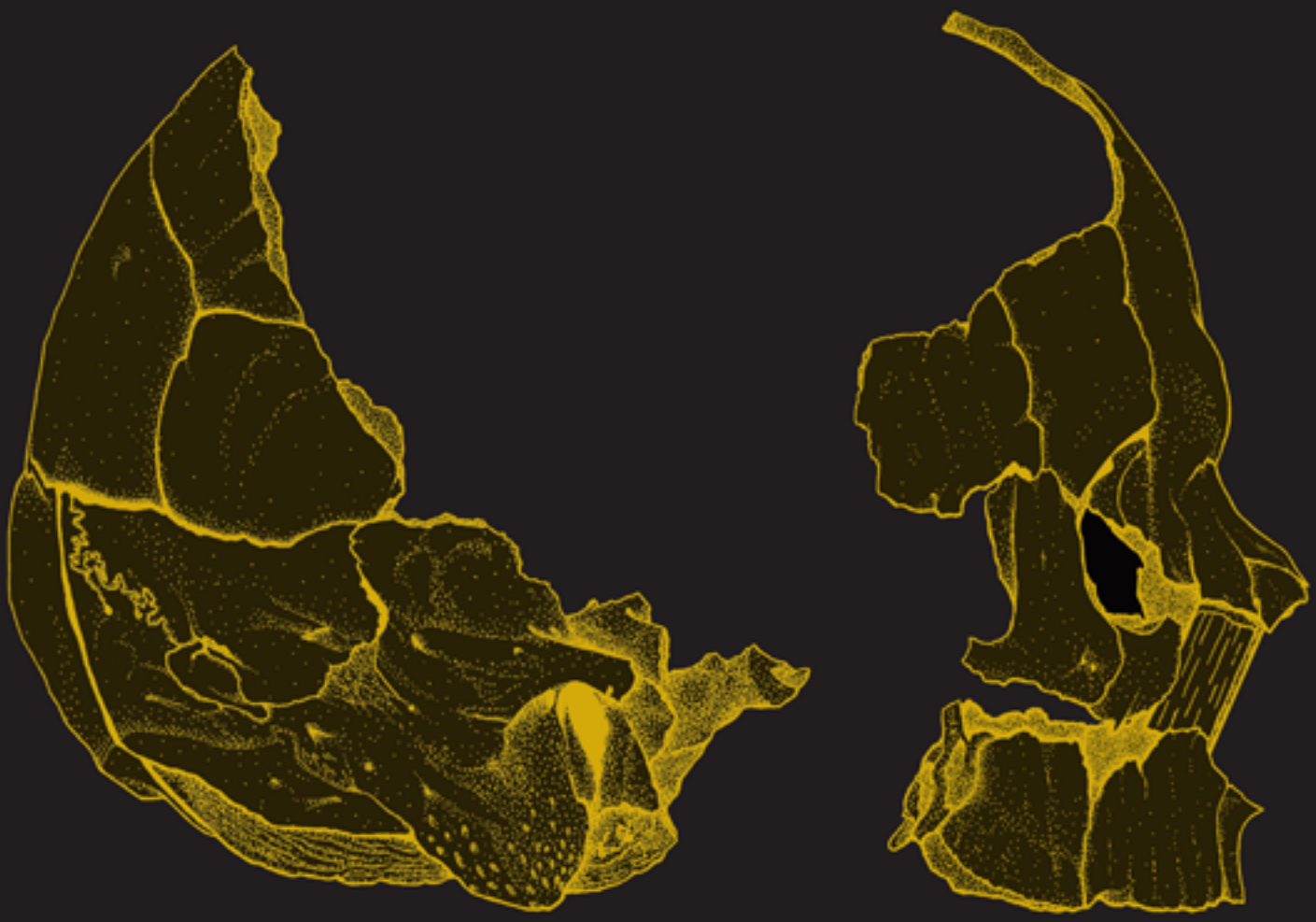

Second Edition

BROKEN BONES

Anthropological Analysis of Blunt Force Trauma

Vicki L. Wedel

Alison Galloway

Second Edition

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Anthropological Analysis of Blunt Force Trauma

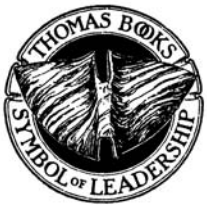
Edited by

VICKI L. WEDEL, PH.D.

and

ALISON GALLOWAY, PH.D, D.-A.B.F.A.

(With 14 Other Contributors)



CHARLES C THOMAS • PUBLISHER, LTD.
Springfield • Illinois • U.S.A.

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We dedicate this book to
the people whose remains we have had the humbling privilege of analyzing. May we never take lightly our task of giving voice to your lives.

To my family and friends for their unwavering support.
VLW

To my daughter, who kept me fed and sane
And the EVC staff, who let me keep my day job.
AG

Published and Distributed Throughout the World by

CHARLES C THOMAS • PUBLISHER, LTD.
2600 South First Street
Springfield, Illinois 62704

ISBN 978-0-398-08768-5 (Hard)
ISBN 978-0-398-08769-2 (eBook)

Library of Congress Catalog Card Number: 2013023909
With THOMAS BOOKS *careful attention is given to all details of manufacturing and design. It is the Publisher's desire to present books that are satisfactory as to their physical qualities and artistic possibilities and appropriate for their particular use.* THOMAS BOOKS *will be true to those laws of quality that assure a good name and good will.*

Printed in the United States of America
UBC-R-3

Library of Congress Cataloging-in-Publication Data

Broken bones : anthropological analysis of blunt force trauma / edited by Vicki L. Wedel, PH.D. and Alison Galloway, PH.D., D.-A.B.F.A. – Second Edition.
pages cm
Includes bibliographical references and index.
ISBN 978-0-398-08768-5 (hard) ISBN 978-0-398-0876-2 (eBook)
1. Forensic anthropology. 2. Blunt trauma. 3. Fractures. I. Wedel, Vicki L.

GN69.8.B76 2013
614'.17–dc2

2013023909

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PREFACE

Forensic anthropologists, in general, cut their teeth examining prehistoric and historical human remains to learn how to determine age, sex, stature, ancestry, and describe traumatic or disease-process changes to bone. These bones, which are not of forensic significance because they are older than 50 years, impart wisdom to us, wisdom on what bone quality, dry or exfoliated cortical bone, and macroscopic and microscopic bone characteristics indicate about postmortem interval and how the passage of time affects bone. The bones also often tell us about peoples' lived experiences. If the remains are part of a population study, the bones allow us to learn how to seriate features, which help us better age individuals and place an individual within his or her population. Further, archaeological and prehistoric studies allow us to speculate about quality of life and make comparisons with neighboring or contemporaneous populations. The concern of osteologists examining prehistoric or historical bone is often to tell the story of a person or population's life.

These kinds of stories, though, which are permissible in archaeological reports and prehistoric monographs, are not the kind forensic anthropologists can include in reports submitted as part of medicolegal investigations. We are limited to describing what evidence we see on bones – descriptions of trauma, for example, whose interpretations must be testable scientific hypotheses. We are looking for similarities to documented cases or published trauma research literature. In examining trauma, we rarely have evidence-based literature or actualistic studies on human bone help us in our interpretations. Further, we choose to remain ignorant of knowledge the coroner or medical examiner might have regarding any alleged crime of which the individual whose remains we are analyzing was a victim so as to avoid biasing our analysis. We must train by apprenticeship to gain the knowledge and experience needed in examining one person's remains and to rely on skeletal features and measurements to best contextualize individuals in relative to known ancestral populations.

The present work provides a discussion on how to train for a career in forensic anthropology and offers guidance on how to complete a thorough trauma analysis. It also provides the labels given to different kinds of fractures

and the biomechanical forces required to cause bone to fail and fracture. Chapter 6 provides a theoretical framework both for evaluating published trauma studies and designing new ones. Experimental trauma research is an area ripe for research, and criteria to consider in choosing which non-human species to use in an actualistic study are offered. This discussion touches on the ethical considerations of using human cadaver bone versus animal bone, and if animal bone is chosen, whether a homologous or analogous species would be better. Further, the range of histological variation both within one non-human species and within a single individual is often underestimated. The range of variation present within one bovine histological thin section is included to demonstrate how overly simplistic some descriptions of non-human bone are (e.g., non-human bone is plexiform). In Chapter 7, common circumstances in which blunt force trauma is encountered are described. Information is provided on variety of causes of death due to blunt force trauma. These causes range from accidental deaths to homicides due to blunt force from motor vehicle accidents, falls, strangulation, child and elder abuse, among others. Epidemiological information on whom is most likely affected by these various kinds of blunt force trauma is drawn from both the clinical and forensic literature.

The meat of this book is contained in Chapters 8 through 11: bone by bone, fracture by fracture, we describe what to call each kind of fracture, what is known about how much force is required to break the bone that way, and fracture specific epidemiological information. These chapters provide an invaluable reference source for forensic anthropologists and other osteologists to consult when looking at and trying to classify a bone fracture.

Case studies are included to bring the book full circle back to considering the micro and macro bone changes that are seen when bone fails and fractures. The case studies are illustrative both of the concepts described through the book and of the high quality analyses forensic anthropologists contribute to medicolegal investigations of death every day. The case studies demonstrate the kinds of stories forensic anthropologists tell: those of a person's death.

Vicki L. Wedel

ACKNOWLEDGMENTS

In the creation of any work, there are many people to whom thanks are owed, and this work is no exception. This book is an update to the first edition, which became a work commonly used by forensic scientists faced with bone fractures to understand. We thank Charles C Thomas Publisher for suggesting a second edition and for Mr. Michael Thomas, our editor, for his patience and guidance.

Fifteen collaborators contributed case studies for inclusion in this book. Their endurance in the lengthy production of this work is most appreciated. The cases our contributors submitted demonstrate the high caliber work forensic anthropologists do on a daily basis.

Each editor's scholarly efforts are university supported. Dr. Wedel was gently nudged towards progress by Dr. Jim May, Chair of the Department of Anatomy at Western University of Health Sciences, and he is to be thanked for his guidance. The members of Western's Paleontology, Anthropology, and Anatomy Research Cluster are a cohort of tenure track faculty whose common goal helped move this manuscript along by providing collegiality, camaraderie, and encouragement.

The University of California, Santa Cruz supported this project by providing Dr. Galloway with the flexibility she needed to write. UCSC and Western University's unfailing support for the forensic anthropology laboratories is greatly appreciated. The University of Arizona, particularly Drs.Walter Birkby and Mary Ellen Morbeck, laid the foundations for this volume.

Finally, both editors owe a debt of gratitude to Dr. Lauren Zephro for her extreme patience and constant mentoring though this process. She was with us all the way and we knew it.

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BROKEN BONES

Section I

TRAUMA ANALYSIS

Chapter 1

TRAUMA ANALYSIS: TRAINING, ROLES, AND RESPONSIBILITIES

VICKI WEDEL, ALISON GALLOWAY, AND LAUREN ZEPHRO

"The game's afoot" is a Shakespearean quote the omniscient detective Sherlock Holmes says with gusto when he sets out to solve a murder mystery. Sherlock Holmes is always portrayed as a one man, crime-solving machine. In reality, identifying victims of crime and determining their cause and manner of death is much more of a team sport. While death investigations are not games, for sure, the analogy of forensic science as a game is conceptually not that far off the mark. Within every death investigation, there are several players: the police and detectives who investigate the circumstances of the death, the forensic scientists who collect and analyze the evidence, and the forensic pathologists who determine cause and manner of death. Ideally, these interdisciplinary players work collaboratively. They abide by rules, some of which include investigation policies and procedures, criminal statutes and laws, and rules of evidence. Further, these team members work together in pursuit of a common goal: identification of the victim and his or her cause and manner of death.

Among the players who collect and analyze the evidence are forensic anthropologists: forensic scientists who are invited by forensic pathologists and coroners to collect and examine human remains when the remains have been buried, become mummified, been cremated, or have otherwise become so completely decomposed that soft tissue is not available or adequate for autopsy. Forensic anthropologists are also asked to evaluate skeletal material when autopsy reveals skeletal trauma that requires the expertise of a forensic anthropologist to describe and explain what type of force caused the particular defect.

The contributions forensic anthropologists make to medicolegal investigations of death are numerous, and on-going research in the field is slowly increasing

the court-vetted methods available for skeletal analysis. Forensic anthropologists are qualified to exhume or otherwise recover remains from death or disposal scenes, but this aspect of forensic anthropology is described in a variety of different sources (Dupras *et al.* 2006, Connor 2007, Pickering 2008). When presented in the morgue or lab with a set of remains, forensic anthropologists always determine how many individuals are present and then proceed to determine the biological profile (sex, age at death, stature, and ancestry) of each individual included in the assemblage. Most cases involve the bones of only one individual, but this must be confirmed by making sure that joints articulate, there is no duplication of elements, and the size and morphology of bones from the left and right side of the skeleton match unless pathology is presented. Once the biological profile has been established, the remains must be examined grossly and under magnification for evidence of trauma or disease. How this is accomplished will be described further in Chapter 2.

In 2008, the Federal Bureau of Investigation along with the Department of Defense Central Identification Laboratory began the development of a series of documents to provide guidance on best practices within the discipline. These documents are the results of collaboration by a wide spectrum of forensic anthropologists under the umbrella of the Scientific Working Group for Forensic Anthropology (SWGANTH). Their documents are being developed and presented to the forensic anthropology community at large, via the SWGANTH website, SWGANTH.org for public comment. Comments are discussed and integrated into final versions of the documents, which are available to the public. Of note, is the fact that the SWG documents are living documents that are undergoing periodic reviews and updates. SWGANTH fits into forensic science trends as a whole since there are other scientific working groups co-sponsored by the FBI for a virtually all of the forensic science disciplines. Within SWGANTH, different subcommittees were assigned the task of providing the principles and best practices in a number of different areas including that of trauma analysis. The present volume is consistent with that text. It identifies the contributions anthropologist make in medicolegal investigations of death including determining the timing of the injuries as to ante-, peri-, or postmortem in nature and establishing the mechanism of injury (projectile, blunt, sharp, thermal, etc.).

This first chapter begins with a description of the education, training and experience a student must pursue to become a forensic anthropologist, a professional member of the discipline of forensic anthropology, and a Diplomate of the American Board of Forensic Anthropology. The second half describes the roles and responsibilities of forensic anthropologists when asked to examine a set of remains for evidence of trauma.

TRAINING AND QUALIFICATIONS

To become forensic anthropologists, students need to have an extensive background in contemporary human osteology and anatomy, an understanding of the legal system in which they will function, and experience with actual casework to provide the context within which we provide our services. These are not skills that can be acquired through a short course. These skills are also not readily adapted from other fields. Typically, students must complete a bachelor's degree followed by graduate school to earn a master's or doctoral degree. Undergraduate students usually complete the requirements for an anthropology major, which includes the traditional four-field anthropology courses: biological, cultural, linguistic, and archaeological anthropology. Archaeological field schools teach students the concepts that practicing forensic anthropologists use in recovering scattered or buried remains. College-level courses in crime scene investigation, offered through criminal justice or public safety programs, are also helpful because they can orient and educate budding anthropologists about how to recognize, document, and collect non-skeletal evidence. The ability of forensic anthropologists to recognize the myriad types of evidence is critical since the crime scene recovery of human remains usually involves contact or discovery of physical evidence. Knowledge of physical evidence, its significance, and potential use will help the forensic anthropologist to work more effectively as a team member in a forensic investigation and not accidentally destroy, contaminate or otherwise mishandle evidence. The inclusion of formal, traditional crime scene training cannot be overstated in importance for forensic anthropologists. In addition to college classes, law enforcement-based training in crime scene investigation may also be an option. Consultation with local agencies for training opportunities is encouraged.

Additionally, students often complete the array of courses included in premedical curriculum: chemistry, physics, and biology. This background becomes an asset in graduate school because studies of decomposition are based on chemistry, bone biomechanics and the physical principles of bone fracture, and bone, both as a tissue and an organ, are all fundamentals of biology. If a foreign language is a requirement for the anthropology major, Latin is one good choice, since most of the anatomy and osteology terms professional anthropologists use are Latin-derived. Many of the major founding texts within the field were developed in Germany, so German is another option. Spanish is always helpful in that many leading forensic organizations are located within Spanish-speaking regions of the world.

Successful graduate training in anthropology involves formal coursework, apprenticing a professional forensic anthropologist on actual forensic cases, and completion of an original research project, written up as a thesis or dissertation. Graduate courses in human skeletal biology teach the student how

bone develops, replenishes itself, and heals from injury. Osteology courses provide hands-on training in identifying each of the 206 bones of the human skeleton, both intact and fragmented, and how they appear in infants and children. Successfully mastering human osteology and being able to identify highly fragmented skeletal elements requires memorizing the joint surfaces, muscle attachment sites, foramina through which blood vessels and nerves pass, and contours of each individual bone. This skill also requires one to think in a three-dimensional manner, since the fragments often do not appear normally aligned in the position in which we see them in textbooks.

Additional methods courses and mentored experience in determining the age, sex, ancestry, and stature of skeletons in teaching collections are necessary. Exposure to real human skeletal material of all ages and demographics hailing from forensic, historical and archaeological contexts is essential for understanding human variation. We can only estimate biological profile and differentiate between bone modification due to trauma if we view the bones within a framework of how bones vary between individuals, how bone tissue varies in the body, and how bone strength changes with age and configuration. To be a forensic anthropologist requires the ability to recognize and interpret normal variation, temporal and geographic variation, pathologies, anomolies, and to be accountable for the human body from the fetal period into old age. To do this effectively, a forensic anthropologist must have been mentored and had exposure to a wide variety of known skeletal material.

Specific to this book's topic are the kind of methods training where a student is taught to recognize and describe trauma. Students gain experience in recognizing and describing trauma, be it sharp force, blunt force, gun shot, or a mixture thereof, by first watching and often scribing for their advisor while he or she systematically examines each bone and bone fragment both with the naked eye and under magnification. The graduate student then proceeds to conduct mock examinations of teaching cases and case reviews with his or her advisor. Senior graduate students may then be asked to collaborate with their advisor on actual cases from start to finish: conducting the gross and microscopic examination, taking the kind of detailed notes that comprise a case file, and co-authoring the case report. This kind of supervised, but actualistic, experience is irreplaceable in the advisor being able to certify that his or her graduate student will be ready after graduation to take on cases of their own. In making this assessment, mentors also have the responsibility to ensure that the personal and professional conduct of their students meets the standards expected by the law enforcement community.

Participation in the analysis of remains from forensic contexts is one aspect of preparing a forensic anthropology graduate student for professional work. Equally important is the completion of an original research project in the form of a thesis or dissertation. Theory courses in anthropology help prepare

students to undertake their own research project by exposing students to the seminal historical literature of the discipline and helping students learn how to read and critically evaluate the current literature. Formulating a testable research question forces students to employ the scientific method and includes selection of the appropriate materials and methods. Choosing what materials to use involves evaluating what autopsy series, museum collection skeleton, imaging techniques, or animal models are available and applicable; how many specimens to include; and how widely applicable the results of the research will be. Institutional requirements for accessing autopsy or museum specimens also require a student to critically examine how they have developed their design to meet ethical and statistical guidelines.

The process of completing a thesis project also helps students develop the skills that will be necessary throughout their career when case reports must be written. Taking on a project with the scope of a thesis or dissertation is formative in helping students learn to complete projects that in the real world will have time constraints and will require them to be able to describe their work in language their peers will understand. Research also trains one in investigating previous work, determining if it is applicable to the question at hand and synthesizing information from many streams. Defending the results of their research helps prepare students for the kind of peer review they will experience after graduation and to some degree simulates what court testimony will be like: extemporaneously answering questions in defense of their results and the methods used to achieve them.

BECOMING A MEMBER OF THE PROFESSION

Students in accredited anthropology programs can become trainee affiliates of the American Academy of Forensic Sciences (AAFS), the largest and most reputable body of forensic scientists. At the annual meetings of the AAFS, results of the latest research are presented for peer review. Workshops provide continuing education opportunities. Advancement in the Academy is partially based on forensic anthropology case review and/or publications. By advancing in membership status from trainee affiliate to associate member to member to fellow demonstrates for the forensic science community that a forensic anthropologist is a lifelong learner who is making measurable contributions to the field.

Forensic anthropologists should also seek specific certification in the discipline. The most common certification is available through the American Board of Forensic Anthropology (ABFA). Other agencies may offer a certification, but interested parties should be careful to check the reputation of the agency supporting the program. Exact requirements for the application to the ABFA should be checked as these are subject to change, depending upon the incorporation

of new standards or inclusion of a broader range of applicants. Qualified individuals for the ABFA can apply to sit for the board examinations. All applications are reviewed for the quality of their case reports, the clarity with which their findings can be interpreted, and their knowledge of the field. The board examination consists of written and practical components. Passing the boards bestows upon the candidate the title "Diplomate of the American Board of Forensic Anthropology." Once certified, all active members must continue to engage in forensic work; report on their casework, reports, and court testimony; and maintain an acceptable level of continuing education.

RESEARCH IN TRAUMA ANALYSIS

Forensic anthropologists may be asked to evaluate a set of skeletal remains to document and describe the defects and then render an opinion about the origin of those defects. This is just the first of many ways forensic anthropologists contribute to trauma analysis. Because the ways a skeleton may be impacted by a blunt instrument are too numerous to list (or even conceive of), our role in publishing case reports (e.g., Wedel *et al.* 2013), once cases have been adjudicated, is of the utmost importance in educating our peers. Further, the role of the forensic anthropologist in designing research projects that further our understanding of how the skeleton reacts then fails when struck is paramount. We cannot solely rely on the research that has been done to date; we must experiment in ways to simulate or model blunt force trauma, determine the validity of the experimental media or models we are using, be mindful of technological changes that alter how trauma is imparted to the body, and publish our findings in order to advance our current knowledge base. Thus the forensic anthropologist has the responsibilities of conducting the skeletal analysis, publishing case reports when possible, and furthering the knowledge generated by conducting trauma research. Each of these roles and responsibilities is discussed in the coming chapters.

Skeletal trauma, especially from blunt force, is highly variable and each case presents a unique set of challenges in the interpretation and reconstruction of the events that produced them. The aim of this volume is to present the framework in which trauma analysis occurs in the forensic setting, provide guidelines that may help facilitate the process of evaluating blunt force trauma, and provide documented support for this growing area of trauma research and its application within forensic anthropology. The care given to the documentation of observed skeletal defects and the depth of work in reconstruction of the events that produced them quickly becomes evident in the quality of the written report and subsequent court testimony. It is upon this foundation that we can advance our influence within this exciting area of forensic analysis.