

Chronic Otitis Media in Ancient American Indians

James W. Ochi, MD,^a Linda Wheelbarger, BA,^b Lawrence W. Dautenhahn, MD^c



American Indian children suffer from chronic otitis media at a rate 3 times greater than the general population.¹ The reason that this population has been so vulnerable to middle ear infections, and for how long they have been vulnerable, is unknown.² Chronic ear infections can lead to permanent hearing loss^{3,4} and contribute to lifelong problems communicating with others. Repeated middle ear infections, which typically begin during early childhood, often lead to radiographic findings such as decreased mastoid air cell pneumatization⁵ that persist throughout life and are best observed by computed tomography (CT) scanning.

The lead author (J.W.O.) practiced for a time in the remote high desert of the Navajo Reservation in Shiprock, New Mexico, where he was the sole otolaryngologist for over 80 000 American Indians.⁶ He saw firsthand how frequently these people suffered in school and at work from hearing loss caused by chronic ear infections and wondered if American Indians who lived in this area centuries ago also struggled with this burden. To investigate this question, we used CT scanning on a set of ancient American Indian skulls to see if there were findings indicative of chronic middle ear disease.

Study specimens are from 2 archaeological sites located on the 12 000-acre B-Square Ranch in

Farmington, New Mexico, which is owned by Tommy Bolack. These ancestral Puebloan habitation sites (AD 850–1300) were excavated by Mr Bolack between 1967 and 1989. The 1978 New Mexico Cultural Properties Act provided for protection of archaeological sites on state land. Private landowners were allowed to conduct field archeology on their property until the “unmarked burial statute”⁷ was added in late 1989, requiring that a professional archaeologist excavate unmarked burials on private land with a permit from the Cultural Properties Act committee. The study specimens were obtained before the unmarked burial statute and were not subject to these regulations.

In addition, there are no direct descendants of the ancestral Puebloans today, although the Hopi, Zuni, Acoma, and the northern Rio Grande Pueblos are distantly related⁸; thus, consent for this study was not requested of existing American Indians in New Mexico or Arizona. The University of California San Diego Institutional Review Board determined that our study did not qualify as human subject research and required no review. Throughout the study, we were keenly sensitive to the concerns of first peoples and treated the skulls studied with the utmost respect. One of us (L.W.) is an experienced and knowledgeable professional

^aDivision of Otolaryngology, Sharp Rees-Stealy Medical Group, San Diego, California; ^bTotah Archaeological Project, Farmington, New Mexico; and ^cX-Ray Associates of New Mexico, PC, Farmington, New Mexico

Dr Ochi conceptualized and designed the study, drafted the initial manuscript, and reviewed and revised the manuscript; Ms Wheelbarger significantly contributed to the acquisition of data as well as drafting the article; Dr Dautenhahn provided radiographic analysis and interpretation of the data and significantly contributed to editing the manuscript; and all authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

DOI: <https://doi.org/10.1542/peds.2017-2308>

Accepted for publication Nov 1, 2017

Address correspondence to James W. Ochi, MD, Division of Otolaryngology, Sharp Rees-Stealy Medical Group, 10243 Genetic Center Dr, San Diego, CA 92121. E-mail: james.ochi@sharp.com

PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

Copyright © 2018 by the American Academy of Pediatrics

FINANCIAL DISCLOSURE: The authors have indicated they have no financial relationships relevant to this article to disclose.

FUNDING: No external funding.

POTENTIAL CONFLICT OF INTEREST: The authors have indicated they have no potential conflicts of interest to disclose.

To cite: Ochi JW, Wheelbarger L, Dautenhahn LW. Chronic Otitis Media in Ancient American Indians. *Pediatrics*. 2018; 141(4):e20172308

archeologist who personally oversaw handling of the specimens to ensure this was done properly.

Each skull was labeled as to its cultural “provenience” (origin) and its archaeological “provenience” (site of archaeological recovery). We performed CT scanning by using a Siemens Biograph TruePoint positron emission tomography and CT scanner with a 190-mm field of view, 200-mA seconds, and 120-kV peaks. A volume acquisition was obtained, and 0.6-mm-thick axial slices were constructed with 0.3-mm overlap; 3-mm-thick sagittal and coronal reconstructions were performed with 0.5 mm between slices.

A total of 20 ancient American Indian skulls were included in this study (Table 1): 1 male, 7 female, and 12 of unknown sex. Fourteen skulls could be assigned a broad age category, with 6 remaining unknown. Five of the 20 specimens (25%) showed evidence of arrested mastoid pneumatization on 1 or both sides (Figs 1 and 2), a finding commonly associated with chronic otitis media. Three of the 20 skulls (15%) exhibited expanded marrow space, or porotic hyperostosis (Figs 3 and 4). Almost all specimens had some degree of flattening of the occiput (Fig 5) caused by carrying infants strapped to cradleboards, a practice that continues in the American Indian culture today.

The ossicles and mastoid air cells are tiny, delicate, and fragile. Fortunately, these structures are encased in bone and were therefore well protected over the centuries from being damaged.⁹ In fact, the bone that encases the middle and inner ears is the densest in the human skeleton.¹⁰ To keep the specimens intact and completely undisturbed, we used CT scanning to peer inside the ancient temporal bones for evidence of chronic otitis media.

We chose mastoid pneumatization as the main evidence for past

TABLE 1 Characteristics and CT Findings of 20 Ancient American Indian Skulls

Provenience	Sex	Age Category, y	Decreased Mastoid Aeration	Porotic Hyperostosis
LK-B-3	Unknown	Unknown	—	X
LK-4	Unknown	Unknown	—	—
MCS-D	Female	35–49	X	—
MCS-E	Unknown	15–19	—	—
MCS-F	Male	20–34	—	—
MCS-H	Female	35–49	X	X
MCS-I	Unknown	15–19	—	—
MCS-J	Unknown	15–19	—	—
MCS-L	Unknown	10–14	—	—
MCS-M	Female	35–49	X	—
TS-5a	Unknown	Unknown	—	—
TS-8	Female	20–34	—	—
TS-9	Female	20–34	—	—
TS-38	Female	20–34	—	—
TS-49	Female	20–34	X	—
TS-50	Unknown	15–19	X	—
TS-86	Unknown	0–9	—	—
TS-101	Unknown	Unknown	—	X
TS-UNK-1	Unknown	Unknown	—	—
TS-UNK-2	Unknown	Unknown	—	—

—, not applicable.

chronic otitis media in our study. There are other radiographic findings associated with chronic ear infections, such as ossicular discontinuity or erosion of the lateral semicircular canal or tegmen.¹¹ A major analytic challenge was to determine with reasonable confidence that the temporal bone changes had not occurred during the many centuries of being buried under tons of earth. Mastoid pneumatization covers a relatively large area of the temporal bone and is a gradual change associated with chronic otitis media.¹²

An obvious drawback of our study is its small sample size, which means that our findings cannot be generalized. Twenty-five percent of the 20 skulls displayed arrested mastoid pneumatization; therefore, it can be inferred from our results that chronic ear infections were not unknown to the ancient American Indians. Another limitation is that the ancestral Puebloan specimens in this study were not related to the Navajo who currently occupy this area.

Despite these limitations, we felt these skulls presented a rare opportunity to look for signs of chronic middle ear

disease in ancient American Indians. One theory regarding the appearance of chronic middle ear disease in this population is that Europeans exposed American Indians to virulent new strains of bacteria to which they had not evolved immunity, causing chronic otitis media.¹³ All individuals in our study lived and died well before Europeans were introduced to American Indians in this area; thus, bacteria that might have arrived with these newcomers did not cause the ear infections.

Chronic middle ear disease often arrests mastoid pneumatization. There is some evidence in the archaeological crania of American Indians¹⁴ and Greenlandic Inuit,¹⁵ suggesting an increase in the incidence of poor mastoid air cell development after exposure to Europeans. The authors of these and other studies,¹⁶ performed at least 20 years ago, generally relied on plain films, whereas we used present-day CT technology, which affords greater clarity and precision than plain film.

Iron deficiency anemia may have increased these individuals' susceptibility to otitis media. Recurrent

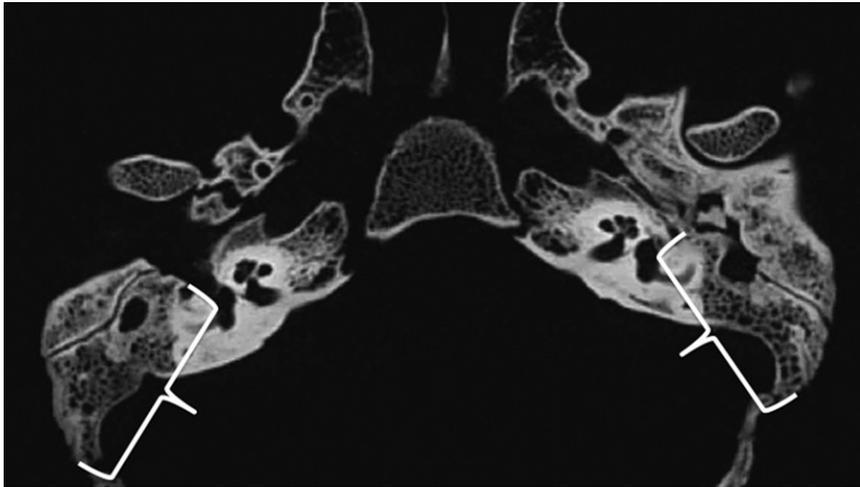


FIGURE 1
Poorly pneumatized mastoid air cells (as denoted by brackets) shown bilaterally on axial CT scan. The skull belonged to a woman, 35 to 49 years old (specimen MCS-M).

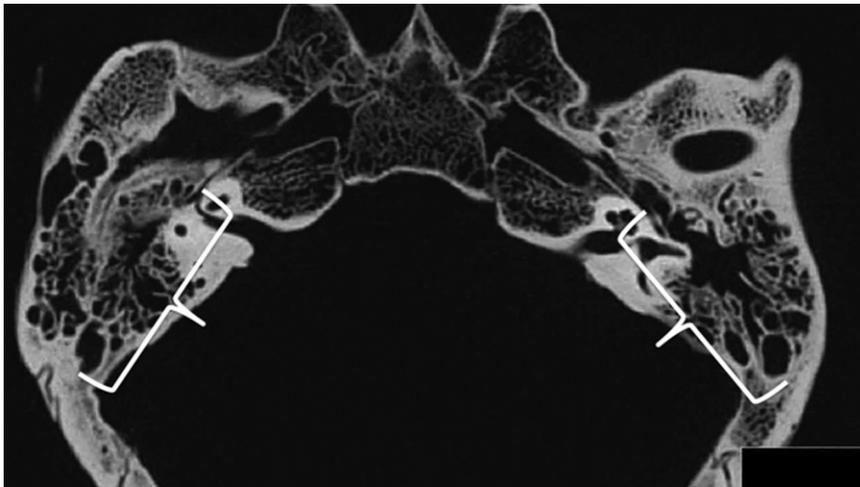


FIGURE 2
Normally pneumatized mastoid air cells (as denoted by brackets) shown bilaterally on axial CT scan. The skull belonged to a woman, 20 to 34 years old (specimen TS-38).

otitis media in children has been linked to iron-deficiency anemia.¹⁷ Porotic hyperostosis is characterized by localized areas of spongy or porous bone tissue, and in our study, was interpreted as increased marrow space. This may result from iron deficiency anemia, and was found in 3 of 20 specimens. Indeed, porotic hyperostosis has been identified in 45.2% to 82.0% of the ancient American Indian skeletal specimens found in this region of the Southwest.¹⁸ Today, American Indians have the highest incidence of hearing loss of

any ethnic group,¹⁹ likely because of suffering from chronic otitis media at a much greater rate than the general population.¹ American Indians have the lowest graduation rate from high school²⁰; the high frequency of hearing loss along with other factors may contribute to this underachievement. Hearing loss and poor academic achievement may also be connected to the unemployment rate of American Indians, the highest of any American ethnic group.²¹ The evidence identified in our study suggests that chronic otitis media



FIGURE 3
Increased skull marrow space (between lines) shown on axial CT scan, which is associated with porotic hyperostosis. The skull belonged to a woman, 35 to 49 years old (specimen MCS-H).



FIGURE 4
Normal skull marrow space (between lines) shown on axial CT scan. The skull belonged to a person of unknown sex, 15 to 19 years old (specimen MCS-J).

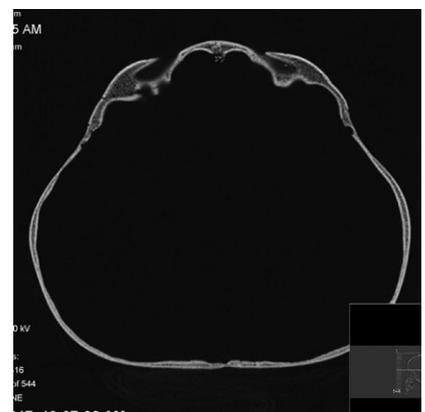


FIGURE 5
Flattening of the occiput due to infant cradleboarding on axial CT scan. The skull belonged to a person of unknown sex, 0 to 9 years old (specimen TS-86).

was common in ancient American Indian populations before European contact; additional research is needed to confirm these findings in a larger sample. Work is required to help present-day American Indians avoid the long-term sequelae of chronic middle ear disease.

ACKNOWLEDGMENTS

We thank Mr Tommy Bolack for granting us access to his unique archaeological collection. We are also grateful to Mr Bolack and Mr Charles LaNasa for their financial support, Mr Gary Wildfong for his logistical contributions, and Ms Jane Buchwald, Chief Scientific Research Writer at Medwrite Medical Communications, for her editorial suggestions.

ABBREVIATION

CT: computed tomography

REFERENCES

- Curns AT, Holman RC, Shay DK, et al. Outpatient and hospital visits associated with otitis media among American Indian and Alaska native children younger than 5 years. *Pediatrics*. 2002;109(3). Available at: www.pediatrics.org/cgi/content/full/109/3/e41
- National Institutes of Health; National Institute on Deafness and Other Communication Disorders (NIDCD). Ear infections in children. Available at: <https://www.nidcd.nih.gov/health/ear-infections-children>. Accessed December 12, 2016
- Acuin J. Chronic suppurative otitis media. *BMJ Clin Evid*. 2007;2007:0507
- Hunter LL, Davey CS, Kohtz A, Daly KA. Hearing screening and middle ear measures in American Indian infants and toddlers. *Int J Pediatr Otorhinolaryngol*. 2007;71(9):1429–1438
- Habesoglu TE, Habesoglu M, Toros SZ, et al. How does childhood otitis media change the radiological findings of the temporal bone? *Acta Otolaryngol*. 2010;130(11):1225–1229
- US Department of Health and Human Services, Northern Navajo Medical Center. Indian Health Service. Available at: <https://www.ihs.gov/navajo/healthcarefacilities/shiprock/>. Accessed May 1, 2017
- New Mexico Cultural Properties Act, N.M. Stat § 18-6-11.2 (1989)
- Ortiz A. *Handbook of North American Indians*. Vol 9. Washington, DC: Smithsonian; 1979
- Homøe P. *Pneumatization of the Temporal Bones and Otitis Media in Ancient and Modern Greenlanders*. Copenhagen, Denmark: Museum Tusulanum Press; 1997
- Hollinshead WH. *Anatomy for Surgeons: The Head and Neck*. Vol 1. Philadelphia, PA: Harper & Row; 1982
- Tatlipinar A, Tuncel A, Öğredik EA, Gökçeer T, Uslu C. The role of computed tomography scanning in chronic otitis media. *Eur Arch Otorhinolaryngol*. 2012;269(1):33–38
- Aoki K, Esaki S, Honda Y, Tos M. Effect of middle ear infection on pneumatization and growth of the mastoid process. An experimental study in pigs. *Acta Otolaryngol*. 1990;110(5–6):399–409
- Bhutta MF. Evolution and otitis media: a review, and a model to explain high prevalence in indigenous populations. *Hum Biol*. 2015;87(2):92–108
- Gregg JB, Steele JP. Mastoid development in ancient and modern populations. A longitudinal radiological study. *JAMA*. 1982;248(4):459–464
- Homøe P, Lynnerup N, Videbaek H. CT-scanning of ancient Greenlandic Inuit temporal bones. *Acta Otolaryngol*. 1992;112(4):674–679
- Gregg JB, Steele JP, Holzhueter A. Roentgenographic evaluation of temporal bones from South Dakota Indian burials. *Am J Phys Anthropol*. 1965;23:51–61
- Golz A, Netzer A, Goldenberg D, Westerman ST, Westerman LM, Joachims HZ. The association between iron-deficiency anemia and recurrent acute otitis media. *Am J Otolaryngol*. 2001;22(6):391–394
- Martin DL, Akins NJ, Goodman AH, Toll HW, Swedlund AC. *Total: Time and the Rivers Flowing: Excavations in the La Plata Valley*. Santa Fe, NM: Office of Archaeological Studies; 2001
- Schoenborn CA, Heyman K. *Health Disparities Among Adults With Hearing Loss: United States, 2000-2006*. Atlanta, GA: National Center for Health Statistics, Centers for Disease Control and Prevention; 2008
- Executive Office of the President. *2014 Native Youth Report*. Washington, DC: The White House; 2014
- Aud S, Fox MA, Kewal Ramani A. *Status and Trends in the Education of Racial and Ethnic Groups (NCES 2010-5)*. Washington, DC: U.S. Government Printing Office, U.S. Department of Education, National Center for Education Statistics; 2010

Chronic Otitis Media in Ancient American Indians

James W. Ochi, Linda Wheelbarger and Lawrence W. Dautenhahn

Pediatrics 2018;141;

DOI: 10.1542/peds.2017-2308 originally published online March 15, 2018;

Updated Information & Services

including high resolution figures, can be found at:
<http://pediatrics.aappublications.org/content/141/4/e20172308>

References

This article cites 11 articles, 1 of which you can access for free at:
<http://pediatrics.aappublications.org/content/141/4/e20172308#BIBL>

Subspecialty Collections

This article, along with others on similar topics, appears in the following collection(s):
Ear, Nose & Throat Disorders
http://www.aappublications.org/cgi/collection/ear_nose_-_throat_disorders_sub
Otitis Media
http://www.aappublications.org/cgi/collection/otitis_media_sub

Permissions & Licensing

Information about reproducing this article in parts (figures, tables) or in its entirety can be found online at:
<http://www.aappublications.org/site/misc/Permissions.xhtml>

Reprints

Information about ordering reprints can be found online:
<http://www.aappublications.org/site/misc/reprints.xhtml>

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®



PEDIATRICS®

OFFICIAL JOURNAL OF THE AMERICAN ACADEMY OF PEDIATRICS

Chronic Otitis Media in Ancient American Indians

James W. Ochi, Linda Wheelbarger and Lawrence W. Dautenhahn

Pediatrics 2018;141;

DOI: 10.1542/peds.2017-2308 originally published online March 15, 2018;

The online version of this article, along with updated information and services, is located on the World Wide Web at:

<http://pediatrics.aappublications.org/content/141/4/e20172308>

Pediatrics is the official journal of the American Academy of Pediatrics. A monthly publication, it has been published continuously since 1948. Pediatrics is owned, published, and trademarked by the American Academy of Pediatrics, 345 Park Avenue, Itasca, Illinois, 60143. Copyright © 2018 by the American Academy of Pediatrics. All rights reserved. Print ISSN: 1073-0397.

American Academy of Pediatrics

DEDICATED TO THE HEALTH OF ALL CHILDREN®

