.S. military samples originate from skeletons dated to the American Civil War, the War of 1812 site of Snake Hill, and the Indian Wars. Dental disease was affected by shifts in dietary trends throughout the nineteenth century. Diets shifted from unprocessed, low carbohydrate foods to cariogenic, processed foods, and finally to higher carbohydrate and refined sugar consumption. Poor living conditions and higher frequencies of infectious disease were added stresses in the Civil War sample (Sledzik, Moore-Jansen 1991). Despite sharing a similar time period to the Oloriz sample, the rates of dental disease are relatively low. The skeletal samples are mainly composed of young to middle-aged male recruits and volunteers (Sledzik, Moore-Jansen 1991). The lack of longevity in individuals in the samples likely accounts for the comparatively low rates of antemortem tooth loss and alveolar abscess. The slightly elevated rates of antemortem loss in the Indian Wars sample may be explained by the practice of tooth extraction as a form of dental care (Sledzik, Moore-Jansen 1991).

Three samples from Native American Great Plains groups also shared the same relative time period as the Oloriz sample. The Native Americans employed horticulture as well as hunting and gathering as their mode of subsistence (Johansson, Owsley 2002). The difference in diet between populations from nineteenth century Spain (more cariogenic food consumption) and those of nineteenth century Native America likely accounts for the dramatic contrasts in levels of dental disease.

The Convento de San Francisco de Quito was founded in 1535. The facility functioned as a cemetery through the 1900s. The samples that originate from the Convento represent different portions of that time period (Ubelaker 1994, Ubelaker, Ripley 1999). The three most recent samples from the Convento have the highest prevalence of dental caries of the Convento samples and are the most similar to that of the Oloriz sample. These elevated values likely represent the availability of sugar in modern times (Ubelaker, Ripley 1999). The similarity to Oloriz data suggests that sugar played a role in the Spanish diet in the nineteenth century as well. Prior to the eighteenth century, sugar was a luxury product throughout Europe, available only to those who could afford it. Only after the start of the eighteenth century did sugar transform into a commonplace item available to everyone (Galloway 2000). This may have affected antemortem tooth loss which also was found at high levels in some samples from the Convento. The prevalence of alveolar abscess and dental hypoplasia was comparatively low through all the samples from Convento de San Francisco.

With the exception of the high prevalence of antemortem tooth loss present in the La Libertad sample, most early Ecuadorean samples present low frequencies of dental disease. La Libertad, Cotocollao, Agua Blanca, and Santa Elena all share this pattern (Ubelaker 1980a, 1980b, 1988a, 1988b). The skeletal sample from La Florida, Quito, Ecuador suggests that both high and low status individuals enjoyed exceptionally good dental health in contrast with most other populations studied from ancient Ecuador (Ubelaker 2000).

TABLE 6. Overview of samples referenced including their approximate dates, location, reference information and the abbreviation used in subsequent tables.

| Sample | Date | Location | Abbr. | Reference |
|---|---|---|---|---|
| Cotocollao | 1000 – 500 BC | Ecuador | Cotocollao | Ubelaker 1980b |
| La Libertad (OGSE-46) | 900 – 200 BC | Ecuador | La Liberdad | Ubelaker 1988a |
| Ayalán non-urn | 500 BC – AD 1155 | Ecuador | Aya non-urn | Ubelaker 1981 |
| La Florida | 340 | Ecuador | La Florida | Ubelaker 2000 |
| Agua Blanca | 800 – 1500 | Ecuador | Agua Blanca | Ubelaker 1988b |
| Ayalán urn | 730 – 1730 | Ecuador | Aya urn | Ubelaker 1981 |
| San Francisco, strata cut upper level | 1540 – 1650 | Ecuador | SF strata UL | Ubelaker, Ripley 1999 |
| San Francisco, strata cut, lower level | 1580 – 1700 | Ecuador | SF strata LL | Ubelaker, Ripley 1999 |
| San Francisco, atrium | 1600 – 1725 | Ecuador | SF atrium | Ubelaker, Ripley 1999 |
| San Francisco, church | 1535 – 1858 | Ecuador | SF church | Ubelaker, Ripley 1999 |
| San Francisco, superficial collection, upper level | 1770 – 1890 | Ecuador | SF super UL | Ubelaker, Ripley 1999 |
| San Francisco, main cloister | 1730 – 1890 | Ecuador | SF cloister | Ubelaker, Ripley 1999 |
| San Francisco, superficial collection, lower level | 1670 – 1709 | Ecuador | SF super LL | Ubelaker, Ripley 1999 |
| San Francisco, boxes | 1850 – 1940 | Ecuador | SF boxes | Ubelaker, Ripley 1999 |
| Mango Montaño (La Tolita ) | 200 BC – 400 AD | Ecuador | Mngo mont | Ubelaker 1988c, 1997 |
| Mango Montaño Cama (La Tolita) | | Ecuador | Mngo cama | Ubelaker 1988c, 1997 |
| Pozo Iglesia (La Tolita) | 200 BC – 90 AD | Ecuador | Pozo Iglesia | Ubelaker 1988c, 1997 |
| H9 (La Tolita) | 200 BC – 90 AD | Ecuador | H9 | Ubelaker 1988c, 1997 |
| Tola Pajarito (La Tolita) | 600 BC – 75/90 AD | Ecuador | Tl Pajarito | Ubelaker 1988c, 1997 |
| Tola Mango (La Tolita) | 600 BC – 200 BC | Ecuador | Tl Mango | Ubelaker 1988c, 1997 |
| Santa Elena | Around 6000 BC | Ecuador | Sta Elena | Ubelaker 1980a |
| Arpadian Age | 1000 – 1301 AD | Hungary | Arapadian | Ubelaker, Pap 2008 |
| Bronze Age | 1900 – 800 BC | Hungary | Bronze Age | Ubelaker, Pap 1996 |
| Iron Age | 800 BC – beg AD | Hungary | Iron Age | Ubelaker, Pap 1998 |
| Copper Age | 45/4400–28/2700BC | Hungary | Copper Age | Ubelaker, Pap 2009 |
| Neolithic | 4000 – 2500 BC | Hungary | Neolithic | Ubelaker *et al.* 2006 |
| Morro-1 | 5500 – 4000 BP | Northern Chile | Morro-1 | Kelley *et al.* 1991 |
| Quitor-5 | 1900 – 1400 BP | Northern Chile | Quitor-5 | Kelley *et al.* 1991 |
| Maitas | 1200 – 800 BP | Northern Chile | Maitas | Kelley *et al.* 1991 |
| Alto Ramirez | 3000 – 1500 BP | Northern Chile | Alto Ram. | Kelley *et al.* 1991 |
| El-Launcho | 4000 – 2500 BP | Northern Chile | El-Launcho | Kelley *et al.* 1991 |
| Snake Hill | 1812 –1814 | US military | Snake Hill | Sledzik, Moore-Jansen 1991 |
| Civil Wars | 1861 – 1865 | US military | Civil War | Sledzik, Moore-Jansen 1991 |
| Indian Wars | 1870 – 1899 | US military | Indian Wars | Sledzik, Moore-Jansen 1991 |
| Voegtly Cemetery | 1831 – 1861 | Pittsburgh, PA | Voegtly Cemetery | Ubelaker *et al*. 2003 |
| Oloriz Sample | 1884 – 1898 | Spain | Oloriz | Oloriz 1899 |
| Rio Comprido | 4815 BP | Prehist. Brazil | Rio Comp | Neves, Wesolowski 2002 |
| Moro do Ouro | 4050 BP ± 80 | Prehist. Brazil | M do Ouro | Neves, Wesolowski 2002 |
| Ilha de Espinheiros II | 2710 BP ± 80 | Prehist. Brazil | I de Esp II | Neves, Wesolowski 2002 |
| Forte Marechal Luz PR | 4290 BP ± 130 | Prehist. Brazil | Marechal PR | Neves, Wesolowski 2002 |
| Enseada I | Not available | Prehist. Brazil | Enseada I | Neves, Wesolowski 2002 |
| Itacoara | Not available | Prehist. Brazil | Itacoara | Neves, Wesolowski 2002 |

| Sample | Date | Location | Abbr. | Reference |
|---|---|---|---|---|
| Forte Marechal Luz CR | 880 BP ± 100 | Prehist. Brazil | Marechal CR | Neves, Wesolowski 2002 |
| Nomad | 1870 – 1900 | US Great Plains | Nomad | Johansson, Owsley 2002 |
| Arikara | 1675 – 1790 | US Great Plains | Arikara | Johansson, Owsley 2002 |
| Pawnee | 1750 – 1820 | US Great Plains | Pawnee | Johansson, Owsley 2002 |
| Omaha | 1770 – 1820 | US Great Plains | Omaha | Johansson, Owsley 2002 |
| Georgia Bight Precontact Preagricultural | 1000 BC – AD 1150 | SE US, Georgia | PC/PA | Larson *et al.* 1991 |
| Georgia Bight Precontact Agricultural | 1150 – 1550 | SE US, Georgia | PC/AG | Larson *et al.* 1991 |
| Georgia Bight Early Contact | 1607 – 1680 | SE US, Georgia | EC | Larson *et al.* 1991 |
| Georgia Bight Late Contact | 1685 – 1702 | SE US, Georgia | LC | Larson *et al.* 1991 |

The La Tolita samples from the northern coast of Ecuador have a low prevalence of hypoplasia, dental caries, and antemortem tooth loss yet a high prevalence of alveolar abscess when compared to previously studied Ecuadorean samples (Ubelaker 1997). The same is true when the sample is compared to the Oloriz data. Differences in frequency of dental disease are most likely due to the changing temporal patterns of diet and subsistence.

Data for Ecuador suggest declining dental health through time most likely due to the long term shift in subsistence and settlement patterns toward agriculture, sedentism, and increased population density (Ubelaker 1992). Subsistence patterns and population density also likely contributed to the frequency of dental disease found in the Oloriz sample.

Data on Northeastern Hungary originate from a range of samples spanning the Hungarian Neolithic, Copper, Bronze, Arapadian, and Iron Ages (Ubelaker *et al.* 2006, Ubelaker, Pap 1996, 1998, 2008, 2009). These samples present lower frequencies of dental disease than the Oloriz sample likely due to temporal differences in diet, subsistence patterns, and other factors. The prevalence of hypoplasia found in the Oloriz sample is located in the middle of the range for the Hungary samples suggesting similar subadult stress levels.

Skeletal samples from the Brazilian Southern Coast represent both preceramic and ceramic groups. A higher prevalence of dental caries found in some preceramic sites suggests a greater amount of carbohydrate consumption during the preceramic period than the ceramic period (Neves, Wesolowski 2002). The prevalence found in the Oloriz sample is much higher suggesting a significantly higher amount of carbohydrate consumption in the Spanish diet during the nineteenth century.

The prevalence of hypoplasia is similar between the Brazilian preceramic and ceramic samples. The lack of significant difference indicates similar degrees of stress among subadults stemming from unspecified causes in both periods (Neves, Wesolowski 2002). The comparatively low rate found in the Oloriz sample points to a lesser degree of stress present in nineteenth century Spain.

Kelley *et al.* (1991) examined dental disease in five ancient Northern Chilean groups. Their study revealed temporal increases in dental disease with the growing dependency on agriculture, suggesting a strong association between subsistence patterns and dental health in this region. An outlier in the Chilean data is shown as an elevated rate of dental caries and antemortem tooth loss in the site of Quitor-5 dating to the later end of the Chilean range. This has been attributed to the consumption of algarrobs and chanares, foods which are high in sugar content and tend to adhere to tooth surfaces. The greater frequencies of dental disease present in the Oloriz sample suggest more agricultural dependence as well as greater availability of cariogenic foods such as sugar.

The Georgia Bight is a coastal area extending from North Carolina to northern Florida with a long history of occupation prior to and continuing after the arrival of Europeans in the sixteenth century (Larsen *et al.* 1991). Data from this region also point to the introduction and intensification of agriculture in the region as a factor in the general increase in dental caries. European mission centers changed the dietary focus of the region to plant carbohydrates, namely maize. The reorientation was particularly dramatic during the Spanish mission period which suggests that the type of diet in Spain during that time was plant carbohydrate focused (Larsen *et al.* 1991). This type of diet also likely contributed to the high prevalence of dental caries, alveolar abscess and antemortem tooth loss seen in the Oloriz sample.

Additionally, increases in dependence on intensive agriculture likely were accountable for increases in dental caries, alveolar abscesses, antemortem tooth loss and hypoplasia in comparison of the Ayalán non-urn samples to the urn samples in Ecuador (Ubelaker 1981).

The data presented in comparative context suggest that dental disease within the Oloriz sample was severe, leading to a high prevalence of bone abscess and antemortem tooth loss. Dental caries likely was a major contributor to tooth loss, along with periodontal disease. Study of the remaining teeth in the Oloriz sample revealed a comparatively high rate of dental caries, strongly implicating dental caries as a factor in antemortem tooth loss. Although genetics may represent a factor, diet likely played a key role in the manifestation of dental disease in nineteenth century Spain.

TABLE 7. Frequency of carious teeth. Value for each sample represents the number of carious teeth observed compared to the number of observation.

| Sample | % Carious | Sample | % Carious | Sample | % Carious |
|---|---|---|---|---|---|
| SF strata LL | – | Sta. Elena | 3 | EC | 8 |
| Mngo cama | 0 | Bronze Age | 3.2 | Pozo Iglesia | 10 |
| H9 | 0 | Itacoara | 3.67 | Aya urn | 11 |
| Tl Mango | 0 | Iron Age | 3.7 | PC/AG | 11.4 |
| Marechal PR | 0 | Arpadian | 3.8 | Alto Ram | 11.5 |
| Marechal CR | 0 | La Libertad | 4 | Snake Hill | 11.9 |
| Agua Blanca | 0 | Pawnee | 4.3 | SF boxes | 13 |
| Morro-1 | 0.6 | Omaha | 4.4 | Indian Wars | 14.0 |
| I de Esp II | 0.75 | Nomad | 4.7 | Maitas | 14.4 |
| Enseada I | 0.76 | SF atrium | 5 | SF cloister | 15 |
| PC/PA | 1.3 | SF church | 5 | Civil War | 21.7 |
| La Florida | 1.7 | Rio Comp | 5.81 | SF super UL | 25 |
| Mngo Mont | 1.9 | SF strata UL | 6 | Oloriz | 27.5 |
| Cotocollao | 2 | Neolithic | 6.3 | Voegtly Cem | 28.5 |
| Copper Age | 2.3 | Arikara | 6.3 | SF super LL | 32 |
| Tl Pajarito | 2.4 | M do Ouro | 7.44 | LC | 34.2 |
| El-Launcho | 2.5 | Aya non-urn | 8 | Quitor-5 | 48.1 |

TABLE 8. Frequency of alveolar abscesses. Value for each sample represents the number of abscesses observed compared to the number of observations for abscesses.

| Sample | % Abscess | Sample | % Abscess | Sample | % Abscess |
|---|---|---|---|---|---|
| Cotocollao | – | Pozo Iglesia | .49 | Pawnee | 4.2 |
| Rio Comp | – | Copper Age | .8 | La Libertad | 4.4 |
| M do Ouro | – | Sta. Elena | 1 | Snake Hill | 4.7 |
| I de Esp II | – | SF strata UL | 1 | Civil War | 4.7 |
| Marechal PR | – | SF boxes | 1 | Voegtly Cem | 4.9 |
| Enseada I | – | Iron Age | 1.5 | SF church | 6 |
| Itacoara | – | Nomad | 2.5 | SF super UL | 6 |
| Marechal CR | – | Neolithic | 2.6 | Mngo Mont | 7.98 |
| Agua Blanca | 0 | SF atrium | 3 | Arikara | 8.4 |
| SF strata LL | 0 | Aya non-urn | 3 | Indian Wars | 9.3 |
| Mngo Cama | 0 | Arpadian Age | 3.2 | Tl Pajarito | 9.8 |
| Tl Mango | 0 | Omaha | 3.6 | Oloriz | 11.4 |
| H9 | 0 | SF cloister | 4 | | |
| La Florida | .4 | SF super LL | 4 | | |
| Bronze Age | .42 | Aya urn | 4 | | |

TABLE 9. Frequency of antemortem tooth loss. Value for each sample represents the number of teeth lost antemortem compared to the number of observations for possible tooth loss.

| Sample | % Antemortem Loss | Sample | % Antemortem Loss | Sample | % Antemortem Loss |
|---|---|---|---|---|---|
| Rio Comp | – | Iron Age | 5.0 | Pozo Iglesia | 11.8 |
| M do Ouro | – | Copper Age | 5.2 | Indian Wars | 12.3 |
| Ide Esp II | – | Mngo Mont | 5.5 | Aya non-urn | 13 |
| Marechal PR | – | Arikara | 5.5 | Arpadian | 13.5 |
| Enseada I | – | Agua Blanca | 6 | Aya urn | 15 |
| Itacoara | – | Sta. Elena | 6 | Maitas | 16.2 |
| Marechal CR | – | Neolithic | 6.0 | Voegtly Cem | 16.8 |
| H9 | 0 | Pawnee | 6.1 | SF church | 23 |
| La Florida | .9 | Tola Mango | 6.3 | La Libertad | 23 |
| Omaha | 2.8 | Cotocollao | 7 | Oloriz | 36.3 |
| Mngo Cama | 2.8 | SF cloister | 7 | SF super LL | 46 |
| Tl Pajarito | 3.7 | Civil War | 7.1 | SF boxes | 49 |
| SF atrium | 4 | Snake Hill | 7.9 | Quitor-5 | 51.2 |
| Morro-1 | 4.3 | Nomad | 9.4 | SF super UL | 69 |
| El-Launcho | 4.6 | Alto Ram | 10.1 | SF strata LL | 89 |
| Bronze Age | 4.7 | SF strata UL | 11 | | |

TABLE 10. Frequency of dental hypoplasia. Value for each sample represents the number of teeth with hypoplasia compared to the number of teeth examined.

| Sample | % Hypoplastic | Sample | % Hypoplastic | Sample | % Hypoplastic |
|---|---|---|---|---|---|
| Nomad | – | SF atrium | 0 | SF strata UL | 4 |
| Arikara | – | SF super UL | 0 | Iron Age | 4.9 |
| Pawnee | – | SF cloister | 0 | La Libertad | 5 |
| Omaha | – | SF super LL | 0 | Agua Blanca | 5 |
| SF strata LL | – | Sta. Elena | <1 | Aya urn | 6 |
| Snake Hill | – | Cotocollao | .3 | Marechal CR | 7 |
| Civil War | – | Bronze Age | .5 | Itacoara | 12 |
| Indian Wars | – | Copper Age | .7 | Enseada I | 16 |
| Marechal PR | – | La Florida | .7 | Voegtly Cem | 18.3 |
| Mngo Mont | 0 | Aya non-urn | 1 | Rio Comp | 19 |
| Mngo Cama | 0 | SF church | 1 | M do Ouro | 20 |
| Pozo Iglesia | 0 | SF boxes | 1 | I de Esp II | 26 |
| H9 | 0 | Neolithic | 1.4 | | |
| Tl Pajarito | 0 | Arpadian | 1.7 | | |
| Tl Mango | 0 | Oloriz | 2.3 | | |

TABLE 11. Comparative data from samples from similar time periods as the Oloriz sample.

| Sample | Date | % Carious Lesions | % Lost Antemortem | % Associated Abscesses | % Hypoplastic |
|---|---|---|---|---|---|
| SF atrium | 1600 – 1725 | 5 | 4 | 3 | 0 |
| Arikara | 1675 – 1790 | 6.3 | 5.5 | 8.4 | - |
| Snake Hill | 1812 – 1814 | 11.9 | 7.9 | 4.7 | - |
| Pawnee | 1750 – 1820 | 4.3 | 6.1 | 4.2 | - |
| Omaha | 1770 – 1820 | 4.4 | 2.8 | 3.6 | - |
| SF church | 1535 – 1858 | 5 | 23 | 6 | 1 |
| Voegtly Cem | 1833 – 1861 | 28.5 | 16.8 | 4.9 | 18.3 |
| Civil War | 1861 – 1865 | 21.7 | 7.1 | 4.7 | - |
| SF cloister | 1730 – 1890 | 15 | 7 | 4 | 0 |
| SF super UL | 1770 – 1890 | 25 | 69 | 6 | 0 |
| Oloriz Sample | 1884 – 1898 | 27.2 | 36.3 | 11.4 | 2.3 |
| Indian Wars | 1870 – 1899 | 14.0 | 12.3 | 9.3 | - |
| Nomad | 1870 – 1900 | 4.7 | 9.4 | 2.5 | - |
| SF boxes | 1850 – 1940 | 13 | 49 | 1 | 1 |

## ACKNOWLEDGEMENTS

The authors wish to thank Juan Carlos Prados, Facultad de Medicina, Departamento de Anatomia y Embriologia Humana I at the Universidad Complutense Madrid, for granting access to the Oloriz collection. Thanks also to José L. Prieto and José Antonio Sánchez Sánchez of the Universidad Complutense Madrid for assisting with the study in Spain.

## REFERENCES

BUIKSTRA J. E., UBELAKER D. H. (Eds.), 1994: *Standards for Data Collection from Human Skeletal Remains, Proceedings of a Seminar at the Field Museum of Natural History.* Arkansas Archaeological Survey Research Series No. 44, Fayetteville. 206 pp.

CAMPBELL T. D., 1925: *Dentition and Palate of the Australian Aboriginal.* University of Adelaide, Publications under the Keith Sheridan Foundation. The Hassel Press, Adelaide. 123 pp.

GALLOWAY J. H., 2000: Sugar. In: K. F. Kiple, K. C. Ornelas (Eds.): *The Cambridge World History of Food.* Vol 1. Pp. 437–449. Cambridge University Press, United Kingdom.

HARTNADY P., ROSE J. C., 1991: Abnormal Tooth-Loss Patterns Among Archaic-period Inhabitants of the Lower Pecos Region, Texas. In: M. A. Kelley and C. S. Larson (Ed.): *Advances in Dental Anthropology.* Pp. 267–278. Wiley-Liss, Inc., New York.

JOHANSSON S. R., OWSLEY D., 2002: Welfare history on the Great Plains: Mortality and skeletal health, 1650 to 1900. In: R. H. Steckel, J. C. Rose (Ed.): T*he Backbone of History:*

*Health and Nutrition in the Western Hemisphere*. Pp. 524–560. Cambridge University Press, United Kingdom.

KELLEY M. A., LEVESQUE D. R., WEIDL E., 1991: Contrasting Patterns of Dental Disease in Five Early Northern Chilean Groups. In: M. A. Kelley and C. S. Larson (Ed.): *Advances in Dental Anthropology*. Pp. 203–213. Wiley-Liss, Inc, New York.

LARSEN C. S., HUTCHINSON D. L., SHOENINGER M. J., NORR L., 2001: Food and stable isotopes in La Florida: diet and nutrition before and after contact. In: C. S. Larsen (Ed.): *Bioarchaeology of Spanish Florida: The Impact of Colonialism*. Pp. 52–81. University Press of Florida, Gainesville.

LARSEN C. S., SHAVIT R., GRIFIN M. C., 1991: Dental caries evidence for dietary change: an archaeological context. In: M. A. Kelley and C. S. Larson (Ed.): *Advances in Dental Anthropology*. Pp. 179–202. Wiley-Liss, Inc., New York.

MOOREES C. F. A., FANNING E. A., HUNT Jr. E. E., 1963a: Formation and Resorption of Three Deciduous Teeth in Children. *Amer. J. of Phys. Anthrop.* 21: 205–213.

MOOREES C. F. A., FANNING E. A., HUNT Jr. E. E., 1963b: Age Variation of Formation Stages. *Journal of Dental Research,* 42: 1490–1502.

NEVES W. A., WESOLOWSKI V., 2002: Economy, nutrition, and disease in prehistoric coastal Brazil: A case study from the state of Santa Catarina. In: R. H. Steckel, J. C. Rose (Ed.): *The Backbone of History: Health and Nutrition in the Western Hemisphere*. Pp. 376–400. Cambridge University Press, United Kingdom.

OCAÑA G., 1913: Memoria 5. *Memorias de la Real Sociedad Española de Medicina Natural,* 7: 343–454.

OLORIZ, F., 1899: El Laboratorio de Anthropologia de la Facultad de Medicina de Madrid. *Revista Ibero-Americana de Ciencias Medicas*, 1: 76–91.

RUFFER A., 1920: Study of Ancient Egyptian Teeth. *Amer. J. of Phys. Anthrop.* 3: 335–382.

SLEDZIK P. S., MOORE-JANSEN P. H., 1991: Dental Disease in Nineteenth Century Military Skeletal Samples. In: M. A. Kelley and C. S. Larson (Ed.): *Advances in Dental Anthropology.* Pp. 215–224. Wiley-Liss, Inc., New York.

STEWART T. D., 1931: Dental Caries in Peruvian Skulls. *Amer. J. of Phys. Anthrop*. 15, 2: 315–326.

UBELAKER D. H., 1980a: Human Skeletal Remains from Site OGSE-80, A Preceramic Site on the Sta. Elena Peninsula, Coastal Ecuador. *Journal of the Washington Academy of Sciences,* 70: 3–24.

UBELAKER D. H., 1980b: Prehistoric Human Remains from the Cotocollao Site, Pichincha Province, Ecuador. *Journal of the Washington Academy of Sciences* 70, 2: 59–74.

UBELAKER D. H., 1981: The Ayalán Cemetery: A Late Integration Period Burial Site on the South Coast of Ecuador. *Smithsonian Contributions to Anthropology,* 29. Smithsonian Institution Press, Washington, DC. 184 pp.

UBELAKER D. H., 1988a: Human Remains from OGSE-46 La Libertad, Guayas Province, Ecuador. *Journal of the Washington Academy of Sciences,* 78, 1: 3–16.

UBELAKER D. H., 1988b: A Preliminary Report of Analysis of Human Remains from Agua Blanca, a Prehistoric Late Integration Site from Coastal Ecuador. *Journal of the Washington Academy of Sciences*, 78: 17–22.

UBELAKER D. H., 1988c: Prehistoric Human Biology at La Tolita, Ecuador, a preliminary report. *Journal of the Washington Academy of Sciences,* 78, 1: 23–37.

UBELAKER D. H., 1992: Temporal Trends of Dental Disease in Ancient Ecuador. *Anthropologie,* XXX, 1: 99–102.

UBELAKER D. H., 1994: *Biologia de los restos humanos hallados en el Convento de San Francisco.* (Also published in English.) Instituto Nacional de Patrimonio Cultural del Ecuador. 134 pp.

UBELAKER D. H., 1997: Skeletal Biology of Human Remains from La Tolita, Esmeraldas Province, Ecuador. *Smithsonian Contributions to Anthropology,* 41. Smithsonian Institution Press, Washington, DC. 53 pp.

UBELAKER D. H., 2000: Human Remains from La Florida, Quito, Ecuador. *Smithsonian Contributions to Anthropology,* 43: 28 pp.

UBELAKER D. H., JONES E. B., LANDERS D. B., (Eds.) 2003: Human Remains from Voegtly Cemetery, Pittsburgh, Pennsylvania. Smithsonian *Contributions to Anthropology*, 46. Smithsonian Institution Press, Washington, DC. 224 pp.

UBELAKER D. H., NEWSON L. A., 2002: Patterns of health and nutrition in prehistoric and historic Ecuador. In: R. H. Steckel, J. C. Rose (Ed.): *The Backbone of History: Health and Nutrition in the Western Hemisphere.* Pp. 341–375. Cambridge University Press, United Kingdom.

UBELAKER D. H., PAP I., 1996: Health Profiles of a Bronze Age population from Northeastern Hungary. – *Annls hist. – nat. Mus. natn. Hung*. 88: 271–296.

UBELAKER D. H., PAP I., 1998: Skeletal evidence for health and disease in the Iron Age of Northeastern Hungary. *Internat. J. of Osteoarchaeology* 8: 231–251.

UBELAKER D. H., PAP I., 2008: Human Skeletal Biology from the Arpadian Age of Northeastern Hungary. *Anthropologie* XLVI, 1: 25–36.

UBELAKER D. H., PAP I., 2009: Skeletal evidence for morbidity and mortality in copper age samples from northeastern Hungary. *International Journal of Osteoarchaeology* 19: 23–35.

UBELAKER D. H., PAP I., GRAVER S., 2006: Morbidity and mortality in the Neolithic of northeastern Hungary. *Anthropologie* XLIV, 3: 241–257.

UBELAKER D. H., RIPLEY C., 1999: The Ossuary of San Francisco Church, Quito, Ecuador: Human Skeletal Biology. *Smithsonian Contributions to Anthropology,* 42. Smithsonian Institution Press, Washington, DC. 32 pp.

Douglas H. Ubelaker
Kristina M. Zarenko
Department of Anthropology
Smithsonian Institution
NMNH, MRC 112
Washington, D.C. 20560-0112, USA
E-mail: ubelaked@si.edu
E-mail: zarenkok@si.edu

Ann H. Ross
Dept of Sociology and Anthropology
NC State University
1911 Bldg 253, Box 8107
NCSU Campus
Raleigh, NC 27695-8107, USA
E-mail: ann_ross@ncsu.edu