The Anthropology of Modern Human Teeth

Second Edition

All humans share certain components of tooth structure, but show variation in size and morphology around this shared pattern. This book presents a worldwide synthesis of the global variation in tooth morphology in recent populations. Research has advanced on many fronts since the publication of the first edition, which has become a seminal work on the subject. This revised and updated edition introduces new ideas in dental genetics and ontogeny and summarizes major historical problems addressed by dental morphology. The detailed descriptions of 29 dental variables are fully updated with current data and include details of a new web-based application for using crown and root morphology to evaluate ancestry in forensic cases. A new chapter describes what constitutes a modern human dentition in the context of the hominin fossil record.

G. Richard Scott is Foundation Professor of Anthropology at the University of Nevada, Reno. He has written two books and edited two books on dental morphology and anthropology.

At his passing in 2013, **Christy G. Turner II** was Regents Professor Emeritus in the School of Human Evolution and Social Change at Arizona State University. He wrote books on dental morphology, cannibalism and violence in the prehistoric Southwest, and cave taphonomy in Siberia.

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The Anthropology of Modern Human Teeth

Dental Morphology and its Variation in Recent and Fossil *Homo sapiens*

Second Edition

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Dedicated to the memory of Thomas Draper Campbell, Albert A. Dahlberg, and P.O. Pedersen, pioneers in the study of human dental morphology

Contents

Preface

The release of *The Anthropology of Modern Human Teeth* (AMHT) in May 1997 was coincident with my retirement from the University of Alaska Fairbanks. To have a book published on your way out the door is not a normal procedure for someone in academic life. For the next four years, the book had little impact on my life. I was retired in every sense of the term for two years. In 1999, I took a job with Elderhostel in Scottsdale, Arizona to avoid a return trip to Alaska where they were tempting my wife with an attractive job in Anchorage. I enjoyed my 24 years in Alaska, but that phase of my life was over. I did not want to go north again after two years in the Arizona desert.

In 2001, through an unusual combination of chance and luck, I found myself back in academia at the University of Nevada Reno (UNR). It was only a temporary lecturer position but it gave me a chance to teach again and that was enough. Ultimately, a three-year lectureship evolved into a tenure-track teaching research position and I started anew as an advanced assistant professor or an assistant professor of advanced years.

This is the 20th anniversary of the first edition and much has transpired over that period. In 2010, Joel Irish and I organized a symposium on dental morphology honoring the contributions of Christy G. Turner II at the American Association of Physical Anthropologists meeting in Albuquerque, NM. Both of my collaborators contributed papers to the symposium that came out in the edited volume *Anthropological Perspectives on Tooth Morphology: Genetics, Evolution, Variation* (Scott and Irish, 2013). Unfortunately, due to health issues, Christy could not attend the meeting. On a visit to Tempe in 2012, we started to plot our next joint project, which was going to be a more detailed and better-illustrated version of the Turner et al. (1991) article on the Arizona State University Dental Anthropology System. My summer trip to Tempe to begin work on that project was scheduled for early August. Regrettably, Christy passed away in July of 2013, marking the end of a long, productive career and a colorful, globe-trotting life (Scott, 2013, 2014) (Figs 1 and 2).

After July of 2013, Christy was no longer with us in person but he remains with many of us in spirit. In January of 2014, I traveled to Tempe and with the aid and kindness of Christy's youngest daughter Korri and his second wife Olga Pavlova, I initiated the Christy G. Turner II legacy project. There were no external funds involved, only the desire to not let decades of hard labor fall victim to silver fish and the ravages of time (e.g., the 5¼-inch floppy drives that stored his data suffered "disk rot" and were no longer usable). During four visits to the Turner home on Campo Allegre, I scanned 30,000 data sheets, hundreds of computer print-outs with the full class frequency distributions for 29 key crown and root

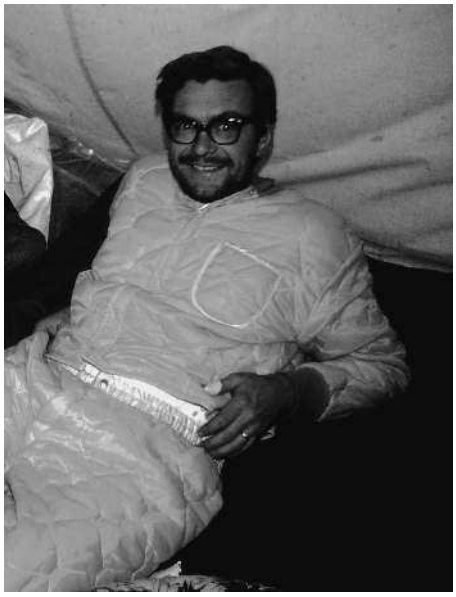

Fig. 1 Christy had two major passions: fieldwork and museum research. In this photo, he was resting in a tent while doing fieldwork in the Aleutian Islands, Alaska.

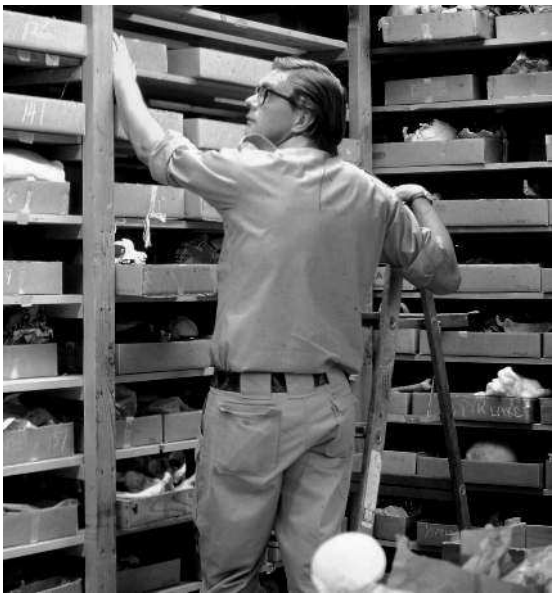

Fig. 2 This photo captures one slice of time for Christy's second passion. He spent untold hours in museums around the world making observations on the dentitions of human skeletal remains, with special emphasis on tooth crown and root morphology.

traits, and 3,000 slides. He remains a co-author of this second edition because it would not be possible without his inestimable contributions to the study of tooth morphology.

Christy and I shared a fondness for idioms so "the show must go on" seems appropriate in this case. I recruited Joel Irish to help with the volume we had planned on the Arizona State University Dental Anthropology System (Scott and Irish, 2017). Joel and I edited another volume the year before (Irish and Scott, 2016), titled *A Companion to Dental Anthropology*, and Blackwell included a photo of Christy looking at teeth on the cover.

The first edition of this volume enjoyed success in terms of sales and citations and Cambridge editors had broached the subject of a second edition several times. The time was not right until 2016–2017 when I had a chance to take my first sabbatical leave at UNR. What better place to spend a sabbatical than at The University of Adelaide, South Australia, with Grant Townsend and colleagues in the Murray Barrett laboratory at the Adelaide Dental School. With 20 years between editions and tremendous strides in genetical and evolutionary studies of teeth, I invited Grant, one of the world's leading authorities on dental genetics, to co-author the second edition. I was in Spain when the reviews for the second edition proposal started rolling in. Two of the reviewers strongly recommended that the topics covered in the first volume be augmented by a chapter on fossil hominin teeth. I was traveling on a train from Burgos to Bilbao, after visiting María Martinón-Torres and her family in Burgos, when I had an epiphany. If Grant was going to contribute to the chapters on dental genetics and ontogeny, Maria would be an excellent collaborator who could bring her considerable expertise to bear on fossil hominin teeth. When I sent a text that invited her to join the team, I told her to take her time and think about it, no hurry. Her response was an almost instantaneous and excited yes! That is how Scott, Turner, Townsend, and Martinón-Torres came to collaborate on this new edition of AMHT.

Although the outline of this volume is much like the first, except for a new Chapter 8 on fossil hominin dental morphology, we took advantage of the data Christy accumulated across four decades. When there is reference to the CGT II database, that signifies the hundreds of Excel spreadsheets with crown and root trait frequencies for samples throughout the world, with special emphasis on Asia, the Pacific, and the New World. For the first volume, Christy provided print-outs for grouped data (e.g., Australia as one large composite sample rather than the 15 samples we now have). The characterization of world variation in Chapter 5 is not radically different than Chapter 5 in the first edition, but there is a new organization and frequencies are based on means computed across multiple samples. Many of the photos of traits in Chapter 2 were scanned from Christy's huge slide collection.

The last two decades have witnessed a major upsurge in theses, dissertations, and articles focusing on dental morphology. We try to cite as many of these as possible to bring our bibliography up-to-date, but there was no space to summarize all these exciting contributions. It is our goal to "kick the can down the road" and discuss

not only what has been done but what needs to be done to make further progress on the dental morphological front. New traits to discover, advanced methods to observe both the "ins" (enamel–dentine junction) and "outs" (outer enamel surface) of morphology, concurrent analysis of morphology and genomics – the list goes on and on. These are exciting times for the study of dental morphology and we encourage individuals and teams of individuals to address and fine-tune the unresolved issues discussed in the following pages.

Acknowledgments

The first edition of this volume would never have transpired without an invitation from the late Gabriel W. Lasker. Little did GRS know what a big role *The Anthropology of Modern Human Teeth* would play in his life. Beyond Dr. Lasker, GRS owes a debt of gratitude to many pioneers in the field with whom he worked at the beginning of his career, including A.A. Dahlberg and P.O. Pedersen. Christy G. Turner II, although no longer with us physically, will always be with us in spirit. His data form the core of the book and his work on peopling problems in the Americas, Asia, and the Pacific lives on in Chapters 6 and 7. His contributions to the field of dental morphology more than warrant retaining his name on this second edition. Although not directly involved in this volume, the contributions of Joel D. Irish are inestimable as he provided essential comparative data for all of Africa. We thank him for his many publications and his systematic and consistent presentation of data, providing a model that should be widely adopted.

GRS was greatly aided by Christy's daughter, Korri D. Turner, and second wife, Olga Pavlova, who welcomed him into their home to scan data sheets and slides. They cannot be thanked enough for their friendship and hospitality. The first edition was produced during the last few years at the University of Alaska, Fairbanks. For writing the second edition, GRS thanks his current institution, the University of Nevada, Reno, for their support and the sabbatical leave they approved. The time was well spent at the University of Adelaide, where GRS worked directly with co-author Grant C. Townsend. Grant and his colleagues in the Adelaide Dental School and the Murray Barrett lab, including Toby Hughes, John Kaidonis, Alan Brook, Corinna Bennett, and many more, are owed a debt of thanks for their help and kindness. On the Reno front, GRS thanks his two physical anthropology colleagues and "besties" for their contributions to this volume and making the life of a long-time (40 years) Lone Ranger so much better. Marin Pilloud generously reviewed chapters and Kyra Stull used her considerable skills with R to produce the box whisker plots in Chapter 5 along with biodistances, trees, and ordinations for Chapters 6 and 7.

GCT acknowledges the foresight of the late Dr. Murray Barrett and Emeritus Professor Tasman Brown from The University of Adelaide who commenced a longitudinal growth study of Indigenous Australians living at Yuendumu in the Northern Territory of Australia and sincerely thanks the participants as well. The dental models obtained from this study serve as a unique resource for studies of the human dentition. Thanks, also, to the twins and their families who have participated in the ongoing studies of teeth, faces, and oral health carried out by the Craniofacial Biology Research Group in the Adelaide Dental School in collaboration with national and international researchers.

Thanks to the many granting agencies that provided funds to support research in dental anthropology by the staff of the Adelaide Dental School, including: the

National Institute of Health, Bethesda, Maryland; the National Health and Medical Research Council of Australia; the Wenner-Gren Foundation for Anthropological Research; the Australian Institute of Aboriginal Studies and Torres Strait Islanders, Canberra; the Australian Dental Research Foundation; the Australian Dental Industry Association; the Australian Society of Orthodontics Foundation for Research and Education; the Financial Markets Foundation for Children; and The University of Adelaide. Special thanks also to Twins Research Australia, the Australian Multiple Birth Association, and Colgate Oral Care for their ongoing support.

GCT would like to thank his family, especially his wife Micka, for their love and support over the years.

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MMT thanks all members of the Atapuerca research team for their arduous and dedicated work and the Dental Anthropology Group at the National Research Center on Human Evolution (CENIEH) for great and exciting teamwork. Thanks also to those individuals who provided access to the studied material and their helpful assistance when examining it: W. Liu, X. Wu, and S. Xing (Institute of Vertebrate Paleontology and Paleoanthropology, Beijing, China), D. Lordkipanidze and A. Vekua (Georgian National Museum, Tbilisi, Republic of Georgia), C. Bernis and J. Rascón (Universidad Autónoma de Madrid, Madrid, Spain), John de Vos (Naturallis Museum, Leiden, The Netherlands), C. Stringer (Museum of Natural History, London), A. Pérez-Pérez, J. Galbany, F. Estebaranz, and L.M. Martínez (Universitat de Barcelona, Barcelona, Spain), G. Manzi (Sapienza-Università de Roma, Italy), J. Svoboda (Institute of Archaeology, Paleolithic and Paleoethnology Research Center, Dolní Věstonice, Czech Republic), I. Tattersall, K. Mowbray, and G. Sawyer (American Museum of Natural History, New York), E. Cunha (Universidad de Coimbra, Coimbra, Portugal), H. de Lumley, M.-A. de Lumley, and A. Vialet (Institut de Paléontologie Humaine, Paris, France), and P. Tassy (Muséum National d'Histoire Naturelle, Paris, France).

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MMT thanks her family, especially Mark Sier, María Sier Martinón, and Mark Sier Martinón, for being the joys of her life.

Finally, we all thank Cambridge editors Dominic Lewis and Noah Tate for their guidance and patience during the production of this second edition.

Prologue

This book is about teeth in general and tooth morphology in particular. Excluding rare cases of anodontia, where individuals never develop teeth, all humans in all places always had, have, or will have teeth. People use and see their teeth every day, but ordinarily take them for granted except when they are a source of pain and discomfort. Most pay even less attention to the morphology of teeth. By feeling the chewing surfaces of the individual teeth at the back of the mouth, one can discern elevations or bumps that are separated from one another by depressions or concavities. These teeth in the back of the mouth are molars, the bumps are cusps, and the depressions are fissures, fossae, grooves, or sulci, depending on their form and depth. More difficult to palpate are the many ridges that are present on the cusps or along the margins of a tooth. It is elements such as cusps, ridges, fissures, and even the number of roots each tooth possesses that occupy the attention of the dental morphologist.

What are human perceptions (or misconceptions) about those hard, white objects in our mouths that we (should) brush and floss every day? Individual knowledge of teeth is highly variable within populations and between different cultures. In *Folklore of the Teeth*, Leo Kanner (1928) reviews a broad range of subjects, including the diversity of views on toothaches and dental hygiene and varied practices in artificial dental deformation. In his first chapter, on tooth number, shape, and eruption, he discusses how many early scholars were misinformed on something as basic as the number of teeth an individual possessed: "We not infrequently meet with individuals of sometimes more than fair intelligence who become embarrassed when questioned as to how many teeth they have" (Kanner, 1928:3).

As dental anthropologists who have observed at least one million teeth, we take for granted what average individuals know about their own teeth. Kanner's observations on dental misconceptions in earlier and recent times stimulated a survey of 80 university students and their friends and families who responded to four questions: (1) how many deciduous (baby) teeth do humans have? (2) how many permanent teeth do humans have? (3) how many types of teeth do humans possess? and (4) do teeth play a role in attracting members of the opposite sex? For the first question, only 19 individuals (24%) responded correctly that humans have 20 deciduous teeth, with answers ranging from 12 to 35. Survey participants were more aware of the number of permanent teeth; 44 (55%) gave the correct answer of 32 (range: 21–40). Regarding types of teeth, 38 individuals (48%) correctly specified four types of teeth, with incorrect answers ranging from one to 11. Part of the confusion was terminological, as some thought cuspids and canines or bicuspids and premolars were different types of teeth. Only 11 individuals (14%) answered all three questions correctly (20-32-4). Regarding the role of teeth in sexual attractiveness, the response to this question was overwhelmingly positive: 75 individuals

(94%) felt teeth were an important element of physical attraction. Some felt so strongly about this that they added exclamation marks after "yes." Jones' (1995) research on sexual selection and physical attractiveness among humans focused on eyes, nose, lips, and facial proportions, but the importance of teeth in physical appearance was not mentioned.

Our survey and the near universal attempts to enhance dental beauty suggest studies of sexual selection should factor "teeth" into their calculations along with other facial features. Lopez et al. (2013) performed an experiment on an internet dating site to evaluate the importance of teeth in attraction. They had two photos of the same young female; photo A was a normal photo with a revealing smile and photo B was of the same individual but her teeth had been moderately mispositioned. Both photos received an equal number of visits but photo A generated four times as many follow-up e-mails as photo B. They conclude: "The scientific literature is in agreement that the smile and the teeth play a significant role in rendering a face attractive" (Lopez et al., 2013:55).

Genes primarily determine the size, form, and morphology of teeth. Teeth, however, interface with the environment following eruption. Because of their visibility and accessibility, teeth can be influenced by behaviors that are intentional, incidental, or accidental. For example, individuals in many cultures are not content with the natural morphology of their teeth but feel a cultural or idiosyncratic urge to produce an artificial morphology in line with their value system. Such tinkering is concentrated on teeth at the front of the mouth (incisors and canines) as they are most visible in social intercourse. Such intentional manipulations of tooth form pale in comparison to the effects of unintentional alterations produced by natural forces over the life of a dentition, for example, though dental wear and pathologies. As this book is focused on the genetic aspects of tooth crown and root morphology, a prologue provides an opportunity to address briefly behavioral and environmental factors that influence dental morphology (Alt and Pichler, 1998; Mower, 1999). Unfortunately, these factors have an impact on those who observe dental morphology.

Intentional Alterations of Tooth Form

There are aesthetic ideals for how teeth should "appear" but these ideals, and how they are attained, vary greatly in different cultures. The western ideal of dental beauty, exemplified by many celebrities, is straight, white, vertically positioned anterior teeth that are all present and accounted for. Dentists and orthodontists make a living helping individuals attain this ideal through scaling, polishing, fillings, crowns, bridges, dental appliances, and dentures, as needed. Except for correcting occlusal problems, individuals are less concerned with the appearance of their molars because these teeth have low visibility in social interactions. However, the mouth, as a primary social organ, does draw the viewer's eye so there is social import attached to the appearance of the incisors and canines and, to some extent, the premolars.

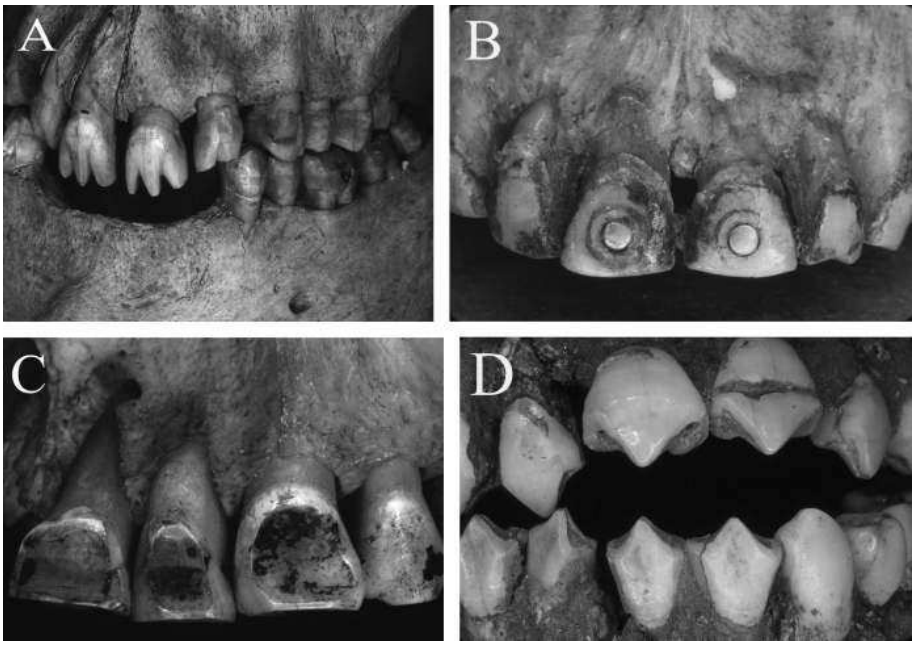

Fig. P.1 Four examples of intentional dental modification: (A) filed upper incisors and ablated (intentionally knocked out) lower incisors and canines, Japan, Jomon period; (B) gold insets in upper central incisors, Southeast Asia; (C) filing of labial surfaces of upper anterior teeth, Southeast Asia; (D) filing of upper and lower anterior teeth, northern Mexico. (All photos from C.G. Turner II collection.)

The western ideal of "attractive" anterior teeth is not universal. In some cultures, straight white teeth are far from ideal. Groups from many parts of the world, especially Africa and Southeast Asia, modify their tooth morphology through artificial deformation. These practices range from the intentional removal of teeth (ablation) to modifying crown form through filing, incising, chipping, staining, banding, and in-setting (Fig. P.1). The following excerpts are from ethnographers and travelers who witnessed firsthand how individuals endured great pain, both literally and figuratively, to change the appearance of their teeth. While westerners might cringe at these descriptions, any individual who wore dental appliances during adolescence can identify with the pain involved in achieving a culturally prescribed dental ideal.

* * *

Tooth Ablation in Central Australia (Spencer and Gillin, 1899:451–452)

> If the operation be performed on a man he lies down on his back, resting his head on the lap of a sitting man who is his tribal *Oknia* (elder brother), or else a man who is *Unkulla* to him (mother's brother's son). The latter pinions his arms and then another *Okilia* or *Unkulla* fills his mouth with furstring for the purpose, partly, they say, of absorbing the

blood and partly of deadening the pain, and partly also to prevent the tooth from being swallowed. The same man then takes a piece of wood, usually the sharp hard end of a spear, in which there is a hole made, and, pressing it firmly against the tooth, strikes it sharply with a stone. When the tooth is out, he holds it up for an instant so that it can be seen by all, and while uttering a peculiar, rolling, guttural sound throws it away as far as possible in the direction of the *Mira Mia Alcheringa*, which means the camp of the man's mother in the Alcheringa.

* * *

Tooth Blackening and Filing on Alor (Du Bois, 1944:83–84)

It is during this period of adolescence that both boys and girls have their teeth blackened and filed ... The actual procedure is as follows: In July or August some young unmarried man, perhaps in his early twenties, announces that he will blacken teeth for the children of the community and designates the field house where it will be done ... He purchases from some friend in the village of Bakudatang a particular type of soil found there ... With the earth he mixes a fruit resembling a green fig. The resulting paste is smeared on a strip of banana bark which each child cuts to fit the size of his mouth ... For at least seven nights, and often ten, the children sleep together in a field house, with the paste held against their teeth by the flexible bark strips ... The children all eat together, being careful to place small bits of food far back in their mouths in order not to spoil the dye. With the same objective a length of thin bamboo is used as a drinking tube during the period.

On the last day or two of the period those who are to have their teeth filed go through the ordeal. The same person who prepared the dye usually does the tooth filing. The subject's head is laid on the thigh of the operator and wedged against his side with his elbow. The jaws are propped open with a piece of corncob. The six upper and six lower front teeth are then filed to half their length with an ordinary knife blade that has been nicked to resemble a saw. Apparently experience makes it possible to avoid the root canal, which occupies only the upper half of the incisors ... It is undoubtedly painful but, as in tattooing, it is bad form to admit it. The result of this filing means that even when the back teeth are occluded, the tongue will show pinkly between the gaping front teeth when a person smiles. *This is considered definitely attractive*. [emphasis ours]

* * *

Brass Insets Among the Iban (Dyaks) (Gomes, 1911:38)

As among the populations of Alor, the Iban of Borneo blacken and file their front teeth. They also take dental modification one step further:

The teeth are often blackened, as black teeth are considered a sign of beauty ... The front teeth are also frequently filed to a point, and this gives their face a curious dog-like appearance ... Another curious way of treating the front teeth is to drill a hole in the middle of each tooth, and fix in it a brass stud. I was once present when this operation

was in progress. The man lay down with a piece of soft wood between his teeth, and the "dentist" bored a hole in one of his front teeth. The agony the patient endured must have been very great, judging by the look on his face and his occasional bodily contortions. The next thing was to insert the end of a pointed brass wire, which was then filed off, leaving a short piece in the tooth; a small hammer was used to fix this in tightly, and, lastly, a little more filing was done to smooth the surface of the brass stud. I am told the process is so painful that it is not often a man can bear to have more than one or two teeth operated on at a time.

* * *

Dental Modification Among the Moi of Vietnam (Frank, 1926:90–91)

At the age of puberty boys and girls alike undergo the formality of having their teeth filed down to the gums. With some kind relative sitting on the chest of the sufferer, lying on his back with his head between the legs of a primitive vise, and with a wooden bit forced into his mouth, a medicine-man breaks off the teeth with stones and hacks and chips them away. It is their idea of making themselves beautiful, and the boy or girl who has not undergone this punishment is not considered marriageable or otherwise of adult status. After a day of this frightful work the operator leaves his victim covered with blood, his gums in ribbons, his lips like hashed-beef-steak, and incapable for a fortnight of eating anything but liquids. Nor is this all, for the patient is then given a stone with which to continue the beautifying process himself, when he has a moment to spare, until not a sign of tooth remains above the level of the gums. Among some of the tribes the lower teeth are given a saw shape, so that the open mouth suggests that of an aged shark that has lost its upper plate.

* * *

Tooth Blackening Among the Annamese (Frank, 1926:168–169)

about marriage time, which in Annam is early in life, every Annamese, of either sex, is expected to have his teeth lacquered black by a process said to be very painful ... Every people has its own style of beauty ... and to the Annamese a person is handsome only if his teeth are jet-black. "Any dog can have white teeth," say the Annamese, looking disparagingly at Europeans. To them white teeth are not only ugly but immoral! For the congare, the Annamese girl, who has not blackened her teeth, is usually, if not always, some Frenchman's darling.

* * *

In some instances, artificially deformed tooth crowns provide clues to past movements of peoples. That is, when people move or are transplanted from one

geographic area to another, they may continue previous cultural practices in their new locale. West Africans, forcibly transplanted to North and South America and the Caribbean in the sixteenth, seventeenth, and eighteenth centuries, maintained to some extent the tradition of filing anterior teeth to points (Stewart, 1942; Ortner, 1966; Stewart and Groome, 1968; Tiesler and Oliva, 2010). Dental mutilation, widespread in Mesoamerica during pre-Columbian times (Romero, 1970; Williams and White, 2006; Tiesler et al., 2017; Watson and García, 2017), has been observed in a handful of American Southwest burials (Turner and Turner, 1999; Burnett, 2017). Given the extreme rarity of this practice in the Southwest, it is likely that the few individuals with modified teeth are of Mesoamerican origin (e.g., traders). Specific patterns of tooth extraction might also indicate historical linkages between the Minatogawa population of Okinawa (ca. 17,000 BP), the Jomon peoples of Japan (12,500–2200 BP), and possibly some Neolithic populations of China (Wu, 1992). These are but a few examples that illustrate the potential applications of ethno-odontology to historical problems. There is now an edited volume devoted entirely to the subject of culturally modified teeth, with sections on Africa, Europe and Northeast Asia, Southeast Asia, Australia, and Oceania, and North America and Mesoamerica (Burnett and Irish, 2017). The papers in this volume illustrate the geographic breadth and cultural import of intentional dental modification.

Unintentional Alterations of Tooth Morphology

While some groups modify their teeth intentionally to denote status and group affiliation or simply to enhance physical attractiveness, others engage in behaviors that result in unintentional alterations of crown morphology (Fig. P.2). For example, habitual pipe smoking leaves a distinct imprint on teeth (Kvall and Derry, 1996). When the upper and lower teeth are occluded, pipe wear produces an oval-shaped opening in the region of the lateral incisors and canines that appears on either or both sides of the mouth, depending on the inclinations of the smoker. Pipe wear has been observed in prehistoric, protohistoric, and modern populations ranging from Melanesia and Siberia to the North Atlantic.

Another cultural practice that leaves a distinctive mark on the tooth crown is the use of labrets, or cheek plugs (Cybulski, 1974, 2010; Torres-Rouff, 2003). The reasons for wearing labrets are like those for intentional dental modification (i.e., group identity, status, physical attractiveness). This practice involves pain as incisions of varying lengths were cut through the cheek just below the lower lip for insertion of the labret(s). Once inserted, the internal face of the labret would contact the outer (buccal) surface of the lower teeth. Depending on the size of the labrets, their placement (medial or lateral), and the length of time worn, the result would be distinct polished facets of varying size on the external (labial or buccal) surfaces of two or more teeth. From prehistoric to recent times, labret usage could be found in many New World populations with widely divergent subsistence strategies, from hunter-gatherer Eskimos in the north to agricultural Mesoamericans in the south.

In addition to pipes and labrets, other repetitive behaviors that involve the insertion of hard objects in the mouth, such as tooth-picks and bobby pins, leave permanent marks on teeth (Ubelaker et al., 1969; Berryman et al., 1979).

Using teeth as tools involves another set of behaviors that results in permanent alterations to the tooth crown. Such usage was a common practice among hunter-gatherer populations prior to the Neolithic Revolution and is not unheard of even today. Who has not used their teeth to break string, tear fabric, open a container, or the like? Granted, tooth-tool use is not what it used to be with pliers, vises, scissors, and a myriad of other tools as more efficient and less risky substitutes for teeth. However, before such tools were developed, teeth served as an intermediary in many task-related activities such as working hides, softening boots, making grass baskets, using bow-drills to create fire, and producing rope or string from sinew. These behaviors, reflected on the teeth as grooves, notches, unusual wear planes, and rounded wear, could affect crown morphology as much as or more than intentional modifications of teeth (Molnar, 1972; Schulz, 1977; Hinton, 1981; Larsen, 1985; Lukacs and Pastor, 1988; Minozzi et al., 2003; Bonfiglioli et al., 2004; Scott and Burgett, 2008; Lorkiewicz, 2011).

Much to the chagrin of dental morphologists, dietary behavior alters the form of teeth more dramatically and on a much more universal scale than any other type

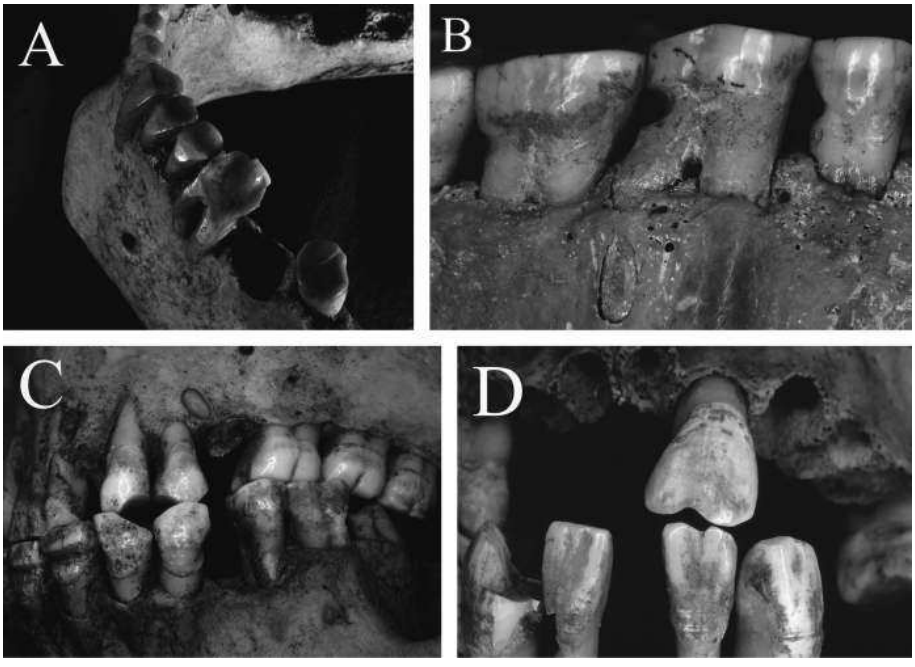

Fig. P.2 Four examples of unintentional dental modification: (A) labret facets on buccal surfaces of lower cheek teeth, Western Alaska; (B) tooth pick groove, Australia; (C) pipe faceting, Siberia; (D) upper and lower incisor notches, Japan. (A from G.R. Scott; all others from C.G. Turner II collection.)

of post-eruptive modification. In earlier human populations, the primary changes occurred through crown wear (Fig. P.3). This is a natural process brought about by the "simple" act of bringing the upper and lower teeth in contact while chewing food (attrition). When food is contaminated with non-food items (i.e., sand, silt, grit, etc.), the process of wear is enhanced even more (abrasion). Tooth substance can also be removed by erosion, often involving acidic food or drink or through stomach acids generated by vomiting. In some instances, enamel chips are removed around the margins of the crowns when an individual bites down on a foreign object accidentally introduced into food (Turner and Cadien, 1969; Scott and Winn, 2011). Wear commences on the occlusal surfaces of the teeth and, in time, eliminates cusps, ridges, and fissures. With the introduction of highly refined foods, rates of dental wear have slowed down in many societies. This advantage is offset by increased frequencies of dental caries, which can destroy teeth more quickly than heavy crown wear. Caries are prone to develop in pits and fissures on the occlusal surface of a tooth crown, precisely the location of many morphological crown traits.

Because of the many behavioral and environmental factors that affect teeth once they have erupted, despite their hardness, it is amazing adults retain any crown morphology. In some skeletal series where post-eruptive modification is compounded by post-mortem loss of single-rooted teeth (especially incisors and canines), some traits might be observable in only a handful of individuals. Roots, however, are much less affected than crowns by behavior and environment so sample sizes for root traits are often much higher than for crown traits. Although this option is rarely available in skeletal studies, many researchers who deal with living populations focus on individuals between 12 and 16 years of age. This narrow window of time is the period when teeth are least likely to be affected by the two major contributors to crown destruction: wear, and caries.

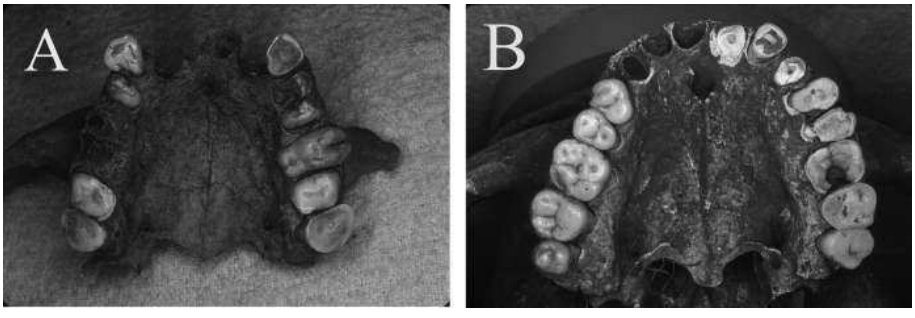

Fig. P.3 Two examples of pronounced but normal wear that obscures morphology: (A) scoring crown traits with such worn and missing teeth would be difficult but *tuberculum dentale* could be scored on the right upper canine and there is potential for scoring root traits but little else; and (B) an unusual case of highly asymmetrical wear – right antimeres are worn flat with secondary dentine over the pulp. The left antimeres show only modest wear and many traits could be scored on this side of the jaw. (Photos from C.G. Turner II collection.)

Dental Anthropology in the Classroom

Given the many genetic, developmental, behavioral, cultural, historical, pathological, and environmental insights that can be gained from teeth, it is not surprising that departments of anthropology and colleges of dentistry are adding a course in dental anthropology to their curricula. A typical one-semester senior-level course in dental anthropology characteristically surveys several topics, with emphasis placed on the instructor's area of expertise, be it primate dentition, modern human dentition, or another subject area. Dental anthropology courses in the United States usually have lab sessions where practical methods are learned, such as fossil identification, dental casting, thin-sectioning, and radiology. A representative course might include the following topics:

1. Introduction. History, theoretical issues, rationale, goals and objectives, applications, scientific method.
2. Morphological variation. Modern human crown and root anatomy.
3. Teeth in populations. Dental characteristics of past and recent human populations.
4. Oral pathology. Caries, periodontal disease, fluorosis, developmental anomalies, others.
5. Teeth and behavior (comparative ethno-odontology). Use, wear, diet, hygiene, mutilation, beauty psychology, folklore.
6. Forensic and bioarchaeological applications. Age, sex, ancestry, individual characteristics.
7. Growth and development. Embryology, eruption, field and clone models, occlusion, mesial drift, symmetry.
8. Dental genetics. Normal and abnormal traits, classic, quantitative, population, and twin methods of analysis, complex adaptive system, epigenetics.
9. Dental microevolution. Reduction, selection, mutation, drift, gene flow, synchronic and diachronic methods of analysis.
10. Vertebrate dental macroevolution. Origin of teeth, major phyletic adaptations, paleontology.
11. Primate dentition. Intra-order variation and relationships to ecology, behavior, and diet.
12. Fossil hominin dentition. Taxonomy, evolution, reduction.

This book emphasizes topics 1, 2, 3, 7, 8, and 12, the areas wherein the authors have conducted most of their research. The authors have traveled extensively throughout the world to collect original observations that form the core of the book's database on modern human dental variation, a database that represents more than 30,000 living, recent, and arch eologically derived individuals.

In a review of the first edition, Mayhall (1998:807) says: "It is unclear who the target audience for this volume is. The authors are noncommittal about their audience and the content does not provide an unambiguous answer." We make no pretense this volume serves as an "introduction to dental anthropology." For an

advanced undergraduate and graduate course in dental anthropology, the authors recommend Hillson (1996). The present work could be "recommended" rather than "required" in a course on dental anthropology. However, with a 20-year vantage, its primary contribution is in graduate education and research. Based on any metric, including a second edition, it found an audience even lacking specific direction from the authors.

In closing this prologue, we note that archaeologically derived teeth and bones are a major source of information for direct and diachronic evidence of human evolution. All synchronic hypotheses about human origins, affinity, and microevolution are accepted or rejected with the evolutionary record provided by teeth and bones. Even with exciting new developments in ancient DNA, research on dental morphology is not passé. Applying genomics and evo-devo models to tooth morphology are among the most exciting developments in the field over the past two decades. The more lines of evidence directed at common historical and evolutionary problems advance the field that much more rapidly.