ABSTRACT

Title of Thesis:	INSIGHTS ON THE APPLICATION OF PHOTOGRAMMETRY AND DIGITAL DATA COLLECTION ON A BIOARCHAEOLOGICAL SAMPLE FROM ÇADIR HÖYÜK IN CENTRAL TURKEY Katherine Titus, Master of Professional Studies, 2024
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This project seeks to answer the question as to how photogrammetry and digital data collection can be used to address the major issues of accessibility, preservation, and ethics on a collection of human remains from the archaeological site of Çadır Höyük located in the Anatolian Plateau. These issues are ubiquitous in the field of bioarchaeology and there is a pressing need to develop new methodologies and research practices to assuage them, especially for researchers working in foreign countries, or researchers who do not have immediate access to collections. The purpose of this research endeavor was to obtain both metric, and photographic data that could be further studied in posterity outside of the host country. Many limitations exist inhibiting researchers in this field as archaeological material, specifically within the country of Turkey, is strictly regulated. This thesis examines the application of photogrammetry in conjunction with the data obtained from a physical bioarchaeological investigation on a collection of ten individuals from

Çadır Höyük and seeks to determine the reliability of digital modeling and digital data collection without having the collection present. This was done with the aspiration of addressing the concerns specific to the study of human remains from contexts outside of the United States while also respecting and abiding by local heritage regulations. Only two three-dimensional renderings were successfully created from the ten individuals using the photogrammetry software AgiSoft, due to issues of preservation and fragmentation. A comparison of craniometric measurements collected from the physical collection and measurements collected from the digital models demonstrated an impressive degree of accuracy between the two datasets, indicating the reliability of the digital models for post-field research. In addition, this demonstrated the efficiency and practicality of obtaining this data from the digital models. The digital modeling and digital data collection on this sample exemplifies the viability and practicality of incorporating this methodology and offers immediate solutions for issues pertaining to preservation, accessibility and ethical treatment of these remains.

INSIGHTS ON THE APPLICATION OF PHOTOGRAMMETRY AND DIGITAL DATA COLLECTION ON A BIOARCHAEOLOGICAL SAMPLE FROM ÇADIR HÖYÜK IN CENTRAL TURKEY

by

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Disclaimer

This document contains images of human skeletal remains.

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Chapter 1: Introduction

This research project seeks to address the question, how do photogrammetry and digital data collection address issues of ethics, accessibility and preservation of a bioarchaeological collection at Çadır Höyük? This question seeks to address the pressing concerns of accessibility, preservation, and ethics regarding human remains through the application of digital data collection and photogrammetry on a small sample collection of remains from the Çadır Höyük Archaeological Project in central Turkey. Using a small collection of ten individuals, I was able to determine if this methodology is not only feasible on such a collection, but whether this is a viable and immediate solution to address these issues. Only two of the ten individuals were suitable candidates for cranial three-dimensional rendering due to the fragmentary condition of the other eight individuals. Although all individuals were analyzed and documented, analysis is focused predominantly on these two individuals, as in addition to being suitable candidates for digital rendering, these interments pose important research questions regarding events at Çadır Höyük. While exploratory in nature, this project highlights the detriment of destructive methodologies, and the need for newer and less invasive techniques within the field of bioarchaeology.

The field of bioarchaeology is crucial to understanding the lives and behaviors of past peoples. Bioarchaeology, or the study of human remains from archaeological sites, relies on the application of skeletal biology principles to understand past human experience. Much can be learned not only from the skeletal remains themselves, but also from the mortuary treatments and burial contexts in which they are found. Burial is about much more than one's final resting place, as "death is not only a biological reality but also a complex cultural event" (Murphy and Le Roy, 2017:1). The data gleaned from remains and burial contexts give researchers a view into the cultures, lifeways, and historic events that these ancient humans experienced. This form of research has the ability to humanize the past by gaining a better understanding of an individual person's life experience. However, the roots of this field of research have historically dehumanized and abused these ancient people as well as their descendant communities. For centuries across the world graves have been looted and destroyed, and human bodies have been bought and sold with little regard for the person to whom remains belong. In the name of science and research, these remains have been stolen, horded, destroyed, and displayed as mere objects. Although attitudes, awareness, and increased legislation regarding human remains have changed dramatically in the past several decades, it is still important for researchers in this field to recognize the wrongs of their predecessors and rectify this darker past. It is the responsibility of the researcher to return the humanity to these individuals and respect the cultures from which they came, as well as the communities within which we work. Despite the great advancements in this field, ubiquitous concerns still remain. Predominantly these concerns revolve around issues of accessibility, preservation, and ethics.

Site Background

The archaeological site of Çadır Höyük is a 32-meter-high anthropogenic mound with an impressive six millennia of continuous occupation from the Chalcolithic to the Byzantine era. The site is located in the rural village of Peynir Yemez in Turkey's Yozgat Province. This remote agricultural region is referred to by scholars as the Anatolian Plateau and is roughly located in central Turkey. This location is not only remote and difficult to access for foreign researchers, but it is also challenging for Turkish native researchers traveling from the major universities as well. The Turkish name for the site, translating to "Tent Mound" in English, gets its name from its tent-like shape.

The Çadır Höyük Archaeological Project has a dedicated team of archaeologists and historians who have conducted extensive excavations on a seasonal basis since 1993. Excavations at Çadır Höyük first began as part of the Alişar Regional Project led by Dr. Ronald Gorny out of the University of Chicago's Oriental Institute. Although the excavations began under the leadership of an American university, over the years scholars from many different countries, as well as prominent Turkish scholars have been a part of the core team. During the time of my research, the excavations were directed by Gregory McMahon, PhD, based at the University of New Hampshire, and Sharon Steadman, PhD, based at the State University of New York (SUNY) at Cortland. Both Dr. McMahon and Dr. Steadman have decades of experience working in the region and have contributed an incredible amount of scholarship and publications based on their research, the most notable contribution being the Oxford Handbook of Ancient Anatolia, published in 2011. Working under Dr. McMahon and Dr. Steadman, I participated in six weeks of excavations at Çadır Höyük in the summer of 2018. I then returned for four weeks in the summer of 2019 under the mentorship of Dr. McMahon and accomplished biological anthropologist, Dr. Amy Michael from the University of New Hampshire, with a small undergraduate grant from the University of New Hampshire.

Over the past three decades, a considerable collection of human skeletal remains has been excavated from the site. Human remains have been recovered from nearly all time periods of occupation, in various contexts, and at many different stages of life. However, the vast majority of remains recovered have been juvenile remains from the Chalcolithic and Bronze Ages. This imbalance in age is not due to an extreme infant mortality rate, although the rate of infant and child mortality was historically high, but rather a differing mortuary treatment between children and adults during these time periods. Adult burials, and fragmentary remains found within the mound have been interpreted as differential, circumstantial mortuary treatments, or potentially expedient burials. Very few cases of complete adult burials have been encountered, and many of the adult remains discovered are fragmentary. The current cultural understanding of this population, based on evidence collected as well as regional understanding from contemporary sites, is that adults would have been interred in a designated burial ground or cemetery located outside of the community. It is presumed by Çadır Höyük archaeologists that a cemetery, or potentially multiple cemeteries, beyond the ancient city walls exists in close proximity to the mound, but the location has yet to be identified.

Human remains along with all other artifacts recovered from Çadır Höyük are stored in a secure depository located at the dig house, about a kilometer from the site. The depository is ceremonially sealed and unsealed by a government official upon the beginning and end of the excavation season. Both the dig house, the site, and the depository have a year-round guard ensuring the safety of site, artifacts, and equipment. The collection cannot be accessed without the official's approval and presence on site. This official is responsible for ensuring that all archaeological and heritage regulations are being adhered to. Only this official and the regional museum director can make decisions regarding the movement of archaeological material. As all archaeological material belongs to the state and is illegal to export or remove without the proper authorization. Together they determine every dig season what artifacts will be selected for the regional museum, if samples can be exported for testing, or if archaeological materials can be relocated. Although the collections are stored in a secure building, the building is not climate controlled, nor is it completely impervious to the elements and pests, making the conditions less than ideal for the long-term storage of more fragile collections such as human and faunal remains. This strict protocol makes accessing collections outside of the dig season nearly impossible. This restricted accessibility has ensured the safety of these collections but has also limited researchers.

Fortunately, with the assistance of prominent physical anthropologist, Dr. Yılmaz Selim Erdal, many individuals have been relocated to Hacettepe University in Ankara where they can not only be stored in a more controlled environment conducive for prolonged preservation but also can be accessed by many researchers. However, at the time of my research, much of the collection remained in the site depository and had not yet been analyzed. Despite the incredible expertise of the Çadır Höyük team, specialization in bioarchaeology was lacking for many decades, which resulted in most of the remains lying dormant and unanalyzed in the depository until Dr. Erdal offered his expertise and curation at Hacettepe University around 2018. Although much of the collection of human remains at Çadır Höyük has been successfully relocated to a more suitable curation facility since the time of this research, this unfortunately is not the case for many dig sites across the region. Even larger facilities like Hacettepe University do not have unlimited storage availability and are selective of the collections they choose to curate. Often larger collections, or sites that are sensationalized or considered more significant are prioritized. Smaller excavations, especially those in remote regions garner less interest and often remain in small depositories similar to that of Çadır Höyük that are unsuitable for the long-term preservation of human remains.

Purpose

This collection of human remains at Çadır Höyük, like many other collections, faces these very same aforementioned concerns of accessibility, preservation, and ethics. The purpose of this research endeavor was to obtain both metric, and photographic, including two-dimensional and three-dimensional, data that could be further studied in posterity outside of the host country. Many limitations exist inhibiting researchers in this field, as archaeological material within the country of Turkey is strictly regulated. I wanted to explore the potential for employing photogrammetry to my data collection on the remains at Çadır Höyük to determine the feasibility of this methodology, as well as determine the reliability of digital modeling and digital data collection. This was done with the aspiration of assuaging the concerns specific to the study of human remains from contexts outside of the United States while also respecting and abiding by local heritage regulations.

By utilizing digital data collection and photogrammetry I was able to produce broadly accessible data that can be accessed from anywhere and can be shared among multiple researchers. This increased accessibility allows the research to continue without the hinderance of travel, expenses, and time constraints from the permitting process. In addition to addressing issues of accessibility, these data can be stored in perpetuity without the same concerns that face the physical collection such as damage, loss, and degradation. Additional research performed on digital collections reduces the physical handling of the remains, resulting in the overall preservation of the physical remains. This thesis argues that the lack of invasiveness and handling of these individuals also lends itself to more ethical practices. Researching remains in this way forces the researcher to explore noninvasive techniques that will not cause physical damage to the individual they are studying. Although not without its flaws, this methodology can offer an immediate and vital solution to the issues of accessibility, preservation, and ethics regarding bioarchaeological collections.

Thesis Organization

This thesis has been organized into seven chapters. The first chapter is this current chapter representing an overview of the project, site history, and the project's significance. This chapter is then followed by a theoretical background which provides the necessary context for digital modeling and its significance regarding accessibility, preservation, and ethics of bioarchaeological collections. Chapter three demonstrates the archaeological timeline of Çadır Höyük as well as the bioarchaeological context at Çadır Höyük. The archaeological context is then followed by the methods chapter elaborating on the bioarcheological methodology and data collection as well as the photogrammetry methods employed to create the three dimensional renderings. This chapter then leads into the analysis of the photogrammic models and a discussion on the uses and their viability for bioarchaeological analysis. The final chapter is comprised of concluding remarks and a discussion of how this research addresses the concerns of accessibility, preservation, and ethics on this collection at Çadır Höyük.

Chapter 2: Theoretical Background

The fields of bioarcheology and physical anthropology have made major advancements in recent decades. As a whole, the treatment of human remains has improved greatly due to new legislation and protections in many countries. Many scholars and researchers maintain high ethical standards while holding others in their field accountable for poor practice. However, this attitude, legislation, and accountability is not shared globally, and despite the progress the field still has a long way to go. Some of the main ubiquitous concerns in the field revolve around issues of accessibility, preservation, and overall ethics. Although no longer a new technology and frequently used in the field of archaeology for many applications, digital modeling and the digitization of bioarchaeological data is relatively underutilized in the field of bioarchaeology despite the myriad of practical research applications (Wrobel et al. 2019: 47). This technology has proven effective for accurate and ethical analysis, preservation, and increased accessibility for researchers (Novotny 2019; Ulguim 2018; Spiros et al. 2022; Wrobel et al. 2019).

The aforementioned issues of accessibility, preservation, and ethics were encountered with the collection of human remains at Çadır Höyük. These issues were arguably more challenging due to differing attitudes towards the treatment of human remains in the region, Turkish heritage regulations, and the remote and limited access to the collection. Utilizing digital modeling for this collection created a digital repository that not only made the collection more accessible, but also addressed issues of ethics and preservation while at the same time abiding by and respecting Turkish heritage regulations. Each of these issues is discussed in the following sections and comprise the essential theory framework for this thesis.

Accessibility

Access to skeletal collections in the field of bioarchaeology is a privilege that not all researchers share equally. "[T]hose with access to physical skeletal specimens and casts, full osteological collections, and education programs with traditional osteological training are amongst the privileged few" (Spiros et al. 2022: 708). This access is often limited to collections that researchers have at their university, if their university holds such a collection, and many of these collections have been subject to scrutiny regarding their origins and acquisition (Williams and Ross 2022). "This moral dilemma around scientific research that utilizes comparative human anatomy collections is particularly problematic for marginalized groups such as Africans and African Americans, whose remains were often acquired illegally and unethically" (Williams and Ross 2022: 861), and remains of Native America and indigenous people globally should be seen in the same light. This dilemma complicates research and colors what researchers have at their immediate disposal or can obtain grants or find the funding to travel to access other collections (Homerski 2023; Spiros et al. 2022).

This issue of accessibility is dramatically increased when it comes to international projects where the research team or project sponsor(s) travel from different countries and continents to work on specific sites. The study of these sites and their collections is often subject to time and cost restraints due to logistical, bureaucratic, and cultural factors (Heath-Stout & Hannigan 2020; Homerski 2023). Even when all permitting, paperwork, and local requirements have been fulfilled, there are often very tight time constraints that restrict the amount of research and data that can be collected (Homerski 2023; Novotny 2019). Additional hinderance and setbacks can occur in more remote, or off grid regions with limited-to-no power and internet, or regions of civil or political unrest. In the 21st century bioarchaeological researchers and students should have fair and reasonable access to ethically obtained bioarchaeological data and collections to foster better research, and ethically obtained data. Although not free of its own issues, ethical dilemmas, and shortfalls, digital modeling and the digitization of bioarchaeological data offers a promising strategy to reach these goals (Evin et al. 2019; Spiros et al. 2022; Wrobel et al. 2019).

In the field of bioarchaeology and physical anthropology, the study of human variation is fundamental to researchers' theoretical understanding of evolution, genetics, culture, and human interaction with the environment (Spiros et al. 2022). Bioarchaeologists create and utilize statistical models to assess correlations between skeletal morphology and things such as gender, ethnicity, age, and lifestyle; however, these models are based off observations and metrics collected from bioarchaeological collections. "Although understanding human variation is fundamental to biological anthropology, many programs and trainees have limited access to resources that allow them to study or experience the wide range variation" (Spiros et al. 2022: 708). Due to issues with accessibility, there is a lack of diversity in population-specific data that leads to skewed and inaccurate data based off lofty generalizations regarding human variability of all populations (Roberts and Mays 2011). "Ideally, researchers construct thoughtful, theoretically informed questions about the nature of human variability and then identify appropriate samples that can best provide the data to address these questions [;] However, such appropriate samples can be elusive, forcing researchers to modify their questions to fit the limitations of available datasets. The sources of many of these biases can be attributed generally to issues of preservation and access, which often dictate what is available to study" (Wrobel 2019: 47).

Simply having access to collections from a wide range of populations throughout various time periods is not the only issue, as the sample size and condition of the remains is also an important factor for collecting these essential data. Researchers prefer focusing on large collections to encapsulate more holistic and accurate population data (Roberts and Mays 2011; Wrobel et al. 2019). Although these larger and more well-preserved collections are invaluable, smaller and/or poorly preserved collections are often neglected despite the potential for "multiple small collections [to] produce sufficient data for statistical analysis" (Roberts and Mays 2011: 629).

Digital modeling, although not yet a one to one comparison with the physical collection, offers a very promising solution to the issue of accessibility. This technology can capture incredible detail, but a thorough bioarchaeological analysis of the remains should still be done with the physical remains rather than a rendering. Although some technologies such X-ray or laser scanning use expensive and specialized equipment, photogrammetry is a simple to learn and cost effective digital modeling method that can be done anywhere with minimal equipment (Evin et al. 2019; Hasset 2018; Novotny 2019; Wrobel 2019). Overall, digital modeling and digital datasets can be accessed from anywhere and can be shared easily among researchers.

Although there are great benefits to increased accessibility of bioarchaeological data and models, there are also ethical pitfalls that researchers need to be conscientious of in regard to open access and permissions (Hasset 2018). Although "3D data capture can enable greater reflexivity in bioarchaeological fieldwork, enrich post-excavation analysis and offer more opportunities for types of immersive, interactive, and informative engagement (Morgan and Eve 2012)"; "sharing should be done in a manner sympathetic to and respecting of the legal rights of the deceased and the communities involved, and ensure that contextualizing information and metadata are provided" (Ulguim 2018: 217). In order to effectively and responsibly share digital bioarchaeological data, researchers must address questions regarding permission, respect, justification, and education (Errickson and Thompson 2019; Spiros et al. 2022).

Preservation

Preservation is a persistent concern and critical issue throughout the field of archaeology, but human remains typically pose more challenges than other artifacts, most importantly because they are people, but also due to their organic nature. Human remains are constantly decaying and breaking down; although the process can be significantly slowed in certain conditions, organic material will inevitably break down and decompose over time. Certain conditions and factors, such as humidity, temperature, light, chemical reactions, insects, and handling, will exacerbate the disintegration and breakdown of organic materials like human and animal bone. (Doğan et al. 2022; Roberts and Mays 2011; Wrobel et al. 2019)

Although bone continues to decay over time, digital modeling, and digital data sets can be stored in perpetuity and can be studied and referenced without risking further damage. Additionally, this method captures a moment where decomposition and degradation have been frozen and the condition and integrity of the facsimile will remain unchanged, even long after the original organic material has decomposed or been reinterred. This hands-off approach can protect the condition and preservation of collections, as repetitive physical contact and handling of human remains leads to damage and loss of integrity over time; therefore, researchers must consider curation strategies for heavily researched and studied collections (Caffell et al. 2001; Roberts and Mays 2011; Wrobel 2019). In addition to heavy handling, many analytical methods such as isotope and DNA analysis require destructive sampling which requires the intentional damage of bone or tooth to acquire data (Evin et al. 2019; Roberts and Mays 2011; Wrobel et al.

2019). Whereas before digital modeling, destructive methodologies meant a total loss of potential data “it is now possible to easily acquire low-cost 3D models of bioarchaeological remains before their destruction or degradation” (Evin et al. 2019: 2).

This practice could provide data pertinent to a future methodology. Such was the case regarding a zooarchaeological study on canines where an inner ear bone, typically utilized for DNA analysis obtained via a destructive methodology, was found to have morphological markers indicative of domestication (Evin et al. 2019). However, due to the destructive sampling utilized in many collections over the years, these data on canine domestication have essentially been destroyed (Evin et al. 2019). Had the bones been digitally modeled prior to their destruction, “it would have been possible, for example, to perform a comparative study of hearing evolution during domestication and the possibility of using inner ear morphology as a domestication marker which alongside the compatible DNA analyses would have been invaluable for the advancement of archaeozoological research” (Evin et al. 2019: 4). Although the overall goal is to render destructive sampling and methodologies obsolete, for now digital modeling offers an immediate solution for preservation (Evin et al. 2019).

Inadequate storage contexts often contribute to the degradation of archaeological collections (Wrobel et al. 2019). Curation standards and conditions can vary greatly between excavation sites everywhere. This discrepancy can be due to lax curation requirements, lack of standards enforcement, and lack of funding and local resources. Rural and remote locations tend to encounter these issues more so than others. This often leaves researchers making do with what they have. “While long-term storage plans are usually required in applications for an excavation permit, solutions are typically inadequate, utilizing rented local houses or simple bodegas constructed at the sites to keep most excavated artifacts” (Wrobel et al. 2019: 48). These storage conditions often expose or even intensify poor climate conditions such as heat and humidity in addition to inviting pests such as insects and rodents (Wrobel et al. 2019).

Even in countries where cultural heritage is highly regulated and protected, like Turkey, archaeologists and museum professionals have voiced concerns regarding inadequate storage and conservation for human remains due to a lack of funding and resources (Doğan et al. 2022). Some professionals in Turkey have stated that the ambiguity of heritage laws in Turkish regulation in addition to a lack of resources "have resulted in a wide range of ad hoc decisions and varying professional practices" in regard to the curation of human remains (Doğan et al. 2022: 92). Turkish archaeologists have mentioned making attempts to move human remains to more suitable locations such as local museums or institutions but have been denied due to a lack of suitable storage (Doğan et al. 2019). These conditions will inevitably lead to the degradation of these collections and data loss. The ideal goal would be to improve the curation of human remains; however, the curation standards and resources available will not change overnight. Digital modeling offers a solution to collect essential information and store it in perpetuity prior to any potential damage. Not only will data be preserved, but there will be a comparative source to track and keep record of any potential damage or degradation of collections, including loss of provenience.

There are still limitations to using digital bioarchaeological data as a means of preservation. These data will not simply exist in perpetuity after their creation. Technology is not fool proof, errors happen, data can be corrupted, or devices can be damaged. Technology is ever changing and the filetypes used now may not be optimal in the future. Ensuring a curation strategy for a digital collection is just as important as one for the physical collection. It is crucial to have proper data storage to ensure multiple safeguards in the event that data are lost. Files should be updated regularly and managed to keep up with software or technology changes.

Ethics

The terms "ethics" and "ethical" are widely utilized and striven for in the field of bioarchaeology, but what exactly does the ethical treatment of human remains entail? The term ethics typically refers to a set of moral principles or values (Merriam-Webster). However, in a medical and scientific context, this refers to avoiding harm and protecting rights of the patient or participant (Kreissl Lonfat et al. 2015). This brings forth the argument of whether one can cause harm to the dead. Kreissl Lonfat et al., whose perspectives come from their bioarchaeological backgrounds in mummy research, categorize harm into two types: physical harm and harm to one's physical identity (Kreissl Lonfat et al. 2015). They further argue that both the interest in protecting the physical and the protection of personal identity "are attributed to a deceased person, [and] imply a duty of the living to protect these interests (Kreissl Lonfat et al. 2015: 1176). Creating guidelines that protect the deceased from these types of harm will provide a "sustainable way of research with and on human remains, now and in the future" (Kreissl Lonfat et al. 2015: 1179). However, harm to personal identity is very difficult to determine for ancient individuals, for whom we often have fragmented knowledge (Kreissl Lonfat et al. 2015). Under these circumstances the researcher has a responsibility to the individual's bodily integrity and must weigh the "invasiveness versus appropriateness" of their research methodologies (Kreissl Lonfat et al. 2015: 1180).

Not all cultures and countries that archaeologists and bioarchaeologists work with and within share the same attitude towards the treatment of human remains. Bioarchaeologists have a responsibility to concurrently respect the current beliefs, wishes, and regulations of the country they are working in, while also respecting the individuals whose remains they are studying. At times, these responsibilities conflict, leaving the researcher in a difficult predicament. For the country of Turkey nationalism and cultural heritage are deeply intertwined (Atakuman 2008; Doğan 2021; O'Donnabhain & Lozada 2014; Özdoğan 2002; Üstündağ and Yazıcıoğlu 2014), and at times the desired national narrative and the historical or archaeological narrative do not align, creating a very unfortunate ethical predicament for researchers and scholars. Within the country of Turkey, there are no current regulations on how researchers handle human remains specifically, as they are held in the same regard as all other archaeological material. Thus, their treatment is up to the discretion of the researcher. One study on the Turkish perspectives towards ethics and the management of human remains in Turkey quoted a prominent Turkish archaeologist stating "[c]oncepts such as ethics, ownership and stakeholder consultation are just typical examples of western sensitivities that are irrelevant to the Turkish context. Turkey does not even have any indigenous communities; why should archaeological human remains be anybody's business but the professionals?" (Doğan et al. 2021: 86). The same study quoted a Turkish archaeologist that stated that human remains "should not be differentiated from animal bones and evaluated free of ethical or emotional responses since 'the priority of science should be producing knowledge'" (Doğan et al. 2022: 93). Although this is simply not true, as there are indigenous populations within the country, nor do all Turkish people and Turkish academics believe this, this rationale is indicative of the institutional academic Turkish perspective, that stems from European colonialism, which has influenced the overall management and treatment of human remains throughout the country (Doğan et al. 2022).

Although predominantly European and North American in origin, there have been international efforts to address universal ethical treatment of human remains. In 1989 the World

Archaeological Congress [WAC] officially adopted the Vermillion Accord on Human Remains, which stipulated archaeological ethics and treatment of the dead (WAC 1989). Additionally, the International Council of Museums [ICOM] published their official code of ethics for museums which stipulates ethical treatment of human remains (ICOM 2017). They state this regarding culturally sensitive material: “Collections of human remains, and material of sacred significance should be acquired only if they can be housed securely and cared for respectfully” (ICOM 2017: 11). They further state, “research on human remains and materials of sacred significance must be accomplished in a manner consistent with professional standards and take into account the interests and beliefs of the community, ethnic or religious groups from whom the objects originated, where these are known” (ICOM 2017: 21). Based on the responses given by Turkish professionals it seems as though they do not agree with these guidelines and statements made by these global institutions (Doğan et al. 2022). In such circumstances, it can be very difficult for the researcher to navigate and determine best practices. Sometimes researchers must work within contradictory ethical standpoints from multiple stakeholders. Ethnographic methods and collaboration with descendant communities is often a great place to begin; however, is difficult when studying ancient individuals for whose beliefs and attitudes towards the dead are not always known. Every case is different, but one must find a balance between respecting the individuals you are studying, respecting wishes of their descendants, and respecting the community or country you are working within; however, a no harm strategy should always be the goal no matter the situation and balance of invasiveness versus appropriateness should be maintained.

Ethically there are many reasons to promote the use of digital modeling of bioarchaeological collections. Predominantly this methodology offers a non-invasive approach which addresses the ethical issues of bodily integrity and Kreissl Lonfat's argument of 'invasiveness versus appropriateness'. In addition, digitization of bioarchaeological data provides a mechanism for more ethical research while adhering to Turkish heritage regulations, respectful and cognizant of Turkish perspectives without imposing western perspectives and emotions regarding human remains. However, in addition to being an ethical solution, the introduction of digital bioarchaeological data and digital modeling has introduced many legitimate ethical concerns that span the entire "lifecycle of digital curation" (Ulguim 2018: 196). "Scholars have grappled with the use of human remains in research for some time including questions of photography as a mode of preservation, but only recently has new technology, such as digital scanning of photos and three-dimensional modeling, come into question ethically" (Spiros et al. 2022: 710). Bioarchaeologists have concerns regarding how and the extent to which bioarchaeological data are presented and displayed in order to avoid dehumanizing the individuals we digitize (Ulguim 2018). "If a picture is worth a thousand words, one could argue that a model is worth a thousand pictures, or a million words [;] however, a stand-alone model cannot be worth a million words, because more contextualizing metadata and paradata are essential for the assessment and reuse of their information" (Ulguim 2018: 208–209). Sharing these data is an essential factor for increasing accessibility and reflexivity of the research; however, researchers must address "metadata curation, accessibility, openness, copyright as well as the ethical implications of sharing digital bioarchaeological data and long-term storage requirements" (Ulguim 2018: 189). Moving forward with this increasingly utilized technology, best practices regarding digital bioarchaeological data and the sharing of, must be developed to be "sustainable, flexible and fast to implement given the pace of change in the digital world […] and simultaneously enable reflexivity and ethically engage new audiences" (Ulguim 2018: 191).

Summary of Theoretical Context

Digitization of bioarchaeological data and the creation of bioarchaeological models provides the field of bioarchaeology with an immediate solution for accessibility, preservation, and more ethical research that can be achieved at a low cost and performed on nearly any collection, at any site. Although there are potential risks and ethical pitfalls, when observing best practices and conscientious safeguards, the benefits of this methodology are significant. The collection of bioarchaeological data and creation of digital models offers an immediate solution to, in some cases, critical curation crises where data loss is imminent. Digital modeling and the collection of digital bioarchaeological data in Turkey offers a solution for researchers to access collections without the hinderance of time and financial constraints, is respectful of the subjects of study while also concurrently respectful of local heritage laws and Turkish wishes and attitudes regarding bioarchaeological collection management.

Chapter 3: Archaeological Context of Çadır Höyük

Excavations thus far at Çadır Höyük have documented a history of continuous occupation spanning over 6,000 years, from the Chalcolithic in the 6th millennium BCE, to the middle Byzantine period in the 13th century CE (Steadman, et al. 2019b: 21). With very few gaps in occupation, this site provides researchers a unique insight into the evolution of early Anatolian society through several distinct time periods. Given the vast occupational history at Çadır Höyük the location was clearly ideal for long-term-settlement. The mound sits upon a subtle natural rise in a river valley surrounded by rich soil and ample freshwater resources (Steadman et al. 2019b: 21). This area offered the residents, travelers, and conquerors many advantages due to the range of natural resources, fertile agricultural land, and access to roads (Ross et al. 2019: 299–300) Excavations and regional survey have found evidence of extensive long-distant trade routes through this region as early as the Middle Chalcolithic period (Steadman et al. 2019b). The data obtained from these excavations have been influential in painting a portrait of societal change through major historic events for over six millennia in this region that lay at the crossroads of several powerful empires that shaped the history of the world.

Timeline of Archaeological Context of Çadır Höyük

Over the six millennia of occupation at Çadır Höyük its inhabitants witnessed great cultural and societal change. The following is a brief synopsis of the major time periods during occupation at Çadır Höyük and what major discoveries have been made thus far. The dating for these time periods is specific to the Anatolian Plateau and is based off the dating of stratigraphic data, through pottery analysis, dendrochronology, and carbon-14 dating, produced from archaeological excavations throughout the region. These dates are widely debated and subject to fluctuation and overlap as more data are produced and dating methodologies improve.

Chalcolithic Period: (ca 6100 BCE – 3000 BCE)

The Chalcolithic period represents a transition from the Neolithic through the utilization and manipulation of naturally occurring metals, predominantly copper. Chalcolithic Anatolia witnessed the rise of some of the first complex urban societies in southwestern Asia (Steadman et al. 2019b: 22). This period saw an increase in agricultural development, globalization, industrialization, and complex socio-political structure. There is no clear time or place when this shift occurred and at "both the start and the end of the Anatolian "Chalcolithic" there is no perceptible break in cultural continuity" (Schoop 2011: 152). At Çadır Höyük, archaeological excavations have revealed a large, established, and well organized Late Chalcolithic settlement with some excavations confirming Middle Chalcolithic occupation as early as 5200 BCE (Ross et al. 2019: 300).

Although evidence of the Middle Chalcolithic has been confirmed, Chalcolithic excavations at Çadır Höyük have been predominantly from the Late Chalcolithic on the southern slope of the mound. The largest exposure of this Late Chalcolithic period at Çadır Höyük has been broken into two distinct consecutive phases. The first phase, the Agglutinated Phase, dates from approximately 3700 BCE to 3600 BCE (Steadman et al. 2019b: 23). Architectural features contemporary with this time consist predominantly of rooms with shared walls referred to as agglutinated architecture (Steadman et al. 2019b: 33). The Agglutinated phase at Çadır contains small rooms clustered around the edges of large courtyards, and this phase is defined by continuous minor architectural modifications (Yıldırım et al. 2018: 169). The next phase, referred to as the Burnt House Phase (3600–3200 BCE), shows a clear shift occurring where the overall layout of this area changed dramatically when the complex appears to have been destroyed by a hearth fire (Steadman et al. 2019b: 33). Much of the existing architecture of the

Agglutinated Phase appears to have been intentionally leveled to create space for "multi-use courtyards" (Yıldırım et al. 2018: 169). Several artifacts as well as child burial placed under the rubble suggest a ritual "house-killing" associated with the intentional destruction of the earlier phase (Yıldırım et al. 2018: 169). Buildings constructed following the destruction appear to be freestanding structures with the addition of designated domestic and non-domestic buildings enclosed by a "wall-and-gate system" (Steadman et al. 2019b: 37). One of these structures is an industrial compound referred to as the "Omphalos Building" (Yıldırım et al. 2018: 169). The assemblage of this area is predominantly comprised of non-domestic and industrial features and artifacts associated with the large scale production of pottery and ceramics (Yıldırım et al. 2018: 170). Evidence produced from these excavations suggests that Çadır facilitated subsistence and trade activities for surrounding settlements and could have functioned as an economic, and perhaps ritual, regional center (Steadman et al. 2019b: 31–37).

Bronze Age: (ca 2700 BCE – 1200 BCE)

The Bronze Age represents a critical moment in Anatolian history. In this time period we see the rise of large cities and the emergence of major empires. Some scholars refer to the Early Bronze on the Anatolian Plateau as a time of "urbanization" in which complex society and extensive far reaching trade networks flourish (Steadman 2011: 231). With the growth of populations and increase in social complexity, there is the development of monumental architecture, and metallurgy as not only for practical use, but as an important indicator of wealth and social status (Steadman 2011: 251–252). Around the Middle Bronze Age in the 2nd Millenium BCE two major imperial powers emerge in Anatolia; the Hittites centered at Ḫattuša, and the Phrygians centered at Gordion (Ross et al. 2019: 299). During the Bronze Age the Anatolian Plateau was dominated by Hittite rule, beginning an "unprecedented territorial and administrative unity" (Ross et al. 2019: 300). Following the establishment of Ḫattuša, Hittite military and diplomatic authority spread across the Anatolian Plateau, including settlements like Çadır Höyük which lay just 60 kilometers southeast of the capital city (Ross et al. 2019: 301). Hittite control dominated the region until its "catastrophic dissolution" marking the end of the Bronze Age in the Anatolian Plateau (Kealhofer and Grave 2011: 423). The fall of the Hittite empire is broadly encompassed in the phenomena known as the Bronze Age Collapse in which many of the large Empires of the Near East fell; speculations of their demise vary from military invasion to ecological disaster (Kealhofer and Grave 2011: 423).

At Çadır, the transitional period between the Chalcolithic and Early Bronze age has been documented. This Transitional period/ Early Bronze I (3200–2900 BCE) demonstrates a regression in socio-economic stability and population (Steadman et al. 2019b: 37). Structures from this period seem to lack the quality and stability of the Late Chalcolithic architecture, and the aforementioned wall-and-gate complex had been blocked and disregarded (Steadman et al. 2019b: 37). Both domestic and non-domestic activities are believed to be shifted further up the slope of the mound, and given their hypothesized location are currently inaccessible for excavation (Steadman et al. 2019b: 37). This evidence suggests that the population receded up the slope of the settlement as a result of socio-economic instability which starkly contrasts with the seemingly prosperous and flourishing economic center that existed just centuries prior (Steadman et al. 2019b: 37).

However, excavations in the Middle to Late Bronze reveal a "revival of political complexity, construction effort, and dedication to a long-term physical setting" (Ross et al. 2019: 300). Given the proximity to the Hittite Capital of Ḫattuša, Çadır Höyük interacted in many ways with the Hittite State (Ross et al. 2019: 300). Evidence suggests that Çadır operated as an ordinary Anatolian town, and the result of varying degrees of imperial pressure appear to show both continuity and change in Çadır during the second and first millennium BCE (Ross et al. 2019: 314). Changes in building types, and economic focus on agro-pastoral techniques are observed during periods of more imposing Hittite influence; however, residents of Çadır Höyük still "maintained traditional social and economic systems, with little evidence for differentiation or upheaval" despite the apparent Hittite political influence (Ross et al. 2019: 314–315). Although it seems as though Çadır maintained some cultural continuity, Hittite rule likely influenced some aspects of their culture and beliefs. Among the 2nd millennium assemblage are votive bowls, idols, and figurines similar to artifacts recovered in Hittite cultic contexts from contemporary sites (Gorny 2006: 42). Casemate walls are constructed and repeatedly rebuilt over the centuries through Middle to Late Bronze age at Çadır, increasingly moving up the slope or toward the interior of the mound over time (Ross et al. 2019: 302). By the end of the late Bronze near the precipice of the Hittite collapse, residents at Çadır appear to have shifted to more industrial activities indicative of metallurgy (Ross et al. 2019: 303).

Iron Age: (1200 BCE – 330BCE)

The Iron Age in the Anatolian Plateau begins with the fall of the Hittite Empire. The Early Iron is sometimes referred to as the Dark Ages as many once large and organized societies appear to fall apart with the collapse of imperial unity and appear to lose technologies such as writing. The Iron Age is defined by fluctuating imperial rule, sociopolitical complexity, and the development of iron technology. For some settlements, impacts of the Hittite collapse were felt harder than others and led to the demise of several settlements across the region; however, others like Çadır, persisted (Ross et al. 2019: 301). This demonstrated the settlement's "distinct regional cultural trajectory", resiliency, and ability to adapt to change (Ross et al. 2019: 301). During the

Middle (900–550 BCE) and Late Iron Age (550–330 BCE), the power void in the Anatolian Plateau was filled by the Phrygian state, shifting political control to the west at Gordion (Ross et al. 2019: 301). Over time Phrygian rule subsided due to Neo-Assyrian and then Persian military and political conflict (Ross et al. 2019: 302). The region of Anatolia eventually became encapsulated under the Achaemenid Empire, subjecting the region to Persian rule in the 6th century BCE (Dusinberre 2013: 1). Although placing a terminal date on the Iron Age is somewhat arbitrary for regions such as the Anatolian Plateau, most scholars mark the end of the Iron with the conquests of Alexander the Great of Macedon and beginning of the Hellenistic period in the late 4th century BCE (Matney 2011: 458).

The archaeological recoveries from Çadır's Iron Age occupation demonstrates this settlement's resilience, endurance, and adaptation to the ever changing imperial command over the region (Ross et al. 2019: 299). At Çadır it appears that the industrial activities that arose during the Late Bronze persisted but shifted focus following the deterioration of Hittite influence. Both industrial and domestic architectural remains of Iron Age occupation are observed at Çadır; however, the main occupation area seems to have been designated to the mound summit, while industrial activities were resigned to outskirts (McMahon and Steadman 2015: 75–76). Trench USS 4, located on the southern slope of the mound, appears to be an industrial area divided into small workspaces. Exposed features reveal a shift from metallurgy to leather and felt production (Ross et al. 2019: 304). By the Middle Bronze archaeological evidence demonstrates another industry shift to textile production, like thread and wool-working (Ross et al. 2019: 305). As of yet, the late stages of the Iron Age are not well represented, but evidence of textile production persists through the Late Iron Age, suggesting that this area was in use for centuries (McMahon and Steadman 2015: 76; Ross et al. 2019: 306).

Roman Period: (330 BCE – 330 CE)

The Anatolian Plateau sees yet another imperial power take command of the region by the end of the 4th century BCE with the conquests of Alexander the Great (Matney 2011: 458). Roman rule then assumes the Macedonian Empire by the late 4th century BCE following the Macedonian Wars. This period of Greek rule is referred to as the Hellenistic period. However, they did not yet have control over much of Anatolia, and the region was briefly controlled by two kingdoms, the Attalids and the Mithridatids, of mixed Macedonian and Persian descent (Mitchell 1984: 133). The Mithridatic Dynasty, or Pontic Dynasty, would have encompassed the Anatolian Plateau region. Although briefly contesting Rome's hegemony in eastern Anatolia, Pompeius Magnus defeated Pontus in 66 BCE, thus assuming full control of Anatolia (Mitchell 1984: 138). Roman rule brought the development of Roman infrastructure to Anatolia such as an extensive and well-maintained road network developed for administrative and military use, but also lent itself to commercial trade and travel (Belke 2017: 28). Control over rural areas such as settlements in the Anatolian Plateau was enforced by aristocratic families and military outposts. In Late Antiquity, Rome began to lose control and territory due to various Barbarian incursions and uprisings, and new states such as the Islamic Caliphate rising to power (Niewohner 2017: 1). Following the major territory losses, Rome was split into the Eastern Roman Empire and Western Roman Empire. Emperor Constantine established the capital of the Eastern Roman Empire in Constantinople, previously called Byzantium, and began Christian rule over the Anatolian region (Niewohner 2017: 1). In 476 CE the Western Roman Empire fell, and the Eastern Roman Empire in Anatolia survives as the last major territory of the Roman Empire by Late Antiquity (Koder 2017: 11; Niewohner 2017: 1).

Although the presence of Roman occupation at Çadır is known, excavations have not yet yielded much archaeological data from this period. Most archaeological evidence at Çadır from the Roman Period dates to the 4th through 7th centuries CE during the Late Roman/ Late Antiquity period (Steadman et al. 2019a: 15–16). Excavations from the North Terrace have revealed a "modest villa or farm with some elements of elite culture, including a well-constructed house and imported pottery" (Cassis et al. 2019: 323). Rural occupation during this period in the Anatolian Plateau is relatively understudied, but regional surveys have indicated the presence of "vibrant, active communities, which incorporated both traditional Roman elements and local identifiers" (Cassis et al. 2019: 324).

Byzantine Period: (330 CE – 1100 CE)

Although still considering themselves Roman, the Byzantine Empire represents an important political and cultural shift in Anatolian society. With the fall of the Western Roman Empire in 476 CE, Anatolia remains as the only remaining major territory of the Roman Empire persisting until the 11th century CE (Koder 2017: 11; Niewohner 2017: 1). Scholars refer to the Eastern Roman Empire as the Byzantine Empire following the establishment of the new capital in Constantinople that was previously named Byzantium (Niewohner 2017: 1). Over the course of the 4th century Anatolia had been Christianized, replacing traditional ritual and worship and establishing churches and cathedrals across the region (Koder 2017: 11; Niewohner 2017: 2). The Early Byzantine demonstrates a trend referred to as "ruralization" where urban areas decline, and rural areas prosper as people begin to leave larger cities and move to more rural areas (Niewohner 2017: 2). Rural areas saw an increase in quality, size, and population during this time until this trend was reversed in the 7th–9th centuries during Persian and Arab invasions when populations fled to seek the larger fortifications provided by urban cities (Niewohner 2017: 2).

The region once again sees a period of peace in the 9th century, and populations steadily began this process of ruralization again in the Middle Byzantine leading to the abandonment of many cities and the prosperity and resurgence of rural villages and settlements (Niewohner 2017: 2). A period of relative peace persisted until the arrival of the Seljuk Turks that once again drove populations to reinforce large urban defenses as the countryside was systematically devastated (Niewohner 2017: 2). Turkish conquest of Anatolia is achieved in the 11th century, officially ending Byzantine control over Anatolia (Niewohner 2017: 6).

At Çadır Höyük, excavations have revealed occupation from the Late Roman period through the 11th century CE when the site was officially abandoned (Steadman et al. 2015a: 106). Çadır's timeline functions somewhat independently from those that broadly encapsulate all of Byzantium. The Late Roman period is dated to the 4th–7th centuries CE (Phase I), followed by the Early Byzantine in the 7th–9th centuries CE (Phase II), and an additional five phases reflecting building and temporal events reflect the 10th – 13th centuries CE from the Middle Byzantine to the end of the Byzantine period (Steadman et al. 2019a: 15–16). In the archaeological record Byzantium is understood not as a whole, but as a "nexus of regional identities, individual sites, and the different time scales of the adaptive cycle" that is better represented as a "system of connected narratives representing individualized transition and endurance, with each regional and local narrative bearing its own significance" (Cassis et al. 2019: 321). This is a crucial approach for understanding Byzantine occupation in the Anatolian Plateau, and Çadır Höyük provides vital insights into this regional identity (Cassis et al. 2019: 322). The Byzantine excavations are predominantly resigned to the North Terrace of the mound, where a housing development demonstrates occupation from the 4th century CE to the Byzantine abandonment in the 11th century CE (Cassis et al. 2019: 322–323). Remains of a fortification on the mound appear to have been constructed in the Late Roman period and then rebuilt and fortified during the Byzantine most likely in response to Arab raids in the 7th–9th centuries when a more medieval economy arose due to "declining imperial reach" and individual settlements were left to defend themselves (Cassis et al. 2019: 324). Some sites in the region were abandoned altogether during this time, but others like Çadır Höyük persisted, but significantly reduced in size (Cassis et al. 2019: 326).

In the 9th century the Byzantine Empire recovered and resolidified their imperial control over Anatolia (Cassis et al. 2019: 326). At Çadır this is reflected by a period of considerable "renewal" identified in the refurbishment of homes and newly constructed, robust fortifications (Cassis et al. 2019: 326). Several building phases have been observed on the summit of the mound between the 9th through 11th centuries (McMahon and Steadman 2015: 76). Excavations on the summit reveal a solid defensive wall connecting at least two towers at the northern and southern ends of the mound (McMahon and Steadman 2015: 77). Within these walls, remains of an open courtyard, stable, storage building, a plaster bin, as well as other stone structures were documented, and a "lead sealing found in the storage building suggest it was in use in the late 11th century" (McMahon and Steadman 2015: 77). In the 10th – 11th centuries these fortifications appear to have become a "safe haven" for residents at Çadır as hasty reconstructions and reinforcements are made to the original fortifications (Cassis et al. 2019: 326–328). However, the construction efforts were not enough to stave off attack, and incursion from either Turkic tribes or "discontented Norman mercenaries" drove the population to flee (Cassis et al. 2019: 326–328). Archaeological evidence suggests that the people who chose to remain at Çadır amid the impending attack did not survive the incursion (Cassis et al. 2019: 326–328). Evidence of violence and abandonment is observed from the recovery of human remains, including the remains of two soldiers or guards, in addition to the recovery of complete animal remains within the stable that were abandoned and left to die as residents were unable to return (Cassis 2017: 373) (Steadman et al. 2019a: 17). This final incursion event demarcates the end of "permanent" occupation at Çadır Höyük; however, ephemeral occupation by an unknown population, potentially Turkic, Greek, or a mixed ethnic group, is observed on the terrace and summit of the mound in the 12 or 13th centuries (Cassis et al. 2019: 323).

<u>Bioarchaeological Context</u>

Over the six millennia of occupation at Çadır Höyük, the archaeological understanding of formal burial practices, with the exception of intramural child burials, are relatively undocumented, as the designated burial ground or cemetery has yet to be identified. The understanding of burial practices over the various time periods is based on regional examples from contemporary sites. Most recovery of human remains outside of prehistoric child burials, are understood to be atypical, circumstantial, or expedient burial practices. The following is a brief overview of the current understanding of burial practices at Çadır Höyük.

Intramural Child Burials

The practice of "intramural" child burial is widely performed and can be observed from prehistoric contexts through to modern times across the world; however, it is most notably documented in the ancient Near East, Levant, and North Africa (Yıldırım et al. 2018: 164). This practice is characteristic of cultural traditions and beliefs from the 5th to 2nd millennia BCE in Anatolia (Yıldırım et al. 2018: 164). The practice of intramural interment refers to the modification or construction of structures or architectural features to bury an infant within that structure or feature. Predominantly these burials are placed under the floors of homes, or within the walls of courtyards, and these locations could be used multiple times to inter multiple individuals within the same space (Yıldırım et al. 2018: 164). It is hypothesized that this practice highlights kinship connections to the dead, connection of the life of the family to the physical home, and a belief that the deceased family member would protect the living (Yıldırım et al. 2018: 164). At Çadır Höyük well over a dozen infant burials have been recovered in association with a variety of architectural features. The majority of these child remains have been recovered from the Late Chalcolithic levels (ca. 3700–3000 BCE) in both domestic and non-domestic spaces (Yıldırım et al. 2018: 164). However, the practice seems to have dwindled during the Bronze Age. The excavations of these burials in various contexts at Çadır demonstrate a "range of overlapping motivations" for this practice (Yıldırım et al. 2018: 164). It is presumed for most burials of this type that individuals were interred at various times through the life of a structure as deaths occurred; however, at Çadır there is an abundance of intramural burials whose interment coincided with ongoing architectural modification or construction, "either by being placed under the foundations or subfloor or by being built into the walls" (Yıldırım et al. 2018: 164). However, this could be attributed to both Chalcolithic building practices and a high infant mortality rate (Yıldırım et al. 2018: 164).

Adult Burial at Çadır Höyük

Adults at Çadır Höyük, throughout the lifespan of the site, who received formal burial treatment would have been interred in a designated cemetery or burial ground nearby, but outside of the settlement area. Given the longevity of this site, it is possible that there are multiple cemeteries, but no investigation has been performed to identify the location(s) or size. Adult remains recovered from the site thus far are predominantly fragmentary, expedient, or circumstantial interments, sometimes recovered in contexts of violence, as in the case of SMW2 L17, or in ritual/symbolic contexts. The only formal burial of an adult recovered from the mound is that of ST-3 F9. This burial is considered to be atypical as there was no clear circumstance for this individual to be buried in this location or manner, nor did it align with any known cultural practices at the site. This individual is presumed to be from the Byzantine period due to the placement of a Byzantine era ceramic placed at her hip. The grave shaft was dug into the 2nd millennium BCE level on the mound (Steadman et al. 2015: 118). The body was prone with her arms folded across her chest and aligned north-south with her head facing south. Byzantine burials would have been designated to a cemetery and buried east to west. This leads researchers to hypothesize that this individual was potentially part of a different ethnic group, presumably interred after the end of permanent occupation at the site. As excavations at Çadır Höyük continue and more research into the cemeteries is performed, we will be able to glean more insights into the burial practices at Çadır Höyük.

Creating a model of SMW2 L17 has opened up several avenues for additional research. This was a child who most likely succumbed to a violent death during an episode of turmoil at Çadır Höyük. Although not much remains of this individual, there is much we can learn from this individual's death. Given what the research has gleaned from Byzantine excavations in the 11th century, there is clear evidence of violence and abandonment of the site (Steadman et al. 2019a: 17). This individual most likely died during the events that led up to the destruction of this phase.

Chapter 4: Methods and Data Collection

Bioarchaeological Methods

The methodology of this research endeavor was twofold. In addition to creating a digital repository, I conducted a standard bioarchaeological assessment on the remains to record their current condition and collect as much metric data as I could within my timeframe. Both methodologies were equally important as the bioarchaeological data provides the necessary contextual information for the digital data. Due to the time constraints of the research season, as well as equipment and resource restrictions, a more intensive analysis was not included in the scope of this research endeavor. Rather the field goals were oriented to collect as much metric and photographic data as I could within my limited research window, as additional research could be gleaned post-fieldwork using the raw data and images.

To accomplish this, I utilized three skeletal data collection forms that I adapted from multiple preexisting forms to fit my specific research needs. One form was tailored for adult skeletal data, the second was specific to subadult skeletal data, and the third was for fragmentary human remains that did not require as much data. The forms consisted of detailed skeletal inventory charts, charts for craniometric data, postcranial metric data, dental analysis, entries for surface observations and condition of the remains, as well as the relevant scoring methods for different types of assessment such as age, sex, and stature. Scoring methods on different skeletal elements were derived from a combination of standard methodologies that will be further elaborated. Further ascertains requiring more than surface level observation, such as cause of death for most of the individuals, lifestyle, and ancestry, required more intensive analysis and was not included in the scope of the initial field data collection; however, these analyses remain possibilities for future research using the metric and digital data collected in the field.

Figure 1: Fragmentary juvenile remains from SES2 feature 18

To achieve accurate sex and age estimates a combination of several standard, widely accepted methodologies were employed for a more holistic approach. Age estimations were made based on metric data and physical attributes of dental development and tooth eruption rate (Meindl and Lovejoy 1989; Mincer et al. 1993; Moorrees et al. 1963a, b; Ubelaker 1978), suture closure (Buikstra and Ubelaker 1994; Meindl and Lovejoy 1985), third molar development and root closure (Mincer et al. 1993; Moorrees et al. 1963a; Moorrees et al. 1963b), sternal rib ends (İşcan et al. 1984), subadult long bone and girdle bone measurement (Cardoso et al. 2017a; Cardoso et al. 2017b; Scheuer and Black 2004; Ubelaker 1978), epiphyseal fusion (Krogman and İşcan 1986), craniometric measurements (Schaefer et al. 2009), and the pubic symphysis (Berg

2008; Brooks and Suchey 1990; Meindl and Lovejoy 1989). Sex estimations were derived from morphological attributes (Bass 2005), cranial features (Acsádi and Nemeskéri 1970; Phenice 1969), pelvic features (Acsádi and Nemeskéri 1970; Phenice 1969) and sacrum and os coxa features (Buikstra and Ubelaker 1994; Phenice 1969). Not all methods were suitable for each individual, as remains varied in stage of development, completeness, and preservation (Figure 1).

Digital Modeling Methodology

Figure 2: Katherine Titus using photogrammetry setup

As part of my digital dataset, I created a photographic skeletal inventory of each individual with high resolution images capturing every bone present in each individual. This photographic inventory was done in tandem with the skeletal inventory chart. I implemented multi-image photogrammetry on remains ideal for successful digital rendering. Unfortunately, only two of the ten individuals were suitable for imaging. I accomplished this using a Sony A6000 mirrorless camera, standardized Bureau of Land Management (BLM) photogrammetry scales, two collapsible LED lights, a PhotoBox and a turn table (Figure 2). The camera was placed on a tripod, and a remote was used to take the photos so that the camera would not be moved once I began taking images. The photo box and lighting were adjusted to eliminate

Figure 3: ST-3 F9 on turn table with photogrammetry scales

shadowing as well as any potential reflection. The remains to be photographed were placed on a turn table with three scales placed around it (Figure 3). Images were taken at consistent intervals marked on the turntable until a complete 360 degree rotation. This was repeated three times, with the camera positioned at three different angles capture the entire surface from multiple vantage points (Figure 3). The remains were then overturned along with the scalebars over to expose the other side, and the process was repeated. The scalebars are overturned so not to confuse the model scaling later in the process. Any bone that was not fixed to the skeletal material, such as loose teeth, being modeled was removed. To prevent any shifting of the object being captured a small amount of moldable clay was used to create an even platform for rounded surfaces such as the superior aspect of a cranium. Any movement of the object being captured between photographs would result in an inaccurate or failed rendering.

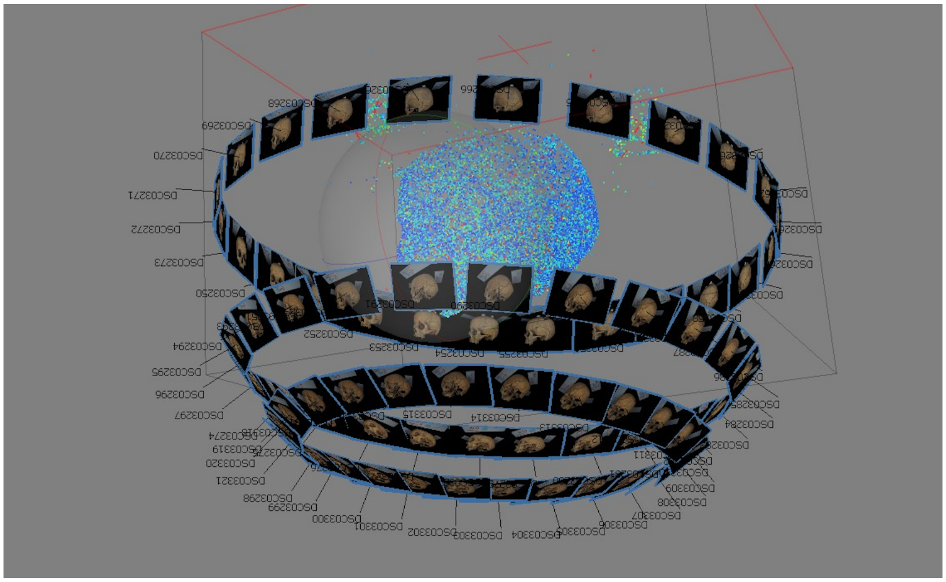

Figure 4: Screen capture of photo locations used to build model in AgiSoft

To build the three-dimensional models, I used a software called AgiSoft Metashape that processes digital images into three-dimensional renderings. Due to access restrictions on this program from my university during the time of my research in 2019, I originally outsourced my photographic data to a peer at Michigan State University, Jack Biggs, PhD, to build my models. The models he built were successful; however, a technical issue occurred after revisiting the data in 2024, the files containing the models unfortunately did not survive a file transfer from the cloud. However, the original photogrammetry photos taken during the field season were safe and were still able to be used to create new models. I gained access to AgiSoft in 2024 through the generosity of a colleague, Eric Prendergast, MA, and I was able to build the models firsthand using the images from 2019.

The process to build these models involved uploading the photos into the AgiSoft software. AgiSoft then compares each photo in relation to one another to create a point cloud of the object in the images. After optimizing the cameras and removing any inaccurate points in the point cloud, the model is built by interpolating the empty space between the known points in the point cloud. Upon completion of the model, a texture is created to mimic the texture captured in the photographs. The higher the quality of images taken; the more detail will appear in the model. Each completed model is created in halves, “chunks”, to build both sides of the model. Because the remains were moved when they were flipped over, the software cannot accurately interpolate all the images together. After creating a model for each half, corresponding identifiable points are selected on each model. The model chunk containing the face of the photogrammetry scales is used to create a scalebar for the model. Four points are selected from the markers on the BLM scales to create two scales in the model with known distances. The two chunks can then be aligned into a complete model.

After the model has been aligned, the known measurements on the BLM photogrammetry scales are entered between the corresponding four points to create two accurate distances. The entire model is then scaled to the parameters of these scales to create an accurate size and scale model. To further test the accuracy of these models, I performed a comparative analysis by replicating the craniometric measurements obtained on the physical remains with measurements taken using the models. To accomplish this, I placed standard craniometric landmarks on the models and created a scalebar to calculate the distance between each point.

Data Storage

The skeletal data collection forms filled out in the field were digitally scanned in the field to a local hard drive, and all digital data was shared onto a cloud drive shared with the Çadır

Höyük Team. The information was stored in multiple locations in attempt to form safeguards against any potential data loss. Any new data produced is stored on multiple protected devices and platforms to prevent data loss.

Chapter 5: Bioarchaeological Data and Analysis

During the duration of the 2019 research season, a total of ten individuals were examined, photographed and documented. Of the ten individuals examined, only one skeleton represented a full adult, and the remainder were subadult skeletons, varying in age and time period. However, of the sample two of the ten individuals were optimal for photogrammetry. This was due to the condition and preservation of the other remains; however, all individuals were photographed, inventoried, and given a superficial bioarchaeological analysis. A broad overview of data obtained from the other eight individuals is displayed in the table below, but the focus of the analysis will be on the two individuals, ST-3 F9 and SMW2 L17, that were digitally modeled.

The ten individuals examined during this research season only reflect a fragment of remains from Çadır Höyük. Due to time constraints, the collection of partial skeletal remains and those not attributed to formal burials were not included in this research endeavor, such as isolated hand or arm bones recovered. The individuals represented in this sample were selected based on complete formal burials of individuals who had not yet been sent to another repository, with the exception of the partial cranium of SMW2 L17, as this individual was optimal for digital modeling and supported important research questions at Çadır Höyük. Subadults make up the majority of the sample, as very few adult burials have been recovered from excavations so far. This is representative of the differing burial practices and beliefs between adults and subadults during prehistoric eras that have resulted in the substantial amount of infant and child remains exhumed from the site. Subadults were recovered predominantly from intramural burial contexts while adults that inhabited Çadır Höyük are believed to have been formally interred in a cemetery outside of the settlement that has yet to be located. The isolated adult burial, ST-3 F9, remains an outlier and poses several research questions as to why this individual was interred contrarily. Due to this, additional investigations of this individual could answer important questions about the latest phase of occupation at Çadır Höyük.

The tables below show a brief synopsis of the analysis of all ten individuals examined. These tables have been divided between adult and sub-adult individuals. More information and data could be gleaned from the adult skeleton due to several factors such as bone size, developmental changes, and pathology over time, whereas data from sub-adult skeletons can be limited due to their lack of development, and small bone size. The individuals are identified by their provenience with a trench and feature or locus number. The tables provide the year of excavation, the associated time period when the individual was interred, the overall condition of the remains, the burial type and associated grave goods, a sex and age estimate where possible, notes on pathological and health indicators, and presumable cause of death where possible. Dates and excavation data were provided using excavation notes and forms as well as published excavation reports (Steadman, et al. 2013, Steadman, et al. 2015, Steadman, et al. 2017, Steadman, et al. 2019). Following the tables a more in-depth analysis is provided for individuals ST-3 F9 and SMW2 L17.

Table 1: Bioarchaeological Analysis of Adult Skeletal Remains

Individual: ST-3 F9	
Year of Excavation	2013
Time Period	Byzantine (~1000–1100 CE)
Condition	Well-preserved. Post-mortem damage on right humeral epiphysis and left femoral epiphysis due to destructive analysis
Burial	Supine with arms folded across chest, oriented south-north (head facing South) with a Byzantine era ceramic pot placed at hip
Sex Estimate	Female
Age Estimate	18–24 years
Pathology & Health	Dental: Heavy attrition, moderate calculus, and linear enamel hypoplasias, twisted second maxillary molars, left maxillary canine

	grew laterally via aveolus of lateral incisor. No surface indicators of disease or trauma
Cause of Death	Unknown

Table 2: Bioarchaeological Analysis of Sub-Adult Skeletal Remains

Individual: USS9 L139	
Year of Excavation	2017
Time Period	Late Chalcolithic (ca. 3705–3210 BCE)
Condition	Poor preservation, very damaged
Burial	Tight fetal position
Sex Estimate	N/A
Age Estimate	Fetus, 7 to 9 months in utero
Pathology & Health	None observed
Cause of Death	Unknown

Individual: USS9 L97	
Year of Excavation	2014
Time Period	Late Chalcolithic (ca. 3500–3300 BCE)
Condition	Poor preservation
Burial	Flexed, Intramural, Jar burial
Sex Estimate	N/A
Age Estimate	Neonate Newborn to 6 months (closest est. 1 month)
Pathology & Health	None observed
Cause of Death	Unknown

Individual: USS10 L58	
Year of Excavation	2014
Time Period	Late Chalcolithic (ca. 3360–095 BCE)
Condition	Fair preservation
Burial	Flexed, Box burial
Sex Estimate	N/A
Age Estimate	Infant 12–18 months
Pathology & Health	Elongated skull (Cranial Modification)
Cause of Death	Unknown

Individual: SES2 F9	
Year of Excavation	2014
Time Period	Late Chalcolithic (ca.3100–3000 BCE)

Condition	Poorly preserved and very fragmented
Burial	Flexed, Intra-mural
Sex Estimate	N/A
Age Estimate	Infant 6–9 Months
Pathology & Health	None observed
Cause of Death	Unknown

Individual: SES2 L27	
Year of Excavation	2018
Time Period	Late Chalcolithic (ca.3100–3000 BCE)
Condition	Poorly preserved and very fragmented
Burial	Flexed
Sex Estimate	N/A
Age Estimate	~12 years
Pathology & Health	Dental Linear Hypoplasias
Cause of Death	Unknown

Individual: USS10 F44	
Year of Excavation	2013
Time Period	Late Chalcolithic (ca. 3090–2910 BCE)
Condition	Fair preservation
Burial	Flexed, pot burial, Intramural
Sex Estimate	N/A
Age Estimate	2–6 months
Pathology & Health	None observed
Cause of Death	Unknown

Individual: ST-7 F99	
Year of Excavation	2016
Time Period	Late Bronze/Hittite (~1500 BCE)
Condition	Very poor preservation
Burial	Half prone, half flexed
Sex Estimate	N/A
Age Estimate	Fetus to perinate
Pathology & Health	None observed
Cause of Death	Unknown

Individual: ST-7 F84

Year of Excavation	2016
Time Period	Late Bronze/Hittite (~1500 BCE)
Condition	Poor preservation
Burial	Flexed
Sex Estimate	N/A
Age Estimate	Perinate to 4 months
Pathology & Health	None observed
Cause of Death	Unknown

Individual: SMW2 L17	
Year of Excavation	2017
Time Period	Middle Byzantine (~1050 CE)
Condition	Well preserved, Left and Right Parietal Bones Only
Burial	Skull fragment associated with pit feature
Sex Estimate	N/A
Age Estimate	2–6 years
Pathology & Health	None observed
Cause of Death	Most likely sharp-force trauma to the skull

Analysis of ST-3 F9 and SMW2 L17

Individual: ST-3 F9

ST-3 F9 displayed hyperfeminine morphological traits and is presumed to be a biological female. She was buried in a grave shaft that cut into a Late Bronze Age, 2nd millennium BCE, context and was oriented with her head facing south (Stedman et al. 2015: 117–118). A Byzantine era pot was placed at her hip, leading the excavation team to believe her to be interred during the Byzantine period (Stedman et al. 2015: 118). This individual is the only formal Byzantine burial recovered from excavations at the mound and is uncharacteristic of Byzantine era burial practices. Based on information provided by the excavation team, this individual was potentially interred by a different ethnic group after the site had been abandoned.

This individual had been previously analyzed by another researcher whose analysis was published in an academic journal in 2015 along with the excavation's findings from that field season. Although the results of the analysis were brief, some of my findings differed from theirs. The initial analysis inferred that this individual had suffered from a "serious growth problem" and had attributed the unusual burial to this individual's physical abnormalities. However, I did not observe any unusual growth abnormalities, outside of her small stature and dental malformities, and I do not believe that any physical attributes were cause for her atypical burial (Steadman et al. 2015: 119). This individual's small stature and dental abnormalities are most likely attributed to nutrition during development, genetics, and lack of modern dentistry. I do not believe that any persuasive evidence exists for this individual's physical appearance attributing for her atypical interment.

In addition to my contrary analysis of physical abnormalities, I believe this individual to be younger than previously estimated. Based on molar wear pattern and the Complex Method of

Figure 5: ST-3 F9 Right humerus cross section and damage

Acsádi and Nemeskéri (Acsádi and Nemeskéri 1970), analysis estimated this individual to be between 28 and 37 years old at time of death (Steadman et al. 2015: 118). Although somewhat dated, this method is still widely used; however, it is not perfect. This method uses a combination of four skeletal elements to obtain an age range for an individual, and a more accurate range can be obtained when all four indicators are accounted for. In the case of ST-3 F9 only two of the four skeletal indicators could be used to calculate an age estimate. However, a recent study found that the Complex Method "tends to overestimate younger ages and underestimate older ages for all skeletal element combinations" (Meyers et al. 2021: 10). Not only is this method not optimal for potentially younger adults, without the use of x-ray imaging this testing requires destructive analysis. In this case, the previous researcher sawed the proximal ends of both the humerus and femur to expose longitudinal cross sections for the analysis (Figure 5) (Steadman et al. 2015: 118). This analysis not only damaged the remains, but it was unnecessary as this method was not well suited for this individual and yielded skewed results. This damage subsequently led to the disintegration of the fragile cancellous bone which has resulted in data loss. Several other newer and more trusted methods using other skeletal indicators can be used to obtain an age without destructive analysis and are better suited for this individual.

Using multiple age estimation methodologies from different skeletal elements, I estimated this individual was most likely between 18 and 24 years old at time of death. Although the discrepancy in age estimation is not extreme, it is important that we practice ethical methods of data collection prior to destructive analysis, especially if the method is not adequate or necessary for the subject you are working with. In this case, it was clear that this was a potentially younger adult based on several skeletal indicators; therefore, the Complex Method would not give an optimal age range for a younger adult in addition to not having reference to all

Figure 6: ST-3 F9 heavy attrition of 1st and 2nd molars

four skeletal markers. Although the severe attrition to the first and second molars (Figure 6) could suggest an older adult, the third molars have little to no wear, suggesting that they erupted shortly before this individual had passed. In addition, the sagittal suture has not fully closed, which typically fuses between 21-30 years of age (Calandrelli et al. 2021). The severe molar attrition is most likely attributed to diet rather than age. Inspection of the roots of the third molars showed that they were not yet fully developed (Figure 7). Using a combination of methods, the degree of third molar root closure displayed by this individual suggests someone most likely in their late teens or early twenties (Mincer et al. 1993; Moorees et al. 1963a; Moorees et al. 1963b). In addition to the dental development observations, using the İşcan et al. 1985 method of investigating the sternal ends of the 4th ribs (Figure 8), this individual showed characteristics of a late teen to young adult (İşcan et al. 1985). Although only one sternal rib end was intact enough for analysis using this methodology, the combination with the other skeletal elements indicate that this individual was closer to their late teens or early twenties, opposed to the previous estimate of this individual ranging between 28 and 37 years of age.

Figure 7: ST-3 F9 mandibular third molar unfused roots

Figure 8: ST-3 F9 sternal end of left fourth rib

Individual: SMW2 L17

Based on excavation data, this individual is believed to have died during one of the later phases of occupation during the Middle Byzantine period (11th century CE) at Çadır Höyük. Only the left and right parietal bones were recovered from excavations (Figure 9); however, much can be told from these fragmentary remains. The excavation reports assumed this individual to have been an adolescent; but bioarchaeological analysis suggests this individual was a child. Based on the general size and density of the cranial vault, the unfused sutures, and the lack of a fontanelle this individual seems to have been between two and six years old at death. Without any dental or postcranial data, a more accurate age range could not be determined. Evidence from excavations of the Byzantine levels at Çadır Höyük suggests episodes of violence

Figure 9: SMW2 L17 posterior side of cranium

Figure 10: SMW2 L17 sharp force trauma to right parietal bone

during the 11th century, ultimately resulting in a violent end to occupation. Analysis of this individual appears to reinforce this narrative in regard to both the burial context and the appearance of trauma to the cranium. This individual was interred in a pit feature just below a level containing comingled remains. Other artifacts and identified features contemporary with this level also confirm a destructive event occurred during this phase (Steadman et al. 2019a: 20). A 30mm wide laceration (Figure 10) penetrating the bone is observed on the right parietal bone indicative of sharp force trauma that was most likely the cause of death for this individual. Placement of this wound suggests the individual could have been fleeing from attack, was unaware the attack, or was executed, as it is on the back the skull, and this act in conjunction with the age of this individual demonstrates the brutality of this event.

Chapter 6: Analysis of Digital Modeling

Of the ten individuals in the sample, only two were optimal for three dimensional rendering with the time, technology, and equipment available during my 2019 research season. Renderings of the crania and jaw of ST-3 F9 and the partial crania of SMW2 L17 were successfully created post-field from the images taken in the field lab using the AgiSoft software (Figures 11, 12, & 13). After completing the models, I was able to compare the physical craniometric measurements taken in the field to craniometric measurements obtained from the digital renderings to determine how reliable these models can be for bioarchaeological analysis.

Figure 11: Digital model of ST-3 F9 cranium

Figure 12: Digital model of ST-3 F9 mandible

Figure 13: Digital model of SMW2 L17 cranium

Unfortunately, eight juvenile individuals, and the post-cranial skeleton of ST-3 F9 were not digitally modeled due to time and resource constraints. In an ideal scenario, all ten of the individuals analyzed in this research season would have been digitally modeled. However, due to the fragmentary state and small size of eight of the juvenile individuals, as well as the large size and volume of adult post-cranial remains, the required effort to attempt modeling them would have required more time and resources than I had at my disposal. In addition, the likelihood of creating a successful model from these images would be much lower, as the shape, size and surfaces would likely not image very well with the method and equipment I used in this endeavor. This is why many who use this methodology in the field of bioarchaeology working in foreign countries and have limited equipment choose the crania for digital modeling as it is a compromise between ease of modeling and amount of data that model can yield. As technology improves, this process will likely become more simplified, reducing the time and resource constraints, and become more applicable to field imaging of fragmentary post-cranial remains.

Although not as detailed as a high-resolution photograph, the renderings of ST-3 F9 and SMW2 L17 still achieve an impressive degree of surface detail. Whereas traditional photographs distort measurements, especially with rounded objects, the digital models can be moved and manipulated to achieve measurements of nearly all surfaces captured in the model. This is an excellent tool for bioarchaeologists performing post-field research, as all surfaces can be easily examined. For many performing post-field research using standard photography alone, they must rely only on the photos taken in the field and hope that they captured every element they require for future use. With the three-dimensional rendering all surfaces are captured and can be examined from any perspective (Figures 14, 15, & 16).

Figure 14: Digital model of ST-3 F9 (anterior, right, posterior, left, inferior, superior)

Figure 15: Digital model of ST-3 F9 mandible (posterior, superior)

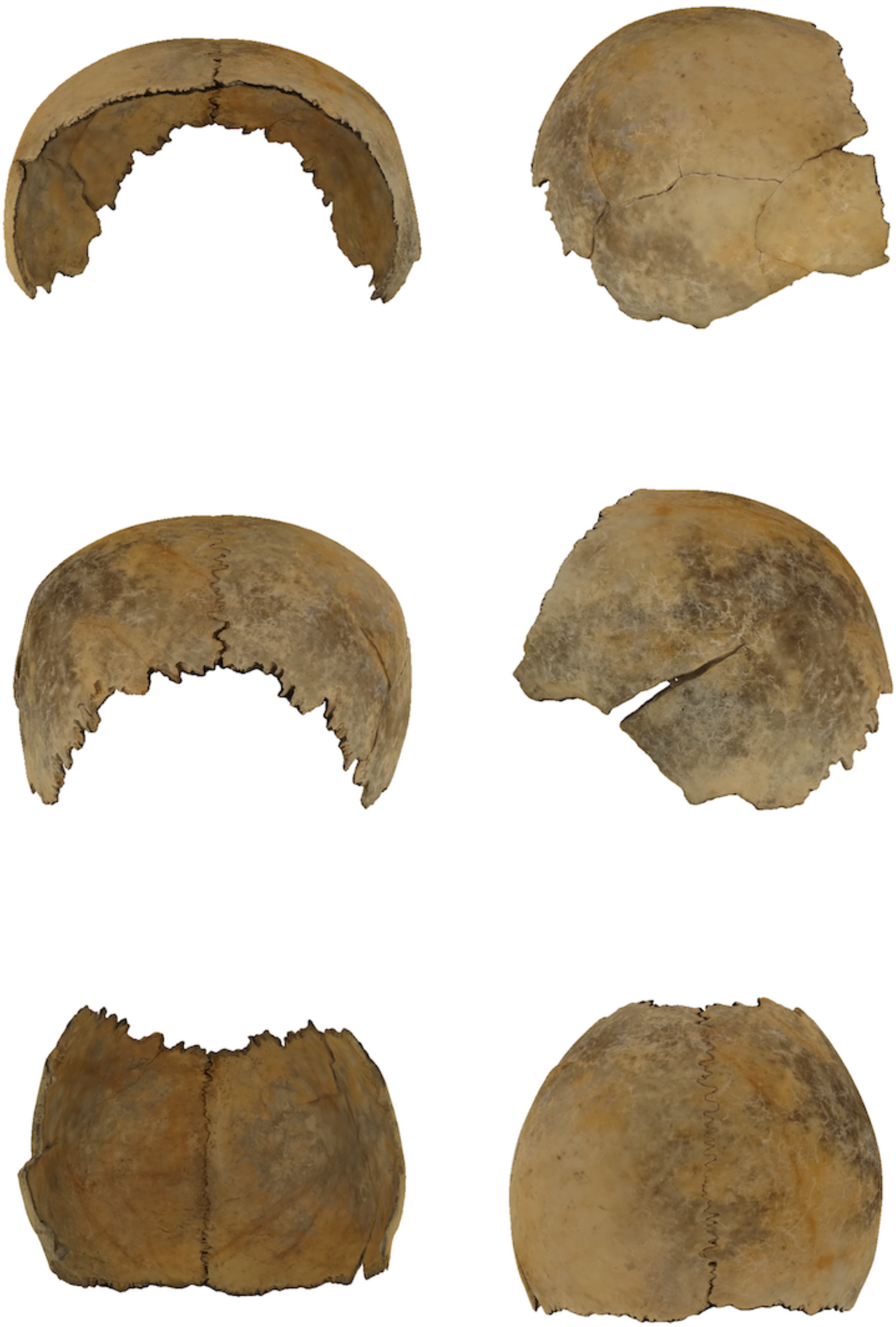

Figure 16: Digital model of SMW2 L17 (anterior, right, posterior, left, inferior, superior)

Measurement Accuracy

To determine the reliability of these renderings for bioarchaeological analysis I compared standard craniometric measurements obtained in the field from the physical crania of ST-3 F9 and SMW2 L17, with measurements obtained from the digital models in AgiSoft. After validating that my models were scaled accurately to my photogrammetry scales, I placed standard cranial landmarks on the models (Figure 17) (Buikstra and Ubelaker 1994). After placing these landmarks, generating the craniometric measurements was very simple and fast as it only required creating a scale bar between any two points on the model (Figures 18 & 19). Measurements were obtained to the thousandth of a millimeter whereas caliper measurements were within one-hundredth of a millimeter. Obtaining these measurements proved to be easier and faster than performing these measurements on a physical cranium with sliding calipers.

In addition to being more efficient, this method was arguably more accurate as it is much easier to replicate measurements, which is notoriously difficult in the field of bioarchaeology. Error is common in craniometric measurements due to mechanical difficulty with measuring equipment, landmark ambiguity, bone irregularities, and researcher error (Heathcote 1981: 34). It is often very difficult for one researcher to replicate the exact measurements of another researcher on the same cranium. However, a digital dataset has the potential to improve measurement reproduction. One study created a comparative analysis of craniometric measurements across multiple data formats including three-dimensional scans. This study found that more complicated landmarks continued to have a high variance in measurements, but others were found to be highly reproducible (Richard et al. 2014).

When comparing the measurements taken in the field with the digital models, I found that the average error margin was a 1.2mm difference between the two metric datasets. Ninety-seven percent were within ±5 mm of the physical measurements, seventy-nine percent were within ±1mm, and forty-six percent fell within ±0.5mm. Although the error margin is relatively small, this should be examined in a broader intra- and inter-observer study using a larger sample size before drawing absolute conclusions. In addition, other photogrammetry software should be compared as well to further determine the reliability and accuracy of this method. However, for the purpose of this study, this small error margin suggests that these measurements are reliable if not arguably more reliable than the physical measurements as there is a greater rate of replicability within the dataset, and less influence of researcher or mechanical failure. In addition, this method of measurement allows researchers to manipulate the skeletal remains and obtain precise measurements without contact and risk of harm as the metal surface of these tools can cause surface damage to the bone.

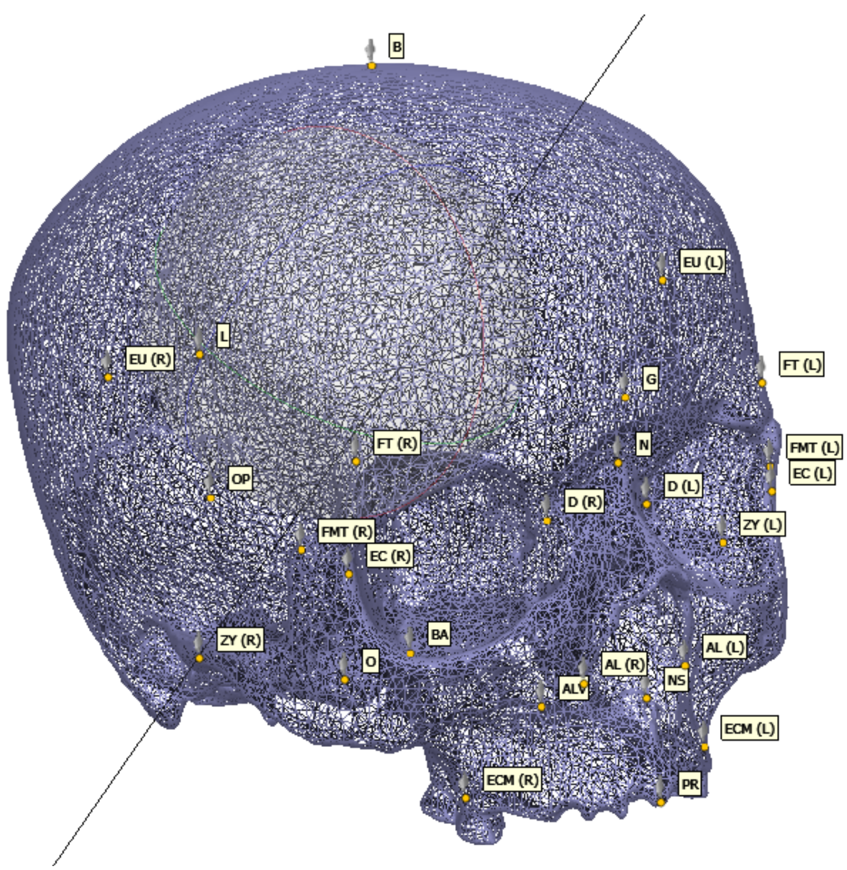

Figure 17: Digital model of ST3- F9 with cranial landmarks

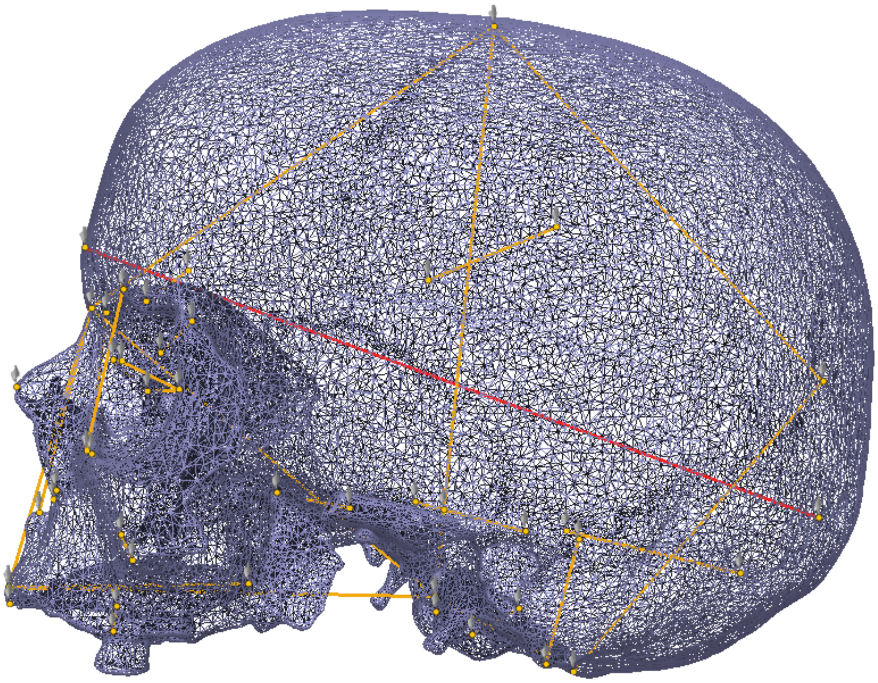

Figure 18: Digital model of ST-3 F9 craniometric measurements left side view

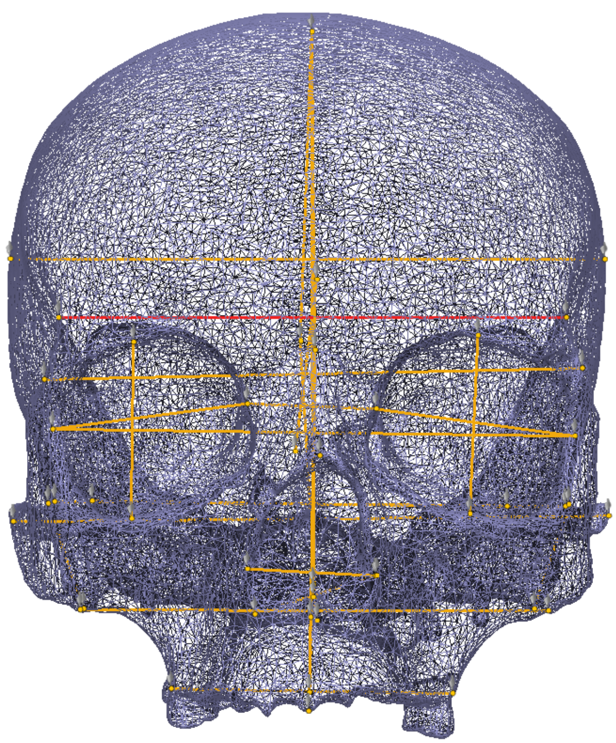

Figure 19: Digital model of ST-3 F9 craniometric measurements anterior view

Future Applications of Digital Modeling

As new methodologies are developed and new technologies emerge, additional data may be required to perform new analyses. Bioarchaeologists are prolific in their exploration of finding better and new ways to analyze skeletal remains. One of the most changing aspects of analysis is finding population specific studies, as humans vary physiologically from one population to another. Proper analysis on less studied populations is often hindered by a lack of diversity in comparative data. However, as more and more populations are researched, new comparative datasets are generated resulting in better bioarchaeological analysis.

Great advancements have been made in the form of shared worldwide databases to input metric data of bioarchaeological collections as well as modern forensic skeletal remains. FORDISC is one of the leading skeletal databases and currently provides age, sex, stature, and ancestry estimations based on metric data from skeletal measurements. However, as a forensic analysis program that is geared towards modern populations, it is not ideal for accurate estimates for historic or ancient populations. Although there is not yet a FORDISC equivalent for bioarchaeological analysis, there are many scholars working on comprehensive bioarchaeological databases. This is predominantly due the aforementioned issue of a lack of diversity in population specific data. With the further development of bioarchaeological databases, AI technologies, and improved algorithms, digital models may become the preferred dataset over traditional metric data. Databases and software are already being developed and employed to interpret digital models of human remains to compute bioarchaeological analyses such as ancestry estimation from three-dimensional renderings (Pengyue et al. 2021). As it is still relatively early in the development of these programs, an open source for this is not yet available to researchers. However, photogrammetry may become an essential part of the bioarchaeological toolkit.

Many possibilities remain for future research on the datasets collected from Çadır Höyük. Three dimensional renderings on other collections have proven to be effective for assessment of skeletal features, ancestry estimation, trauma examinations, and facial reconstruction (Jurda et al. 2019). Given the atypical burial context of ST-3 F9, an ancestry analysis using the digital model may provide crucial insight into motivations behind this individual's interment. The digital model of SMW2 L17 can provide answers to several remaining questions about this individual. Due to the lack of dentition and sub-cranial skeletal material, providing an accurate age estimation is difficult. Additional non-standard measurements of the parietal bones can be compared to a study on cranial ratios to determine a more accurate age estimation (Fife 2014). In addition, the digital rendering can provide insights on the sharp force trauma injury similar to forensic analysis to determine the type of weapon, force, and trajectory that was wielded to cause it. This may provide evidence as to what group may have been responsible for the violence and destruction, as it has yet to be determined who was responsible. Insights into the type of weapon used could help narrow down what group may have been responsible.

Key Takeaways

These digital renderings of the crania allow researchers to glean much of the same data that the physical crania would, as the craniometric comparison suggests that these facsimiles are quite accurate. However, there are drawbacks from this approach as it is not yet a one-to-one comparison to the physical skeletal remains. This methodology is not a replacement for physical analysis of human remains, but rather is a tool that can be employed to facilitate research constraints as well as address pressing concerns in the field of bioarchaeology.

Chapter 7: Conclusion

This research focused on a mixed methodology approach by incorporating digital data collection and photogrammetry that centered on ethical research practices. The results of this endeavor produced several intriguing insights. A total of ten individuals were given a preliminary analysis, and a thorough physical and photographic inventory was created. Of the ten individuals, two were optimal for photogrammetry, and two three-dimensional facsimiles of their crania were created. The rendering's accuracy and viability of this dataset was tested and found to be reliable. This project created a tangible, reliable dataset that did not exist prior, increasing accessibility so that the data can be studied by researchers outside of the country of Turkey. The data produced can easily be analyzed, and shared in a manner that does not involve additional handling or transportation that could result in damage, loss, or disrespectful treatment of the individual. Future research can be performed using this data ethically and non-invasively while also adhering to the local heritage laws and regulations.

The goal of this research was to create a digital dataset, including the bioarchaeological data, photographic inventory, and three dimensional renderings, to increase accessibility, preservation, and ethical research practices on this sample of remains at Çadır Höyük. Employing photogrammetry in this endeavor proved difficult as the majority of the remains in my sample were too damaged or fragmentary to produce successful models. Although the process of creating models of fragmentary remains is possible, currently the creation of successful three dimensional renderings of fragmentary remains and sub-cranial skeleton was not possible in the scope of this project. The two successful models rendered from ST-3 F9 and SMW2 L17 provide accurate three dimensional facsimiles of two crania that can be analyzed and measured to a high degree of accuracy. As many important research questions surround the deaths and contexts of these individuals' interments, these models can be accessed and shared indefinitely among researchers without the risk of additional damage or unnecessary handling. Unlike the physical remains, these models can be shared outside of the country and even 3D printed into a physical replica for additional research without the physical remains being present.

The damage and inaccurate analysis of individual ST-3 F9 presents intriguing insights into why addressing preservation, accessibility, and ethics is so important. The destructive testing on individual ST-3 F9 was not only unethical and unnecessary but destroyed the integrity of some skeletal elements. Destructive testing can sometimes glean important data that cannot be obtained using other non-invasive methods. However, the researcher must contemplate whether the outcome of the analysis outweighs the destruction or damage of the sample. Using destructive testing on human remains adds additional ethical considerations that must not be taken lightly. Although the ethical sentiment regarding the treatment of human remains is not shared universally, there are also many other reasons most researchers can agree upon as to why this testing is not always the best course of action. Once the sample or specimen is destroyed it cannot be reversed, and it is unlikely that any more data can be gleaned after. In the case of ST-3 F9, the destructive analysis was not necessary as several other skeletal indicators could have been used to achieve the same goal, and with more accurate results. The destruction of the epiphysis of the humerus and femur have advanced the decay of the remains, leaving the remains more fragile as the delicate internal cancellous bone erodes and leaves the epiphysis hollow. Currently this damage has created data loss and will lead to more data loss in the future. Additionally, without any photographs or documentation of these areas prior to the damage, unfortunately that data can no longer be recovered. From an ethical perspective, I believe that the application of this methodology without the proper documentation of the process was inappropriate. As researchers we have a responsibility to protect the identity and personal interests of the individuals we study. However, it is important to highlight cases such as this to learn from so we may better prevent harm in the future. Employing more ethical practices and weighing the "invasiveness versus appropriateness" of research methods will help create more sustainable research practices now as well as in the future (Kreissl Lonfat et al. 2015: 1179–1180).

The previous age assessment of ST-3 F9 placed this individual in an age range of 28–37 years at death, whereas my assessment placed her more likely in the range of 18–24 years at death. Although this age estimation is not drastically different, the life experience of someone potentially in their late teens versus their late thirties is very different given the shorter life expectancy during the Byzantine period. The life expectancy during the Byzantine period in Anatolia was affected by high mortality rates during childbirth, infant mortality, disease, living conditions, and diet (Demirel 2017). This was most likely a younger adult who, despite the shorter lifetime expectancy, still had many years ahead of them. This individual was within healthy childbearing age, and showing no indications of physical disability or injury, would have been an asset to their family and community. Whereas an individual in their late thirties during this period would potentially have more health risks during pregnancy and would have been considered an older member of society. Although this individual's age in no way detracts from their presumed value to their family and community, it shifts the narrative of this individual's life experience. Although difficult to achieve with ancient individuals, as there is much we do not know about them, giving identity to these individuals and recognizing them as people each with their own individual life experiences and beliefs is important.

Analysis of SMW2 L17 was intriguing as the evidence of sharp force trauma reinforces the archaeological understanding of Çadır Höyük during the 11th century. Previously assumed to be an adolescent, this analysis estimates this individual to be a young child. This analysis shifts the perception of this individual and highlights the brutality of the events that led to the downfall of permanent settlement at Çadır Höyük. The digital modeling of this individual was important. Due to the lack of development of these bones they are very fragile, and any additional handling of these remains could lead to additional damage. With the three dimensional rendering and metric data collected, these remains can continue to be studied non-invasively without additional contact.

Currently we are witnessing a time in the field of bioarchaeology where great advancements in both ethics and technology are coalescing, and this research is more relevant than ever. Digital modeling and digital data collection on this collection exemplifies the viability and practicality of incorporating this methodology and offers immediate solutions for issues pertaining to preservation, accessibility, and ethical treatment of these remains. Although not without flaw, the application of this methodology to this field is still relatively new and will continue to improve in the future. Researchers must be conscientious of issues pertaining to data loss, ever changing technology, and unethical data sharing to avoid potential mishaps or failures and appropriate data management, and a digital curation plan should be implemented to provide for extended accessibility into the future.

The dataset collected during this project offers a multitude of research possibilities utilizing the digital models. More testing should be conducted to further validate the replicability and accuracy of obtaining accurate craniometric data by using a larger sample collection, using multiple software platforms, and multiple researchers. In addition, all skeletal remains from the

Çadır Höyük project should be inventoried and photographed in the same manner as the small sample I studied, and where possible three dimensional renderings should be created. This way the entire collection can be accessed remotely and referenced for subsequent research endeavors without severe hinderances of cost and time constraints. This also avoids further damage to remains with less contact and handling. Easier access to these data will result in more research and better results as the data can easily be shared by among multiple researchers without the need to travel. As these data pertain to human remains, it is considered sensitive, and it will be up to the discretion of the Çadır Höyük team as to who can access these data. Especially in this context, it is important to respect the cultural, legal, and ethical standards of the host country, as well as the population you are researching, including the descendant communities when possible. So long as these stakeholders are being respected and regulations abided by, implementing this mixed method approach will benefit all involved. The data obtained from this collection have already yielded intriguing insights, and the datasets offer even more research potential that will result in a better understanding of the people who inhabited Çadır Höyük. This methodology should become standard practice for bioarchaeological research, not intended to replace the physical study of human remains, but as an integral tool for research that not only enhances research potential but addresses several critical issues in the field.

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