

3D Dead: Ethical Considerations in Digital Human Osteology

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ABSTRACT: Humans have interacted with the remains of our dead for aesthetic and ritual purposes for millennia, and we have utilized them for medical, educational, and scholarly pursuits for several centuries. Recently, it has become possible to use digital technologies such as 3D scanners and printers for reconstructing, representing, and disseminating bodies. At the same time, there is growing interest among academics and curators in taking a more reflexive approach to the ethical and social dimensions of conservation. This paper considers theoretical and practical aspects of ethics as they apply to the 3D scanning and printing of human skeletal remains for curation or dissemination, provides case studies from our work in the United States, and suggests guidelines for best practices.

Keywords: 3D scanning; human skeletons; biological anthropology; ethics; USA

Los seres humanos hemos interactuado con los restos humanos de nuestros muertos por razones estéticas y rituales por milenios. Asimismo, estos restos han sido utilizados para conducir investigaciones médicas, educativas, y académicas por varios siglos. Recientemente, con la ayuda de la tecnología digital de los escáneres e impresoras 3D ha sido posible reconstruir, representar, y difundir estos cuerpos. Al mismo tiempo, los académicos y los conservadores proponen ser más reflexivos al lidiar con las dimensiones éticas y sociales del campo de la conservación. Este artículo considera los aspectos teóricos y prácticos de la ética de los escaneos e impresiones 3D de restos óseos humanos para su conservación y diseminación, aporta casos prácticos de nuestros trabajos investigativos en los Estados Unidos como ejemplos, y sugiere normas para una práctica adecuada.

Ethical Issues in the Collection and Curation of Human Remains

Ethical principles ask practitioners to formally consider the people and communities they work with, their treatment, and the values that underlie those practices. As such, ethical standards are a core feature of the professionalization process. Ethical concerns have recently become deeply felt as an essential goal for bioarchaeologists in the practice of curating

human remains in our academic institutions or using curated collections in our research (see Clegg 2020; Nystrom 2017; Squires et al. 2019). The need for ethical guidelines is perhaps most acutely felt in the realm of digital curation, with the increasingly widespread use of 3D replication and online repositories (Hassett 2018a, 2018b; Hirst et al. 2018; Ulguim 2017, 2018; Wild 2020; Wrobel et al. 2019). Biological anthropologists effectively find themselves in a position to establish guidelines through discussions with

stakeholders and an internally derived set of professional ethics (Turner 2005; Walker 2000; Williams and Atkin 2015), as there are few institutional guidelines or civil laws governing the curation, transportation, destructive analysis, or public accessibility of human remains, particularly in the United States, where legislation has focused almost exclusively on Native American remains (Ubelaker 2011) or preventing the disturbance of the recently dead (DeWitte 2015). This article serves as a suggestion for formalizing this work by providing a consideration of ethical principles, stakeholders, and goals in digital osteology and offers a set of guidelines for labs and institutions to develop a set of best practices for 3D curation.

Public and academic institutions, including museums and universities often already possess large collections of human remains, from a variety of sources, in varying states of preservation, and with differing quality of and resources for curation (Cassman et al. 2006). Upon gaining employment at these institutions, early career professional biological anthropologists are suddenly responsible for these collections. Without specific training in ethics, legalities, or curation issues from our respective graduate programs, we are called upon to handle a suite of ethical challenges, expectations, and responsibilities in our interaction with these materials (Larsen and Walker 2005; Squires et al. 2019).

Any discussion of ethics in skeletal biology, however, should begin with an acknowledgment of the fact that biological anthropology and bioarchaeology are rooted in a colonial and racist history. We have yet to address much of the harm that has been caused by this history, and our discipline has only just begun to develop an antiracist and anticolonial agenda for the future (e.g., ABA, 2021). In the first half of the twentieth century, the field of archaeological human skeletal research was primarily shaped by the perspectives of figures such as Earnest Hooton (1887–1954) and Aleš Hrdlička (1869–1943), who were also strong proponents of “racial sciences” and eugenics (Buikstra and Beck 2006). As well, the majority of human skeletal collections in the United States that have been used to conduct anthropological research were assembled by privileged white scientists in the same time period. Early key figures in the discipline—Samuel Morton (1799–1851), Henry Bowditch (1840–1911), and Frederick W. Putnam (1839–1911)—felt little compunction about collecting human remains to serve as anatomical “specimens” for teaching and research in anatomical variation and pathology (DeWitte 2015; Fabian 2010; Knoeff and Zwijnenberg 2016; Redman 2016; Thomas 2000). Large reference collections of human remains were

assembled through donations or were excavated from cemeteries and archaeological sites without the permission of those communities and with little to no consideration of the ethical dimensions of establishing, maintaining, or utilizing these collections. To make matters worse, many of these assemblages were used for research that perpetuated racist ideologies, discrimination, colonialism, and structural or everyday violence, and in some cases, this research was influential in establishing eugenics or as a justification for genocide. It was not until the last decades of the twentieth century that we saw much progress toward ethical practice in regard to obligations to descendant communities, repatriation of mortuary remains with laws such as the Native American Graves Protection and Repatriation Act (NAGPRA), or reflexivity about representation of people included in these collections as “others” in our discipline. While this is not the only step that needs to be taken, ethical guidelines regarding the use of new technology on ancient skeletal remains are a basic and necessary starting point to ensure accountability and avoid further harm to Black and Indigenous people as well as to antecedent and descendant communities.

Because the use of human skeletal collections for research involves ethical concerns from several overlapping communities—including scientists, doctors, anthropologists, archaeologists, and museum curators—there are three major traditions to consider: bioethics, anthropological ethics, and scientific ethics. Bioethics—a field developed for practitioners and researchers of human health sciences and formalized in the United States in the 1970s—has three basic tenets: respect for persons, beneficence, and justice (Beauchamp 2016). Anthropological ethics, as it became formalized beginning around 1979–1980, also posits that our first responsibility is to the people with whom we work and whose lives we study, not just the deceased but their living relations and descendants (American Anthropological Association [AAA] 2009; Wax 2006). One of our values as anthropologists is that these groups should be given priority in determining if, when, and how remains are utilized. A related responsibility is to recognize all concerned parties as equal stakeholders, with consideration given to their diverse traditional or philosophical backgrounds. Third, as scientists we are ethically responsible for curating collections of scientific value to ensure replicability and future research opportunities. Lastly, there is a growing concern with public outreach in STEM, using our research on humans to foster discussion and public education.

These ethical systems sometimes contradict one another; therefore, deontological theories of ethical practice—concerned primarily with intrinsic right or

wrong, “natural law,” and prescriptive rules of conduct—may be less useful than utilitarian theories of ethics, by which one weighs the morality of a decision based on its potential good and seeks to maximize “good consequences” (Velasquez and Rostankowski 1985). The utilitarian approach helps to reconcile the anthropological, bioethical, and scientific concerns of our discipline, because it implies there is no absolute right or wrong; rather, moral duties are situational and instrumental. However, for the utilitarian approach to be just and ethical, it requires deep reflection and flexibility. Otherwise it is more likely that history will judge us to be unethical in hindsight.

Anthropology departments are increasingly employing 3D laser scanning and printing technology to achieve utilitarian goals; this, however, adds an entirely new, potentially public, realm of consideration. The authors of this paper are early adopters of this digital technology, deeply implicated in this pursuit, but also involved in researching the ethical considerations. In this paper we raise ethical issues and concerns of 3D scanning and printing of human remains and continue a conversation about ethical practice in our discipline, with the goal of facilitating the reflexivity demanded by utilitarian ethical approaches and of avoiding colonial, racist, and ethnocentric biases. The paper is organized as a set of Socratic questions and a discussion of issues subsumed under these headings, focused mainly on bioarchaeology as practiced in the United States. Ideally, these topics will allow both students and practitioners to extend their critical thinking and communication skills regarding human skeletal remains and assist them in developing their own set of personal and professional ethics.

Why 3D-Scan, Curate, and Print Human Remains?

Any discussion of 3D laser scanning and printing of human remains among academic professionals necessitates delineating clear benefits to the practice. What are the potential benefits of 3D scanning and printing of human remains? Human skeletal materials are a source of evidence from which data can be collected about human biological variation, pathology, history, lifestyle effects, and evolution. Preserving and curating these collections is therefore a necessity for the practice of biological anthropology. 3D scanning is a relatively inexpensive, quick, and accessible means of digitally representing and disseminating archaeological information, from the excavation of entire sites (e.g., Forte 2014; Forte et al.

2015) to the surface morphology of fossils and artifacts, including human skeletal remains (e.g., Tocheri 2009).

There is no doubt that 3D scanning and printing are valuable technologies for curation, research, and teaching, but this is perhaps most true for the rarest items of interest to biological anthropologists—hominin fossils. Traditionally, anthropologists in possession of these rare artifacts of human evolution would cast fossil remains and potentially could make molds available to others for the purposes of teaching and research. Casting remains can be a valuable means of conserving and sharing their morphology, and in some unfortunate cases these casts are all that remain of fossils (see Boaz and Ciochon 2004:24–32). However, there have been cases where casting has damaged the fossils and led to political disputes that hampered scientific access to hominin remains (Cullotta 2005). Casting was once the only way for scientists to preserve and disseminate fossils, but 3D scans, including CT, are far less risky, as the likelihood of damage is significantly lower.

It is not uncommon for original fossils and even physical casts to be stored in locked museum vaults. For security reasons this is understandable, but it means that access to these items is strictly controlled and exceedingly difficult to obtain. Historically speaking, it has been common and almost expected that paleoanthropologists would prevent widespread access to fossils, particularly when they were still performing the initial cleaning, reconstruction, and analyses of these fossils (Gibbons 2002). This practice limits participation in the field by underrepresented groups and also limits replicability of the published research, which goes against scientific ethics. One advantage to producing research-quality 3D scans of fossils and making these publicly available online is that it avoids the problems of proprietary perspectives that prevent access by young scholars, those from other labs, or underrepresented communities in science (Mafart 2008; Reed et al. 2015; Weber 2001; Willermet 2016).

The open-access movement in science suggests that making 3D fossil scans available to the research community at large—and even to the public—enhances research potential, educational utility, and curation goals of the paleoanthropological community (Hawks 2015a). The 3D scans allow curators to avoid the potential damage due to overuse, repeated measuring, casting, and other research activities. However, thus far there are few research teams in the world that have made their hominin fossils publicly available. It is our hope that 3D scans of the fossils at AfricanFossils.org and the Morphosource files of *Australopithecus sediba* and *Homo naledi* will serve

as a model for the future (Hawks 2015b; Killgrove 2015a). It is up to each research team to provide these scans of the original materials, as proprietary and copyright issues apply to the scanning of casts.

Some issues, such as overuse, are common to both paleoanthropological remains and anatomically modern human skeletal remains (Caffell and Jakob 2019; Caffell et al. 2001); however, modern bones raise additional issues in a variety of contexts, including forensic science, anatomy, medicine, and archaeology (Kuzminsky and Gardiner 2012). Because these bones can also be the remains of spiritually or ritually important ancestors, scientists can face ethical challenges and requests to yield those remains back to their descendant communities or other stakeholders if objections to their study arise. In the United States, repatriation to a descendant community is also legally regulated, following the passage of NAGPRA in 1990, which was intended to guarantee certain rights to Native American communities over the remains of their ancestors. Although there are loopholes in the law (Kakaliouras 2012, 2017), the spirit of the agreement can be honored through ethical practice. For example, it is our view that human remains under the purview of NAGPRA should not be 3D scanned and made available for research, teaching, or dissemination unless an agreement has been reached with the relevant stakeholders.

Many of the world's collections of human remains do not fall under the purview of laws like NAGPRA, however, and thus obligations to descendant communities must be individually examined as part of ethical professional practice (Jenkins 2010; Márquez-Grant and Fibiger 2011). Many of these remains have been repatriated, reburied, damaged, or lost to science: museum curation facilities return remains to formerly colonized people and places; remains are scheduled for reburial according to agreements devised during planned excavation of historic burial grounds; curation facilities close, burn down, or stop accepting responsibility for the remains they have stored in the past; curators are poorly trained or posts sit unfilled for periods of time as remains are forgotten, lost, and destroyed; political upheaval opens the door to looting or purposeful destruction of cultural heritage, including human remains (Ubelaker and Khosrowshahi 2019). Some are even sold on the "red market" (Huffer and Chappell 2014; Huffer and Charlton 2019). In these types of cases it may be inappropriate, inexpedient, or impossible to conduct 3D scanning of the remains. However, in other circumstances, and particularly if consent has been given 3D scanning and digital curation may be viewed as part of the curation process itself.

Increasingly, 3D scanners are inexpensive and readily available. Basic apps like Scandy Pro are free and can produce simple yet high-resolution 3D meshes from iPhone photographs, and the iPhone 12, released in late 2020, includes an integrated LiDAR scanner. Handheld scanners like 3D Systems' Sense 2 or XYZPrinting's 3D Scanner Pro represent the entry range of laser-based scanners, whose cost of a few hundred dollars puts them in reach for many researchers. More precise but less portable scanners from companies like NextEngine and Artec3D may be preferred by researchers or curators hoping to create high-quality scans of small objects, but they come with a larger price tag. Some of this cost may be borne by researchers who plan to scan human remains in order to satisfy U.S. governmental federal funding agency mandates for data sharing, improving replicability, and minimizing the risk of measurement error by storing copies of landmarked skeletal elements in the repositories. These are priorities explicitly mandated by major funding organizations like the National Science Foundation, the National Endowment for the Humanities, and National Geographic, and the cost of 3D scanning and printing technology may be covered by those same grants.

Furthermore, there is some potential for 3D scanning technologies to improve our ability to communicate research findings to diverse audiences and to use human remains as a teaching tool. Using 3D scanning and printing technologies may substantially improve facial reconstructions (Boutin et al. 2012) and even court testimony (Errickson et al. 2014). Scans are fundamentally valuable for teaching skeletal anatomy and pathology. Not every academic program has access to a collection of adult remains for osteology teaching; it was for this reason that Killgrove started a public digital repository for 3D scans of medical skeletons in the teaching collection at the University of West Florida (<https://github.com/killgrove/Virtebra-UWF>). Many institutions do not have fetal and infant remains they can use for teaching purposes, so Robbins Schug created a private repository for two fetal skeletons on loan from the North Carolina Office of the Chief Medical Examiner (OCME), which can be accessed through a curated membership program (<https://osteoteaching.wordpress.com>). By making skeletons available in an accessible 3D scanning archive, we avoid some problems, such as accidental student damage as they learn to measure or make other observations on the bones (Caffell et al. 2001). In some cases, particularly with very young individuals or archaeologically derived skeletons, the remains can be easily damaged because they are fragile to begin with.

In addition, 3D scans are very useful for teaching about pathology. The variety of pathological

conditions that affected the human skeleton was quite different prior to the advent of modern medicine and antibiotic therapies. In the face of the third epidemiological transition, whereby drug-resistant infectious diseases are reemerging, paleopathological bones are an increasingly valuable interdisciplinary teaching resource. The rarity of these types of skeletal remains was the impetus for the University of Bradford, Museum of London Archaeology, and the Royal College of Surgeons of England to create the website Digitised Diseases, which serves as a repository for pathological skeletal elements from world-renowned collections (<http://www.digitiseddiseases.org>) (Williams and Atkin 2015; Wilson et al. 2017a, 2017b). A similar effort is forthcoming from the U.S. National Museum of Health and Medicine. Although a limited selection of these types of materials is available for purchase from companies like Bone Clones, Skulls Unlimited, The Bone Room, or France Casting, the expense of each individual element leaves many institutions without adequate teaching facilities. Additionally, there have been recent discussions about the ethics of purchasing human remains from companies like these, even though it is legal in many U.S. states (Hugo 2016; Killgrove 2015c). Thus, academic 3D scanning and printing infrastructure, which is fundamentally a nonprofit endeavor, is a valuable resource for teaching and research on pathology across socioeconomic lines as well (Killgrove 2015b).

One important ethical issue to consider as materials like these are made available to the public is that the remains, the diseases, and their skeletal manifestations are often decontextualized. The Digitised Diseases project made an important contribution not only in providing scans of the anatomy but also in creating a written resource for the general public that describes the conditions and what it was like to live with these conditions in the past. In cases where radiographs or other imaging modalities were used, those documents were linked to the scans, and an effort was also made to describe what the pattern of lesions would be across the entire skeleton even if only one or a few elements from a given individual had actually been scanned. The decision to disallow public printing of the elements from the repository was influenced in part by U.K. legal requirements; for example, the materials curated by the Royal College of Surgeons fall under the purview of the Human Tissue Act (2004) (Jo Buckberry, personal communication, 14 September 2015).

Who Is Scanning and Printing Human Remains?

By and large, academics, researchers, professors, students, and staff at public institutions produce most

3D scans of human remains, as these projects are conducted or permitted by those professionals who are ultimately responsible for collections of remains that are publicly owned. Primarily, their intentions have been to provide free, high-quality osteology teaching resources to other academic professionals or to make data from research projects broadly available to other researchers. There is also an intention of public edification and public outreach in many projects. For example, Digitised Diseases shares models of skeletal pathology as a means of making the discipline more broadly relevant (Killgrove 2015b; Stojanowski and Duncan 2015).

The academic professionals who find themselves in a position of responsibility for collections of human remains have a duty to curate them to the highest standard possible, given the resources available at their state- and federally funded institutions. This is a long-term goal for many facilities, as they seek to improve substandard practices held over from earlier times, practices that do not always conform to improving standards. Along with standard curation efforts—inventory of the remains, re-associating commingled elements, individually labeling skeletal elements, seeking a climate-controlled lab facility with museum-quality storage cabinets and locked drawers lined with Ethafoam®—finding funding for and developing a 3D scanning facility to develop and maintain a 3D teaching resource using these materials was a high priority for two of the authors of this paper, upon being hired for academic positions (Killgrove and Robbins Schug).

The collections of human remains that we digitized are technically property of the states of North Carolina (OCME) and Florida (University of West Florida [UWF]). While members of the general public would not usually be allowed to access human skeletal remains outside of an official outreach or educational event, 3D scanning opens up this possibility. For example, Killgrove and her graduate students have made scans of one of UWF's adult skeletons available to students and the public (<https://github.com/killgrove/Virtebra-UWF>), with the goal of allowing more people access to virtually study this material (Zechini et al. 2016). Killgrove also maintains 3D scans of skulls from the archaeological site of Oplontis (Naples, Campania), which was destroyed by the eruption of Mount Vesuvius in A.D. 79. Hosted on SketchFab, these scans are viewable but not downloadable or printable (<https://facesofoplontis.com/3dscans/>). In keeping with ethical perspectives on ancient Roman remains, the scans are annotated and aimed at educating the public on antemortem pathologies as well as postmortem taphonomy at this site. Public outreach in this manner might be considered by most people to be an appropriate way to use anatomical remains.

The fetal osteology scans Robbins Schug maintains online are considered an important public resource because of the relative dearth globally of fetal remains available for osteology teaching. However, and perhaps more importantly, they are also considered sensitive materials because of their young age, their recent death, and the potentially fraught sociopolitical dimensions of presenting fetuses in contemporary digital spaces. Although these remains are unclaimed or were donated to the North Carolina OCME for research and teaching purposes, explicit consent for digitization was not granted. Out of respect for parents and families, their identity is protected and the remains are only available for viewing and downloading by professionals in the field upon providing an academic e-mail address. This proprietary attitude is intended to protect the remains from misappropriation, misrepresentation, or other unintended uses. The internet and particularly social media are known for the deliberate repurposing of imagery to gain political or social capital.

The treatment of certain remains, such as fetal bones, can be expected to vary regionally. The determination of what is an “appropriate” use of 3D scans and prints is often left to the individuals involved in their creation, and currently there is no agreed-upon best practice. Many professors will have to go through a process of drawing up a policy for curation and usage individually, or in many cases this has to be done among the members of a departmental or university-level committee. We strongly recommend that researchers consider potential uses and misuses of the 3D models (such as commercialization, printing, sharing without content warnings) before they post their models to an online repository. As these guidelines are developed to ensure that our discipline remains ethical, we must balance the need for sensitivity to families and communities left behind with the need for the remains to be accessible to researchers and possibly to the general public.

Who Are the Humans We Scan and Print?

Who are the humans who are in publicly owned teaching and research collections, how did they come to be there, how should we seek to reconcile public versus private interests, and what is the impact of these issues on the ethical considerations of 3D scanning and printing? In some regions, such as the U.K., academic collections are archaeologically derived. For the most part, individuals who comprise institutional skeletal collections in the United States are purchased from skeletal supply companies or people

whose bodies were donated for research and education purposes.

As an example, at Appalachian State the majority of the skeletal collection came from the North Carolina OCME (now in Raleigh), and thus we know the identity of each individual and whether they were unclaimed or donated by their families with the intention that they be used for educational purposes. That is, this collection is fully documented, with death certificates and, in most cases, a clear chain of custody from the OCME to the Forensic Decomposition Research Facility at the University of Tennessee, Knoxville, to Appalachian State’s curation facility. These individuals are of known provenience and deeply contextualized, but because of their forensic derivation and recent death, they also represent a set of ethical issues to public availability. They were donated to this public facility during a period before 3D scanning and printing were invented. Although there is no archived copy of the consent agreement provided to families, we can be certain those materials contained no mention of the possibility of digital curation as the donation program ended at the end of the twentieth century. Families certainly did not specifically consent to having their family member digitized or available for downloading and printing.

Although many individuals in institutional collections are of known derivation, identified and fully documented, there are also often remains that, for a variety of reasons, are unprovenanced. These remains have their own set of ethical considerations. Both Appalachian State and UWF have small collections of human skeletal material purchased in the later decades of the twentieth century. Many of these skeletons are from people who lived in South Asia and whose skeletal and dental elements were sold for educational purposes, many presumably without the knowledge or consent of the deceased individual or their families. The fact that these remains were legally purchased in the United States does not absolve us of ethical concerns, because human skeletal remains from South Asia were part of a large trade conducted outside the United States, generally speaking, without adequate documentation or controls. The ethical morass of how this material came to be sold is amply described elsewhere (Carney 2007, 2011; Huffer and Chappell 2014; Quigley 2001), but it suffices to say here that some of this material may have ties to grave robbing, black or red markets for human remains, and possibly other illegal activity. Thus, these anonymous, unprovenanced, or undocumented individuals would have to be considered deeply decontextualized and would potentially bring a large set of ethical concerns to the table.

Appalachian State also has a small collection from the excavation of a historic cemetery and a very small set of completely unprovenanced, undocumented, unidentified, and decontextualized remains that were in the collection prior to the arrival of Robbins Schug and for which little information is available. Archaeologically derived skeletal material may be viewed as a public resource, and the private or personal aspects of these materials may be discounted due to their antiquity. However, this material is primarily kept out of the classroom except for occasional relevant uses. The 3D curation of those materials might be appropriate. However, skeletal material donated by members of the public, other academic departments, or law enforcement officers is decontextualized in a way that suggests it should not be made publicly accessible in a digital laboratory space. It is unclear if these individuals have living descendants who could be consulted, and the lack of specific identity makes it unlikely that this could ever happen. Those individuals are not used for teaching, and 3D scans should not be publicly available, in our view.

Certainly, there are additional concerns about the dissemination of remains from individuals from enslaved populations, poorhouse cemeteries, incarcerated or institutionalized populations. There is an obvious concern generated from the fact that those individuals did not donate their remains for study. However, the study of these remains may be rationalized as a service to understanding more about subaltern histories and experiences (de la Cova 2010, 2011, 2012, 2015; Nystrom 2014, 2017). For 3D scanning and public dissemination, however, there must be an added concern about how those remains might be misappropriated or misused by members of the public who are willfully insensitive or who are pushing a political or ideological agenda.

It is increasingly clear today that social justice is not a uniformly progressive tack; there are regressive moments and regressive spaces where 3D scans of the skeletons of marginalized people could be used to further injustice against those communities. If remains from these sources were to be scanned, it might be wise for scholars to think about how they can protect the legacy of those scans and balance access with privacy, such as by choosing file types that can be visualized but that prevent printing.

Who Are the Stakeholders? What Are Their Interests and Concerns?

Scientists tend to think of human skeletal remains as valuable resources for teaching, developing new

methods, or addressing anthropological questions. Other groups, however, have equally important priorities and ideas about the meaning of human remains (Larsen and Walker 2005). Given the wide variety of sources for human remains in publicly owned collections, there are also a variety of people who have a vested interest in whether the remains are digitally scanned and made publicly available, particularly for downloading and printing. Of all of the stakeholders and ethical concerns, perhaps one of the most pressing is how Native American remains would be treated in this regard (Loveless and Linton 2019). If remains fall under the legal obligations of NAGPRA, should scientists document those in 3D, store those scans, or print them prior to repatriation? Do 3D scans and prints have to be repatriated along with physical remains? Who owns these data and digital objects? What are our obligations for consultation?

There are no easy answers to these questions, and because the law does not yet specifically address this issue, situational variation demands that ethical practice would include consultation with all stakeholders. In some cases, descendant communities will not want mortuary remains 3D scanned and may invoke the falseness of a dichotomy between “real” and “digital” objects or realms (Boellstorff 2016). In other cases, 3D scanning could break down exclusivity in controlling the narratives and the meaning of archaeological objects (Dawson and Levy 2015) and open a new kind of space for “preclusive alliances” with Indigenous communities that have an interest in participating in interpretation (Dawson et al. 2011; Isaac 2015).

If human remains fall outside of the legal and ethical obligations of NAGPRA, meaning they are not culturally affiliated with specific descendant Native American populations, we should still consider whether they are tied to a particular descendant community and request consultation with designated representatives of those communities to weigh the benefits of 3D curation. If remains are possibly Native American but no descendant communities have been identified, it is probably most appropriate to forgo scanning them until their status is determined.

Public institutions may also be storing archaeological materials from other countries; materials that were entrusted to archaeologists long before the internet, social media, or digitization were ever imagined. What are the ethical implications of digitizing the geographically distant dead? Do they differ from ethical concerns of presenting photos at conferences, publishing photos in academic journals that lie behind a paywall, or providing photos to internet news

outlets? Can digitizing them open a new avenue for repatriation? Unlike a physical lab space, where remains are accessed through a professional anthropologist and are subject to gatekeeping, digitized resources are public in an entirely new way, and once they are public they are out of the control of professional anthropologists. Terms such as *objects*, *representations*, *accessibility*, and *public* have new meaning in the digital age. This requires us to consider the benefits to open access to human remains as well as the drawbacks, such as compromising confidential identities.

In addition, if scans are publicly accessible, in downloadable formats, they are usually stored on private, for-profit company servers. These companies do not feel the same ethical obligations to maintaining repositories as an academic institution or a museum would. If the repository has an associated cost, individuals and institutions will become obligated to maintain those expenses. A related concern is that when a repository is created, individuals and institutions have to determine who will be responsible for maintaining 3D archives once they are created and who will serve as the gatekeeper for the downloading and printing of those scans (if that is permitted). Most scientists agree there is no circumstance where human skeletal material should be used for individual profit, but do we have a responsibility to democratize public resources by putting them under a Creative Commons license, for example? If so, a citable DOI might be attached to these materials so that the person who has invested labor in creating the scans can get citations for their efforts to make these available. As “ownership” of the dead and co-opting and contesting the powerful imagery of the dead has been a theme in history and archaeology for centuries (e.g., Echo-Hawk and Echo-Hawk 1994; McEvoy and Conway 2004; Moon 2019; Morell 1995), we expect that the conversation about ownership of the digitized dead is only beginning.

This brings us to a whole set of other questions that must be considered: Who owns 3D scans of human remains? The skeletal material may be publicly owned, but is there a proprietary aspect to making the scans themselves—an investment of time and labor? What about when students who have created a repository graduate and leave an institution? What if a faculty member leaves, retires, or dies without planning for maintenance of these repositories? What if graduate students or faculty argue that they performed the labor of scanning the remains and they want to “take” the scans with them when they move to new institutions? What if they leave academia? What if they decide to sell scans or prints for profit in an alt-ac or post-academic scenario? Furthermore,

when an individual creates a set of scans, they choose the kinds of metadata that will be stored with each scan (the contextual information so valuable to anthropological research). Should those metadata be standardized for record keeping and/or preservation (Greenberg 2010; Wilson 2010)? Does the researcher have a responsibility to provide the full context of the skeletal remains, or should some context remain private? To save color and textural information about the surfaces of objects? To produce high-resolution, research-quality scans? To provide information about post-processing? Should these 3D data or prints be returned or destroyed if repatriation is accomplished, and if so, in what time frame? That there are so many questions only confirms the need for continued discussion on this subject and the development of standard practices.

Who Should Be Able to Access These Remains, and for What Purposes?

The matter of who should be able to access 3D scans of skeletal material and for what purpose is essential but also case-dependent. Should 3D scans of human remains be publicly accessible, downloadable, and printable? How do 3D scans differ from other types of information about skeletons? Researchers and teachers often make photographs of human remains publicly available in our scholarly publications but also in popular media reporting, museum displays, and other forms of outreach. We have long used 2D representations (photos and drawings) to illustrate specific aspects of a skeleton or skeletal element for research or teaching purposes. In fact, it is uncommon to publish a scientific paper *without* photographs or drawings of the remains in question. However, controversy has arisen about the display of photographs as well, even within relatively private intellectual spaces (see Harries et al. 2018).

On 14 October 2016, George Nicholas, on behalf of the program committee reviewing abstracts for the Society for American Archaeology, sent an e-mail to certain members who had registered for the annual meeting in which he encouraged them to not present any analysis of human remains without the descendant community’s knowledge and consent, or contrary to agreements made with such parties. More surprising, but along those same lines, bioarchaeologists presenting at the meetings were asked to consider showing drawings of human remains rather than photographs as a courtesy to the audience and descendant communities. Finally, the e-mail stated, “in connection with the SAA Principles of Accountability and Intellectual Property, we ask presenters to

be mindful of the potential harms that may come from sharing sensitive information publicly without permission from the source (e.g., family genealogies, sacred object meanings, sacred practices, previously unpublished archaeological analyses not completed by the presenter).” This communication exemplifies the fact that standards for ethical practice are highly variable among communities of anthropologists and in some cases are becoming increasingly rigorous in regard to using 2D or even verbal representations of human remains and funerary and sacred objects. In the case just outlined, the conference organizers and members of the ethics committee requested that even ideas as to the meaning of objects or practices should be vetted by descendant communities prior to presenting them at the meeting.

Unlike drawings or photographs, which depict an event or object in a specific frame of reference and are specifically intended to highlight certain aspects over others, a 3D object is not constrained in this way. Viewers can approach the object from a completely neutral perspective (or with their own subjective biases), free from the intentions or the added emphasis of the author, depending on the mode of access. In this way, 3D replicas democratize subjects and scientific bodies in a way that the 2D representation could never accomplish. The democratization of subjects is part of the concern scientists have about 3D scans being represented on social media. For example, if new scans are added to a digital repository, there may be an announcement of this fact on social media, most commonly Twitter, Facebook, and blogs. An image of the 3D scan may be provided to generate interest among the professional audience or to let subscribers know new scans are available.

We need a more reflexive examination of this phenomenon. What are the ethical concerns in distributing 2D photos and 3D scans? Is there a place for digital representations (2D or 3D) on social media at all, and if so, is contextualization the only ethical requirement (Errickson and Thompson 2019)? Is this a valuable form of public outreach? Do benefits of STEM outreach outweigh the risks of human skeletal material being reappropriated in ways that are disrespectful to the dead or their descendants, or in ways that are unintended and beyond control? What kinds of misrepresentations, internet memes, or other stories might be created from these materials? What are the potential risks of 3D scans being subject to internet trolls, to criminals, or to unexpected and previously unknown realms of the dark web? In a sense, we can learn something about this from the ethical issues surrounding CT scans and MRIs of contemporary medical patients, which are strewn all over Google images and are often of unknown derivation,

despite the ethical orientation, laws, and concerns of the medical establishment (Dodds 2015).

One wonders about the enhanced potential for unintended consequences when the powerful forces of the internet and 3D scanning combine. If 3D scans are publicly available online, they will certainly exist long after all of us are gone, when the world is dramatically different from anything we can imagine today. Anthropologists have traditionally served a role as gatekeepers of human remains, ensuring they are only available for professional and academic purposes. Yet the internet democratizes information in ways that can yield infinitely surprising and valuable new kinds of information (Williams and Atkin 2015). There is a tension between our role as curator, which values access to data for researchers, and our role as gatekeeper, which values maintaining a level of respect and decorum for remains of once-living people. We cannot predict how the lines between real bodies and digital creations could blur in the future, creating a space for a post-truth type of hybrid or a post-modern Piltdown scenario. One thing we know is that culture change will put our old-fashioned perspectives to the test of time, and we should strive to avoid alienating future publics as much as practicable.

Toward a Set of Ethical Guidelines for 3D Scanning in Bioarchaeology

Although it is impossible to predict where this conversation will go in a hundred years—or even ten—or to answer the questions we have posed here, we offer a list of ethical principles that guide our work given our collective nine years of experience with 3D scanning human remains in the U.S. the U.K., and Italy. In addition to the ethical standards we already follow (AAA 2009; American Association of Physical Anthropologists 2003; British Association of Biological Anthropology and Osteoarchaeology [BABAO] 2019; Department for Culture, Media, and Sport 2003, 2004; Society for American Archaeology [SAA] 1996; World Archaeological Congress 1989), when 3D scanning is considered as a means of curating or disseminating human remains, the following guidelines (adapted from Cassman et al. 2006 and as a complement to BABAO 2019 guidelines) might be considered:

1. Human remains must be treated with dignity and respect at all times. Scanning, dissemination, and printing activities should only be conducted for teaching, research, and outreach purposes. The potential value of the activity should be considered in light of repositories already available.

2. Before any human remains are 3D scanned, bioarchaeologists and other responsible parties must fully consider their derivation and whether they were legally acquired. Unprovenanced donations should not be made publicly available as 3D scans. Additionally, researchers should consult with their department and/or institution to develop the parameters under which generation of 3D data will take place.
3. Before archaeological remains are scanned, consult with descendant communities if possible. If the descendant community is amenable to 3D scanning, develop appropriate collaboration goals and boundaries. Discuss whether remains will be publicly accessible, the benefits and limitations of different file formats, and whether the remains can be shared on social media or printed. Create a written agreement and consider including this agreement, its provisions, or relevant conclusions in the repository.
4. If no descendant community is identified but remains might be Native American, do not 3D scan the remains until their status is determined and until the remains can be affiliated and that group properly consulted, if applicable.
5. Human remains and scans of human remains should not be private property. When human remains are 3D scanned, those data should always be accessible to other researchers to promote access, representation, and replicability in science. Scanning repositories should not be proprietary; they should not exclude other researchers.
6. Make efforts to identify appropriate repositories for 3D scans of remains. Consider whether it is appropriate to make the scans available to the public or whether they should be in a restricted repository that is accessible only to academics or professionals in allied fields. Make scans available to the largest possible audience, given each collection's specific ethical considerations. If a gatekeeping process is necessary to access the scans, ensure it is fair and equitable.
7. Be aware of potential misuses of 3D scans if they are public, downloadable, and/or printable. Consider implementing a membership or vetting process (at least a log-in so that bots cannot easily scrape the files) for people to use the scans, think about which file types are included and the different potential uses of each, and write an educational disclaimer about the ethics of printing.
8. Real and virtual remains should never be removed from institutional repositories or made public without permission of the responsible institution or stakeholders (for which institutions should develop written policy guidelines). Provisions should be made for access to repositories in the case of an individual person's departure from the institution, retirement, or death.
9. Students who participate in scanning activities should be acknowledged in the repository creation statements. From the outset, lab directors should identify appropriate avenues of compensation, establish written guidelines for division of labor, access to data, rights of authorship, and other rights and responsibilities for research and maintenance of the scans or the repository.
10. Individuals who use materials from a repository should provide a citation or other acknowledgment in any published works, blog posts, or other product resulting from the research.
11. Funding agencies that contribute to the creation or maintenance of a repository for 3D scans should be acknowledged in the documents associated with the scans and in any resulting publications.
12. Human remains are part of a public trust, never to be used for advertising or commercial purposes. If there is a monetized project to disseminate remains, the endeavor must be nonprofit, and the money should be used to facilitate the teaching, research, and outreach mission of the institution and its relevant members, students, faculty, and staff. 3D scans made publicly available should carry a CC BY-NC (noncommercial) license.
13. Science outreach is fundamentally different from advertising. If human remains or scans of remains are used to promote science literacy and STEM engagement activities, caution is warranted about respectful representation.
14. Any and all use of the scans or images of the scans should be vetted and approved by the parties responsible for the repository.
15. For outreach and teaching activities in which it is likely that human remains could be damaged from overuse or careless handling, scanned and printed remains should be considered preferable to the use of real human remains.
16. In cases of pathological conditions, the eventual goal should be to scan the entire skeleton if it is available, rather than limiting scans to affected elements, to provide context and the potential for future analysis.
17. Conserve metadata for skeletal elements and attach it to scans in digital repositories whenever possible. Metadata should include contextual, taphonomic, methodological, and landmark data, as well as professional interpretation of

pathological elements, as applicable. For fossils and pathological elements, the surface color/texture files should also be attached as metadata.

18. In cases where human remains are donated or on loan from medical examiners' offices, through public donation programs, or other official channels, consider adding a section to the donor information sheet that describes 3D scanning and seeks permission for those activities.
19. If a researcher brings in foreign remains to their own country to be scanned, consider ethical implications. Add this ethical module to applications for institutional research, research visas, and grant funding so that all institutional regulatory bodies are involved in decision making and vetting the proposed project.
20. If remains were purchased from a commercial outlet, consider copyright implications of 3D scanning. Casts and reproductions should never be scanned unless authorized. Human skeletons and other original anatomical material purchased from a commercial outlet belong to the institution, but their derivation should be specifically attached to the scans in the form of metadata.
21. When using 3D scanning data from other institutions or projects, researchers should consider all of the above points with respect to the repository they are working with. Being a conscientious colleague means paying close attention to the context and rules of the other project, while also respectfully raising any ethical issues with the appropriate stakeholders.
22. Ethical standards set forth by professional organizations should be revised as soon as practicable to specifically account for the issue of 3D scanning and printing; laws and regulations regarding excavation, analysis, and storage of human skeletal remains must be followed; and the spirit of agreements like NAGPRA should be honored until the law is amended to reflect the digital reality of the twenty-first century. Researchers should postpone scanning human skeletal remains until they have ethical guidelines in place (from professional organizations, institutions, departments, or their own lab policies).

Conclusions and Future Work

Ethics are, by their very nature, an evolving set of guidelines, and the ethics covering 3D digitization of human skeletal remains are no different. As this

aspect of our discipline is rapidly expanding, we are beginning to see a swift but thoughtful response to ethical concerns about digitizing skeletons from anthropologists around the world. Some of the first works to address ethics of scanning skeletons have been blogs and listserv posts (e.g., Atkin 2015a, 2015b; Killgrove 2015b, Ulguim 2018; Wild 2020). At the 2016 World Archaeological Congress session on Digital Bioarchaeology: New Dimensions, New Methods, New Ethics, it was agreed that a new resolution regarding the creation, dissemination, and curation of digital bioarchaeological data would be ratified (Hassett et al. 2018). The British Museum has already put out guidelines that include respectful digitization of their holdings (Antoine and Ambers 2014). Additionally, a recent book titled *Human Remains: Another Dimension: The Application of Imaging to the Study of Human Remains* has a chapter that covers aspects of dissemination and ethical considerations in 3D imaging of skeletons (Márquez-Grant and Erickson 2017), and Squires et al.'s 2019 edited volume *Ethical Approaches to Human Remains* is similarly pushing forward a discussion of ethical issues with novel technology.

We have generated the above list of best practices based on our shared disciplinary history as well as our shared experiences in using 3D scanning and printing for research, education, and outreach. The list, however, should not be considered prescriptive; all scholars must develop ethical guidelines for their labs based on their own circumstances. Rather, this paper raises awareness as to the stakeholders, issues, and questions specific to this major challenge of digitization of human remains. In providing baseline guidance for developing an ethical practice, we demonstrate the importance of ethical use of this new and rapidly changing twenty-first-century technology and encourage other practitioners to build on this framework in the future.

Acknowledgments

The authors would like to thank Siân Halcrow, Joshua J. Wells, Mariana Zechini, and the anonymous reviewers for their advice and comments on this work. Thanks to Andrea N. Acosta for the Spanish language translation of the abstract.

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