Dental Cementum in Anthropology

Tooth enamel and dentin are the most studied hard tissues used to explore hominin evolution, life-history, diet, health, and culture. Surprisingly, cementum (the interface between the alveolar bone and the root dentin) remains the least studied dental tissue even though its unique growth, which is continuous throughout life, has been acknowledged since the 1950s. This interdisciplinary volume presents in three parts state-of-the-art studies in cementum analysis and its broad interpretative potential in anthropology. Part I describes cementum biology; Part II presents optimized multi-species and standardized protocols to estimate age and season at death precisely. Part III highlights innovative applications in zooarchaeology, paleodemography, bioarchaeology, paleoanthropology, and forensic anthropology, demonstrating how cementochronology can profoundly affect anthropological theories. With a wealth of illustrations of cementum histology and accompanying online resources, this book provides the perfect toolkit for scholars interested in studying past and current human and animal populations.

Stephan Naji is a bioarchaeologist specializing in paleodemography, particularly in demographic and health transitions. His current research focuses on optimizing cementochronology within the broader evolutionary context of chronobiology for histological and virtual age-at-death estimation. He also actively promotes life-history events identification and modeling in cementum through interdisciplinary collaborations.

William Rendu is a zooarchaeologist interested in the mobility of past human societies. He implemented cementochronology during his PhD to discuss the seasonal distribution of Neanderthal activities. He is now continuing this work with a larger chronological framework as director of the International Research Laboratory ZooSCAn in Siberia.

Lionel Gourichon is a zooarchaeologist. His research interest lies in the emergence of food production in Southwest Asia and the Mediterranean area, in particular on human–animal relationships and the process of domestication. He actively contributes to methodological advances in bioarchaeology to improve the study of mammal and bird remains.

Dental Cementum in Anthropology

EDITED BY

STEPHAN NAJI
New York University
Commonwealth War Graves Commission

WILLIAM RENDU
Université Bordeaux, CNRS, PACEA, France
Institue of Archaeology and Ethnography SB RAS (ZooSCAn)

LIONEL GOURICHON
Université Côte d'Azur, CNRS, CEPAM, Nice, France

CAMBRIDGE UNIVERSITY PRESS

CAMBRIDGE
UNIVERSITY PRESS

University Printing House, Cambridge CB2 8BS, United Kingdom

One Liberty Plaza, 20th Floor, New York, NY 10006, USA

477 Williamstown Road, Port Melbourne, VIC 3207, Australia

314–321, 3rd Floor, Plot 3, Splendor Forum, Jasola District Centre,
New Delhi – 110025, India

103 Penang Road, #05–06/07, Visioncrest Commercial, Singapore 238467

Cambridge University Press is part of the University of Cambridge.

It furthers the University's mission by disseminating knowledge in the pursuit of education, learning, and research at the highest international levels of excellence.

www.cambridge.org
Information on this title: www.cambridge.org/9781108477086
DOI: 10.1017/9781108569507

First published 2022

Printed in the United Kingdom by TJ Books Limited, Padstow Cornwall

A catalogue record for this publication is available from the British Library.

Library of Congress Cataloging-in-Publication Data
Names: Naji, Stephan, 1975– editor. | Rendu, William, 1979– editor. | Gourichon, Lionel, 1972– editor.
Title: Dental cementum in anthropology / edited by Stephan Naji, William Rendu, Lionel Gourichon.
Description: Cambridge, United Kingdom ; New York, NY : Cambridge University Press, 2021. | Includes bibliographical references and index.
Identifiers: LCCN 2021024982 (print) | LCCN 2021024983 (ebook) | ISBN 9781108477086 (hardback) | ISBN 9781108569507 (ebook)
Subjects: MESH: Dental Cementum – physiology | Paleodontology – methods. | Cementogenesis
Classification: LCC RK51.5 (print) | LCC RK51.5 (ebook) | NLM GN 209 | DDC 617.6/34–dc23
LC record available at https://lccn.loc.gov/2021024982
LC ebook record available at https://lccn.loc.gov/2021024983

ISBN 978-1-108-47708-6 Hardback

Additional resources for this publication at www.cambridge.org/naji.

We would like to dedicate this book to wonderful colleagues and friends who paved the way of cementochronology for us, supported our endeavors, and brightened our lives.

Jean-Pierre Bocquet-Appel (1949–2018) – a mentor, a pioneer, a visionary scholar, and a generous friend. He was a true anthropologist. Farewell.

Anne Pike-Tay (1956–2020) – an inventive, challenging, and luminous archaeozoologist and paleoanthropologist. We owe her a lot.

Vicky Wedel (1974–2021) – a dedicated researcher who strived to use anthropology as a platform to speak for those who no longer had a voice. You were a gentle soul, and it was a privilege knowing you; we will miss you dearly.

****

To Galina A. Klevezal, whose publications are still the benchmarks of interdisciplinary studies on cementum – we thank you sincerely for your outstanding scientific rigor and dedication.

To Joël Blondiaux, who trained every anthropologist in France in cementochronology – thank you so much for your patience, generosity, and brilliant scientific intuitions.

Contents

Contributors

Hala Alarashi
University of Côte d'Azur CNRS, CEPAM, Nice, France

Priscilla Bayle
Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

Bruno Bizot
Service Régional de l'Archéologie PACA, Ministère de la Culture et de la Communication, Aix-en-Provence, France

Joël Blondiaux
Centre d'Études en Paléopathologie du Nord, Walincourt-Selvigny, France

Jean-Pierre Bocquet-Appel†
Université Aix-Marseille, Marseille, France

Philippa Brewer
Natural History Museum of London, London, UK

Timothy Bromage
Department of Biomaterials & Biomimetics, New York University College of Dentistry, NY, USA

Jane E. Buikstra
School of Human Evolution and Social Change, Center for Bioarchaeological Research, Arizona State University, Tempe, AZ, USA

Zhonghou Cai
Advance Photo Source, Argonne National Laboratory, Lamont, AZ, USA

Paola Cerrito
Department of Anthropology, New York University, NY, USA

Michael B. Chavez
College of Dentistry, Biosciences Division, The Ohio State University, Columbus, OH, USA

Thomas Colard
Department of orthodontics, Lille University, Lille University Hospital, Lille, France. Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

Ian J. Corfe
University of Helsinki, Helsinki, Finland

Aviva A. Cormier
Department of Anthropology, Vassar College, NY, USA

Christine Couture-Veschambre
Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

M. Christopher Dean
Department of Cell and Developmental Biology, University College London, London, UK

Amélie Debroucker
Department of Oral Radiology, University of Lille, Lille University Hospital, Lille, France

Alex R. DeCasien
Department of Anthropology, New York University, NY, USA

Emmanuel Discamps
Université Toulouse Jean Jaurès, CNRS - TRACES Toulouse, France

Todd R. Disotell
Department of Anthropology, New York University, NY, USA

Sofiann El Ayoubi
Department of Oral Radiology, University of Lille, Lille University Hospital, Lille, France

Felix Engel
Faculty of Medicine, Albert-Ludwigs University Freiburg, Global Health Center for Medicine and Society, Freiburg, Germany

Guillaume Falgayrac
Marrow Adiposity and Bone Lab, Littoral Côte d'Opale, Lille, France

Brian L. Foster
College of Dentistry, Biosciences Division, The Ohio State University, Columbus, OH, USA

Jan Garrevoet
Deutsches Elektronen-Sychrotron DESY, Hamburg, Germany

Mietje Germonpré
Royal Belgian Institute of Natural Sciences, Brussels, Belgium

Pamela G. Gill
Natural History Museum of London, Bristol, UK

Lionel Gourichon
University Côte d'Azur, CNRS, CEPAM Nice, France

Kenneth P. Hermsen
Creighton University, School of Dentistry, Omaha, NE, USA

Simon Hillson
Institute of Archaeology, University College London, London, UK

Emmanuel d'Incau
UFR des Sciences Odontologiques, University of Bordeaux, Bordeaux, France

Mareike C. Janiak
Department of Anthropology and Archaeology, University of Calgary, Alberta, Canada

Elodie-Laure Jimenez
Royal Belgian Institute of Natural Sciences, Brussels, Belgium ; University of Aberdeen, School of Geosciences, Scotland, UK

Katrin Koel-Abt
Forensic anthropologist; Kenyon International Emergency Services

Tamara N. Kolli
College of Dentistry, Biosciences Division, The Ohio State University, Columbus, OH, USA

Laëtitia Lanteri
CNRS/Université Aix-Marseille, Marseille, France

Adeline Le Cabec
Department of Human Evolution, Max Planck Institute for Evolutionary Anthropology Leipzig, Germany/Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

Bruno Maureille
Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

Sheila Mendonça de Souza
Escola Nacional de Saùde Pùblica, Rio de Janeiro, Brazil

Stephan Naji
Department of Anthropology, New York University, NY, USA
Commonwealth War Graves Commission, Western Europe Area – FRANCE

Elis Newham
Queen Mary University of London, London UK

Francisco H. Nociti, Jr.
Department of Prosthodontics and Periodontics, Division of Periodontics, Piracicaba Dental School, University of Campinas-UNICAMP, São Paulo, Brazil

Leigh Oldershaw
Department of Anthropology, The Ohio State University, Columbus, OH, USA

Megan Perry
Department of Anthropology, East Carolina University, Greenville, NC, USA

Michael Price
Santa Fe Institute, Santa Fe, NM, USA

Akacia Propst
Department of Anthropology, McMaster University, Hamilton, Canada

Eric Pubert
Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

William Rendu
Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France / ZooSCAn, CNRS, Institute of Archaeology and Ethnography SB RAS, Novosibirsk, Russia

Solange Rigaud
Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

Kate Robson Brown
University of Bristol, Bristol, UK

Valentin Ruano Rubio
Data Science Data Engineering, Broad Institute, Cambridge, MA, USA

Carlos Sánchez-Hernández
Institut Català de Paleoecologia Humana i Evolució Social, Tarragona, Spain

Bérengère Saliba-Serre
CNRS/Université Aix-Marseille, Marseille, France

Frédéric Santos
Univ. Bordeaux, CNRS, MCC, PACEA, UMR 5199, Pessac, France

Aurore Schmitt
CNRS/Université Aix-Marseille, Marseille, France

Philipp Schneider
University of Southampton, Southampton, UK

Martha J. Somerman
National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), National Institutes of Health, Bethesda, MD, USA

Kathryn M. Spiers
Deutsches Elektronen-Synchrotron DESY, Hamburg, Germany

Stuart R. Stock
Northwestern University, Evanston, IL, USA

Nancy K. Tang
Independent Researcher

Amber E. Trujillo
Department of Anthropology, New York University, NY, USA

Manon Vuillien
University of Côte d'Azur, CNRS, CEPAM Nice, France

Mathew J. Wedel
Western University of Health Sciences, College of Dental Medicine, Pomona, CA, USA

Vicki L. Wedel†
Western University of Health Sciences, College of Dental Medicine, Pomona, CA, USA

Nicholas Wilson
Uniformed Services University, Bethesda, MD, USA

Ursula Wittwer-Backofen
Faculty of Medicine, Albert-Ludwigs University Freiburg, Global Health Center for Medicine and Society, Freiburg, Germany

Iris Zeng
Department of Anthropology, New York University, NY, USA

Foreword

Unlocking the Potential of Cementum Layering

Daniel Antoine, The British Museum, London

The world of dental histology opens up a wealth of information on human growth and development. My early insights into this world involved evaluating the periodicity of cementum layering using teeth with a known age of extraction as part of my undergraduate research. The results were mixed, in part due to the small sample size and the complexity of imaging cementum under a scanning electron microscope. Simon Hillson and I had hoped that this form of microscopy would facilitate the counting of cementum layers! To a certain extent, it did. In some teeth, counts were similar to the age of extraction (Hillson & Antoine 2003); in others, they differed from it, and some individuals had finer layers in between more defined ones. At the time of the study, the literature was relatively sparse and I was guided by a handful of key papers (e.g., Charles et al. 1986; Condon et al. 1986). By the time I was involved in another cementum project (Huffman & Antoine 2010), I had changed my focus to enamel microstructures. A chance meeting with Stephan at a poster symposium on cementum during the 2012 American Association of Physical Anthropology meetings in Knoxville (US) revealed to me how far the field had moved forward! Following a similarly successful symposium at the 2017 meetings in New Orleans, I am very pleased that Stephan, William, and Lionel followed through to produce this comprehensive, much-needed, and remarkably insightful volume. Although the periodicity and use of incremental structures in enamel and, to a lesser extent, dentine have benefited from more anthropological research (Antoine et al. 2018), it is clear that work on cementum layering, particularly in humans, has – until recently – been more sporadic. This, in part, reflects the fact that both cementum and dentine are more susceptible than enamel to diagenetic changes, affecting our ability to observe their growth structures in many archaeological and fossil teeth (Tang et al. 2016). The highly mineralized enamel offers some protection to the dentine immediately below its surface. This is not the case for the roots on which cementum is deposited.

Combining the latest research on cementum into this single book is a major achievement and represents a giant step forward. The volume is underpinned by several chapters that explore the biology of cementum and provide the crucial background for a fuller interpretation of the histological structures being observed. A range of preparation protocols, imaging methods, and applications are also clearly presented.

Questions regarding our ability to record such structures, as well as their periodicity, are discussed in some detail. However, some questions remain, offering avenues for future research (e.g., Chapter 1). The lessons learned from work on other hard tissues may offer some valuable insights. The interpretation of incremental structures in teeth not only requires a clear understanding of the biological processes that lead to their formation, but it must also account for the physics behind the imaging techniques used to analyze such complex tissues. In transmitted light microscopy, for example, structures are usually made visible by the scattering of light through a relatively thick 100 µm "thin section." Over such a thickness, many variables can impact what is being observed. For example, as the layers of cementum curve around the roots, they are unlikely to be perpendicular to the plane of section and some optical interference is likely. By assessing the impact of the preparation methods (e.g., different mounting resins and planes of section), by offering clear preparation protocols, and by using multiple imaging techniques on the same tooth (e.g., Chapters 10 and 14), this volume helps us understand some of the challenges involved in imaging cementum, particularly in diagenetically altered tissues. Moving forward, the narrower optical plane of laser confocal microscopy could, for example, be used to clarify some of the structures seen in transmitted light microscopy (both can be used to image the exact same area; see Antoine et al. 2009). Such multi-imaging approaches are likely to lead to a better interpretation of what is being observed, including any complex layering patterns (e.g., doubling, sublayering, and accentuated lines) and what may be impacting our ability to record such structures. Despite the time and labor often required to image dental microstructures, the development of more sophisticated imaging techniques should help overcome some of these difficulties. The insights gained are worth the effort! This much-needed volume offers an essential framework for future research that will, hopefully, act as a catalyst to a plethora of new work. Well done!

Antoine, D., Hillson, S., & Dean, M. C. (2009). The Developmental Clock of Dental Enamel: A Test for the Periodicity of Prism Cross-Striations in Modern Humans and an Evaluation of the Most Likely Sources of Error in Histological Studies of This Kind. *Journal of Anatomy* **214**, 45–55.

Antoine, D., FitzGerald, C. M., & Rose, J. C. (2018). Incremental Structures in Teeth: Keys to Unlocking and Understanding Dental Growth and Development. In M. A. Katzenberg & A. L. Grauer (eds.), *Biological Anthropology of the Human Skeleton*, 3rd ed. Oxford: John Wiley & Sons, 225–56.

Charles, D. K., Condon, K., Cheverud, J. M., & Buikstra, J. E. (1986). Cementum Annulation and Age Determination in Homo Sapiens. 1. Tooth Variability and Observer Error. *American Journal of Physical Anthropology* **71**, 311–20.

Condon, K., Charles, D. K., Cheverud, J. M., & Buikstra J. E. (1986). Cementum Annulation and Age Determination in Homo Sapiens. II. Estimates and Accuracy. *American Journal of Physical Anthropology* **71**, 321–30.

Hillson, S., & Antoine, D. (2003). Ancient Bones and Teeth on the Microstructural Level. In G. Grupe & J. Peters (eds.), *Deciphering Ancient Bones – The Research Potential of Bioarchaeological Collections*. Documenta Archaeobiologiae, Rahden/ Westf.: Leidorf, 141–57.

Huffman, M., & Antoine, D. (2010). Analysis of Cementum Layers in Archaeological Material. *Dental Anthropology* **23** (3), 67–73.

Tang, N., Le Cabec, A. & Antoine, D. (2016). Dentine and Cementum Structure and Properties. In J. D. Irish & G. R. Scott (eds.), *A Companion to Dental Anthropology.* Oxford: John Wiley & Sons, 204–22.