

ANCIENT CELTS: MYTH, INVENTION OR REALITY? DENTAL AFFINITIES AMONG
CONTINENTAL AND NON-CONTINENTAL CELTIC GROUPS

By

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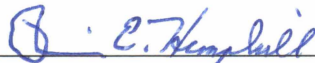
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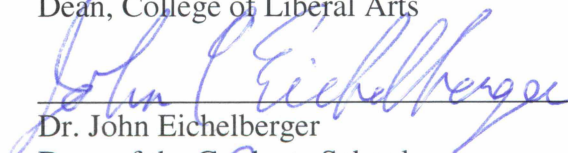


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ANCIENT CELTS: MYTH, INVENTION OR REALITY? DENTAL AFFINITIES AMONG
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A

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Abstract

Dental anthropological study of the proto-Celts, and continental and non-continental Celtic tribes during the Iron Age, particularly its applicability in estimating biological affinities of these tribes, has been generally overlooked. The present study helps fill the gap in the current understanding of these groups in several ways. First, 36 morphological traits in 125 dentitions from four regional samples, representing the proto-Celts, the continental and non-continental Celts, along with a comparative European Iron Age sample, were recorded and analyzed. Frequencies of occurrence for each dental and osseous nonmetric trait were recorded for each sample. Second, the suite of traits was then compared among samples using principal components analysis, (PCA), and the Mean Measure of Divergence (MMD) distance statistic. Multidimensional scaling and cluster analysis were subsequently employed on the triangular pairwise MMD distance matrix to graphically illustrate the relationships between samples. These biological distance estimates suggest the following: 1) dental phenetic heterogeneity is evident across samples, 2) the proto-Celtic sample does not show any evidence of population continuity with the continental Celtic sample, 3) there is a significant difference between continental and non-continental Celtic samples, and 4) there is a comparably significant difference among the Celtic, proto-Celtic and comparative samples. Simply put, the comparative results suggest that these groups represent biologically distinct populations. These findings were compared with published cultural, linguistic, genetic and bioarchaeological information to test for concordance between dental analysis and other lines of evidence. Several previous studies defined the Celts linguistically, using languages to link all the populations. The present study does not support these findings, and suggests there is more genetic diversity than previously assumed under this linguistic hypothesis.

Thus, it appears that the transition from proto-Celtic to Celtic culture in these regions, and the subsequent spread of Celtic culture to Britain during the La Tène period, may have been primarily a cultural transition. The present study comprises the most comprehensive dental morphological analysis of the Celts to date, contributes to an improved understanding of Celtic tribal relationships and microevolution, and provides an initial impression of Celtic relationships to other European populations during the Iron Age.

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Chapter 1: Introduction

The term Celt has been applied to various groups and /or cultures since 700 BC, and has been used to describe populations at various levels of specificity. In this study, the term Celt is used to refer to populations associated with the Hallstatt and La Tène cultures, which have been associated with the Celts through linguistic and archaeological evidence since the 19th century. The Celts are collectively known as a group of people in Iron Age Europe who spoke Celtic languages and had cultural similarities. However, the relationship between the biological, linguistic and cultural factors within and among the groups remains uncertain. A few limited studies have been undertaken to look at dental nonmetric traits among European populations from specific regions, but none have examined the distribution of these traits among the diverse populations associated with the Celts.

Biological affinity between and within human populations can be determined through biological distance analysis, which reflects both genetic and environmental differences (Bunimovitz, 1990; Buikstra, 1977; Buikstra et al., 1990). Biological distance, or biodistance, is an analytical method for measuring the relative divergence within and between populations through morphological (e.g., dental morphology and nonmetric cranial markers) and metric (e.g., geometric morphometric, odontometric and craniometric analysis) variation in bones or teeth in order to define patterns that are presumed proxies for genetic data (Bunimovitz, 1990; Buikstra et al., 1990; Hillson, 1996; Irish, 1993; Larsen, 1997; Turner, 1983; Turner et al., 1991). Data derived from biodistance analyses are used in conjunction with statistical methods to approximate biological affinity, and to estimate the extent of microevolutionary forces affecting populations in both model-free and model-bound analyses.

Biological affinity studies can be based on dental morphological traits effectively, which are suitable for biological distance analyses as many traits are independent of age, sex, and one another, the high genetic component in frequency and expression and because the degree of intergroup variation in trait frequencies is high (Irish, 1993, 2005; Irish et al., 2014; Larsen, 1997; Scott, 1973; Scott and Turner, 1997). Affinity studies have been shown to be an effective tool for establishing close biological relationships, or the lack thereof, between and within populations in numerous studies (Coppa et al., 2007; Coppa et al., 1998; Cucina et al., 1999;

Irish, 1993, 1997, 1998a, b, c, 2005, 2006, 2008; Irish and Turner, 1990; Matsumura et al., 2009; Vargiu et al., 2009). Teeth have a propensity to survive in the archaeological record, and can provide genetic, pathological, environmental, developmental and behavioral information through the application of a wide range of statistical methods (Hillson, 1996; Turner et al., 1991). Teeth express genetically inherited patterns and morphological features, consequently, their evolutionary history facilitates diachronic comparisons between populations (Irish, 2008). Furthermore, morphologically, teeth are little affected by environmental factors that can affect the rest of the skeleton, thus, they have been considered by many to be an exceptional choice for use in biodistance analyses (Irish, 2000, 2008; Scott and Turner, 1997; Turner et al., 1991).

Data were collected using the Arizona State University Dental Anthropological System (ASUDAS). The standardized ASUDAS system consists of >100 non-metric crown and root traits, for permanent teeth, scored with the assistance of 24 reference plaques. A subset of 36 of traits, based on the work of Irish (1993), will be used for this study. Non-metric traits were scored following the ASUDAS scoring procedures outlined in Turner et al (1991). Dental nonmetric (i.e., morphological), these traits were recorded from 125 individuals of four samples dating to the Middle Iron Age and will be compared using principal components analysis and, the mean measure of divergence statistic. Multidimensional scaling will be used to provide a graphical representation of the triangular matrix of pairwise mean measure of divergence distances and cluster analysis based upon this same matrix will be used to further illustrate the distances among the samples (Harris and Sjøvold, 2004; Irish, 1993, 1997, 2005, 2006, 2010; Kruskal and Wish, 1978; Sjøvold, 1973, 1977).

The samples are from populations representing proto-Celts (Hallstatt D), continental (Munsingen-Rain) and non-continental Celts (Yorkshire), and a temporally contemporaneous comparative sample from outside the known range of Celtic expansion (Pontecagnano). The skeletal collections recovered from Hallstatt, Munsingen-Rain and Yorkshire have provided researchers with the potential to investigate biological affinities among the continental and non-continental Celtic populations as well as the potential source of the cultural changes that occurred in the British Isles during the Iron Age. While these cemeteries have been the focus of numerous previous studies, their focus has been on grave goods, skeletal and dental inventories,

cemetery descriptions and material cultural comparisons to cemeteries of similar age (Anthoons, 2007, 2011; Collins, 1973; Collis, 2003; Cunliffe, 1984, 1991, 1994, 1997, 2009; Dent, 1982, 1985, 1995; Giles, 2012; Hodson, 1964, 1968, 1990; Stead, 1991). Dental analyses and biological affinity analysis have yet to be conducted on the skeletal material recovered from these cemeteries.

Objectives and goals of the study

The objective of this thesis is to investigate whether the diachronic changes in material culture evident in the cemeteries associated with continental and non-continental Celts were accompanied by concomitant biological change; whether non-continental Celts show any biological affinity to continental Celts outside of Gaul; whether there is evidence for population continuity between proto-Celtic and Celtic populations; whether the inhabitants of Yorkshire during the Iron Age are described as Celtic based on a nominal association with Celtic material culture; whether a specific dental complex that serves to unite continental and non-continental Celts can be defined; and whether the continental Celts (i.e., Munsingen-Rain) represent a biologically distinct population.

Research questions

The following research questions are addressed in this study.

1. Was population movement from continental Celtic populations (i.e., Munsingen-Rain), outside Gaul responsible for the diachronic changes in material culture in the British Isles during the Iron Age?
2. Is there evidence for population continuity between the proto-Celtic Hallstatt D (i.e., Hallstatt D) and Celtic La Tène (i.e., Munsingen-Rain) samples?
3. Is there sufficient evidence to suggest that the inhabitants of Yorkshire during the Iron Age were Celtic or is it a nominal association based on cultural diffusion?
4. Is there a specific dental complex that can be identified among the Celtic samples that unites continental and non-continental Celts?
5. Do the continental Celts (i.e., Munsingen-Rain) represent a biologically distinct population?

Hypotheses

The following hypotheses were tested using PCA and MMD analyses to determine whether there are significant differences in dental nonmetric traits among samples,

1. Ho: There is no difference in non-metric dental trait frequencies between the continental Celtic Munsingen-Rain sample and the non-continental Celtic sample from Yorkshire.
Ha: There is a difference in nonmetric dental trait frequencies between the continental Celtic Munsingen-Rain sample and the non-continental Celtic sample from Yorkshire.
2. Ho: There is no difference in dental nonmetric trait frequencies between the proto-Celtic sample from Hallstatt D and the Celtic La Tène sample, thereby suggesting biological continuity between the populations represented by these samples.
Ha: There is a difference in dental nonmetric trait frequencies between the proto-Celtic Hallstatt D sample and the Celtic La Tène sample, thereby suggesting a biological discontinuity in the populations represented by the samples.
3. Ho: There is no difference in dental nonmetric trait frequencies among non-continental and continental Celtic samples, which reflects the unlikelihood of a region-specific Celtic dental complex.
Ha: There is a difference in dental nonmetric trait frequencies among non-continental and continental Celtic samples, which reflects the possible presence of a region-specific Celtic dental complex.
4. Ho: There is no difference in the frequencies of nonmetric dental traits between the Munsingen-Rain and Pontecagnano samples, which reflects biological affinity between Munsingen-Rain and other European populations.
Ha: There is a difference in nonmetric dental trait frequencies between the Munsingen-Rain and Pontecagnano samples, which reflects biological dissimilarities between the Munsingen-Rain and Pontecagnano populations.

Significance

This study will contribute to the fields of dental anthropology, bioarchaeology, and Celtic studies in several ways. 1) This study will help fill a gap in the current knowledge and understanding of regional variation in nonmetric traits within Iron Age Europe. Despite the current knowledge of nonmetric data that comprise the European dental complex, little is known

about the regional variability of these traits. Research into variation within the European dental complex is largely reported through population-specific analyses (Pacelli and Marquez-Grant, 2010; Haniara, 1968; Hsu et al., 1999; Hallgrímsson et al., 2004). Although the results of previous studies into European nonmetric trait variation indicate the presence of regional variation within Europe, regional variation within Europe has not been the focus of these studies. In sum, nonmetric dental traits have been used to reconstruct population movements and determine biological affinities among populations covering wide geographic areas. However, European populations have not been analyzed and documented to the same extent; as a result, the nature and patterning of variation in nonmetric traits within this region is remains relatively unknown.

2) Current understanding of the nature of biological affinities among the Celts can be improved through the comparison of continental and non-continental Celtic populations. The Celts have been described as a group of tribes that inhabited continental Europe during the Iron Age (Collins, 1997a, 1999; Chadwick, 1970; Cunliffe, 1984, 1991, 1994, 1997; Giles, 2012; Karl, 2010; Koch, 2003, 2006, 2007, 2009b, 2013; Kruta, 2004; McCone, 2008; Meid, 2008). The exact geographical spread of the Celts is disputed, particularly their supposed migration into the British Isles (Collins, 1999; Collis, 2003; Cunliffe, 1997, 2009; Giles, 2012; Koch, 2006, 2007). While classical Greek and Roman historians attest to the existence of the continental Celts, their presence as a biologically distinct population is currently disputed (Chapman, 1992; Collis, 2003; James, 1999; Laing, 2006; Scheeres, 2014). Although genetic evidence suggests the presence of different Y chromosome variation and mtDNA haplogroups in regions associated with the continental and non-continental Celts; the condition of the skeletal collections used in this analysis are unsuitable for aDNA analysis (Arnason et al., 2000; Busby et al., 2012; Capelli et al., 2003; Cruciani et al., 2007, 2011; De Beule, 2009; Di Giacomo et al., 2004; Faux, 2008; Helgason et al., 2001; Hill et al., 2000; Lell and Wallace, 2000; Lucotte, 2015; McEvoy et al., 2004; Myres et al., 2011; Oppenheimer, 2012; Richards, et al., 2002; Rosser et al., 2000; Semino et al., 2004; Sykes, 2006; Torroni et al., 1998, 2001; Wilson et al., 2001). Therefore, biological affinity will be determined through dental nonmetric trait analysis. It remains uncertain whether the continental Celtic groups and the non-continental Celtic groups are members of the same

biological population; while recent studies based on archaeological evidence have begun to dispute their supposed biological relationship, a biological affinity study has yet to be conducted.

3) Current understanding of the biological diversity during the Hallstatt D and La Tène periods will be improved through an analysis of the biological affinities between proto-Celtic populations and fully Celtic populations. The history of proto-Celtic groups in continental Europe remains uncertain. The first people to have adopted cultural characteristics regarded as Celtic were members of the Iron Age Hallstatt culture, specifically the later phase of the culture, Hallstatt D, in central Europe (Cunliffe, 1997; Collis, 2003; Hodson, 1964; Koch, 2006). The concept of the Celt has been pervasive historically, and while attempts have been made to increase understanding of the exact nature of the Celtic presence in the British Isles, far fewer attempts have been made to interpret the relationships between the continental proto-Celtic groups and fully Celtic groups and their subsequent, if any, relation to the inhabitants of the British Isles (Cunliffe, 1997, 2009; Collis, 2003; Halkon, 2013; Hodson, 1964; James, 1999). The Hallstatt skeletal collection has not been the subject of much research, nor has its supposed connection to later fully Celtic cultures, such as Munsingen-Rain, been explored. An in-depth analysis of the biological affinity between the Hallstatt D and Munsingen-Rain skeletal collections will improve current insight into population continuity or lack thereof during the Hallstatt D-La Tène cultural transition.

4) Comparison of continental Celtic and non-continental Celtic samples will improve current understanding of population movement into the British Isles. Comparison of continental Celtic populations to populations in the British Isles during the Iron Age will increase current understanding of the presence of the Celts, and Celtic material culture, in the British Isles. While archaeological, genetic, and linguistic evidence suggests that there was some degree of Celtic presence in the British Isles, specifically in Yorkshire, the degree of contact actual physical between non-continental and continental groups outside Gaul and their subsequent impact on the inhabitants of the British Isles is disputed.

Organization of the thesis

Chapter 2 presents the historical and archaeological background of the continental and non-continental Celts. This chapter provides an overview of the historic sources mentioning the

Celts. A chronological history of the archaeological cultures associated with the continental Celts is also provided. The archaeological background and dispersal of the proto-Celtic Hallstatt culture is presented, followed by evidence offered by an array of researchers in support of the contention that the Hallstatt culture served as a precursor to the fully Celtic La Tène culture. The archaeological background and dispersal of the fully Celtic La Tène culture is presented, followed by evidence supporting the La Tène culture as Celtic. Finally, evidence of cultural continuity between the Hallstatt and La Tène cultures is presented. This chapter provides a baseline for the archaeological, chronological, and cultural continuity in relation to the Celts, while also providing a baseline for specific cultural associations with the ancient Celts in an effort to contextualize the population-specific information in the next chapter to a greater extent.

Chapter 3 provides a description of the historical sources mentioning the continental and non-continental Celts and their geographic placement. The archaeological, linguistic, and genetic evidence pertaining to the presence of the continental and non-continental Celts and proto-Celts is also provided. The population history and biological interactions with other populations are also presented. This chapter describes the population history of the proto-Celts, as well as the continental and non-continental Celts.

Chapter 4 provides the methodological background, including a literature review regarding dental nonmetric trait affinity analyses, and the Arizona State University Dental Anthropological System (ASUDAS). The advantages and disadvantages of using teeth as a research tool for biological distance analysis are also presented.

Chapter 5 describes the statistical methods used as well as the reasoning for why the selected statistical tests were chosen. The background information for the samples used in this study, as well as the dental traits used in this study is presented.

Chapter 6 includes a series of tables and graphs that display the results of the biodistance analyses and results from the Wilcoxon signed rank test for interobserver repeatability, and the results from principal components analysis, mean measure of divergence, multidimensional scaling and cluster analyses. A brief explanation of the results is given.

Chapter 7 provides an in-depth discussion of what the results suggest. Each hypothesis is discussed in turn and this discussion is followed by the conclusions of the study. Possible future work concerning the data and similar analyses are also considered.

Chapter 2: Historical and archaeological background

Archaeological culture and ethnicity

The material record has been attributed to specific populations throughout the history of archaeology (Daniel, 1950; Trigger, 2006). With the advent of the culture history paradigm in the late 19th and early 20th centuries, a systematic framework for the classification of cultures in space and time was established. The culture history approach provided the dominant framework for archaeological analysis throughout most of the 20th century (Trigger, 2006). Processual and post-processual archaeologists rejected culture history interpretations of past populations as nothing more than an end-product in itself. Even these latter archaeological schools of thought (processual, post-processual) are still largely dependent upon material evidence that has been described and classified on the basis of what is an essentially a culture historical epistemology (Trigger, 2006; Jones, 1997). One of the main assumptions underlying the culture history approach is that bounded cultural entities, derived from the archaeological record, correlate with specific populations, ethnic groups or tribes. An archaeological culture can have diverse origins and the unifying features that give it apparent coherence, as recognized and acknowledged archaeologically, may be the result of an array of broad processes, such as exchange networks, symbolic change, or adoption of farming by hunter-gatherer groups (Cohen, 1978; Francis, 1947; Trigger, 2006). It has been assumed that Celtic and proto-Celtic tribes possessed Hallstatt and subsequently La Tène material culture because, such assemblages are found in nearly all the areas where linguistic evidence suggests that a Celtic language was spoken (Cunliffe, 1997; Hubert, 1934; Koch, 2006). However, La Tène culture is not confined exclusively to Celtic-speaking people, as aspects of La Tène culture were incorporated into other cultures and regions including Dacia, Germany, Thrace, and the Roman and the Golasecca cultures. The problem is that where direct linguistic evidence is lacking, archaeology has no means of either verifying or falsifying the association of Iron Age tribes with the Celts ethnically.

The Romans and Greeks did not describe the Celts ethnographically, but instead referred to them in reference in relation to themselves, using their culture, and level of sophistication, as the standard or pinnacle (Collis, 2003; Cunliffe, 1997). As a result, we are left with pejorative descriptions of the Celts, and limited if any descriptions of their cultural practices, the validity of

which are called into question. Because the term ethnicity has been used prolifically to refer to diverse socio-cultural phenomena, and has no universally accepted definition, its application for the delineation of archaeological ethnic groups, such as the Celts, is problematic.

Ethnic groups have been described as social and cultural entities that have distinct boundaries, characterized by relative isolation and a lack of interaction, and/or culturally constructed categories that inform social interaction and behavior (Cohen, 1978; Dragadze, 1980; Eriksen, 1992; Jones, 1997; Patterson, 1975; Shennan, 1989). Ethnic identity has been constructed based on shared cultural practices and/or socio-structural relations that exist independently of the perceptions of the populations concerned, or through the subjective processes of perception and derived social organization of the individuals themselves (Bentley, 1987; Eriksen, 1992; Jones, 1997; Shennan, 1989). The tribes inhabiting Iron Age Europe can therefore neither be described as Celtic nor as post-Celtic as it cannot be determined whether they no longer possess all the cultural traits that originally defined the Celts, nor can these traits be defined. Although the presence of specific cultural practices in the regions, in which the Celts were originally described as inhabiting, may be posthumously linked with the Celts, the presence of regional diversity renders the description of the Celts as an ethnic group difficult, if not impossible. The disputed origin of the term *Celtae/Keltoi* calls into question the utility of the term as an ethnic identifier.

The origin of the term *Keltoi/Galli* in Greek and Latin, respectively, is uncertain (Collis, 2003; Cunliffe, 1997; James, 2005). The term *Keltoi* has been argued to either be of Celtic or Greek origin, possibly meaning the “tall ones” (Koch, 2003, 2006). The etymology of the Roman terms *Galli/Gallia* is also uncertain, possibly meaning “to be able to”, “to gain control of”, “stranger”, “enemy” or even “enemy of the state”, and has alternatively been described as an ethnic tribal name (Koch, 2003, 2006, 2009a, b, 2013; Helmut et al., 2001; Stempel, 2008). The various reconstructions of the terms *Keltoi/Celtae* and *Galli/Gallia* suggest that they may have been applied as exonyms by neighboring populations, i.e., the Greeks and Romans, although it is possible that they derived from the name(s) of Celtic tribes. Moreover, the pejorative and descriptive nature of these terms also suggests that they were applied as exonyms rather than as self-identifying ethnic terms. The Romans and Greeks habitually used the terms *Galli/Gallia* and

Keltoi/Celtae interchangeably for people who spoke Celtic languages and possessed Celtic material culture, as the terms are used today (Collis, 2003; Cunliffe, 1997; Moore, 2011). The inclusion of all of the Celtic tribes (as known to the Greeks and Romans and in the modern sense) under the term Celtic, without any knowledge as to their degree of biological relatedness, is derived from archaeological, linguistic, art, and classical lines of evidence. As such, their associations are superficial at best. While it is currently believed that the Celts did not represent a cohesive population, but were instead a loose association of tribes, these disparate tribes are still referred to as Celtic-based on the above lines of evidence. This stereotype of the Celts, while simplified and generalized, still captures popular imagination. Ultimately, the view of the Celts as a distinct ethnic group depends on the origin of the term *Celtae/Keltoi* and whether it was applied specifically in a derogatory or descriptive nature to the various barbarian tribes inhabiting central Europe, or whether it represents a population-specific identifier.

The concept of the Celts as an Iron Age people who spoke an array of Celtic languages and who had similar cultural and burial practices resulted in the conception of the Celts as a homogenous population with a shared single ethnic identity. This view of the Celts has predominated since the discovery of the archaeological cultures that later became associated with them during the 19th century (Collis, 2003; Cunliffe, 1997). However, linguistically, the concept of the Celts as a unified population who shared a common language began earlier, during the 18th century (See Chapter 3 below). The essence of being Celtic, as applied to Iron Age populations in Europe, is based on diverse lines of evidence including, language, art, classical texts, and archaeology. The interpretations of the Celts and their place in Iron Age European society based on this evidence have been inextricably linked and jumbled, creating a situation in which the ensuing view of Celtic Iron Age Europe has been perceived as timeless and traditional, yet has little explanatory value. Determining who the Celts were requires an examination of the above lines of evidence and their interaction. The problem of defining what should be meant by the terms Celt and Celtic is dependent on the relationships between genetic affinity, material culture, ethnicity, and language, if any.

Celtic core and periphery/expansion models, with their emphases on either external or internal exchange and/or cultural assimilation, have dominated the interpretation of both late

Hallstatt and later La Tène Europe despite the difficulties associated with these assumptions, because the analytical context of most recent explanatory frameworks remains entwined with the classical world (Cunliffe, 1979, 1988; Dietler, 1994; Fitzpatrick, 1993; Wells, 1980, 1984; Woolf, 1993). It is clear, then, that there is no intrinsic Celtic European unity and that the idea of Celtic Iron Age Europe has developed in an almost *ad hoc* manner. The designation Celtic is geographical as much as it is cultural. It does not necessarily indicate that these people spoke Celtic languages or called themselves Celtic. While the theoretical basis of a Celtic Iron Age Europe is weak, the idea of Celtic Iron Age Europe as mapped by the distribution of Celtic objects remain prevalent and the correlation between the Iron Age and the Celts is now over a century old and still commands widespread acceptance.

Hallstatt archaeological background, location, and spread

The Hallstatt culture is one of the earliest Celtic cultures and is named after the town of Hallstatt in Stiermarken, Austria where material evidence of this early Celtic culture was found. The first archaeologist at the site was Johan Georg Ramsauer in 1846, who eventually uncovered 1,045 burials (Hodson, 1990). The Hallstatt type site is the Hallstatt cemetery, which dates mostly to the 7th and 6th centuries BC and includes some impressive “chieftain’s” graves. The culture is divided into four periods; Hallstatt A, HaA (1200-1000 BC), Hallstatt B, HaB (1000-800 BC), Hallstatt C, HaC (800-650 BC), and Hallstatt D, HaD (650-475 BC) (Hodson, 1990; Koch, 2006). The cemetery is one of the richest known of its kind, with a wide range of weapons, brooches, pins, and pottery, as well as imported Italian bronze vessels that, have been used to date the cemetery (Hodson, 1990). The frequency of imported items increases throughout the later phases of the Hallstatt period. The increasing volume of trade items is reflected by the grave goods that accompanied the emerging nobility, which include funerary carts (Collis, 2003; Gifford, 1960; Hodson, 1990; James, 2005; Poppi, 1991). These finds fed the growing curiosity about Europe’s past sparked by the new scientific approach to excavation and documentation of antiquities pioneered by Thomsen and Worsaae (Heizer, 1962). Scholars gradually began to broaden the 18th century definition of the Celts through a growing focus on linguistics and through searching for material remains (i.e., artifacts) associated with them (Clive, 2010; Hodson, 1990; Kruta et al., 1991). The Hallstatt culture spread from Austria to encompass much of central Europe, including southern Germany, Austria, Switzerland, northern Italy, France, Slovakia, Slovenia, Croatia, the Czech Republic and Hungary (Collis, 2003; Cunliffe, 1997;

Hodson, 1990; Koch, 2006). This large area has been further divided into the eastern and western sub-zones, with the eastern sub-zone encompassing northern Croatia, eastern Slovenia, western Hungary, southwestern Slovakia, eastern and lower Austria, the eastern Czech Republic, and northern and central Serbia (Collis, 2003; Cunliffe, 1997; Hodson, 1990; Koch, 2006), while the western sub-zone includes northeastern France, northern Switzerland, southern Germany, the western Czech Republic, western Austria, and central and northern Italy (Koch, 2006; Kossack, 1959). The eastern Hallstatt sub-zone includes eastern Austria, eastern Czech Republic, southwestern Slovakia, western Hungary, eastern Slovenia, northern Croatia and northern and central Serbia (Koch, 2006; Kossack, 1959).

During the Hallstatt D period, the richest graves, those with carts and costly imports, tend to be more concentrated in the western sub-zone of the Hallstatt culture, than in previous periods (Cunliffe, 1997; Collis, 2003). This westward shift appears to be correlated with the establishment of a new Greek trading colony at Massalia (present-day Marseilles) located near the mouth of the Rhone River. The new chiefdoms lie in close proximity to the major trade routes connecting the Rhine, Seine, Loire, and Upper Danube Rivers with the Rhone River corridor (Cunliffe, 1997; Collis, 2003). As in the preceding periods, the aristocracy of this period also appears to have derived much of their wealth through trade (Collis, 2003; James, 2005). Trade provided the basis for the accumulation of wealth and influence, which was evident by the presence of rich or princely graves containing high quality trade items and luxury items (Kossack, 1959).

In the western sub-zone the graves were situated in deep chambers beneath hills, either man-made or natural, and were richly furnished with weapons, large wooden wagons or carts (some individuals were buried sitting or lying in these wagons or carts), and harnesses for horses (Collis, 2003; Cunliffe, 1997). In the eastern sub-zone during the preceding HaC period, in contrast to the rather uniform grave goods of the western sub-zone, the graves were filled with mostly defensive weapons, such as shields, helmets, armor, spear heads and axes (Collis, 2003; Cunliffe, 1997; James, 2005). However, in the western sub-zone during the HaC period the elite were buried with swords, or a dagger, during the HaD period (Hodson, 1990; Koch, 2006). Chariot, or cart, burials are common in the western sub-zone while warriors were commonly

buried in armor in the eastern sub-zone (Collis, 2003; Cunliffe, 1997; Hodson, 1990; Koch, 2006). The differences in grave goods suggest that the tribes inhabiting the western and eastern zones may be distinct populations that only interacted with one another through trade. The main distinguishing features used to differentiate the eastern and western regions are burial practices and grave goods (Collis, 2003; Cunliffe, 1997; Hodson, 1990; Koch, 2006).

Little is known about the early Hallstatt periods, HaA and B, for it is not until the HaC period that there is evidence of significant building activities and fortifications (Cunliffe, 1997; Koch, 2006). Inhumations do not occur until the HaC period, for during the HaA and HaB periods, cremations, buried in jars or pots were the common funerary practice (Collis, 2003; Cunliffe, 1997; Hodson, 1990). Cremations were common during the HaA period, and the burials from this period are simple, with few grave goods (Collis, 2003; Cunliffe, 1997; Hodson, 1990). Iron is rare and Villanovan (an early Iron Age culture in northern Italy associated with the Etruscans) influence is apparent in the pottery used in the cremation burials (Koch, 2006; James, 2005; Mallory, 1992; Mallory and Adams, 1997; Weissenbacher, 2009). Wealth began to increase in the area during the HaB period and the wealthier individuals were cremated and buried with many grave goods. As in the earlier HaB period, while cremation predominates, however, during the latter half of the period, tumulus or barrow, burials appear (Collis, 2003; Cunliffe, 1997; Hodson, 1990; Koch, 2006). Little is known about these earlier periods, as the elements, e.g., metalwork, which were later associated with Celtic culture, had not yet distinguished themselves from those of the Villanova culture. Consequently, both cultures shared similar burial characteristics and the associated archaeological cultures were similar (Cunliffe, 1979, 1997; Hodson, 1990; Meid, 2008). The changes in burial practices between HaB and HaC may reflect migration, diffusion or cultural assimilation from the surrounding cultures; however, it is evident that the populations possessing Hallstatt culture experienced a dramatic change in social stratification (Collis, 2003; Cunliffe, 1997; Hodson, 1990; Koch, 2006).

Wealth began to increase in the region during the HaC period. The accumulation of wealth enabled populations to become more stratified, as the differences between the wealthy and the poor became more pronounced and an elite class emerged for the first time (Collis, 2003; Cunliffe, 1997; Hodson, 1990; Koch, 2006). The evidence for such stratification is found in

grave goods, most of which were made of bronze or iron and elaborate in design, and are markedly more complex than those from the preceding period, while objects of gold and silver are rare (Collis, 1984, 2003; Cunliffe, 1984; Hodson, 1990). Throughout this period, iron swords first appear mixed among those made of bronze, and inhumations and cremations co-occur. During this period there are some rich inhumation burials that are walled with planks and contain carts. Another indication of the increasing wealth is the presence of imported products in wealthy graves (Hodson, 1990). Differentiation in burial practice begins to appear during the HaC period, with wealthier burials occurring in wooden chambers accompanied by, swords, rich pottery and personal ornaments, most of which are made of bronze (Gleirscher, 1996; Hodson, 1990; Pare, 1991). By the 6th century BC inhumation is almost universal. Burials of female tend to be accompanied by a rich assortment of bronze ornaments, including anklets, bracelets, and brooches, while males were often buried with various weapons, such as daggers, swords, and spear heads, or, in some regions, axes (Gleirscher, 1996; Hodson, 1990; Pare, 1991). Imported goods from the Mediterranean region; appear in the richest graves, along with local pottery, ornaments, and gold objects, but rarely weapons. Imported bronze vessels appear during the HaC period, and many male burials are unaccompanied by grave goods (Bofinger et al., 2006; Cowen, 1968, 1970; Hodson, 1990; Hopkins, 1957; Krause, 2006; Maier, 2003).

The amount of grave goods increased and became more elaborate during the HaD period. Burials were predominantly inhumations (Hodson, 1990). The grave goods, indicate a culture in which the rich were buried with their personal belongings. Wagons or carts mark the presence of burials throughout the Hallstatt region and; all the wagon burials during the Hallstatt period are of four-wheeled carts (Collis, 1984, 2003; Cunliffe, 1984; Hodson, 1990). Cart burials have been used to link the diverse regions possessing Hallstatt material culture together, despite regional differences in burial practice (Collis, 2003; Cunliffe, 1997; James, 2005; Maier, 2003). It appears that wheels began to be removed in vehicle burials during the later periods (5th and 4th centuries BC), for during the early HaD period the carts were buried whole, while (Collis, 2003; James, 2005). Hallstatt culture populations were not isolated in central Europe. Instead, they had far-reaching contacts through trade with different communities (Collis, 2003; James, 2005). Thus, the presence of a wagon, or chariot, in a burial during this period cannot be used as a reflection of cultural unity.

Two noteworthy examples of regional differences in cart burial practices are the burials at Vix, an HaD-early La Tène era site located near Mt. Lassois in France, and the so-called Hochdorf Chieftain burial dated to the HaD period, and located in the Baden-Wurtemberg region of Germany (Collis, 2003; Cunliffe, 1997; James, 2005). While both sites are found in the western Hallstatt sub-zone, there are striking differences in the placement of the four-wheeled cart in the grave (Collis, 2003; Cunliffe, 1997; James, 2005). In the Vix burial, the wheels had been removed and were placed against a wall of the burial chamber, while in the Hochdorf Chieftain burial the wagon was buried with the wheels affixed (Biel, 1981; Berthelmer-Ajot, 1991; Claude, 2003; Cunliffe, 1997; James, 2005; Joffrey, 1954, 1961, 1962). The woman at Vix was buried in the cart while the Hochdorf Chieftain was buried across from it. A further difference is reflected in the discovery of a yoke in the Hochdorf burial and the lack of one in the Vix burial, suggesting either differences in the use of the cart, or different cart types (Collis, 2003; Cunliffe, 1997; James, 2005). The cart at the Vix burial may have been used as a litter or hearse to carry the woman into the tomb, while the cart at the Hochdorf Chieftain burial may have been pulled by horses (Cunliffe, 1997; James, 2005). The difference in the placement of the cart may indicate a difference in the burial practices in each region, possibly reflecting different tribes with different customs. As there are differences in the amount and type of grave goods, as well as the use and placement of carts in burials throughout the Hallstatt region, it is likely that different tribes, each with different customs (as reflected in their burial practices) inhabited the region, were linked through trade and their control of different trade routes (Collis, 2003; Cunliffe, 1997; James, 2005). However, the differences in cart burial practices may also reflect temporal differences for these burials are dated by the type of grave goods and are assigned to a specific period (i.e., HaC). As such it is unknown whether cart burials represent cultural assimilation, diffusion, or evolution of burial practices. Furthermore, these burials are characterized typologically in relation to grave goods, and the associated descriptions are vague at best, with no attempt at data synthesis. A further confounding factor is that the distribution of tribes throughout Iron Age Europe is unknown.

The influence of the Hallstatt culture spread into other nearby cultures, thereby increasing the difficulty of describing the inhabitants of central Europe during this period by their

archaeological culture (Collis, 2003; Cunliffe, 1997; James, 2005). The Golasecca culture (9th-4th century BC), a late Bronze Age culture in northern Italy, shares burial features as cremation and subsequent burial in jars or pots with the early Hallstatt culture (Gimbutas, 1965; Koch, 2006; Kruta et al., 1991; Ridgway and Ridgway 1979). These similarities have been attributed to the Golaseccans acting as intermediaries between the Etruscan populations to the south and Hallstatt culture communities to the north in trade (Koch, 2006; Kruta et al., 1991, 2004; Ridgway and Ridgway, 1979). Another archaeological culture that has ties to the Hallstatt, and thus the Celts, is the Canegrate culture, found in northern Italy, near present-day Milan (Collis, 2003; Cunliffe, 1997; James, 2005). The Canegrate culture developed during the Bronze Age (13th century BC) and continued into the Iron Age (James, 2005; Kruta et al., 1991). A necropolis found at the type site of Canegrate, in Lombardy, exhibits burial practices that are similar to those during the same period north of the Alps and has been argued to represent the first migratory wave of proto-Celtic people across the Alps and into northern Italy, although Celtic cultural elements in both the Golaseccan and Canegrate cultures could be related to cultural diffusion and/or assimilation (Kruta et al., 1991, 2004).

Both the Golasecca and Canegrate cultures have been described as Celtic based two criteria (Collis, 2003; Cunliffe, 1997; James, 2005). The first is similarities in bronze work between the Canegrate culture and that found in sites throughout the western Hallstatt region. The second is the Lepontic (an early Celtic language) inscriptions found in Golasecca culture sites, which have led to the interpretation that the precursor language of the western Hallstatt region was also Celtic or proto-Celtic (Collis, 2003; Cunliffe, 1997; James, 2005). While the Hallstatt and La Tène cultures have been predominantly associated with the Celts, the Golasecca and Canegrate cultures are not, with few exceptions (Collis, 2003; Cunliffe, 1997; James, 2005). The strong association between the Celts and the Hallstatt and La Tène cultures is derived from the linguistic work of Edward Lhuyd (1707), who described the languages spoken in the regions associated with the Hallstatt and La Tène cultures as Celtic based on Caesar's description of people in Celtic Gaul referring to themselves as "Celts" (Lhuyd 1707). Subsequently, when the Hallstatt and La Tène sites were found in the 1800s, they were described as Celtic following the convention that the Celts had inhabited central Europe because of the, archaeological similarities shared across the Hallstatt and La Tène regions and Gaul (Collis, 2003; Cunliffe, 1997).

Consequently, the concept of the Celts is derived predominantly from a linguistic theory. However, because there is no evidence as to what language(s) were spoken throughout the Hallstatt and La Tène regions, we cannot know what they called themselves, nor can we determine which tribe Caesar was talking about when he described a tribe in Gaul referring to themselves as “Celts” (the exact number of tribes is not agreed on, however, between 30 and 60 tribes are believed to have inhabited Celtic Gaul, based on descriptions by the Greeks and Romans) (Collis, 2003; Cunliffe, 1997; James, 2005).

Why Hallstatt D is believed to be proto-Celtic

The linguistic evidence, derived primarily from place names in the Hallstatt region, indicates that a proto-Celtic language was spoken by the inhabitants of this extensive area. However, the place name evidence comes from fragmentary inscriptions associated with the Golasecca and Canegrate and Hallstatt cultures (Collis, 2003; Hodson, 1990; James, 2005; Kossack, 1959; Koch, 2007). Furthermore, it is difficult to determine with which culture these inscriptions are associated. The Hallstatt culture proper is restricted to the later HaC and HaD periods, both which have been described as proto-Celtic (Collis, 2003; Hodson, 1990; James, 2005; Koch, 2007). The HaD period is also believed to be proto-Celtic because the La Tène culture developed close to the end of this period farther north, and this cultural development has been interpreted as the consequence of the actual physical movement of the Hallstatt populations subsequent to an avalanche at the end of the HaD period that destroyed the salt mine located here (Collis, 2003; Koch, 2007). With the collapse of the salt mine and the wealth associated with it, the elites were only able to maintain their wealth through their control of the changing trade routes hence the movement of the populations (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). The HaC period has also been described as proto-Celtic based on two assumptions, that the defining characteristics of the HaD and subsequent La Tène periods began during this period, and that a proto-Celtic language was spoken by the populations associated with it (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007).

The association between the HaC period and the proto-Celts, whether through language or culture, has been a paradigm for many years. This paradigm is based predominantly on a reconstructed language and the belief that a proto-Celtic language was spoken over vast regions of central Europe at this time (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). However,

this paradigm does not account for the presence of the Celts in the Iberian Peninsula where similar artifact types, such as torcs and fibulae, albeit with significant regional differences, have been found (Koch, 2006, 2013). The similarities in the artifact assemblages of this region and those in central Europe that later were to become Celtic-speaking, has led to the assumption that the Celtic artifacts associated with both regions are representative of the same culture or people (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007, 2013). Alternatively, the presence of Celtic material culture and language in the Iberian Peninsula may derive from trade and small-scale population movement. Nevertheless, the paradigm that HaC or HaD was proto-Celtic represents a linguistic hypothesis (Koch and Minard, 2012; Koch, 2013). The regional differences in material culture have not been interpreted to the same extent, nor have the diverse populations of proto-Celtic and Celtic Europe been the subject of a biological affinity analysis. The association and description of the proto-Celts and the Celts based on their perceived linguistic similarities dates to the beginning of the field of Celtic studies. Therefore, the descriptions of the proto-Celts are based primarily on a reconstructed language.

While the proto-Celts may be associated with the HaC period linguistically, they may be associated with the later HaD period archaeologically (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007, 2013). Improved absolute and relative dating and typological analysis of metallurgical categories have indicated that key types, such as the Gundlingen swords, spread from the Atlantic zone (the western portion of Europe that borders the Atlantic Ocean, including the British Isles, Iceland, Belgium, the Netherlands, central and northern Portugal, north and northwestern Spain, the southwestern and western regions of France, western Scandinavia and northern Germany) to west-central Europe (Koch and Minard, 2012; Koch, 2013). The direction of this spread stands in opposition to the associations between the Celts and proto-Celts with the Hallstatt and La Tène cultures, which are believed to have spread westward from west-central Europe to the Atlantic zone (Koch, 2007, 2013). However, the description of a population(s) as proto-Celtic or Celtic depends on what is meant by the terms “proto-Celtic” and “Celtic.” The terms have been alternatively used to represent a language, an art style, an archaeological culture, and applied to a diverse array of populations and/or tribes throughout continental and non-continental Europe (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). The HaD period has been interpreted to represent the proto-Celts through the similarities and continuities

in material culture (e.g., sword type). The association between the HaD period and the proto-Celts is based on archaeological evidence (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). In this thesis, HaD was chosen to represent the proto-Celts based on the above criteria.

La Tène archaeological background, location, and spread

The initial division of the Iron Age into the earlier Hallstatt and later La Tène periods by Desor (1873) was purely a chronological division, for there was no ethnic interpretation concerning the populations associated with the archaeological material. The early chronological divisions of the La Tène period into early, middle, and late were based primarily on differences in artifact style and shape (e.g., brooch and scabbard shape) (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). The later chronology of Reinecke (1965), in which the Iron Age was divided into Hallstatt A-D and La Tène A-D, is widely used. However, the initial chronology is problematic because Reinecke devised his scheme exclusively from material from southern Germany (Collis, 2003). The initial chronology of Dechelette (1910), in which the Iron Age was divided into Hallstatt I, II and La Tène, I, II, III, has begun to replace that of Reinecke in modern research. Dechelette (1910) regarded burial practice as a distinctive feature that could be used to distinguish between groups, and he described the Celts as exhibiting extended inhumation, although other burial types, such as cremation, have been subsequently identified at Celtic cemeteries. He also traced the antiquity of the Celts back into the Hallstatt period in Western Europe (Dechelette, 1910). However, Dechelette assigned the earliest objects decorated in the Celtic style to the La Tène I period, following the association of the Celts with the La Tène culture, with a distribution concentrated in an east-west zone encompassing southern Bohemia, Bavaria, Baden-Wurtemberg and north eastern France, which largely corresponded to the area he assigned to the Celts (Dechelette, 1910). However, the subdivisions of the La Tène period are currently referred to as, La Tène A (LTA, 450-390 BC); La Tène B (LTB, 400-300 BC); La Tène C (LTC, 300-100 BC), and La Tène D (LTD, 100-50/15BC), ending with the Roman occupation of Gaul (Collis, 2003; Cunliffe, 1997). At the beginning of the 5th century BC, the rich chiefdoms of the HaD period, such as Mont Lassois and Heunburg, were abandoned and the associated rich burials ceased. Around the same time, wealthy warrior societies began to appear to the north of the princely centers of the HaD period (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). The people inhabiting these new princely centers are believed to have been Celtic

speakers who developed the La Tène culture (Caulfield, 1981; Collis, 2003; Dechelette, 1910; James, 2005).

The La Tène culture was a European Iron Age culture named after the archaeological site of La Tène, which is located on the northern side of Lake Neuchâtel in Switzerland (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). The culture dates from 450 BC to the 1st century BC and spread to encompass Belgium, Switzerland, eastern France, Austria, southern Germany, the Czech Republic, Poland, Slovakia, Slovenia, Hungary and Romania (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). Coincident with these shifts in settlement location was a major shift in trading patterns. Over 2,500 objects, mostly metal, were excavated at the type site of La Tène (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007). Weapons predominate: 166 swords, most without traces of wear, 2,700 lance heads, 22 shield bosses, 385 brooches and chariot parts were found; some animal and human bones were found as well. Two wooden bridges, originally over 100 m long, were also found (De Navarro, 1972; Cunliffe, 1997). Interpretations of the site vary. Some have suggested that the site was destroyed by high water or was a ritual or sacrificial place after a successful battle (Collis, 2003; Cunliffe, 1997; De Navarro, 1972; James, 2005; Koch, 2007). Interestingly, there were almost no ornaments commonly associated with females found. After 500 BC, archaeological evidence suggests that trade with Massalia via the Rhone halted, and the Mediterranean contacts and trade routes were reoriented over the Alps to the new Greek towns of Spina and Adria, located near the Italian Adriatic coast, as well as the new Etruscan settlements in the Po Valley (Collis, 2003; Maier, 2003; Meid, 2008; Verger, 1987). However, the zone from which these imports originated now stretched farther north, as the find locations indicate (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007; Maier, 2003; Meid, 2008).

The La Tène culture appears in similar regions as the Hallstatt culture, sometimes without a definitive cultural break such that elements specific to each culture appear contemporaneously (Caulfield, 1981; Collis, 2003; James, 2005; Poppi, 1991). The La Tène culture appears to have developed around two zones of power and innovation. The first was located in the Marne (Champagne region in France), and Moselle (Rhineland region in Germany) valleys in the west, with trading links to the Po Valley via the central Alpine passes and the Golasecca culture

communities (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007; Poppi, 1991). The second is a Bohemian zone in the east with separate links to the Adriatic via the eastern Alpine routes and the Venetic culture (an Indo-European people who inhabited north-eastern Italy) (Bretz-Mahler, 1971; Cunliffe, 1997; Collis, 2003). A subsequent shift in settlement centers took place in the 4th century BC, just as it did during the HaC to HaD period (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007; Poppi, 1991).

Why La Tène culture is believed to represent fully a Celtic material culture

In some diverse regions, Hallstatt chariot burials continue into the early La Tène period, suggesting cultural diffusion of ideas and/or cultural assimilation of the diverse tribes and languages in continental Europe during the Iron Age rather than any large-scale population movements resulted in the continuation of Hallstatt burials (Collis, 2003; Cunliffe, 1997; James, 2005; Koch, 2007; Poppi, 1991). Some cemeteries in the Champagne and Hunsrück-Eifel regions, exhibit an unbroken burial tradition from the Hallstatt to La Tène period, which has led to the assumption that the La Tène culture developed in these regions and was not brought in from elsewhere through contacts with other cultures or through trade (Bretz-Mahler, 1971; Collis, 2003; Cunliffe, 1997; Egloff, 1991; James, 2005). However, as the cemeteries that exhibit continuity from the Hallstatt to early La Tène periods occur in different regions in Germany and in France it is difficult to determine whether the La Tène culture developed *in situ* or was derived from trade and/or cultural diffusion and assimilation, or all of these processes, of the diverse tribes throughout the regions associated with the Celts (Collis, 2003; Egloff, 1991). Although the burials in these regions reflect both Hallstatt and La Tène traditions (e.g., chariot burials), this need not be interpreted as evidence for the association of these cultures with the Celts; for trade was common throughout the regions occupied by the Hallstatt and La Tène cultures, and likely resulted in cross-cultural contact (Collis, 2003; Cunliffe, 1997; Egloff, 1991; James, 2005; Koch, 2007). The La Tène cultural pattern was significantly different from the earlier Hallstatt culture. While both the Hallstatt and La Tène cultures imported goods from the Mediterranean, particularly wine vessels and drinking paraphernalia, the La Tène tribes created their own distinctive stylistic forms that combined elements from the imported Etruscan objects (Frey, 1991; Hodson, 1968; James, 2005). Like the elite burials in the HaD period, vehicles were common, however, the four-wheeled vehicles change to two-wheeled vehicles, the latter of which are believed to have been adopted from the Etruscans (Collis, 2003; Frey, 1991; Hodson,

1968; James, 2005). La Tène groups abandoned the hillforts used by Hallstatt communities and instead resided primarily in small dispersed settlements (Hawkes, 1931). The social stratification observed in the HaD cemeteries practically disappears (Collis, 2003; Cunliffe, 1997; Hodson, 1968; James, 2005; Koch, 2007).

While continuity in burial type may reflect continuation in cemetery use, it does not necessarily reflect population continuity. The change from four-to two-wheeled cart burials suggests there may have been a change in burial customs as well (Furger-Gunti, 1982, 1991; Harbison, 1969; Kuznetsov, 2006; Pare, 1991; Piggott, 1986). One suggestion as to the link between the collapse of the HaD chiefdoms and the subsequent appearance of the La Tène chiefdoms is that the Hallstatt chiefdoms were too dependent upon controlling the trade routes and upon supplies of imported luxury items (Collis, 2003; Cunliffe, 1997; Hodson, 1968; James, 2005). This would have made them vulnerable to disruptions of their trade routes with Massalia or upheavals in the “warrior fringe” to the north, which developed into the La Tène cultures of the Marne and Moselle Valleys (Cunliffe, 1997; Collis, 2003; Maier, 2003). The movement of trade centers, combined with the growing power of their proto- La Tène neighbors to the north, may have led to the destruction and/or collapse of the Hallstatt chiefdoms (Collis, 2003; Cunliffe, 1997; Hodson, 1968; James, 2005; Koch, 2007). The extent to which the Hallstatt and La Tène cultures intermixed biologically during this period is unknown. Nevertheless, profound change is indisputable from the HaD to La Tène, though this change does not suggest population continuity (Collis, 2003; Cunliffe, 1997; Hodson, 1968; James, 2005; Koch, 2007).

The differences in burial practices, for example, occur throughout the La Tène region, a finding that is more in line with the cultural diffusion and/or assimilation of ideas and practices through the region, as in the Hallstatt period (Collis, 2003; Cunliffe, 1997; Hodson, 1968; James, 2005; Koch, 2007). Some societies and/or tribes identified archaeologically with La Tène material culture were described by Greek and Roman authors from the 5th century BC onwards as Keltoi, Celts, Galli, and Gauls. Burial customs were not unified throughout the La Tène region, as in the Hallstatt region, instead localized groups had their own burial customs and distinctive artistic styles (Collis, 2003; Cunliffe, 1997; Hodson, 1968; James, 2005; Koch, 2007). During the LTA period, tumulus tombs, cremations and inhumation burials are common (Collis,

2003; Cunliffe, 1997; Hodson, 1968; James, 2005; Koch, 2007). A similar burial rite, lacking the richer burials, is found throughout much of central Europe, the Swiss Plateau, southern Bavaria, northern Bohemia, southern Moravia, Slovakia, southern Poland, eastern Romania, the Hungarian Plain, Lower Austria, and Slovenia (Collis, 2003; Cunliffe, 1997; Hodson, 1968; James, 2005; Koch, 2007). These flat inhumation cemeteries begin locally in Switzerland and Austria in the LTA period, such as at the Munsingen-Rain cemetery, but are more typical of the LTB period (Hodson, 1968).

Flat inhumation cemeteries fade in popularity in the LTC period. In the LTB and LTC periods in northern France the focus on visible burials shifts away from the Champagne and Aisne Valley into the Paris Basin, and is evident in eastern Yorkshire, in the Arras culture, which features crouched inhumation burials under a tumulus (Stead, 1979; Cunliffe, 1997; Collis, 2003; Thomas, 2003). In all these areas there are some richer graves with two-wheeled vehicles, especially in northern France, and some with weapons (Cunliffe, 1997; Collis, 2003; Stead, 1979). In the later LTC period and into the LTD, cremation becomes the dominant funerary practice in a zone encompassing western Germany, Hesse, Hunsrück-Eifel, northern France, and Champagne, but also with outliers in Lorraine and Burgundy, such as at Mount Beuvray, and in south-eastern England, associated with the Aylesford-Swarling culture (Cunliffe, 1997, 2009; Collis, 2003; Stead, 1979). While the inhumation burials during the La Tène period appear similar, the observed similarities and differences should not be interpreted to represent purely social differences, as the biological affinity between tribes in the La Tène period is unknown (Arnold, 1995, 2005; Collis, 2003; Cunliffe, 1997; Stead, 1979). The richer burials include imported Italian bronze vessels and wine amphorae. Different communities have their own interpretations of the norms, which can and do shift through time (Arnold, 1995, 2005; Collis, 2003; Cunliffe, 1997; Stead, 1979). There are few firm boundaries either geographical or chronological as one tradition can evolve into another. Furthermore, regional differences in burial practice throughout the La Tène region can be linked to small-scale migration and the cultural diffusion of ideas and/or practices. The regional differences throughout the diverse geographical regions associated with the Celts may also be the result of cultural assimilation, either through diasporas or the domination of local groups by another culture. The wide geographic distribution of the burial practices associated with the Celts may be related to

spontaneous or forcible cultural assimilation among the diverse populations in continental and non-continental Europe, combined with the cultural diffusion of ideas throughout the region. While the skeletal collections associated with the continental Celts have not been the subject of much osteological or biological affinity analyses, isotopic analyses of samples from the Celtic core (the region in which the La Tène culture developed) and expansion areas (the regions the La Tène culture subsequently spread to) have indicated a low rate of migration.

Scheeres (2014) analyzed the strontium isotopic signatures of individuals recovered from cemeteries in the Celtic core and expansion areas (represented by the Nebringen, and Monte Bibele cemeteries in southern Germany and Northern Italy respectively), during the early La Tène period, that appear to have different rates of mobility based upon available archaeological evidence (Scheeres, 2014). The burials in the Celtic core are predominantly associated with widespread and typical finds from the early La Tène period supplemented with Mediterranean objects. By contrast, artifacts associated with those buried in cemeteries within the expansion area include both Etruscan and La Tène objects (Arnold, 1995, 2005; Collis, 2003; Cunliffe, 1997; Scheeres, 2014; Stead, 1979). No observable changes occurred during the use of the Nebringen cemetery, while new burial customs appear in the Monte Bibele cemetery, which suggest transalpine contacts (Frey, 1991; Scheeres, 2014; Vitali, 1991). The individuals at Nebringen were predominantly locals, although only 17 were analyzed. Comparable mobility rates are evident at Monte Bibele, where only four out of 21 individuals analyzed were non-local (Scheeres, 2014). The low frequency of non-local individuals at Monte Bibele is comparable to that found at the Munsingen-Rain cemetery (Scheeres et al., 2013; Scheeres, 2014). While it is tempting to conclude that the low incidence of non-local individuals in the Celtic expansion area suggests that the spread of La Tène culture into this region was primarily a cultural movement, accompanied by small-scale migrations; it has not been determined whether the individuals analyzed represent a primary or secondary settlement. However, further analysis is necessary to determine whether this pattern is present in other areas within the Celtic core and expansion regions. Although the Celts as they are known today are not believed to represent a cohesive ethnic group, the Celts are still strongly associated with the inhabitants of the British Isles and with the Hallstatt and La Tène cultures, regardless of their regional differences (the non-continental Celts will be discussed more in chapter 3).

Furthermore, the classical authors describe the Celts themselves as numerous tribes, indicating that they were not a unified people (Collis, 2003; Cunliffe, 1997; James, 1999, 2005). However, in spite of this fact, the Celts have been linked to the La Tène culture in such a way that groups possessing La Tène culture are believed to be Celts. The concept of the La Tène culture as Celtic is associated with the belief that the Celts represented a specific cultural and biological group (Collis, 2003; Cunliffe, 1997; James, 1999, 2005). Even though the La Tène cultural material was shared by several diverse populations or tribes (as was the Hallstatt cultural material), and also exhibits fundamental variants it is still described as Celtic, with no explanation given for the regional variants. Moreover, these regional variants may simply be the result of trade; the same can be said for the presence of La Tène objects throughout central Europe and into Britain. The presence of La Tène cultural material beyond the “limits of the Celts” may indicate that it was shared by several diverse people (Collis, 2003; Cunliffe, 1997). Because this culture is exclusively associated with the Celts, the regional variants present within the La Tène region have not been the focus of much, if any, research. The Hallstatt and La Tène cultures are regarded differently; the Hallstatt culture is divided into different zones, while the La Tène culture is not (Collis, 2003; Cunliffe, 1997; James, 1999, 2005). The association between these cultures and the Celts is not questioned. Although the remains of people other than Celtic speakers may have been included under the Hallstatt and La Tène cultural labels; it is possible that the artifacts associated with the late Hallstatt period represent the earliest Celts as defined by their description in the classical texts. Because it is impossible to determine whether the inhabitants of the Hallstatt and La Tène regions spoke a similar language, or similar dialects, their descriptions as Celtic speakers is, at best, an assumption based on archaeological similarities. While the Hallstatt cultural label likely included other cultural groups, the La Tène culture developed in part of the Hallstatt area and has come to be associated with the Celts almost exclusively.

The association between the Celts and the La Tène culture is also related to the presence of La Tène material in Gaul (Collis, 2003; Cunliffe, 1997; James, 1999, 2005). However, it should be remembered that HaD burials are also present in Gaul, specifically in France. The association between the Celts and the Hallstatt and La Tène cultures is supported, in part,

through the presence of both HaD and early La Tène burial practices in parts of Gaul (Collis, 2003; Cunliffe, 1997; Hubert, 1934; Meid, 2008). However, as previously stated, this association does not necessarily indicate population continuity, nor does it support the application of the term Celt as an ethnonym. The La Tène culture extended across Gaul, and into Italy, Austria, southern Germany, the Czech Republic, Poland, Slovakia, Slovenia, Hungary and Romania (Collis, 2003; Cunliffe, 1997; James, 2005). It is difficult to imagine that the presence of La Tène material culture in such diverse regions can be linked to the presence of a single Celtic culture, even if in name alone.

Evidence of cultural continuity from Hallstatt D to La Tène (A)

The late Hallstatt tradition of extended inhumation becomes dominant during the HaD and continues through the LTA transition in eastern and northern France (Marnian culture), and the central Rhine-Mosel (Hunsrück-Eifel culture), as well as the Ardennes, northern Bavaria, and southern Bohemia (Collis, 2003; Cunliffe, 1997). The richer burials contain two-wheeled vehicles, some of which are dismantled, a practice not common in the Hallstatt period, as opposed to the burial of complete four-wheeled vehicles that was common in the preceding HaD period (Collis, 2003; Cunliffe, 1997; James, 2005).

The original division between the Hallstatt and La Tène cultures was purely chronological; however, from the mid-19th century, ethnic meanings had begun to be applied to some of the characteristic features such as art style, weapons and personal ornaments (Barth, 1969; Collins, 1997a, b; Collis, 2003; Cunliffe, 1997; James, 2005). It is difficult to determine whether Hallstatt and La Tène represent cultures in their own right with specific origins followed by diffusion and assimilation, or whether they are overarching terms like western-Neolithic within which separate cultures can be identified (Collis, 2003; Cunliffe, 1997). The former is generally more accepted, and while the specific origins of the Hallstatt culture are neither easily defined, nor are they reflective of a general evolution of archaeological cultures, as Reinecke's (1965) terminology implies (Reinecke, 1965). The origins of the La Tène culture have been sought in western Germany, in particular among sites assigned to the Hunsrück-Eifel culture (Collis, 2003). However, local groups and cultures have been defined on the basis of burial rites and ceramics for the Hallstatt period, while for the La Tène period with its Celtic implications,

such divisions have been of lesser interest, except in the definition of its origin (Arnold, 1995, 2005; Cunliffe, 1997, Collis, 2003; Davies, 2000).

The Hallstatt-La Tène transition has been seen as crucial for the arrival of the Celts, but as described earlier, the initial division between the two periods had no such significance. The Celts were thought to be, if not indigenous, at least present in the Bronze Age (Cunliffe, 1997). By the 1900's, the gulf between the two cultures had come into existence and was defined largely by the adoption of La Tène art, brooch, and sword types (Collis, 2003; Hodson, 1968; James, 2005). While a change in art style does not necessarily indicate a change in population, the adoption of a new or different art style in diverse regions does not indicate the presence or movement of the same population.

Chapter 3: Continental and non-continental Celts

Archaeological evidence for the presence of the non-continental Celts

The La Tène culture in the British Isles is predominantly found in Yorkshire and is believed to have arrived through a series of waves of cultural influence from various parts of continental Europe, each affecting and changing the native population in different ways (Cunliffe, 1997; Raftery, 1981, 1991). Many of these influences may be ascribed to trade, while others are believed to have involved the actual physical migration of people. The Yorkshire burials were classified as La Tène based on similarities in burial practices (e.g., chariot burials and square barrows) to the La Tène burials in the Champagne region based on a survey by Dechelette (1910). Burials in Yorkshire dating from the pre-Roman Iron Age are identified as belonging to the Arras culture and they are markedly different from burials in the surrounding areas (Stead, 1979; Raftery, 1981, 1991; Whimster, 1981). The Arras culture is a middle Iron Age archaeological culture in East Yorkshire, and takes its name from the site of Arras, where the first excavation of a chariot burial in the British Isles was recorded (Stead, 1979). The culture is defined by its distinctive burial practices, which are restricted to Yorkshire, although similar practices are found in burials from the La Tène period in continental Europe (Stead, 1979). The Arras culture has also been linked to the La Tène tribes in Gaul through a perceived similarity between the Roman tribal designations in each region, *Parisi* and *Parisii*, respectively (Halkon, 2013; Harding, 2004; Hodson, 1964; Jacques and Rossignol, 2001).

The similarities in tribal designation have led to the assumption that the Arras culture was an offspring of the *Parisi*, of Gaul, who introduced the La Tène culture to eastern Yorkshire (Hodson, 1964). However, the British *Parisi* are known from only a single reference by Ptolemy in his *Geographica*, written around AD 150 (Halkon, 2013). The *Parisii* of Gaul are also only known from a single reference by Caesar in his account of the Gallic wars (Dunham, 1995; Hanford, 1983; Long, 2005). Furthermore, there is a gap of approximately four centuries between the appearance of the British *Parisi* and the Gaulish *Parisii* tribal designations in the early Roman period, and the posited invasion of the Arras culture during the 4th century BC (Halkon, 2013). The similarity of the tribal designations can be linked to the Roman practice of extending cultural labels across diverse regions based on observed similarities in cultures and/or populations (Collis, 2003; Cunliffe, 2009; Halkon, 2013). However, if the link between the

British *Parisi* and the Gaulish *Parisii* derives from a Roman ethnonym, the association between the inhabitants based on this criterion is disputed (Halkon, 2013). Moreover, the observed similarity between the burials of the *Parisi* in Yorkshire and those in continental Europe does not necessarily indicate that the different tribes were members of the same culture (Halkon, 2013). Rather, the similarities may reflect the movement of ideas and/or small-scale migration. Furthermore, no inscription with the name *Parisi* has ever been found in Yorkshire. This fact when, combined with the differences in burial practice in Yorkshire and Gaul, the similarities between these two tribes are likely to be in name only (Stead, 1979). However, despite the lack of tangible evidence connecting the British *Parisi* to the Gaulish *Parisii*, the belief that the Arras culture was derived from the Gaulish *Parisii* tribe remains a prevalent paradigm (Halkon, 2013; Hodson, 1964; Stead, 1979). While the chariot burials associated with the Arras culture are similar to those ascribed to La Tène cultural areas in Western and Central Europe, close inspection of the burial practices in each region does not support a direct link between them (Chadwick, 1970; Fitzpatrick, 1984, 2007; Hawkes, 1960; Stead, 1979, 1991).

The characteristic burial practices used to link the non-continental Celts (i.e., those of eastern Yorkshire) to the continental Celts include, chariot burials, and square barrows (Collins, 1975, 1991; Collis, 2003, 2004; Cunliffe, 1997; Dupuis, 1940; Stead, 1991; Stillingfleet, 1846). There is a debate as to whether the vehicles should be called carts or chariots; the former implies everyday transport while the later implies use during war (Cunliffe, 1997). The terms have been used interchangeably by numerous authors. In this thesis the term chariot is used as it is the most prevalent description of the vehicle burials associated with both the continental and non-continental Celts (Collis, 2003; Cunliffe, 1997, 2009; Halkon, 2013). A vehicle may be defined as a mechanical apparatus that provides a mechanical advantage for the purpose of transporting a load (this includes people, goods, and materials). Vehicles may be segregated into two major categories based on the number of wheels: two-wheeled vehicles may be called chariots, while four-wheeled vehicles may be called wagons or carts, however, the absence of weapons from the majority of Yorkshire graves suggests that this is unlikely (Stead, 1984, 1991). In the category of chariots, a distinction should also be made between use in battle and use in civilian applications. As most of the organic material has decayed, it is difficult to deduce how these vehicles functioned (Stead, 1984, 1991). However, regardless of the original intended use, the practice of

interring chariots is assumed to represent the same ritual, or symbolic, use by the continental and non-continental Celts. The Yorkshire chariot burials can be divided into two groups, those in which the chariots have been dismantled and those in which the chariots have been buried complete (Stead, 1991). The distribution of dismantled vehicle seems to be restricted geographically to the central area of Yorkshire at either side of the Wolds Valley and may indicate some form of shared identity or tribal grouping (Anthoons, 2011; Stead, 1991). The outliers at Pexton Moor, Cawthorn, Ferry Fryston and Newbridge were all buried intact, as are most, but not all, continental examples (Anthoons, 2011). Although the complete chariot burials in Yorkshire were on the ground surface and not in graves, they were nevertheless interred in a manner similar to the Haute-Marne tradition in the Champagne region, in which the wheels were either removed and placed against the grave wall or not removed prior to burial (Stead, 1991). Conversely, in continental Europe, the chariot is typically buried complete and often used as a type of coffin, and in some cases separate holes were dug in the grave floor for the wheels (Stead, 1991). There are some dismantled chariots in Champagne as well. However, the chariots in Champagne are not dismantled in the same way as those in Yorkshire (Stead, 1991). In the Champagne region when the wheels were removed, they were placed against the wall of the grave. When the chariot was buried complete, they were placed in separate holes dug into the grave floor (Stead, 1991). No region in continental Europe has a chariot burial practice identical to those in Yorkshire (Stead, 1965b; 1991). It is unknown how the chariot burials were used to designate specific individuals or social classes, if this burial ritual was strictly followed or was incorporated into the existing funerary practice of different tribal groups (Stead, 1965b).

It has been argued that the chariot burials in Yorkshire represent a secondary insular development, derived from an initial burial tradition imported from continental Europe (Collis, 2003; Cunliffe, 2009; Stead, 1991). However, the differences in chariot burials throughout the Yorkshire region (e.g., chariot placement), combined with the lack of archaeological evidence supporting a migration prior to the Roman arrival in the British Isles, do not support this interpretation. Furthermore, it is not known whether the act of dismantling the chariot prior to burial was consistent with the same practice or ritual as not dismantling it prior to burial, nor can we determine whether the social status was the same for both individuals (Collis, 2003; Cunliffe, 2009; Stead, 1991). The differences between chariot burials in Yorkshire and continental Europe

support the cultural diffusion of Celtic culture into the region. Alternatively, if the chariot burials occurred in a short time span, then the abundant differences may represent a cemetery in which the dead were buried, but in a fashion not associated with any particular tribe. However, the Iron Age chariot burials from East Yorkshire that have been radiocarbon dated, range from the fourth to second centuries BC (Collis, 2003; Cunliffe, 2009; Stead, 1991). The only example outside Yorkshire was found at Newbridge near Edinburgh and was dated between 520-370 BC (Carter and Hunter, 2003 a, b; Jay et al., 2012). Since the chariot burial practice was present in Yorkshire for a significant length of time, it is possible that the differences are related to tribal mixing and/or incorporation of continental burial traditions. Alternatively, it is possible that the differences in burial practices may reflect changes in funerary practice over time. Still further, it may be possible that no chariot burials survive from the earliest phase of settlement in Yorkshire, so the tradition represented in the archaeological record could be a secondary development.

While the burial of an individual with a chariot may be symbolic, it is impossible to tell for certain, due to the lack of a writing system. Symbols have different meanings across cultural, or tribal, boundaries that could explain the differences in the chariot burial practices, and the presence or absence of weapons in these burials. The dissimilarities in burial practices may indicate distinct tribal boundaries in which each tribe maintained their individual cultural practices. Alternatively, such differences could indicate the mixing of different tribes, each expressing their individual tribal cultures. However, without evidence supporting the presence of diverse tribes in Yorkshire and clearly defined boundaries for the different tribes, and those in continental Europe it is difficult to determine the extent of any tribal mixing (Stead, 1965a, 1991). Furthermore, the assumption that the similarity in burial practices indicates the continental and non-continental Celts were members of the same population is inherently problematic. While chariot burials are common in both continental and non-continental Celtic cemeteries, there are several key differences, the extent of which are on par with the difference in the square barrows in continental and non-continental Celtic cemeteries.

Square barrows are one of the most characteristic monuments of the Iron Age in East Yorkshire (Stead, 1965a, 1991; Stillingfleet, 1846). While square barrows have been recorded in the North Yorkshire Moors and Howardian Hills further north, they are most common on the

Yorkshire Wolds (Stoertz, 1997). Few examples outside Yorkshire of square barrow enclosures have been found (Stead, 1965b, 1979). It is believed that this burial tradition was of continental origin as it may be found extended over most of continental Europe during the La Tène region, prior to moving into Yorkshire (Stead, 1965b, 1979). While square barrows, have been used to link the Yorkshire La Tène cultures to those in the Champagne region specifically, the Yorkshire square barrow burials, are also similar to those in Germany, the middle Rhine, the Hunsrück-Eifel region, and Czechoslovakia (Anthoons, 2011; Laing, 2006; Stead, 1965b, 1979, 1991). The square barrows in Champagne are not as restricted in funerary practices as those in Yorkshire (Stead, 1965b, 1979, 1991). Square barrows in Champagne have been divided into different types, funerary enclosures and temples or centers of worship. While the exact function of these so-called centers of worship is debated, the barrows of this type are larger than their non-continental counterparts, and the vast majority lack burials (Stead, 1965b, 1979, 1991). The square barrows and chariot burials may have been of continental origin, but appear to have been locally adapted as the styles differ from their continental counterparts (Boyle, 2004; Brown et al., 2007; Dupuis, 1940). A further difference between the burial practices in Yorkshire and continental Europe is evident in the positioning of the body of the interred individual(s). Burial positions in Yorkshire are crouched or flexed while those in continental Europe are uniformly extended (Stead, 1991). The non-continental Celtic burials in Yorkshire are further distinguished from those in continental Europe by the absence of weapons in the majority of burials (as compared to those in continental Europe) and by the presence of “speared burials” (Stead, 1965b, 1991).

The La Tène burials in Yorkshire possess an Iron Age burial rite that involves throwing spears at bodies in graves, known as “speared burials” (Stead, 1991). This burial practice is believed to have involved driving spears into the body prior to burial, and has been found at several cemeteries in Yorkshire. The exact meaning of the speared corpse ritual is still debated (Giles, 2012; Stead, 1991). Like dismantled chariot burials, the speared corpse ritual seems to have been restricted geographically (Stead, 1991). The speared burial practice is restricted to Yorkshire, and is not found in conjunction with chariot burials in continental Europe (Giles, 2012; Stead, 1991). The spearheads from the Yorkshire burials differ markedly from the continental examples in manufacture (not as thick in the center) (Stead, 1991). The spearheads

used in this ritual were impractical for hunting weapons, as they lacked a mid-rib (or median ridge) and therefore would have been prone to bending or breaking upon impact (Stead, 1991). These burial rites, square barrows, chariot burials and speared burials, have no parallel in any earlier culture in Yorkshire, suggesting that these practices were introduced into the region at the same time (Stead, 1965b, 1979).

The Yorkshire burials can be further distinguished from their continental counterparts based on the quality and distribution of pottery (Giles, 2012; Stead, 1991). Pottery is frequently found in square barrows in Yorkshire, though none have been associated with the chariot burials. Conversely, pottery is rare in the Champagne region, though when it does appear, it is impressive in quality and quantity (Gifford, 1960; Stead, 1991). Pottery found in the Yorkshire burials consist of simple basic containers made with a strictly limited function in mind. Little time and effort appears to have been expended on their manufacture (Stead, 1991). They are minimum input vessels and are in marked contrast to earlier funerary vessels, such as beakers, collard urns, and food vessels of the late Neolithic and Bronze Age (Stead, 1991). More commitment of time and effort of manufacture is evident in these earlier vessels, particularly the surface treatment and decoration of the exterior (Stead, 1991). It may be that pottery was more highly prized as a grave good during the Neolithic and Bronze Age than in the middle Iron Age (Gimbutas, 1965; Stead, 1965b). However, not all of the food vessels during the Neolithic and Bronze Age were highly decorated. There is a limited group of small, plain, shapeless vessels that share typological traits with the pottery in Yorkshire (Stead, 1991). The pottery associated with the Yorkshire inhumations bear little resemblance to any wares produced in the Champagne region and stands in stark contrast to the local metalwork.

Although some metalwork was locally produced and inspired by continental designs, it is clear that there were metal workers of great skill operating within the region, as exemplified by the objects from Yorkshire (Giles, 2007; Stead, 1991). However, the apparent crude nature of the pottery compared to the sophistication of the metalwork is noteworthy. This discrepancy may indicate a difference in the skill of the craftsman, or in the importance of the objects themselves to members of the culture (Giles, 2007; Stead, 1991). However, it is also possible that the quality metalwork was produced in continental Europe and thus acquired by the inhabitants of Yorkshire

through trade (Fitzpatrick, 1984, 2007; Stead, 1991). Some of the metal objects found in this region appear to be regional copies of continental styles influenced by trade (Giles, 2007; Harding, 2004, 2007; Stead, 1991). In spite of the large number of burials and a series of rich grave goods, La Tène art is not common in Yorkshire; the few surviving examples are associated with the sword burials rather than with the chariot burials (Lloyd and Liang, 1992; Stead, 1965a, 1979). Several of the Yorkshire La Tène ornaments have been decorated with inlay, some of which has been described as shell, or paste. As such, the materials used appear to represent local substitutes for the coral that is found in similar objects recovered from early La Tène contexts in continental Europe (Piggott, 1950; Pleiner, 1993; Rapin, 1991; Stead, 1965b; Stead et al., 2006).

There are few examples of direct La Tène period imports, and even small pieces of Mediterranean coral seem to have been traded as raw material rather than as part of finished items (Giles, 2007; Harding, 2004, 2007; Stead, 1991). The majority of the Yorkshire ornaments belong to a distinctly British tradition that includes several features derived from continental Europe no earlier than the LTB period (Laing, 2006; Stead, 1965b, 1988, 1996). The designs of La Tène metalwork in Yorkshire are strikingly different from those found in continental Europe. The Yorkshire examples are more simplistic and unrefined (Giles, 2007; Harding, 2004, 2007; Stead, 1991). It has been suggested that the inhabitants of East Yorkshire were 'less than fully conversant' with the burial rites they were supposed to be adopting (Higham, 1987). Stead (1979) concluded that although there had been a clear exchange of ideas that exerted a powerful effect upon the community, they might have been introduced by a powerful wealthy minority, mercenaries or farmers (Stead, 1979). While large-scale migration from continental Europe into the British Isles during the La Tène period is not believed to have occurred, the movement of ideas (both funerary and artistic), as well as the exchange of objects and substances, does imply some degree of contact with continental Europe. Although the differences in burial practice, type and quality of grave goods in Yorkshire may represent chronological rather than biological divisions, the skeletal collections have not been the focus of much osteological analysis.

Previous examination of the individuals recovered from the cemeteries in the Yorkshire Wolds included some limited osteological analysis (Stead, 1991). Burials near each other occasionally share distinctive nonmetric skeletal traits, as is evident at Kirkburn, where adjacent

burials both possess a same parietal foramen (Stead, 1991, 1988). At Burton Flemming some graves shared a metopic suture (Stead, 1991, 1976). At Wetwang Slack three adjacent burials shared a particular spine deformity (the description of which is not elaborated), while two others shared a metopic suture, which have also been interpreted as indicators of kinship (Dent, 1985, 1995; Stead, 1991). It has been argued that these patterns reflected family groupings within the cemeteries. However, the original studies are not available for analysis, and the references to them are vague. However, the validity of these early osteological analyses is questionable as they were utilizing features which are relatively common to determine biological relationships (Stead, 1991). Although, in spite of the vague nature of these initial studies, other analyses (e.g., isotopic), have been conducted on the skeletal remains associated with Yorkshire.

Isotopic evidence from the chariot burials at Wetwang Slack shows a predominance of local individuals, with the occasional newcomer, such as the male from Kirkburn grave K5 (Stead, 1991). His isotope signature suggests that he was an immigrant to Yorkshire, the nearest area with a similar isotopic signature is the North Yorkshire Moors, where examples of the chariot burial rite are attested (Giles, 2012). The grave goods associated with this individual also suggest he was a non-local (Giles, 2012). The male in the K5 burial was buried under the dissembled vestiges of a chariot, with a chainmail tunic, draped over the body. The chainmail associated with this burial have not been found associated with any other burial in Yorkshire, but have been found in continental Europe (Giles, 2012). The ferry Fryston chariot burial has also been argued to represent that of a non-local individual. However, this assumption is based on strontium isotopic analysis of a cow tooth associated with the burial, as the human skeletal remains were not suitable for isotopic analysis (Horstwood et al., 2008). Similarly, the Iron Age individuals at Wetwang Slack were mostly locals, although only eight burials could be analyzed (Montgomery et al., 2007; Jay et al., 2013). Only one individual had an isotopic signature suggesting a non-local origin, although this does not preclude mobility between areas in the Wolds, such as inter-marriage systems (Montgomery et al., 2007; Jay et al., 2013). Second generation incomers would have a local strontium isotope profile, and it is possible that the limited sample used for isotopic analysis missed a first generation immigrant group (Stead, 1991). The isotopic evidence for small-scale migration is in line with the archaeological evidence for cultural mixing in areas associated with the continental and non-continental Celts, and

suggests that a higher level of biological diversity was present in both regions than previously assumed.

The isotopic results from the Wetwang Slack and Kirkburn cemeteries cannot be compared to other cemeteries in Yorkshire or in continental Europe as isotopic analyses have not been conducted on these individuals recovered from these sites as yet. However, if the pattern evident at the Wetwang Slack cemetery is recurrent at the other Yorkshire cemeteries then the chariot burial tradition may not likely represent an intrusive population movement, although other lines of evidence will need to be considered as well. It is possible that the majority of the Iron Age inhabitants of the Wolds were locally born and residentially stable, but that these communities had ties with and were open to incoming individuals from the nearby regions with which they had contact (Cunliffe, 1991). Further analysis is required to determine whether this pattern is represented by the other cemeteries in the Yorkshire Wolds region (Collis, 2003; Cunliffe, 1997). Cultural diffusion and small-scale migration is also supported by the classical descriptions of the inhabitants of the British Isles, in relation to the La Tène cultures of continental Europe. The classical Greek and Roman authors differentiated between the inhabitants of the British Isles and those in Gaul, for no classical authors describe the Celts as inhabiting Britain. The term *Celtae*/ Celt was reserved for continental people inhabiting Gaul (Collis, 2003; Cunliffe, 1997; James, 1999, 2005). While there is evidence for the presence of different tribes in Yorkshire during the Iron Age, a composite sample from five different cemeteries in Yorkshire was used in this study due to the similarities in burial practices and the association between these cemeteries and the La Tène culture. This was also undertaken in order to obtain an adequate sample size for analysis (Stead, 1965b, 1991). The biological affinities of the populations represented by the different cemeteries in Yorkshire will be the subject of future work.

Linguistic evidence for the presence of the continental and non-continental Celts

The term Celt is primarily a linguistic term. The first descriptions of the Celts by the classical Greek and Roman authors identified them as a specific ethnic group who spoke a distinctive language, referred to as continental Celtic (Evans, 1983). This language has been partially reconstructed from place names, inscriptions, words borrowed into Germanic or Italic

languages, and references in Latin texts (Charles-Edwards, 1995; Renfrew, 1987). Continental Celtic likely had a range of dialects, although how many and how they were related is not known (Evans, 1979; Fleuriot, 1988; Rickford, and Rickford, 1995; Schmidt, 1986). The continental Celtic languages appear to have died out around AD 500 (Evans, 1983, 1986; Schmidt, 1986; Renfrew, 1987). By contrast, in the British Isles the Celtic languages survived (Charles-Edwards, 1995; Renfrew, 1987). The Celtic languages were first described by Edward Lhuyd, in his *Archaeologia Britannica* (1707), wherein he defined the language family of the Gauls; he named this family of languages Celtic, based on the descriptions of Caesar and the belief that the area in which the Gaulish languages were spoken corresponds to the region inhabited by the *Celtae* according to the classical Greek and Roman writers, such as Tacitus (Collis, 2003; Cunliffe, 1997). Tacitus also described the languages spoken in Britain and Gaul as being similar (Collis, 2003; Cunliffe, 1997). However, he did not travel to either region and was not basing his statement on firsthand information (Moore, 2010). Therefore, the descriptions of the Celts are intrinsically linked with the spread of the Celtic languages.

The Celtic languages are classified as a branch of the Indo-European (IE), family of languages. The IE language family has around 445 languages and dialects, and includes most of the major extant languages of Europe and parts of western, central, and south Asia (Kortlandt, 1989; Forster and Toth, 2003; Fortson, 2004; Mallory, 1992; Mallory and Adams, 1997). While Celtic is accepted as an IE language, its place within this language family is still debated (Britain and Trudgill 1999; Dyen et al., 1992; Charles-Edwards, 1995; Evans, 1983; Fortson, 2004; Mallory, 1992; Mallory and Adams, 1997). The earliest records of Celtic language(s) are the Leptonic inscriptions of Cisalpine Gaul, the oldest of which predate the La Tène period (Ball and Fife, 1993; Evans, 1995; Isaac, 2010; Joseph, 2010; Renfrew, 2013). Evidence for insular Celtic (the Celtic languages in the British Isles), is available only from about AD 400 (Prosdocimi, 1991; Charles-Edwards, 1995; Korolec, 1995). The Celtic languages represented by these early inscriptions are distinguished by the difference in the expression of the k^w and p sounds.

Two primary criteria have been used to establish a linguistic division within the Celtic languages. The first is the development of an IE k^w sound (and a $k + u$ sound), which is expressed differently in the P and Q Celtic languages (Cowgill, 1975; Campanile, 1976; De Hoz, 1992;

Forester and Toth, 2003). P-Celtic languages include the continental Gaulish language and the Brittonic branch of insular Celtic (common Brittonic is the ancestor of Welsh, Cornish, and Breton). Q-Celtic languages include the continental Celtiberian and the Goidelic branch of insular Celtic (Goidelic is the ancestor of the Gaelic languages Irish, Scottish, and Manx) (Collis, 2003; De Hoz, 1992; Edward, 1904; Fleuriot, 1988; McCone, 1991; Oppenheimer 2007; Wodtko, 2010, 2013). The k^w sound appears as a ku or K sound in Celtiberian and in some Gaelic dialects (where it is transliterated as a Latin q sound, hence the term Q Celtic for these languages). Alternatively, the IE k^w sound appears as a p sound in the Goidelic languages (Manx, Irish and Scottish Gaelic). The IE k^w sound also appears as a p in Gaulish, Brittonic and Leptonic (Collins, 1999; Collis, 2003; Edward, 1904; Eska, 1998; Fleuriot, 1988; Renfrew, 1987; Schmidt, 1986; Sims-Williams, 1998a; Oppenheimer, 2007, Waddell, 1969; Wodtko, 2010, 2013). It is believed that these changes occurred after the split between insular Celtic languages and the continental Celtic languages.

While the Celtic languages are divided based on the use of a P sound in the Brythonic languages and a Q sound in the Gaelic languages, the importance of this division is debated. It is unknown whether this division is a convenient way to describe the two languages or a valid way of dividing them (Heine, 2008; McCone, 1996, Oppenheimer, 2007; Trask, 1996). Further divisions have been postulated among the Celtic languages including the Italo-Celtic language branch; however, this division is not believed to represent a specific language or language family (Cowgill, 1970; Forester and Toth, 2003; Isaac, 2004, 2010; Kortlandt, 1981, 2007; Russell, 1995; Schmidt, 1991; Warnow, 1997; Watkins, 1966; Weiss, 2012; Winfred, 1997). Rather the Italo-Celtic language branch represents a nominal division between the Italic and Celtic languages based on the suspected existence of an ancestral Italo-Celtic language (Forester and Toth, 2003; Schmidt, 1991; Warnow, 1997; Watkins, 1966). A multifurcation of Indo-European language branches rather than a common Italo-Celtic branch has been indicated by the perceived linguistic relationships among the continental Celtic languages (De Hoz, 1992; Forester and Toth, 2003; Isaac, 2004, 2010; Kortlandt, 1981, 2007; Watkins, 1966; Winfred, 1997). Because the continental Celtic languages, their relationships to one another and to other languages, and their diffusion throughout Europe are unknown, the relationships among the continental Celtic and other Indo-European languages are hypothetical.

The grouping of the Italic and Celtic languages into a separate branch within the Celtic and Indo-European language families is based on the presumption of shared features between the two languages, however, shared features between two languages does not necessarily facilitate the formation of a new language branch (Forester and Toth, 2003; Schmidt, 1991; Warnow, 1997; Watkins, 1966). Shared features and words between the Italic and Celtic languages may have derived from word borrowing across linguistic boundaries; alternatively, the presumption of shared features may simply be that, a presumption (De Hoz, 1992; Forester and Toth, 2003; Isaac, 2004, 2010; Kortlandt, 1981, 2007; Schmidt, 1991; Warnow, 1997; Watkins, 1966; Winfred, 1997). The presence of shared features is based on the Leptonic, Celtiberian and Italic descendant branches. While the Italic and Leptonic languages are believed to have been spoken in close proximity (in northern Italy, there is no evidence that the Italo-Celtic or Leptonic languages were spoken farther south than present-day Milan) the Celtiberian language was spoken predominantly in the Iberian Peninsula (Forester and Toth, 2003; Isaac, 2004, 2010; Kortlandt, 1981, 2007). It is unknown how closely the Celtiberian language is related to other continental Celtic languages.

Furthermore, the Celtiberian language is believed to have derived from a mixing of a Celtic language and local Iberian languages, as such it is unknown how closely Celtiberian represents a Continental Celtic language (Forester and Toth, 2003; Isaac, 2004, 2010; Kortlandt, 1981, 2007). If the Italic and Celtic languages derived from a common proto-language, the length of time since their split from an ancestral language and from each other cannot adequately be documented as the relationship between these two languages is unknown, nor is the duration of the period of common ancestry between these languages (Forester and Toth, 2003; Isaac, 2004, 2010; Kortlandt, 1981, 2007). Brief periods of common ancestry among language families may not be evident through lexicostatistical dating; therefore it cannot be determined whether Italo-Celtic existed as a language, whether the split between the Italic and Celtic branches occurred at a relatively early date, or if the term Italo-Celtic is a purely nominal designation based on a perceived linguistic relationship (Forester and Toth, 2003; Isaac, 2004, 2010; Kortlandt, 1981, 2007; Schmidt, 1991; Winfred, 1997).

The insular Celtic languages are more similar to one another than to the continental Celtic languages (Falileyev, 2007; Gohil, 2006; McCone, 1996; Parsons and Williams, 2000; Parsons, 2012; Oppenheimer, 2007). The split between insular and continental Celtic is believed to have occurred at some point between 3,200 and 2,500 BC; when the Brythonic and Goidelic languages were more similar to one another (Fortson, 2004; Gray and Atkinson, 2003). Gaulish is believed to have separated from the other insular languages by 5,200 BC; indicating that the insular Celtic languages arrived in the British Isles early. The date of 5,200 BC represents the oldest possible movement into the British Isles (Gray and Atkinson, 2003). Alternatively a date of $3,200 \pm 1,500$ BC, years was proposed for the split between Gaulish, Goidelic, and Brythonic, although this date should be regarded as tentative, as it is based on only three descendant branches (Edward, 1904; Forester and Toth 2003; Gray and Atkinson, 2003).

While lexicostatistics (the quantitative comparison of lexical cognates) and glottochronology (the attempt to use lexicostatistical method to estimate the length of time since one or more languages diverged from an earlier proto-language) can be used to estimate the timing of the linguistic diffusion of Celtic languages into the British Isles, there are several inherent problems with either method (Bergsland and Vogt, 1962; Campbell, 1988; Gray and Atkinson, 2003; Haarmann, 1990; Sankoff, 1970). Glottochronology examines the chronological relationships between languages, following two assumptions; first, that there is a relatively stable basic vocabulary shared by all languages and second, that any linguistic replacements occur analogical to radioactive decay, in a rate of constant percentages per time elapsed (Bergsland and Vogt, 1962; Campbell, 1988; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Kirk et al., 1985; Swadesh, 1952; Thomason and Kaufman, 1988). While glottochronology has been found to account for a significant proportion of the variance among Indo-European languages, the accuracy of the timing of language divergence using this method is inherently controversial (Bergsland and Vogt, 1962; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Hoijer, 1956; Holm, 2003; Sjoberg and Sjoberg, 1956). When borrowed words are included among descendant language branches, the resulting divergence time estimate can be distorted, as word borrowing across linguistic boundaries does not necessarily indicate a linguistic change (Brainerd, 1970; Campbell, 1988; Dyen, 1962, 1963; Gray and Atkinson, 2003; Holm, 2003; Sankoff, 1970; Thomason and Kaufman, 1988). A further problem involves the notion of dialect

continuum, which complicates language mapping and diffusion estimates (Bergsland and Vogt, 1962; Gray and Atkinson, 2003; Holm, 2003; Kirk et al., 1985; Thomason and Kaufman, 1988). Languages can be spatially dispersed, due to migrations or to incursions by other populations, and in the absence of integrative mechanisms such separated languages will eventually diverge from one another to form dialects that can be unintelligible over time and appear to represent distinct languages (Brainerd, 1970; Campbell, 1988; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Sankoff, 1970).

However, in spite of the linguistic gradient, there is no significant language border between groups speaking different dialects, as the linguistic change is gradual. Grouping such languages and/or dialects together as a single coherent language erroneously conveys the impression that the populations speaking these related languages and/or dialects composed a single linguistic community (Campbell, 1988; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Kirk et al., 1985; Sankoff, 1970). However, as there is no universally accepted definition of what constitutes a dialect verses a separate language, it is difficult to determine whether dialect or language boundaries are more accurate in regards to population separation (Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003). A further issue with glottochronology and lexicostatistics is how new languages emerge (Campbell, 1988; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Kirk et al., 1985; Sankoff, 1970). New languages can emerge based on descent from a common proto-language, as well as from changes in language structure and word borrowing across linguistic boundaries (Campbell, 1988; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Kirk et al., 1985; Sankoff, 1970; Thomason and Kaufman, 1988).

Borrowing of words across linguistic boundaries does not necessarily indicate a change in language boundaries, rather it can indicate interaction between individuals of populations speaking different languages with or without gene flow (Campbell, 1988; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Kirk et al., 1985; Sankoff, 1970). The distribution of Celtic place names throughout continental Europe may indicate interaction among the various Celtic tribes throughout the region (through trade or genetic admixture), and/or the application of Celtic place names by the Romans to regions possessing similar material culture

(or similar languages, as defined by the Romans). The consideration of syntax (the set of rules, principles, processes and word order that govern the sentence structure of a given language) and phylogeny (the system of relationships among speech sounds) along with the lexicon results in differential linguistic relationships (Campbell, 1988; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Kirk et al., 1985; Sankoff, 1970; Thomason and Kaufman, 1988). Further issues with glottochronology and lexicostatistics include the differential rate of change evident among modern languages, the rate of word replacement and change is likely to be different for each word or feature in a given language, linguistic changes are likely to have derived from events which are unforeseeable and therefore cannot be computed uniformly, the results of linguistic dating and divergence are often at odds with known and archaeologically derived data, and difficulties in finding equivalent terms across languages (Bergsland and Vogt, 1962; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Holm, 2003; Thomason and Kaufman, 1988). Since the timing of linguistic diffusion derived from lexicostatistics and glottochronology are often at odds with known data and language systems, the application of these methods to unknown language systems, such as the continental Celtic languages, is highly suspect.

The dates given by Gray and Atkinson (2003) and Forester and Toth (2003) are consistent with a Neolithic/Bronze Age migration. Linguistic dates suggest an early introduction of Celtic languages in the British Isles; however, the archaeological evidence for the spread of Celtic material culture, during the Iron Age, is at odds with this perspective (Cunliffe, 2009; Charles-Edwards, 1995; Evans, 1986, 1995; Jackson, 1948; Fortson, 2004; Green and Piggott, 1983; Green, 1998; Greenwell, 1906; Halkon, 2013; Hodson, 1964; James, 1999). If the Celtic languages moved into the British Isles during the Neolithic /Bronze Age, then their movement cannot be connected to the movement of La Tène material culture during the Iron Age. There is some evidence for a degree of cultural continuity from the Bronze Age into the Iron Age (i.e., settlement patterns and house structure), and given the lack of evidence for a large-scale migration, it is likely that the insular Celtic languages were already established in the British Isles prior to the movement of people bearing the La Tène material culture into Yorkshire. The movement of the Celtic languages into the British Isles does not necessarily have to have occurred solely through the movement of people into the same region. Cultural contact, through

trade for example, may have brought some insular Celtic linguistic elements, such as place names (used by the Romans), into the region prior to immigration of people speaking Celtic languages (Collis, 2003; Cunliffe, 1997; James, 1999, 2005). Cultural assimilation and diffusion of the La Tène culture into the British Isles may have also resulted in the Celtic linguistic presence in this region, although population movement which resulted in the spread of Celtic languages into this region cannot be ruled out at this stage. However, the presence of insular Celtic languages in the British Isles is adequate to designate the inhabitants as Celtic, regardless of the gap in the movement of Celtic languages and material culture.

The Celtic languages have been used to link diverse populations together without knowledge of their biological relationships (Cunliffe, 1997; Evans, 1979; Forester and Toth 2003). It is unreasonable to assume that there is biological affinity among people who speak an unreconstructed language, as is it unknown whether a Celtic language was spoken throughout the diverse regions to which the La Tène culture spread. It is also unreasonable to assume that population movement alone drove the spread of Celtic languages, especially in an area dominated by trade as words may be borrowed across linguistic boundaries and the linguistic relationships among the diverse populations and/or tribes in Iron Age Europe is unknown. The relationship between the continental Celtic and the insular Celtic languages is controversial, due to the nature of the known continental inscriptions, all of which are fragmentary, and the fact that these languages are extinct. The presence of Celtic languages and the presence of Celtic place names have been assumed to indicate that Celtic people were present in the region.

The Romans had a habit of affixing the name of the local tribe to a region, e.g., Celtic Gaul. The Romans seldom completely changed the place names they encountered during their military campaigns (Cunliffe, 1997; Falileyev, 2007; Heine, 2008; Parsons, 2012; Sims-Williams, 2006). The distribution of Celtic place names extends throughout the areas associated with the Celts, northern Gaul, southern Germany, and central Europe and into Britain and Ireland (Falileyev, 2007; Oppenheimer, 2007). While there is a record of Celtic inscriptions from Cornwall, Wales, Ireland and Scotland before and after the Roman invasions, around AD 43, their relative frequencies are low (Fortson, 2004; Forester and Toth, 2003; Sims-Williams, 2006). While place names have been used as evidence for the presence of Celtic languages in a

particular region, and that the area was Celtic-speaking and thus inhabited by Celtic people, this may not be the case (Falileyev, 2007; Sims-Williams 1998b, 2006; Joseph, 2010; Parsons, 2012). For example, in Albania and Kosovo both Pannonian and Celtic inscriptions and place names have been found; however, the majority of the tribal and place names are Pannonian in origin (Falileyev, 2007; Sims-Williams, 1998a). Therefore, the presence of Celtic place names does not necessarily designate an area as Celtic speaking and inhabited by Celtic people. While this belief is not as prevalent as it was initially, it is still utilized as a method to designate the spread of the Celts and the Celtic languages, regardless of the relationships between the Celtic languages.

Genetic evidence for the presence of biologically distinct continental and non-continental Celtic populations

The majority of the studies analyzing genetic variation among the Celts rely on DNA from the modern Celtic fringe (*i.e.*, the six Celtic “nations”, Ireland, Scotland, the Isle of Man, Wales, Cornwall, and Brittany), to constitute a baseline for Celtic DNA (Busby et al., 2012; Capelli et al., 2003; Hill et al., 2000; Lell and Wallace, 2000; McEvoy et al., 2004; Oppenheimer, 2012; Richards, et al., 2002; Rosser et al., 2000; Semino et al., 2004; Simoni et al., 2000; Sykes, 2006; Torroni et al., 1998, 2001; Wilson et al., 2001). The distribution of Y-chromosome and mtDNA throughout continental Europe has been the focus of numerous previous studies; however, few studies have linked specific haplogroups, or sub-types to the continental and non-continental Celts. While few previous studies have attempted to link specific haplogroups, or sub-types to the Celts, their focus has predominately been on Y-chromosome variation.

The distributions of the specific sub-types of the R1b haplogroup have been argued to be associated with the continental and non-continental Celts, as high frequencies are present where Celtic languages were spoken and the Hallstatt and La Tène material cultures were present (Lucotte, 2015). The high frequencies of Y-chromosome haplogroup sub-types, R1b-S145/ L21, R1b-S28/ U152, R1b-S21/U106, and I-L38/S154, observed where Celtic languages were spoken, has been used to link these sub-types and the continental Celts (Lucotte, 2015). The sub-type R-S145/L21 has been dubbed the insular Celtic haplotype, as high frequencies occur in the British Isles and along the Atlantic façade (the Atlantic coastline of continental Europe) (Lucotte, 2015).

This haplotype occurs at high frequencies in areas where insular Celtic languages were spoken and where they are still spoken today (Busby et al., 2012; McEvoy et al., 2004). The high frequencies of this sub-type occur in Western Europe, Brittany, southern Britain, and in northern Portugal (Faux, 2008; Lucotte, 2015; Richards, et al., 2002; Rosser et al., 2000; Torroni et al., 1998, 2001). The R1b-S28/U152 haplotype is found in geographical areas where the historical, linguistic, and archaeological evidence signifies the presence of the La Tène and Hallstatt Celts (Faux, 2008). The highest frequencies of the R-S28/U152 sub-type occur in France, northern Italy, and France. While lower frequencies occur in southern Germany, Switzerland, the Czech Republic, Slovakia, and Austria (Faux, 2008). As the high frequencies of this sub-type are in southwestern France and northern Italy, and decreasing progressively to the north, west, and east in the rest of Europe, this haplogroup has been dubbed the Southern European R1b haplotype or the Alpine haplotype (Busby et al., 2012; Cruciani et al., 2011; De Beule, 2009; Lucotte, 2015; Myres et al., 2007, 2011). The R1b-S21/U106 sub-type has been associated with the so called River Celts, as it is common around the western core of the Urnfield and Hallstatt area, along the Rhine to the Netherlands and along the Danube to Bulgaria (De Beule, 2009, 2011; Lucotte, 2015; McEvoy et al., 2004).

The I-L38/S154 sub-type has also been associated with the spread of the La Tène culture (Capelli et al., 2003; Cruciani et al., 2011; Lucotte, 2015). The distribution of the I-L38/S154 sub-type is similar to that of the R1b-U152 north of the Alps (Faux, 2008). The I-L38/S154 sub-type is scattered around the Rhineland, although the distribution is mostly limited to the Alpine valley, Switzerland, the German Rhineland, the Harz Mountains, the Low Countries, eastern France, and the British Isles (where the insular Celtic languages were spoken) (Capelli et al., 2003; Cruciani et al., 2011; Lucotte, 2015). This lineage is believed to have spread from Germany to England via Belgium during the late Iron Age with the La Tène culture. Because this sub-type occurs in high frequencies in the Alpine region in Italy where the Gaulish tribes settled, it is possible that this haplotype was brought to Italy by the migrations of Celtic tribes after the arrival of Italic tribes from the Alpine Danube region (Capelli et al., 2003; Cruciani et al., 2011; Lucotte, 2015). The I-L38/S154 haplotype may have been autochthonous to the region between the Alps, Central Germany, and the Low Countries, and was later assimilated into the Celtic gene pool during the Hallstatt and La Tène periods (Capelli et al., 2003; Cruciani et al., 2011; Lucotte,

2015). While some haplogroup sub-types, have been associated specifically with the continental Celts, those associated with the non-continental Celts are not typically subdivided. Sykes (2006) argues that there is a difference between continental and non-continental Celts based on the distribution of the Y-chromosome R1b haplotype; however, the haplogroup distribution was not examined through microsatellite markers.

R1b varies in frequency throughout the British Isles, although the highest proportion of R1b is found in men with Gaelic surnames, the remaining Y-chromosome haplogroups include I and J. MtDNA distribution in the British Isles involves haplogroups U5, H, T, and J predominantly (Capelli et al., 2003; Hill et al., 2000; Lell and Wallace, 2000; Oppenheimer, 2012; Richards, et al., 2002; Rosser et al., 2000; Semino et al., 2004; Simoni et al., 2000; Sykes, 2006; Torroni et al., 1998, 2001; Wilson et al., 2001). MtDNA analysis of haplogroup J contains two sub-types that have been found to show some linguistic specificity, particularly in the British Isles (Arnason et al., 2000; Simoni et al., 2000; Wilson et al., 2001). One sub-type, J-16192, is believed to represent a non-continental Celtic mtDNA sub-type, since it has only been found in high concentrations, in areas speaking Celtic languages in Britain including, Cornwall, Wales, Scotland, and Northern Ireland (Arnason et al., 2000; Cruciani et al., 2007; Di Giacomo et al., 2004; Helgason et al., 2001; Hill et al., 2000; Lell and Wallace, 2000). The J-16193 sub-type is believed to represent a Mediterranean or British Celtic mtDNA sub-type, since it is present in high frequencies in the Goidelic speaking areas of Britain and Ireland (Arnason et al., 2000; Cruciani et al., 2007; Di Giacomo et al., 2004; Helgason et al., 2001; Hill et al., 2000; Lell and Wallace, 2000). Overall, the continental Celtic Y-chromosome haplogroups include R1b-S28/U152, R1b-S21/U106 and I-L38/S154, while the potential mtDNA haplogroups include H5, J and K (Arnason et al., 2000; Cruciani et al., 2007; Di Giacomo et al., 2004; Helgason et al., 2001; Hill et al., 2000; Lell and Wallace, 2000). The non-continental Y-chromosome haplogroups include R1b-S145/L21, I and J, the potential mtDNA haplogroups include H, T, J-16192, J-16193, U4 and U5 (Arnason et al., 2000; Capelli et al., 2003; Cruciani et al., 2007; Di Giacomo et al., 2004; Faux, 2008; Helgason et al., 2001; Hill et al., 2000; Lell and Wallace, 2000; Lucotte, 2015; Oppenheimer, 2012; Richards, et al., 2002; Rosser et al., 2000; Semino et al., 2004; Simoni et al., 2000; Sykes, 2006; Torroni et al., 1998, 2001; Wilson et al., 2001). Viewed as a whole, the genetic evidence indicates that the Celts were a diverse biological

population, predominately differentiated through sub-types of the major European Y-chromosome and mtDNA haplogroups, indicating tribal variance. However, the few studies correlating specific haplogroups, and sub-types, to the Celts predominantly involve Y-chromosome and do not involve specific populations associated with the Celts. Instead, the previous genetic studies attempt to document the geographic distribution of haplogroups in broad regions where archaeological and linguistic evidence indicates the presence of the Celts, rather than looking at the regional variation among the diverse tribes associated with the Celts.

The few genetic studies that have attempted to examine the populations associated with the Celts, have documented the presence of regional variation in the R1b sub-types (Arnason et al., 2000; Cruciani et al., 2007; Di Giacomo et al., 2004; Helgason et al., 2001; Hill et al., 2000; Lell and Wallace, 2000). Suggesting that there is more regional variation among the populations and/or tribes associated with the Celts than previously assumed through examination of the broad geographic distribution of haplogroups (specifically the R1b haplogroup) in continental and non-continental Europe. However, in spite of this shortcoming the presence of genetic differences between the continental and insular Celtic regions; the results are in line with the linguistic and archaeological evidence indicating cultural assimilation and diffusion and small-scale migration. The differences in haplogroup frequency and sub-type within Gaul and the Hallstatt and La Tène regions indicates differences in the populations associated with Celtic material culture and those described by Caesar as referring to themselves as Celts. These differences are likely related to differential migration rates throughout the region. Genetic differences are also evident between the Celtic groups in the British Isles and the continental Celtic regions.

Summary

Previous studies have defined the Celts through perceived similarities in archaeological culture, and linguistics (Chadwick, 1970; Collins, 1997a, b, 1999; Cunliffe, 1984, 1991, 1994, 1997; De Marinis, 1977; Dietler, 1994; Dunham, 1995; Giles, 2012; Karl, 2010; Royrvik, 2012; Koch, 2003, 2006, 2007, 2009b, 2013; Kruta, 2004; Maier, 2003; McCone, 2008; Meid, 2008; Oppenheimer, 2007; Poppi, 1991). While these studies have attempted to establish the presence of the continental and non-continental Celts, they were operating under the premise that the term Celt is biological as well as cultural. However, the pejorative definitions associated with the term

Celt in antiquity, the inherent linguistic nature of the modern term, and the inconsistent application of the term by classical Greek and Roman and modern authors, make application to a specific population and/or tribe difficult (Collis, 2003; Cunliffe, 1997; James, 2005). The application of the term Celt as an ethnonym is further complicated by the general consensus in the field of Celtic studies that there is some degree of shared identity (either biological or cultural), among the diverse populations and/or tribes associated with Celtic material culture. However, the nature of this shared identity, either biological or cultural, is not further elaborated. Furthermore, it is unknown if the term Celt was applied to specific groups by the classical Greek and Roman authors or if it was a self-applied ethnonym. The term Celt has been defined through perceived similarities in archaeological culture, and linguistics in previous studies. While these studies have attempted to establish the presence of the continental and non-continental Celts, they were operating under the premise that the term Celt is biological as well as cultural. However, in spite of the biological application, the modern concept of the Celts is intrinsically linked with linguistics, to the extent that any region in which a Celtic language was spoken is believed to be inhabited by a Celtic population and/or tribe in spite of the regional differences in material culture (Collis, 2003; Cunliffe, 1997; James, 2005).

The regional differences in the archaeological culture, linguistics and genetics associated with the continental and non-continental Celts, have been predominantly examined typologically or chronologically (Collis, 2003; Cunliffe, 1997; James, 2005). The regional differences have not been interpreted to represent the presence of diverse populations and/or tribes associated with the continental and non-continental Celts. The populations and/or tribes that possessed Celtic culture are believed to have been Celtic, in spite of the fact that trade likely accounted for the presence of Celtic cultural objects in the diverse regions Celtic material culture subsequently spread to (Collis, 2003; Cunliffe, 1997; James, 2005). While the Celts are no longer recognized as a cohesive group the term Celt is still used to designate specific biological populations. However, the biological affinities among the diverse tribes and/or populations associated with them are not known. The regional differences in the archaeological cultures associated with the Celts have not been the focus of much research, nor has the population history within the regions these cultures spread to. Although genetic studies have indicated diversity throughout the regions associated with the continental and non-continental Celts, the similarities in archaeological culture and

language have been sufficient to label these diverse groups as Celtic (Arnason et al., 2000; Cruciani et al., 2007; Di Giacomo et al., 2004; Helgason et al., 2001; Hill et al., 2000; Lell and Wallace, 2000). However, the cultural changes from the proto-Celtic to Celtic period and the subsequent spread of Celtic material culture throughout continental Europe and into the British Isles may have been predominantly cultural. The accepted convention that all populations possessing Celtic material culture were Celtic and spoke Celtic languages is still prevalent in the field of Celtic studies in spite of the growing awareness of the genetic differences between the Celtic regions in Iron Age continental Europe. In order to fully understand the level of biological diversity among the Celts, it is necessary to move beyond the convention that La Tène =Celtic. The archaeological and genetic diversity within these regions suggests the presence of diverse populations and/or tribes, thus differences in dental nonmetric traits should be observed.

Chapter 4: Methodological background

Dental anthropology

Dental anthropology, a subfield of biological anthropology, is defined as the study of humans and their closest relatives through analyses of their teeth. It is associated with bioarchaeological analysis and incorporates techniques from the fields of genetics, anatomy, paleontology, and dentistry. The anthropological study of teeth focuses on the subtleties and variation in tooth size and morphology. Variation in the phenotype of the dentition can result from genetics, environment, diet, dental ontogeny, and maternal health. Even though teeth can be influenced by and directly interact with the environment, the size, form and morphology, excluding pathological conditions, are predominantly influenced by genetics (Berry, 1974; Larsen, 1997; Scott, 1973; Scott and Turner, 1997; Turner, 1967).

The traits included in the ASUDAS system possess a high genetic component in expression and are evolutionarily conservative. Furthermore, there is a moderate to high genetic influence on tooth structure, size and form. Heritability accounts for 60-90% of tooth size, class and morphology, as revealed through twin studies. (Biggerstaff, 1969; Bockmann et al., 2010; Irish, 2015; Hughes et al., 2007; Hughes and Townsend, 2011, 2013; Larsen, 1997; Lundstrom, 1967; Martinon-Torres et al., 2007; Mihailidis et al., 2013; Rightmire, 1999; Scott, 1973; Scott and Turner, 1997; Townsend and Martin, 1992; Townsend et al., 2009; Woodroffe et al., 2010). Due to the moderate to high genetic component, analyzing variability in tooth form and morphology provides insight into the degree of variation at the macroevolutionary (between and among species), and microevolutionary (within and among populations) levels (Turner, 1969; Hawkey, 1998). Genetic influence on tooth size and morphology enables comparisons and detection of microevolutionary and macroevolutionary variation within and between populations (Larsen, 1997; Nichol, 1990; Scott and Turner, 1997; Turner, 1969).

Microevolutionary dental analysis

Microevolutionary analysis is based on examining the evolutionary changes that occur within a species through natural selection, genetic drift, mutation, and gene flow. Biological distances between and among populations are determined through similarities observed in

polygenic skeletal and dental trait expression (Bernal et al., 2010; Bunimovitz, 1990; Buikstra et al., 1990; Campbell, 1925; Edgar, 2007). The dental analysis of microevolutionary patterns and biodistance estimates within populations fall into two types of study, dental metric and nonmetric (i.e., morphological). Dental morphological study involves the examination of specific nonmetric crown and root traits. Nonmetric dental traits are discrete anatomical units that occur in varying degrees of expression within, between, and among populations, thus making them ideal for biodistance and affinity analyses (Campbell, 1925; Garn et al., 1965; Nichol, 1990; Scott and Turner, 1988; Townsend and Brown, 1978).

Differences in dental morphology observed between populations, defined as communities of interbreeding individuals, can be explained as resulting from one or more evolutionary forces. Populations that share several attributes, such as specific morphological traits, are more closely related than populations in which differences are observed (Irish and Turner, 1989; Turner, 1989). Crown and root morphological traits show patterns of distinctive geographic variation. Significant differences between populations suggest more influence from genetic drift, mutation, gene flow, and consequently relatedness among population, which should decrease as spatial distance increases from progressively lower gene flow (i.e., isolation by distance). Multivariate, univariate, and descriptive statistical analyses of multiple morphological traits can be used to explore inter-and intra-variation between populations (Bedrick et al., 2000; Harris and Sjøvold, 2004; Hanihara, 1994; Hillson, 1996; Irish, 1993, 1998a, b, c, 2000, 2005, 2010; Irish and Guatelli-Steinberg, 2003; Sjøvold, 1973).

Metric and nonmetric dental traits involve a polygenic mode of inheritance and a quasi-continuous range of expression. While more research is necessary to fully understand the modes of inheritance, a complete understanding of these processes is not essential to perform affinity analyses (Berry, 1978; Biggerstaff, 1973; Coppa et al., 2007; Dahlberg, 1971; Hughes et al., 2007; Irish, 1993, 2010; Kimura, et al., 2009; Sadier et al, 2014; Scott and Turner, 1997; Turner, 1967). The structure and form of human teeth are under moderate to strong genetic control and are indicators of biological affinity among and between populations. Through documentation of frequency of occurrence and expression and subsequent statistical comparison it is possible to infer degrees of relationship between, within and among populations (Berry, 1978; Campbell,

1925; Nichol, 1990; Shaw, 1931; Scott and Turner, 1988; Townsend and Brown, 1978). Early studies investigating nonmetric traits revealed variation in the frequency of occurrence and expression between populations (Hellman, 1928; Hrdlička, 1920; Kraus et al., 1959). Hrdlička, (1920) was the first to describe and classify the degree of shovel-shaped incisors among human and non-human populations, indicating similarity between the dentition of Asians and Native Americans. Observations and descriptions of cusp number, groove pattern, and variation in root structure were documented by T. D. Campbell (1925), M. Hellman (1928), and J.C.M Shaw, (1931) who also urged physical anthropologists to place more emphasis on the study and analysis of dental variation.

Several traits were found to be characteristic of certain macroregional populations, such as incisor shoveling in Mongoloid populations and Carabelli's cusp in Caucasian populations (Hrdlička, 1920; Kraus et al., 1959). In 1956, Dahlberg created a series of reference plaques in an attempt to standardize the observations and descriptions of nonmetric traits. Hanihara (1963) also developed a series of reference plaques similar to Dahlberg's for deciduous teeth, after which it became apparent that broad-scale standardization was essential to enhance comparability in the growing field of dental morphometrics. A comprehensive series of dental plaques and scoring forms for permanent teeth were developed by Christy Turner II and coworkers 1991. The series of plaques was named the Arizona State University Dental Anthropological System (ASUDAS) and became the standard and most widely recommended method used to identify nonmetric dental traits (Hillson, 1996; Scott and Turner, 1988; Turner et al., 1991). The ASUDAS system consists of 24 rank-scale plaques, with detailed descriptions of each trait and the various forms of expression, for scoring 36 discrete crown and root traits of the adult permanent dentition. The benefits associated with this system include: the traits themselves are evolutionarily stable, they can be observed through mild levels of dental wear (if the antimere is available, in extreme cases), they are easy to locate and identify, they are independent of one another, sexual dimorphism does not affect their expression, they are independent of tooth size, and there is a substantial amount of comparable data (Irish, 2005, 2006; Scott and Turner, 1997; Turner et al., 1991). The ASUDAS system has led to the identification of specific dental complexes, a collection of nonmetric traits shared in specific macroregional populations at high, intermediate and low frequencies that differentiate them from other macroregional populations.

Dental morphological studies of particular ethnic groups, or odontographies, were established through Turner's research. Subsequently, these studies led to the development of specific dental complexes, collections of dental traits that frequently occur in specific ethnic groups. Dental complexes are based on nonmetric traits as observed on permanent teeth, although several nonmetric trait analyses have been conducted using deciduous teeth (Aguirre et al., 2006; Hillson and Antoine, 2003; Kieser, 1984).

In addition to the specific methods for documenting nonmetric dental morphological data, specific types of statistical analyses are standard as well. The analysis of multiple traits through any number of multivariate, univariate and/or descriptive statistical analyses such as Mahalanobis D^2 , and C.A.B. Smith's mean measure of divergence, both of which are commonly used with nonmetric data, can be used to identify inter-and intra-population affinities (Irish 2010). Other statistics used for nonmetric trait frequencies include principal components analysis, discriminant function analysis, biodistance statistics, cluster analysis, and multidimensional scaling to identify relationships between and among populations (Hillson, 1996; Hanihara 1994; Harris and Sjøvold, 2004; Irish, 1993, 1998 a, b, c, 2000, 2005, 2006, 2010; Sjøvold, 1973).

While over 100 non-metric traits have been observed and described 36 of these have been used in many studies over the years and have proven particularly successful in characterizing and comparing populations (Coppa et al., 1998, 2000, 2007; Cucina et al., 1999; Hanihara, 2008, 2010; Irish, 1993, 1997, 1998 b, c, 2000, 2005, 2006, 2008, 2010, 2015; Irish et al., 2014; Irish and Guatelli-Steinberg, 2003; Matsumura et al., 2009; Turner, 1969; 1984, 1985). These include discrete crown traits, such as Carabelli's trait and incisor shoveling, as well as root variants and lower molar root number (Irish, 1993; Turner et al., 1991). For a detailed description of the dental morphological variation among and between populations, see Scott and Turner (1997).

Disadvantages of using teeth as a research tool

Although there are many advantages to using teeth as a research tool, there are also several disadvantages. Information can be lost through wear and pathology, related to individual age and post-depositional damage. The global range of dental variation has not been completely

documented, resulting in patterns of regional population affinity and variation that are not completely understood. Fluctuating asymmetry, the differential expression of a morphological trait on alternate sides of the dentition, can have a negative effect on trait expression; however, this downside can be avoided. While fluctuating asymmetry occurs throughout the dentition; the antimeres can be scored with confidence in relation to the level of trait expression. Most traits are present on both antimeres because teeth are mirror images of each other, albeit inexact. As such, antimeres can be scored following two methods. One method involves counting only one side in all specimens (Haeussler et al., 1988). The second method is to score both antimeres and, allowing for asymmetry, count the side with the greatest expression (Scott and Turner, 1997). Because dental traits are continuous variants, they are difficult to score consistently into ordinal grades; differences in trait frequencies can exist between analyses that result in differential population affinity assessments. To avoid potentially biased data, proper scoring procedure should be exercised (Burnett et al., 2013; Nichol and Turner, 1986; Stojanowski and Johnson, 2015; Turner et al., 1991). Dental wear can also contribute to differential trait scoring, as the near-occlusal traits are more affected at the early wear stages (Burnett, 2015). Wear is a potential source of frequency bias in dental morphological study (Burnett et al., 2010, 2013). As previously mentioned, scoring of nonmetric traits can be biased in two ways. The first is designated as grade shift, which occurs when a trait is scored as having a lesser frequency (trait downgrading) or having a greater frequency than actually present (trait upgrading) expression than is actually present. Both trait downgrading and upgrading affect the frequencies of occurrence, by reducing or increasing frequencies of occurrence, respectively (Burnett et al., 2010, 2013).

Wear-related biases can be determined through analysis of trait frequencies across wear grades, which can indicate systematic grade shifting. Frequency biases have been identified in previous studies (Burnett et al., 2010, 2013). Significant wear biases have been found in the frequency of incisor shoveling, maxillary premolar accessory ridges, and lower molar cusp number. Wear related biases have also been reported in U11 shoveling, U11 double shoveling, UM1 enamel extension, LM2 cusp number, and LM1 deflecting wrinkle (Stojanowski and Johnson, 2015). These biases can lead to both intra- and inter-observer error through differential scoring, although this effect can be minimized by examination of trait frequencies across wear

grades. Frequency of occurrence can be compared to tooth-specific wear scores to determine the relationship between wear and morphology, and between patterns of missing data to determine whether observer error accounts for differential trait recording.

The rank scale plaques comprising the ASUDAS system promote intra-and inter-observer recording repeatability, especially between observers (Stojanowski and Johnson, 2015). Strict adherence to the ASUDAS standards and the use of intra-observer error checks can minimize the effects of error (Hillson, 1996; Turner et al., 1991). Intra-and inter-observer error can be limited through multiple scoring events by the same and/or numerous individuals, statistical analysis of the results, such as a paired samples t-tests, can determine whether the discrepancies in the results fall within an acceptable range. Additional measures, such as grade dichotomization, are used to address concordance issues between observers (Nichol and Turner, 1986; Turner et al., 1991; Stojanowski and Johnson, 2015).

Another potential disadvantage to the study of dental nonmetric traits is the lack of knowledge of the exact modes of inheritance. However, previous dental nonmetric analyses have indicated population affinities in line with genetic and known linguistic evidence and distribution without a complete understanding of the modes of inheritance. Dental traits have been argued to be polygenetic with a quasi-continuous range of expression or the existence of a gene model for specific traits (Dahlberg, 1971; Nichol, 1990; Noss et al., 1983; Scott, 1973; Turner, 1969, 1969). However, because dental size and morphology have a substantial genetic component (60-90%), understanding the exact modes of inheritance is not necessary for affinity studies. The lack of standardization, however, is not as easy to overcome.

The lack of standardization in scoring procedures between studies results in error when utilizing previously published data. Because dental traits are continuous variants and are thus difficult to score consistently along an ordinal scale, they may be evaluated based on individual training and/or personal opinion (Hillson, 1996; Turner et al., 1991). However, with the advent of the ASUDAS system, this issue has been somewhat reduced, as high inter-and-intra observer concordance and repeatability has been found (Haeussler et al., 1988; Nichol and Turner, 1986; Scott and Turner, 1997). Adherence to the ASUDAS protocols and intra and inter-observer error

trials combined with statistical analysis can minimize the effect of differential trait scoring. Asymmetry in the left and right antimeres may also impact dental nonmetric trait analysis, as the morphology of one antimer is not necessarily matched by the opposite. Some studies have indicated that fluctuating asymmetry of nonmetric traits increases from the mesial to distal members within the dental fields (Saunders and Mayhall, 1982). However, a high degree of concordance has been found between the left and right antimeres, and little evidence has subsequently been found for directional asymmetry (Garn et al., 1966; Mizoguchi, 1992).

Advantages of using teeth as a research tool

Although there are disadvantages to the analysis of dental nonmetric traits, their effects can be minimized through careful adherence to the ASUDAS system and the use of inter-and-intra observer checks. The loss of information through dental wear and/or post-mortem depositional damage can be minimized if the antimer is available for analysis. Overall, the disadvantages of dental morphological analysis do not preclude its use, for analysis of dental morphological variation can determine broad and regional scale population differentiation and affinity, the results of which have been independently corroborated by genetic and linguistic analyses when the linguistic distribution is known. However, when the linguistic distribution and relationships are unknown the link between languages and populations is tenuous, although dental phenetic relationships can be used to approximate the linguistic (and genetic) boundaries. Dental morphological analysis is therefore a useful tool for determining biological affinity among, between, and within populations.

Teeth have several attributes that make them especially suited to anthropological analysis. They are hard, primarily the enamel, which has the lowest porosity and highest density of all body tissues (Hillson, 1996; Kraus et al., 1969). The mineralized fluorhydroxyapatite enamel covers the crown, thus protecting the underlying dentine; making the teeth less susceptible to degradation after death (Hillson, 1996). Therefore, teeth are better able to survive in the archaeological record. Teeth act as the intermediary between individuals and their environment; their use as tools and everyday interaction with the environment can leave diagnostic scars. This relationship allows for interpretations about the interactions between

individuals and their environments, resulting in discernable clues as to diet, health and the cultural use of teeth (Frayer et al., 1988; Larsen, 1985; Merbs, 1983; Molleson and Jones, 1991).

Teeth are also less affected by the environment than other living tissues such as bone. Once teeth are formed, they do not change, with the exception of attrition and pathological damage. Because environmental stressors do not affect teeth as much as other living tissues, they can be used for short-term affinity studies within and between populations (Turner, 1969; Hillson, 1996). Teeth also evolve slowly, enabling long term diachronic studies through analysis of tooth morphology. However, dramatic changes in both dental morphology and tooth size are evident subsequent to the development of food production and ceramic technology. Samples of both living and dead individuals can be compared, thereby allowing for comparisons between extinct and extant populations. Moreover, teeth, while complex, display a largely consistent range in size within species and sex (Irish, 1993; Scott, 1973; Scott and Turner, 1997; Turner et al., 1991). As previously mentioned, teeth are evolutionally conservative (Irish, 1993; Scott and Turner, 1997; Turner et al., 1991). Therefore, teeth are well-suited to provide insight into numerous genetic, pathological, behavioral, cultural, and environmental relationships, making them a preferred subject of biological inquiry. Dental analysis has been employed in several fields, including, genetics, growth and development, pathology, forensics and hominid origins, because of the attributes mentioned above.

On a global scale, morphological trait frequencies have been found to vary according to broad geographical categories, and the moderate to high genetic component associated with dental nonmetric traits enables their use in population affinity studies. Nonmetric traits are discrete anatomical units that are expressed at differing frequencies within and among populations, thus allowing for interpretations at both micro-and macroevolutionary levels. Through analysis of the frequencies of occurrence and expression and subsequent statistical comparison, it is possible to determine the degree of affinity between and within populations. Regional and global relationships have been revealed through nonmetric trait analysis, the results of which are in line with genetic and linguistic evidence where known. Indicating the patterns of population affinity indicated through dental non-metric analysis is not a result of the analysis, but actually representing a true affinity relationship. While there are some differences between the

results of dental nonmetric trait analysis and genetic analysis, the discrepancies between the two are likely due to regional differences in haplogroup distribution and not the result of erroneous relationships created through non-metric trait analysis.

Because ASUDAS traits do not follow simple inheritance patterns, the phenetic differences and similarities between and within populations can be used to approximate levels of genetic affinity (Irish, 1997, 2010; Jackes et al., 2001; Scott and Turner, 1997). Thus dental nonmetric traits can be used to determine the amount of gene flow between populations. During the early period of nonmetric trait analysis, researchers utilized these traits to describe and document population differences and general differences in trait expression. These comparative studies were used on both global and regional scales. Based on the observed dental similarity, the derivation of modern populations from a common ancestral population fairly recently was supported (Turner, 1984, 1985). On a regional scale, the frequency of trait expression between prehistoric populations from India was determined to be intermediate in relation to trait expression to Europeans and Asians, indicating biological affinity (Lukacs and Walimbe, 1984). Specific dental complexes have been identified for the Mongoloid and Australian dentitions based on the frequencies of specific dental traits such as incisor shoveling, Carabelli's cusp, and Tomes root. Variations in the frequencies of nonmetric dental traits have enabled regional divisions based on population history. Based on the variation in frequency in dental nonmetric traits populations have been classified into broad geographical categories based on their specific combination of high, intermediate, and low morphological trait expression.

Western Eurasians are characterized by morphologically simple teeth overall (Mayhall et al., 1982). Sub-Saharan Africans have high frequencies of lower first molar cusp 7, Carabelli's cusp UM1, and cusps 5 LM1, and 6 LM1. Sino-Americans exhibit higher frequencies of dental morphological variation, and exhibit more morphological traits. The Sunda Pacific groups, in Polynesia and Micronesia, fall into the middle range for trait frequency. Finally the Sahul-Pacific groups, Australia, New Guinea and other Melanesian groups, exhibit high and intermediate frequencies, of several morphological traits (Townsend et al., 1990; Hanihara, 1968). While there is evidence for global scale variations in morphological trait frequencies there is also regional variation that can indicate variations within the broad dental complexes. The ASUDAS

system is the most widely used and useful method for scoring and evaluating dental nonmetric traits. The use of standardized plaques minimizes inter-and intra-observer error and enables common terminology to be used. Only those traits that have been associated with genetic heritability are included in the system (Nichol and Turner, 1986; Scott and Turner, 1997).

Chapter 5: Materials and methods

The continental Celtic samples are represented by the proto-Celtic Hallstatt D sample (650-475 BC), from Hallstatt, Austria, which comprises 30 individuals. The fully Celtic Munsingen-Rain collection (420-240 BC) from Munsingen, Switzerland, which is comprised of 33 individuals. The non-continental Celtic sample is represented by a pooled sample from five middle-Iron Age cemeteries from Yorkshire, representing a composite sample dating from 400-100 BC spanning La Tène A, B, and the first half of C in the British Isles. The sample was pooled to obtain an adequate sample size for statistical analysis. The cemeteries represented by the British Isles sample are all contemporary with the fully Celtic Munsingen-Rain collection and have similar burial features and customs. In total the British Isles sample is comprised of 31 individuals.

The comparative sample derives from the site of Pontecagnano located in Campania, Italy (7th-4th century BC). The entire skeletal collection from this site comprises some 700 individuals, of which a sub sample of 31 randomly chosen individuals dating to 650-300 BC (spanning La Tène A and B) were selected for analysis (sample locations are presented in Figure 1). The Pontecagnano collection was chosen because it is contemporaneous with the continental Celtic samples and its location places it outside the known area of habitation of the later Celts (sample abbreviations are presented in Table 1).

The continental fully Celtic, proto-Celtic and comparative individuals that possessed permanent teeth were scored for 36 discrete dental traits. Each dentition was scored multiple times under similar conditions to minimize for intra-observer error (intra-observer error is discussed further in chapter 6). Additional summary data, including cemetery association, grave/individual number, age, and sex is presented in Tables 2 through 5



Figure 1: Map of Europe with sample locations highlighted (figure modified from generic mapping tools).

Table 1: The four samples used in this thesis

Samples	Region	Date	No.
British pooled (Brit) ^a	Yorkshire, England	400-100BC	31
Munsingen-Rain (MunRain) ^a	Munsingen, Switzerland	420-240BC	33
Hallstatt D (HalD) ^a	Hallstatt, Austria	650-475BC	30
Pontecagnano (PON) ^a	Campania, Italy	650-300BC	31

^a Sample abbreviations used in subsequent Tables and figures

Table 2: Distribution of individuals: non-continental Celts *indicates a chariot/ cart burial

Cemetery/Grave Number	Age	Sex
Rudston, R3	35-35	Female
Rudston, R6	35-45	Female
Rudston, R17	25-35	Male
Rudston, R30	17-25	Female
Rudston, R76	17-25	Female
Rudston, R78	25-35	Male
Rudston, R91	25-35	Female
Rudston, R143	17-25	Male
Rudston, R133	25-35	Male
Rudston, R94	17-25	Probable Male
Rudston, R174	17-25	Male
Rudston, R175	17-25	Probable Male
Rudston, Grouped with R97, R107, R112	17-25	Female
Rudston, R99	15-17	Unknown
Rudston, R106	17-25	Female
Rudston, R81	17-25	Male
Rudston, R50	17-25	Male
Rudston, R55	17-25	Male
Garton Station, GS6	35-45	Male
Garton Station, GS10	25-35	Male
Garton Station, GS4	17-25	Male
Garton Station, GS1	17-25	Female
Burton Fleming/Bell Slack (site), BF40	17-20	Female
Burton Fleming/Bell Slack, BF42	17-25	Male
Burton Fleming/Bell Slack, BF46	25-35	Male
Burton Fleming, BF52	17-25	Female
Burton Fleming, BF63	25-35	Male
Wetwang Slack, 340	35-45	Female
Kirkburn, K7	17-25	Female
Kirkburn, K9	17-25	Male
Burton Fleming/Argam Lane (site), R205	25-35	Probable Male
Total		31

Table 3: Distribution of individuals: continental Celts: Munsingen-Rain

Grave Number	Age	Sex
6	15-20	Female
8a	30-40	Female
8b	10+/-1	Unknown
10	18-30	Male
11	12-14	Female
13b	7-9	nd
19	10	Unknown
20	30-40	Male
28	>60	Male
31	20-40	Female
32	35-45	Female
34	20-30	Male
39	12-15	Female
40	30-40	Female
43	>50	Male
52	50-70	Male
61	35-50	Female
67	25-35	Male
72	40-55	Male
78	20-30	Male
91	30-45	Male
122	35-45	Male
129a	40-50	Male
130	25-40	Female
134	40-55	Male
135	25-35	Female
158	30-45	Female
173	30-50	Female
175	7-8	nd
178	30-40	Female
180	35-45	Female
181b	30-50	Female
183	35-45	Male
Total		33

Table 4: Distribution of individuals: continental proto-Celts: Hallstatt D

Grave Number	Age	Sex
1A	18-25	Probable Female
2	20-30	Unknown
3	20-60	Unknown
4	15-18	Male
4.1	15-18	Probable Male
8	30-60	Probable Male
8.1	30-60	Probable Male
12	18-25	Probable Male
12.1	35-45	Male
14	30-60	Male
14.1	30-60	Probable Male
16	35-45	Male
17	20-30	Unknown
17.1	20-30	Probable Male
18	55	Male
21	35-45	Probable Male
22	30-60	Unknown
23	17-20	Unknown
24	25-35	Unknown
25	25-35	Male
26	20-30	Male
27	18-21	Probable Male
31	40-60	Male
33	20-30	Unknown
38	25-35	Unknown
45	30-45	Probable Female
46	40-60	Male
54	30-50	Female
845	25-30	Unknown
845.1	25-40	Probable Male
Total		30

Table 5: Distribution of individuals: comparative sample: Pontecagnano

Grave Number	Age	Sex
271	18	Unknown
276	23	Male
282	21.5	Female
283	13.5	Unknown
3200	23	Male
3338	25.3	Female
3410	14.5	Unknown
3467	15.5	Unknown
3471	15	Unknown
3501	15	Unknown
3502	18	Unknown
3516	14.5	Unknown
3536	16	Unknown
3608	18	Unknown
3640	34.33	Female
3684	15.5	Unknown
3692	25	Female
3707	14	Unknown
3708	16.5	Unknown
3715	23.5	Female
3731	23.5	Male
3738	14	Unknown
3739	29	Male
3985	18	Unknown
3987	19	Male
4015	31	Male
4019	23.5	Female
4031	17	Male
4075	15	Unknown
4313	23	Male
4327	15	Unknown
Total		31

British Isles cemeteries

The skeletal collections from the mid-Iron Age cemeteries in Yorkshire have been the subject of much research over the years; however, previous studies have focused on the grave goods, dental and skeletal inventories, descriptions of the cemeteries and comparisons to continental cemeteries of similar age. Although dental analyses have been conducted, pathologies have been the main focus. To date, no biological affinity analyses have been conducted. The Iron Age cemeteries that comprise the British Isles samples used in this analysis

include; Rudston makeshift, Garton Station, Burton Fleming, Wetwang Slack, and Kirkburn (Figure 2). All of these cemeteries are located in the north-eastern part of Yorkshire Wolds; and are associated with the Arras culture (Giles, 2012; Stead, 1991).

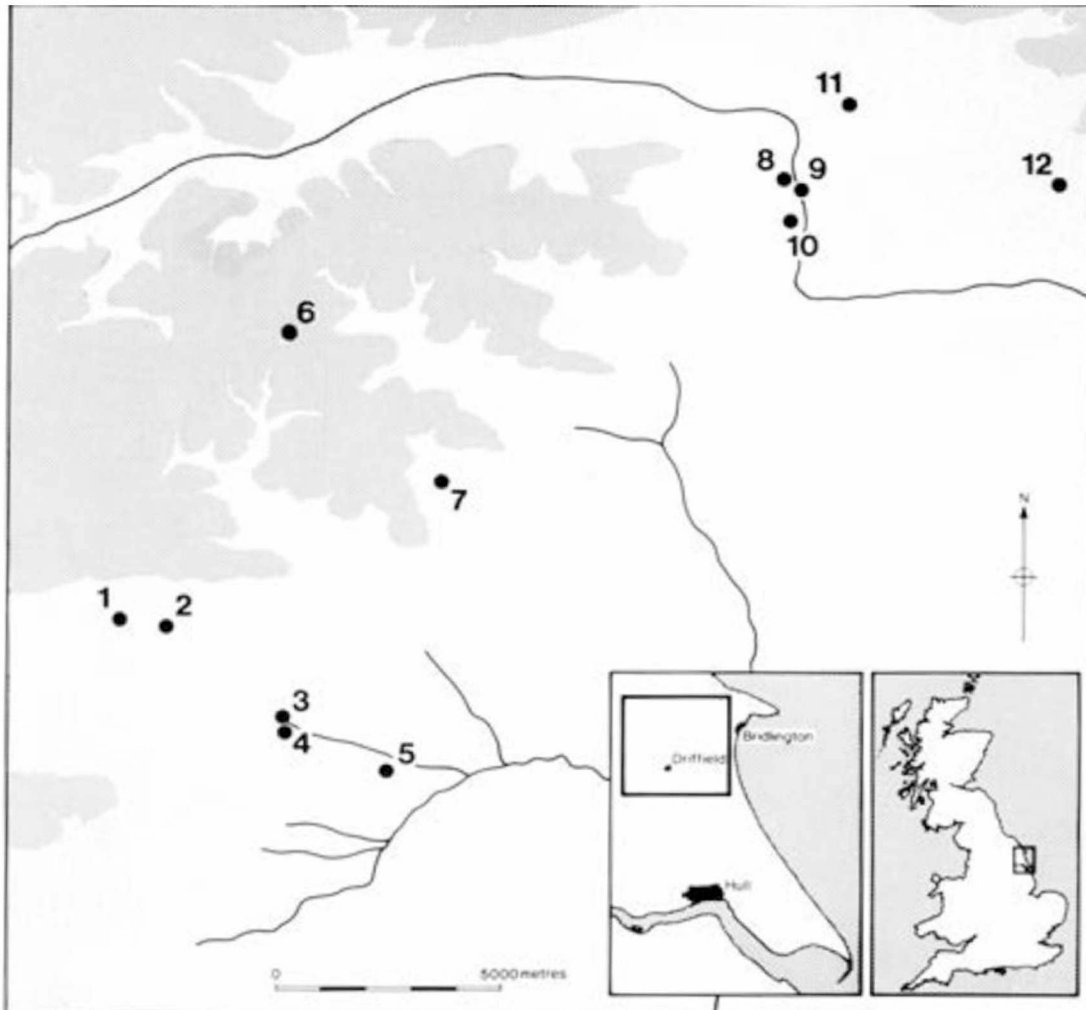


Figure 2: East Yorkshire, showing the sites of excavated Iron Age burials; **1.** Wetwang Slack; **2.** Garton Slack; **3.** Garton Station; **4.** Kirkburn; **5.** Eastburn; **6.** Cowlan; **7.** Danes Graves; **8.** Burton Fleming (BF1-22), **9.** Rudston (R190-208); **10.** Rudston (Makeshift, R1-189); **11.** Burton Fleming (Bell Slack, BF 23-64); **12.** Grindale (Huntow) (Stead, 1991). Bold numbers indicate the cemeteries used in this study.

Rudston Makeshift Cemetery

The cemetery extends for 600 meters east-to-west and 750 meters north-to-south. Burials R1-R189 are arranged in a reverse L pattern (Figure 3) (Giles, 2012; Stead, 1991). The interment

area is bounded on the southern side by a pair of ditches, one rather substantial, while the other appears to be a flanking ditch, and by tightly regimented barrows that follow the alignment of the valley and the river course (Giles, 2012; Stead, 1991). This suggests the presence of a route that ran from the northern part of the valley into the Burton Flemming and Rudston Makeshift cemeteries and settlement locations, following the Gypsey Race. The eastern edge of the cemetery was most likely bounded by the original course of the Gypsey Race before it was diverted further to the east (Stead, 1991). Excavations began in 1967 (R1-22) at the southern end of the cemetery. Further graves (R26-44) were excavated in 1969 in the northern section, followed by excavations (R68-89 and R94-114) in the north-eastern section in 1970-1971 (Stead, 1991). The remaining burials (R135-175, R177-188) were located in the ditch and excavated between 1973 and 1975 to the west and east of the cemetery, respectively (Giles, 2012, Stead, 1991). Groups of graves were excavated at well-spaced intervals throughout the cemetery to in an effort to identify any differences and/or changes in burial customs and grave goods (Giles, 2012; Stead, 1991).

A total of 154 barrows were excavated, 11 of which yielded no central grave and 16 of which were not excavated completely (Stead, 1991). Age and sex were determined through analyses of tooth eruption, epiphyseal and cranial suture closure, and examination of secondary sex characteristics (Stead, 1991). The typical type of barrow was between 4 and 5.4 meters wide, the smallest being only three meters (R142), while the largest was 10 meters across (R53 and 130). Central graves were found in less than half of the barrows throughout the cemetery (Giles, 2012; Stead, 1991).

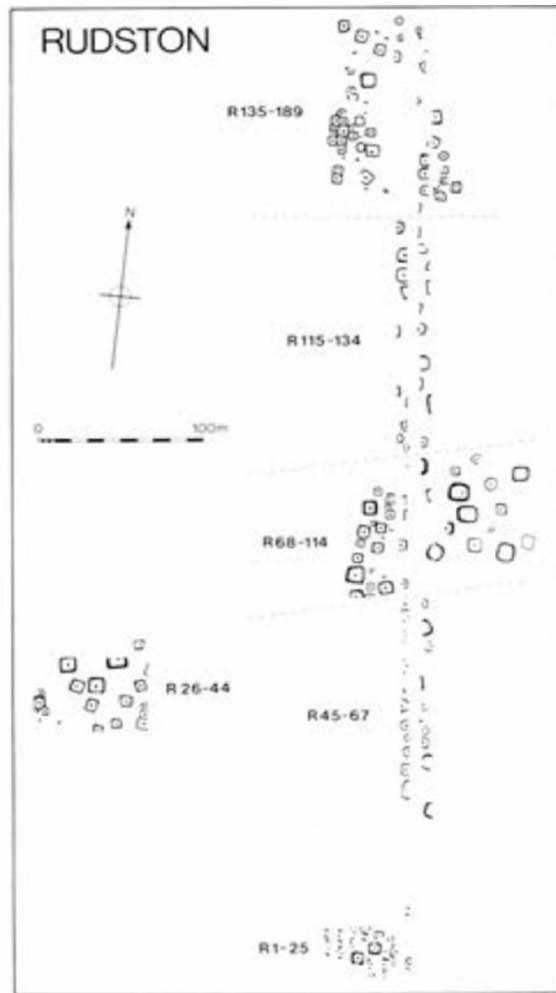


Figure 3: Rudston Makeshift Cemetery; relative positions of R1-189 (Stead, 1991).

Garton Station

This cemetery lies at the eastern end of the Great Wolds Valley along the route followed by the old Malton to Diffield railway line. Excavation began in 1984 when two large square barrows were tested with a gradiometer to document any near-surface anomalies (Figure 4). Of the four large square barrows excavated, only one had a central grave, which was a chariot burial, while nine of the small-to medium-sized barrows had large and deep graves dating to the Iron Age (Brewster, 1971, 1980; Giles, 2012; Stead, 1991). Age and sex were determined through analyses of tooth eruption, epiphyseal and cranial suture closure, and examination of secondary sex characteristics (Stead, 1991).

While there are notable similarities between the burials at the Rudston Makeshift cemetery and Garton Station, there are some prominent differences as well, including secondary burial composition and barrow type. As at Rudston, secondary burials were found within the surrounding ditches however, the majority of these contained the remains of infants. The secondary burials were often interred in the top fill layer of the grave pit, or barrow mound, or within the associated enclosure ditch (Giles, 2012; Stead, 1991).

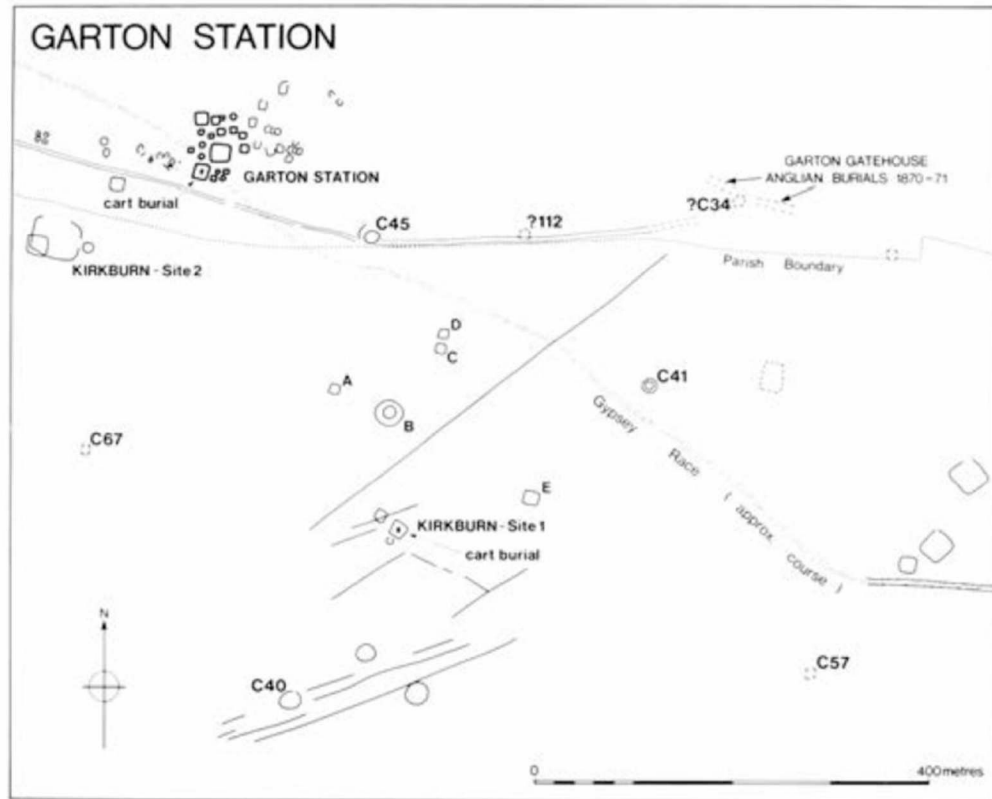


Figure 4: Garton Station and Kirkburn, showing the excavated areas (based on a plan by the National Monuments Record); the numbered barrows were excavated by J.R. Mortimer (Stead, 1991).

Burton Fleming

The cemetery encompasses 22 burials from the Argam Lane site and 42 from the Bell Slack site, and is closely associated with the Rudston Makeshift cemetery. The 22 square barrows associated with the Argam Lane site were excavated in 1972 and all had central graves (Figure 5). The flanking ditches surrounding the barrows lacked any secondary burials (Riley,

1988; Stead, 1991). The burials were arranged in two rows and were roughly aligned with the Gypsy Race.

The 42 burials associated with the Bell Slack site were excavated in 1978 and these excavations revealed that they were partly disturbed by Roman-British ditches. Age and sex were determined through analyses of tooth eruption, epiphyseal and cranial suture closure, and examination of secondary sex characteristics (Stead, 1991). No rows of barrows could be discerned, but their overall distribution was aligned with the valley. The barrows were average in size, between 4 and 5 meters square, and were flanked by a network of shared ditches in the northern end of the cemetery (Giles, 2012, Stead, 1991).



Figure 5: Burton Fleming, unexcavated barrow ditches are shown in tone (Stead, 1991).

Wetwang Slack

This cemetery lies near the Village of Garton on the Wolds in the East Riding of Yorkshire. Excavations began in 1965 and continued until 1975. In total, 238 enclosure ditches were spread along the southern edge of the cemetery, all but 18 of which contained a central grave. While some enclosure ditches were found without a central grave, they were clustered along the western edge of the cemetery (Dent, 1985, 1995). Two types of graves have been described within the cemetery; primary graves, which are central to a ditched enclosure, and secondary graves, which are cut into, or around, the burial platform or ditch. In total, 127 graves were found along the enclosures, where the majority of the juvenile burials were located (Giles, 2012; Stead, 1991). Age and sex were determined through analyses of tooth eruption, epiphyseal and cranial suture closure, and examination of secondary sex characteristics (Stead, 1991).

The majority of the burials were either crouched or contracted, with many on their left side and oriented north-south. The secondary burials were commonly found interred in the top fill of either the grave pit, under the barrow mound, or in the surrounding enclosure ditch (Brewster, 1971, 1980; Dent, 1985, 1995; Giles, 2012). This type of burial rite is commonly associated with juveniles and/or infants. As at the Garton Station, Rudston Makeshift and Burton Flemming cemeteries, chariot burials have been found at Wetwang Slack. In total, three chariot burials have been uncovered, all which were aligned along the north-south axis of the cemetery. One of which contained the remains of a young woman, which represents an unusual association in the Arras culture (Stead, 1991). The young woman was interred on her right side, with her arms extended and legs bent, as were the other two males buried with their chariots.

Kirkburn

This cemetery lies south of the Garton Station cemetery in the eastern end of the Great Wolds Valley. Excavations began in 1987 at a large square barrow (12-12.5 m²) that subsequently revealed a chariot burial. The cemetery is laid out in a similar manner as the Garton Station cemetery, with a series of square, and some round, barrows flanked by enclosure ditches. Age and sex were determined through analyses of tooth eruption, epiphyseal and cranial suture closure, and examination of secondary sex characteristics (Stead, 1991). A large oval enclosure, some 47 meters long and flanked by a shallow ditch with a six meter wide causeway was

excavated in the north-west corner of the cemetery. Attempts at dating the structure were inconclusive, although a piece of pottery dated to the Neolithic was found in the flanking ditch. The Kirkburn cemetery appears to have been in use, on and off, for an extended period of time.

When considered overall, the British Isles sample is comprised of five middle-Iron Age cemeteries in Yorkshire. This sample was pooled to obtain an adequate sample size for statistical analysis. Individuals were chosen based on the presence of nearly complete dentitions as described in the British Museum archives. The burials represented by the Rudston Makeshift, Garton Station, Burton Fleming, Wetwang Slack, and Kirkburn cemeteries are curated by the British Museum London, England, and span from the 4th- 1st Centuries BC, encompassing the early to mid/late La Tène periods.

Continental Celtic sample: Munsingen-Rain

Munsingen is a small town located to the east of the Aare River in Switzerland. Excavation began in 1906 and 220 graves were uncovered, of which the skulls of 77 individuals and some postcranial bones were preserved (Figure 6) (Hodson, 1968). The Munsingen-Rain collection was chosen for analysis as this collection represents a fully Celtic population possessing La Tène material culture, and because this collection has not been the focus of a biodistance analysis nor is it suited for DNA analysis (as such dental nonmetric analysis can be used to determine biological affinity). The majority of the burials were supine and extended, and there did not appear to be any segregation of the sexes or ages at death within the cemetery. Age and sex were determined through analyses of tooth eruption, epiphyseal and cranial suture closure, and examination of secondary sex characteristics (Stead, 1991). British archaeologist Frank Hodson (1968) conducted supplementary work on the chronology within the cemetery through analysis of types of fibulae found in the graves (Hodson, 1968). The northern part of the cemetery dates to the LTA period, while the burials at the southern end of the cemetery date to the LTC period. Overall the cemetery appears to have been in use from 420 to 240 BC.

An abundance of grave goods have been recovered from the Munsingen cemetery. Some of the subadult burials were accompanied by grave goods typically found with adult females, while some burials contained no grave goods at all (Hodson, 1964). Weapons and lances have

also been found in male graves. The abundance of grave goods and the continuity of cemetery use have led to the claim that the entire population was of high social status. The vast majority of the 77 individuals analyzed from the Munsingen-Rain cemetery are housed in the Archaeological Service of Bern, Switzerland, while five skulls are curated at the Natural History Museum, in Bern, Switzerland.

The skeletal collection of Munsingen-Rain has been the subject of much research over the years (Hodson, 1968; Kutterer and Alt, 2008; Moghaddam et al., 2014, 2016). However, previous studies have focused on the grave goods, craniometric analysis, skeletal inventories, isotopic analysis, general descriptions of the cemetery, and the dispersal of the La Tène culture. Although, previous analyses have been conducted on the skeletal material recovered from the cemetery, they have been limited due to the condition of the collection and, to date, biological affinity analyses have not been conducted.

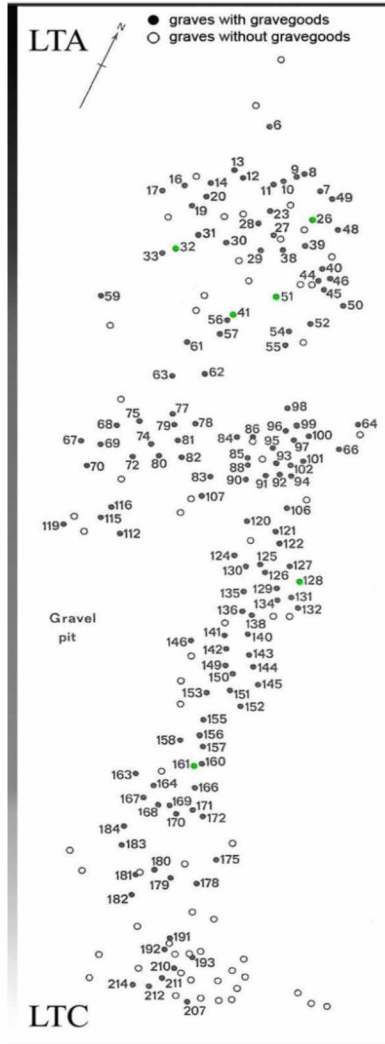


Figure 6: Distribution of graves within the La Tène cemetery of Munsingen-Rain (Hodson, 1968).

Continental proto-Celtic sample: Hallstatt

This cemetery is located in the Salzkammergut region of Austria, where much of the material evidence associated with the early Celtic culture was first identified. Excavations began in 1846-1863 when Johann Georg Ramsauer, an Austria mine operator and later director of the excavations at the Hallstatt cemetery, exhumed 980 graves. Excavations continued until 1899 yielding a total of 1,045 burials. Age and sex were determined through analyses of tooth eruption, epiphyseal and cranial suture closure, and examination of secondary sex characteristics (Hodson, 1990). The burials analyzed for this sample represent a group of burials excavated by

Frederick Morton in 1937-9, and are housed in the Natural History Museum in Vienna, Austria. The individuals span from 650-350 BC, representing the HaD period (Figure 7). The Hallstatt collection was chosen for analysis as this collection represents a proto-Celtic population (from the type site of the Hallstatt material cultural type site) possessing Hallstatt material culture, and because this collection has not been the focus of a much analysis nor is it suited for DNA analysis (as such dental nonmetric analysis can be used to determine biological affinity).

The skeletal collection from Hallstatt has not been the subject of much research over the years (Biel, 1981; Collins, 1986; Hodson, 1990; Hopkins, 1957). Previous studies have focused on the grave goods, general descriptions of the cemetery, and the dispersal of the Hallstatt culture. To date, biological affinity and dental analyses have not been conducted.

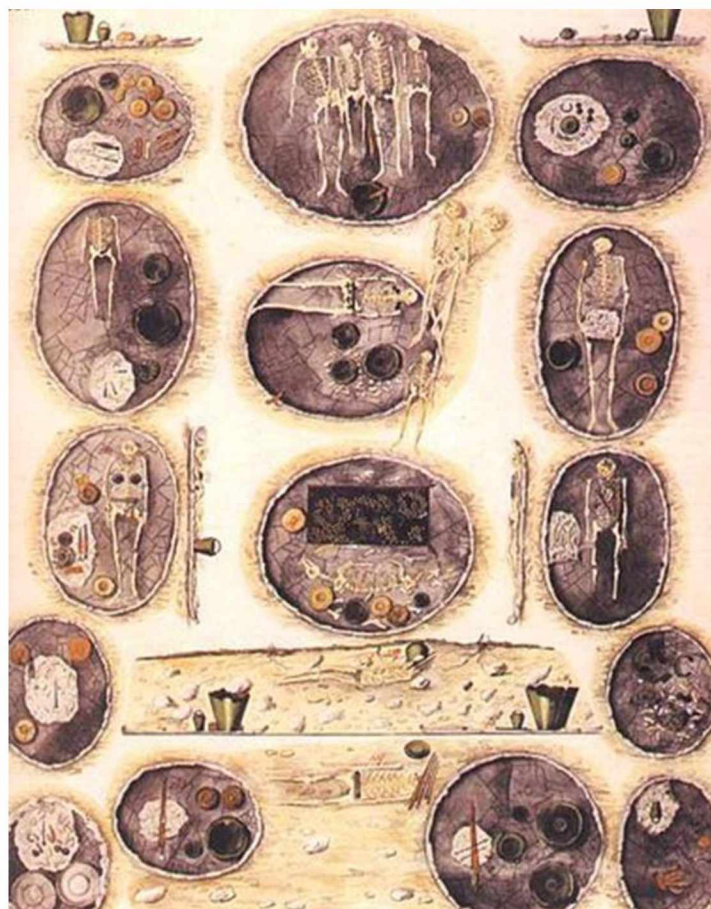


Figure 7: Drawing commissioned by Johann Ramsauer documenting the cemetery at Hallstatt, watercolor painting done by a local artist (Johann Georg Ramsauer, 1874).

Comparative sample: Pontecagnano

This cemetery is located in the town of Pontecagnano in Campania, Italy. Pontecagnano was first settled in the late Bronze Age. By the 5th century BC it was an independent city populated by a mix of native Italic people known as, Samnites (from the internal highlands), Etruscan colonists, and some Greek settlers from nearby colonies (D'Agostino, 1974; Fredericksen, 1974). Excavations at Pontecagnano have focused on the cemeteries in response to their disturbance by highway construction. In total, over 6,000 graves have been excavated and they span from the 9th-3rd centuries BC (D'Agostino and Gastaldi, 1988; De Natale, 1992; Serritella, 1995). Overall, the past studies have found the population of Pontecagnano to be typical for ancient urban groups. The population is characterized by moderate stature, longevity (compared to other regions), high rates of enamel hypoplasia and physical stress markers, high trauma (especially in

males), and high rates of dental disease. The majority of the burials are individual inhumations with a variety of tomb forms. The skeletons from the Pontecagnano cemetery have been the subject of many anthropological studies (Becker, 1993; Cencetti, 1989; Germana and Fornaciari, 1992; Fornaciari et al., 1986; Petrone, 1995; Robb, 1994, 1997, 1998; Scarsini and Bigazzi, 1995).

The burials studied here form part of a group of burials curated by the Museo Nazionale Di Anthropologia (Florence). The burial customs changed markedly from the 9th through 3rd centuries BC at Pontecagnano. Thus, for the purposes of this study, it was felt appropriate to limit the sample to burials from a discrete and roughly homogenous period, the 7th through 3rd centuries BC. The burials used in this study represent a randomly chosen sample spanning from 650-300 BC. The Pontecagnano sample was chosen to be the comparative sample because the location of the cemetery lies outside the known are of maximum Celtic expansion and is contemporaneous with the other samples.

The skeletal collection from Pontecagnano has been the subject of some research over the years (Robb, 1994, 1998). Previous studies have focused on the grave goods, dental and skeletal inventories, biological affinity studies, descriptions of the cemeteries, and comparisons to continental cemeteries of similar age. While dental analyses have been conducted, including pathological and affinity studies this sample was included for purely comparative purposes. The samples will be referred to following the abbreviations in Table 1 in the statistical analysis

Methods: data collection

The primary goals of the present study were to estimate the biological affinities between the middle-Iron Age non-continental and continental Celtic populations; to establish the biological affinities between the continental proto-Celtic and fully Celtic populations and to establish the presence, or lack thereof, of a biologically distinct Celtic population using dental nonmetric data. Each sample was examined for observable dental morphological crown and root traits. All observed traits, with the exception of UII midline diastema are part of the ASUDAS (Irish, 1993; Turner et al., 1991). The 36 discrete crown and root traits were recorded for each sample. In cases of bilateral expression, both antimeres were recorded. In order to allow for asymmetry,

the side with the greatest degree of trait expression was counted in an effort to establish the maximum genetic potential for each trait for each individual. To maximize sample size in cases where only one side WAS present that side was scored and assumed to represent the highest expression (Scott and Turner, 1997; Turner, 1985; Turner et al., 1991). Significant dissimilarities by side may be random, as different traits are affected among studies, as such, it is standard procedure to pool the sexes (Turner et al., 1991). The ASUDAS system is well established for determining intra-trait variations (Coppa et al., 2007; Cucina et al., 1999; Irish, 1993, 1997, 1998 a, b, c, 2000, 2005, 2006, 2008, 2010). The sexes were combined for each sample, following ASUDAS protocol (Irish, 1997).

Quantitative analysis

The 36 traits were entered into SPSS version 20.0, and were dichotomized into categories of present or absent based on each trait's appraised morphological threshold, as described by Scott (1973), Nichol (1990), Turner et al., (1991) and Irish (1993), to calculate intersample phenetic distances with the MMD (Haeussler et al., 1988; Sjøvold, 1977). Dichotomization facilitates tabulation of trait frequencies and is required before the data are compared using MMD (Sjøvold, 1973, 1977; Green and Suchey, 1976; Harris and Sjøvold, 2004; Irish, 2010).

Principal components analysis (PCA)

PCA is used to edit and remove problematic traits prior to MMD analyses. Those traits having any missing data are deleted, because the analysis is not intended to correct for trait observations of less than 10 (Green et al., 1979; Green and Suchey, 1976). Fixed or largely invariant traits are removed as well, because they provide no useful information for identifying differences among samples, and can result in negative MMD values. The latter is a statistical artifact that has no "biological meaning" (Harris and Sjøvold, 2004, p 91). The remaining traits are submitted to PCA to identify those traits that are most likely to drive intersample variation, and those that are minimally discriminatory. In the current study any variable not receiving a PCA loading of at least $|0.05|$ on any orthogonal vector was eliminated from further analysis (Irish et al., 2014).

In PCA, the original correlated variables are linearly transformed into a smaller set of uncorrelated compound variables. The reduction in dimensionality, or variance, produces fewer linearly uncorrelated variables, or principal components. The first principal component explains the greatest amount of variance, followed by the second component and third component, and so on. These principal components retain most of the information from the original variables while remaining mutually uncorrelated and orthogonal. Correlations, also called loadings, are computed between the original variables and the principal components. The specific dental traits that are accountable for the observed inter-sample variation are identified, and this aspect is why PCA was chosen for the present study. Varimax rotation is a change of coordinates used in PCA that maximizes the sum of the variances of the squared component loadings. Varimax rotation was chosen for this analysis because the difference between large and small component loadings can be maximized. It is recommended that the inter-sample distances be based on as many traits as possible; however, these traits should not be highly correlated with one another represented by a Kendall's tau-b (t_b) value of ≥ 0.05 , as differential weighting of the underlying dimensions may lead to erroneous distances (Sjovold, 1977). Inter-trait correlations were assessed by submitting the undichotomized rank-scale ASUDAS data to the Kendall's tau-b correlation coefficient.

Mean measure of divergence (MMD)

Following the assumption that phenetic similarity approximates genetic affinity among samples, a distance statistic that provides a quantitative estimate of inter-sample biological distance and phenetic similarities based on the similarities among the traits was used, (Irish 2006). C.A.B. Smith's mean measure of divergence (MMD) statistic, paired with the Freeman and Tukey angular transformation, which corrects for low (< 0.05) or high (> 0.95) trait frequencies and small sample sizes, is used to test the hypotheses in this analysis (Freeman and Tukey, 1950; Green and Suchey, 1976; Irish, 2010; Sjovold, 1973, 1977). In order to determine whether the samples differ significantly, each MMD value is compared to its standard deviation (SD). If the MMD is greater than two times its standard deviation ($MMD > 2XSD$), then the null hypothesis ($P_1 = P_2$, where P_1 = one population and P_2 = a second population) is rejected at the 0.025 level (Irish, 2010, Irish et al., 2014; Sjovold, 1977). The MMD distance statistic was chosen because it has several advantages over other distance measures, which include its

handling of missing data, for traits that have little or no “contributory information” can be deleted from further analysis (Harris and Sjøvold, 2004, p 91).

The MMD distance statistic has been used in many affinity studies (Berry and Berry, 1967, 1972; Berry, 1974; Irish and Turner, 1990; Irish, 1993, 1997, 1998, a, b, c, 2005, 2006, 2008, 2010; Irish and Guatelli-Steinberg, 2003; Irish et al., 2014; Larsen, 1997; Sjøvold, 1973, 1977). It is a dissimilarity measure, meaning that low values indicate greater affinity while high values are indicative of greater phenetic distance between samples (Irish, 2010). MMD values have been shown to correlate strongly with geographic distances, making the statistic applicable to affinity studies (Irish, 2010). The MMD formula with the Freeman and Tukey (1950) angular transformation incorporated is as follows:

$$MMD = \frac{\sum_{i=1}^r (\theta_{1i} - \theta_{2i})^2 - (1/(n_{1i} + 1/2) + 1/(n_{2i} + 1/2))}{r} \quad \text{(Equation 1)}$$

Where:

r = number of uncorrelated traits

θ = angular transformation, where the observed proportion, p , is an unbiased estimator of the population proportion, P , that here $\theta = [1/2] \sin^{-1} (1 - (2k)/(n+1)) [1/2]$

$\sin^{-1} (1 - 2(k+1)/(n+1))$

k = count of positive observations of trait “i”

n = number of individuals examined for trait “i”

Multidimensional scaling

Multidimensional scaling (MDS) was chosen to illustrate the relationships identified by the MMD statistic. MDS was chosen because it is an effective and largely unbiased method to illustrate affinities between samples (Irish, 2010). MDS produces two and three dimensional representations of the proximity data, as a geometric configuration of points (Cox and Cox, 2001; Kruskal and Wish, 1978). Although MDS can be done in a number of dimensions, two-dimensional scaling was chosen for this study. Shorter distances indicate similarity while larger distances indicate dissimilarity. The spatial representations of the samples were produced by SPSS 20.0 procedure Proxscal.

PCA, MMD, and MDS were chosen as the best methods available for this analysis because of their respective abilities to determine the specific dental nonmetric traits that are accountable for the inter-sample variation while also providing an estimate of inter-sample biological distance based on similarities in the nonmetric traits. Thus, the combined results of these methods can be used to identify key traits driving inter-sample variation, to identify inersample dental phenetic affinities, and graphically illustrate those affinities. The detailed examination of the results and interpretations are provided in chapter 7.

Chapter 6: Results

Differences in the frequency of 36 dental traits provide the evidentiary basis for comparing and describing Proto-Celtic and continental and non-continental Celtic samples. As discussed in Chapter 5, these traits were recorded using the ASUDAS system and are dichotomized into values of present or absent according to standard procedure (Haeussler et al., 1988; Irish, 1993; Turner, 1985). The number of individuals per sample expressing a particular trait was determined, along with the total number of individuals for whom the trait could be scored. From these data, the percentage of each trait's occurrence in each sample could be calculated. From an examination of the resulting data a characterization of each sample based on the suite of dental traits and a rudimentary dental phenetic comparison between samples can be obtained. The dental trait percentage and frequencies for each sample are presented in Table 6 below. As previously mentioned, one of the samples is geographically and descriptively associated with the proto-Celts (Hallstatt D), one is associated with the continental during the La Tène period (Munsingen-Rain), and one is associated with the non-continental Celts during the La Tène period from the British Isles (pooled Yorkshire sample), while the remaining sample is not associated with the Celts (Pontecagnano) and was included for comparative purposes. As discussed in Chapter 3, while the Celts are not recognized as a cohesive group, they are nevertheless perceived to be a biological entity and the degree of biological diversity among the proto-Celts, continental and non-continental Celts is unknown. Table 6 presents the 36 nonmetric dental and intra-oral osseous traits used in this study.

Table 6: The 36 nonmetric dental and intra-oral osseous traits used in this study. (Trait descriptions are provided in the appendix). *Denotes the 20 traits used for the final MMD analysis.

Sample	BRIT	MunRain	HalD	PON
Trait				
1.Winging UI1	0%	0%	0%	0%
(+ = ASU 1)	0/31	0/33	0/30	0/31
2.Lab Curve UI1	0%	6%	3%	22%
(+ = ASU 2-4)	0/31	2/33	1/30	7/31
3.Palatine Torus	0%	0%	0%	0%
(+ = ASU 2-3)	0/31	0/33	0/30	0/31
4.Shovel UI1	0%	0%	0%	0%
(+ = ASU 2-6)	0/31	0/33	0/30	0/31
5.Dbl. Shovel UI1	0%	0%	0%	0%
(+ = ASU 2-6)	0/31	0/33	0/30	0/31
6.Int. Groove UI2*	38%	30%	40%	19%
(+= ASU +)	12/31	10/33	12/30	6/31
7.Tuber Dent UI2*	58%	60%	30%	22%
(+ = ASU 2-6)	18/31	20/33	9/30	7/31

Table 6: Continued.

8.Bushman Canine UC	0%	0%	0%	0%
(+ = ASU 1-3)	0/31	0/33	0/30	0/31
9.Dist Acc Rid UC*	29%	57%	33%	29%
(+ = ASU 2-5)	9/31	19/33	10/30	9/31
10.Hypocone UM2*	48%	27%	40%	58%
(+ = ASU 3-5)	15/31	9/33	12/30	18/31
11.Cusp 5 UM1	12%	0%	0%	3%
(+ = ASU 2-5)	4/31	0/33	0/30	1/31
12.Carabelli's UM1	25%	24%	10%	19%
(+ = ASU 2-7)	8/31	8/33	3/30	6/31
13.Parastyle UM3*	25%	27%	20%	32%
(+ = ASU 1-5)	8/31	9/33	6/30	10/31
14.Enamel Ext UM1*	38%	33%	26%	41%
(+ = ASU 1-3)	12/31	11/33	8/30	13/31

Table 6: Continued.

15.Root No. UP1*	32%	27%	43%	25%
(+ = ASU 2+)	10/31	9/33	13/30	8/31
16.Root No. UM2*	35%	30%	63%	29%
(+ = ASU 3+)	11/31	10/33	19/30	9/31
17.Peg-Reduce UI2	0%	0%	0%	0%
(+ = ASU P or R)	0/31	0/33	0/30	0/31
18.Odontome P1-2	0%	0%	0%	0%
(+ = ASU +)	0/31	0/33	0/30	0/31
19.Cong Abs. UM3	0%	0%	0%	0%
(+ = ASU -)	0/31	0/33	0/30	0/31
20.Midline Dia. UI1	0%	0%	0%	0%
(+ = $\geq .5\text{mm}$)	0/31	0/33	0/30	0/31
21.Ling Cusp LP2*	61%	27%	23%	58%
(+ = ASU 2-9)	19/31	9/33	7/30	18/31

Table 6: Continued.

22.Ant Fovea				
LM1*	61%	33%	33%	41%
(+ = ASU 2-4)	19/31	11/33	10/30	13/31
23.Mandibular				
Torus	0%	0%	0%	0%
(+ = ASU 2-3)	0/31	0/33	0/30	0/31
24.Groove Pat				
LM2	6%	0%	36%	3%
(+ = ASU Y)	2/31	0/33	11/30	1/31
25.Rocker Jaw*	22%	24%	30%	22%
(+ = ASU 1-2)	7/31	8/33	9/30	7/31
26.Cusp No. LM1	6%	0%	16%	0%
(+ = ASU 6+)	2/31	0/33	5/30	0/31
27.Cusp No.				
LM2*	19%	18%	26%	12%
(+=ASU 5+)	6/31	6/33	8/30	4/31
28.Def Wrinkle				
LM1	25%	54%	20%	22%
(+ = ASU 2-3)*	8/31	18/33	6/30	7/31
29.C1-C2 Crest				
LM1	29%	42%	16%	32%
(+ = ASU +)*	9/31	14/33	5/30	10/31

Table 6: Continued.

30. Protostylid				
LM1	19%	27%	23%	25%
(+ = ASU 1-6)*	6/31	9/33	7/30	8/31
31. Cusp 7 LM1	3%	6%	0%	0%
(+ = ASU 2-4)	1/31	2/33	0/30	0/31
32. Tome's Root				
LP1	29%	30%	43%	22%
(+ = ASU 3-5)*	9/31	10/33	13/30	7/31
33. Root No. LC*	32%	18%	30%	25%
(+ = ASU 2+)	10/31	6/33	9/30	8/31
34. Root No. LM1*	32%	21%	26%	29%
(+ = ASU 2+)	10/31	7/33	8/30	9/31
35. Root No. LM2				
*	29%	15%	36%	32%
(+ = ASU 2+)	9/31	5/33	11/30	10/31
36. Torsomolar				
LM3*	19%	24%	16%	29%
(+ = ASU +)	6/31	8/33	5/30	9/31
Sample size	N=31	N=33	N=30	N=31

^aASU rank-scale trait breakpoints from Irish (1993,1997,1998a,b,2005,2006) and Scott and Turner (1997).

The dental nonmetric traits presented in Table 6 were scored twice under the same conditions on different days. Although some differences in the ASUDAS scores were encountered, these differences never occurred across a trait breakpoint (e.g., on the order of a grade one verses a grade two). Intra-observer scoring error was calculated using a Wilcoxon signed rank test, the results of which fell into the acceptable range (Table 7). Since the P-value is greater than 0.05, the null hypothesis that there is no difference between the first and second set of nonmetric trait observations was not rejected. The inter-observer error test indicates that there is a high degree of inter-observer repeatability and concordance.

Table 7: Wilcoxon signed rank test for inter-observer repeatability.

Test Statistics ^a	
	obser2 - obser1
Z	.000 ^b
Asymp. Sig. (2-tailed)	1.000

Overall dental heterogeneity among the samples is evident. Compared to the other samples, the British sample has higher frequencies of Cusp 5 UM1, Carabelli's trait UM1, Ling Cusp LP2, Anterior Fovea LM1, Root Number LC, Root Number LM1, and Cusp 5 UM1. The Munsingen-Rain sample has high frequencies of Tuberculum Dentale UI2, Canine Distal Accessory Ridge UC, C1-C2 crest LM1, Deflecting Wrinkle LM1, Protostylid LM1, and Cusp 7 LM1. The Hallstatt D sample has higher frequencies of rocker jaw, Interruption Groove UI2, Root Number UP1, Root Number UM2, Groove Pattern LM2, Root Number LM2, and Tome's Root LP1. While the Hallstatt D sample has high frequencies of some mass-additive traits, such as cusp Number LM1, the majority of the traits that occur at high frequencies in this sample are root traits. The Pontecagnano sample has high frequencies of Hypocone UM2, Labial Curvature UI1, Parastyle UM3, Enamel Extension UM1 and Torsomolar LM3. Dental heterogeneity is evident between the individual sample pairs as well. Some traits occur at similar frequencies among the sample pairs but they are of insufficient influence to affect the overall phenetic dissimilarity. The dental nonmetric traits observed at high frequencies are characteristic of

morphologically simple, mass-reduced dentitions, often associated with European populations, in spite of high frequencies of a few mass-additive traits (such as Tuberculum Dentale U12). While the Hallstatt D sample has high frequencies of some mass additive traits and root traits, overall the traits observed in this sample are characteristic of a simplified mass-reduced dentition, the high frequencies of these traits do not affect the phenetic relationships among the samples. All of the samples analyzed share a simplified mass-reduced dentition characteristic of European populations.

Principal components analysis

After the trait frequencies were calculated, the data were submitted to PCA to identify the specific nonmetric traits most responsible for the observed inter-sample variation. All noncontributory traits, those which occurred at 0% across all samples, were removed from further analysis. These include, Winging UI1, Palatine torus, Shoveling UI1, Double Shoveling UI1, Bushman Canine UC, Odontome P1-P2, Congenital Absence UM3, Midline Diastema UI1, Mandibular torus, and Peg-Reduced UI2. This initial round of trait editing reduced the number of traits to 26. As the sample size in the MMD must be larger than 10 in any subgroup for the Freeman-Tukey transformation for unequal sample variances to work, Cusp 7 LM1 was removed from further analysis, reducing the number of traits to 25. These percent data were then submitted to PCA to identify additional largely noncontributory traits across all samples. Three components with eigenvalues >2.0 were obtained that accounted for 100% of the total variance (Figure 8). However, examination of the accompanying scree plot (not shown) suggests that the first two components which account for 75% of the variance are the most important. However, PCA always has the highest explanatory power for the first several components, and the usual threshold for non-consideration of a principal component is an eigenvalue of less than 1.0. Unrotated loadings for these components are listed in Figure 8.

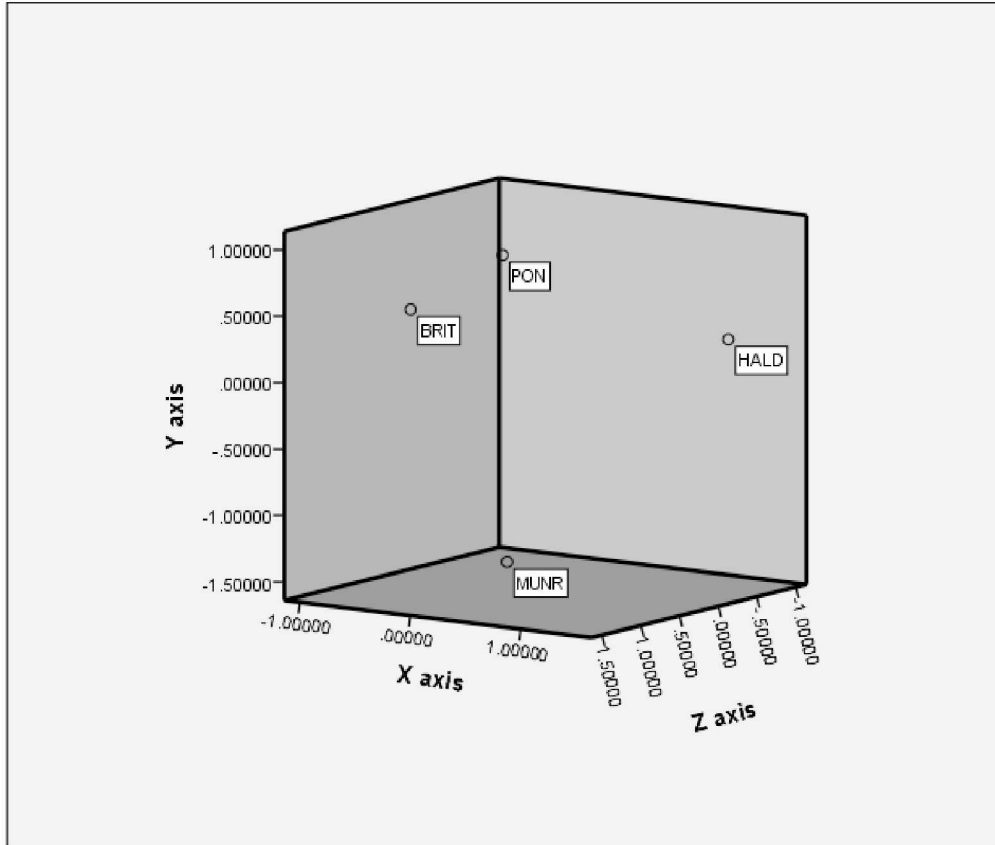


Figure 8: 3D scatterplot of the first three components among the samples for 25 dental traits. The first two components account for 75.844% of the total variance (43.386% on the x-axis, 32.548% on the y-axis and 24.156% on the z-axis). Methodological details and the sample abbreviations are defined in Chapter 5.

Table 8: Component loadings, eigenvalues and variance explained for the samples

Trait Number	Component		
	1	2	3
2	0.818	0.352	-0.455
*6	0.804	-0.136	0.579
*7	-0.170	-0.564	0.808
*9	-0.204	-0.979	-0.022
*10	-0.244	0.96	-0.139
11	-0.399	0.843	-0.361
12	-0.303	0.060	0.951
*13	-0.961	0.207	-0.184
*14	-0.850	0.504	0.152
*15	0.997	0.079	-0.004
*16	0.982	0.048	-0.182
*21	-0.558	0.752	0.351
*22	-0.211	0.592	0.778
24	-0.296	-0.020	-0.955
*25	0.909	-0.215	-0.356
26	0.081	-0.438	0.896
*27	0.971	-0.208	0.119
*28	-0.413	-0.898	0.151
*29	-0.848	-0.515	0.128
*30	-0.388	-0.566	-0.727
*32	0.963	-0.265	-0.057
*33	0.515	0.785	0.343
*34	0.036	0.915	0.402
*35	0.537	0.799	-0.27
*36	-0.897	0.058	-0.438
Eigenvalue	10.846	8.115	6.039
Variance (%)	43.386	32.458	21.156
Total Variance	43.368	75.884	100.00

* Trait numbers from Table 6. The 20 final traits used for MMD analysis after editing
 Boldface numbers indicate “strong” loadings (i.e., > |0.5|).

Traits with strongly positive and negative values ($>|0.5$) are responsible for driving most of the inter-sample variation. Very strong (>0.7) positive loadings for component 1, x-axis, include Labial Curvature UI1, Interruption Groove, Root Number LP, Root Number LM1 and Root Number LC, and are most responsible for pushing the samples with high percentages of these traits towards the positive end of the x-axis. Conversely very strong negative loadings (>-0.7) include torsomolar LM3, parastyle UM3, and enamel extension UM1. Very strong positive loadings for component 2, y-axis, include cusp 5 UM1, hypocone UM2, lingual cusp LP2, root number LC, and root number LM2. Similarly, very strong negative loadings for component 2, y-axis, include canine distal accessory ridge UC, and deflecting wrinkle LM1. As a result, Carabelli's UM1, groove pattern, and cusp number LM1 were dropped from further analysis, even though they have loadings of 0.951, -0.955 and 0.896 respectively for component 3 (see Figure 8 and Figure 9 for 3 dimensional and 2 dimensional component loading graphs respectively). These trait choices were reinforced by subsequent varimax rotation, which maximizes the differences between large and small loadings, which yielded three components with eigenvalues >1.0 which accounted for 100% of the total variance (not shown).

However, as previously mentioned, the threshold for non-consideration of a principal component is an eigenvalue of less than 1.0. As such, the trait choices indicated by varimax rotation do not need to be removed from further analysis. However, subsequent analyses were conducted with these traits (Carabelli's UM1, groove pattern, and cusp number LM1) included and removed in order to determine whether the phenetic similarity and spatial patterning was significantly different among the samples. It is recommended that intersample distances be based on as many traits as possible; however, these trait should not be highly correlated with one another, as differential weighting of the underlying dimensions may render the results inaccurate (Sjovold, 1977). Inter-trait correlation was assessed by submitting the rank-scale ASUDAS data to the Kendall's tau-*b* correlation coefficient. Two further trait pairs were found to be highly correlated by Kendall's tau-*b* (i.e. $t_b \geq 0.05$), labial curve UI1 and deflecting wrinkle LM1 ($t_b=1.0$) and cusp 5 UM1 and hypocone UM2 ($t_b=1.0$). In conjunction with their relatively low loadings and small sample sizes, labial curve UI1 and cusp 5 UM1 were removed from further analysis. In the end 20 traits, denoted by asterisks in Table 6, were used for the final MMD comparison.

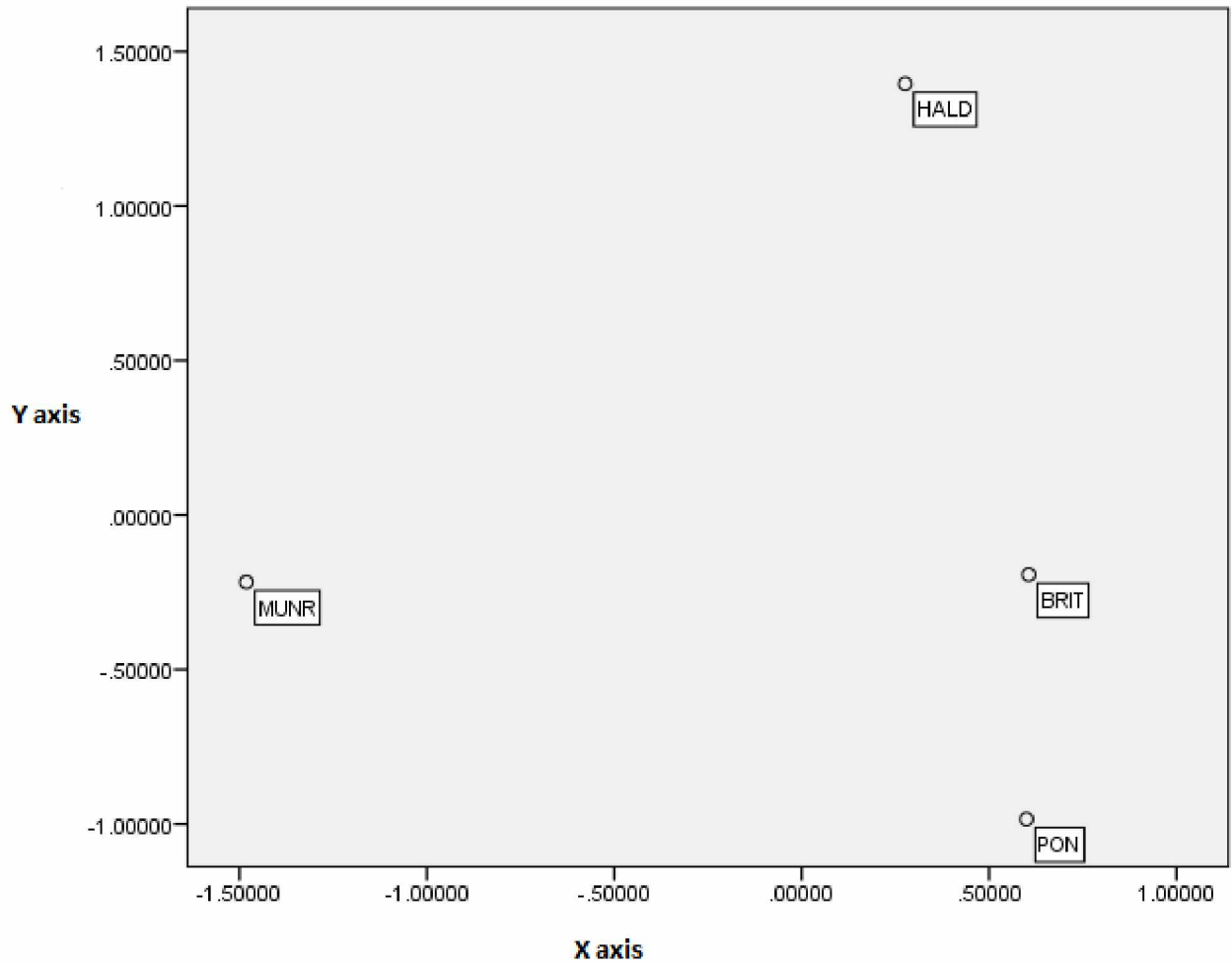


Figure 9: 2D scatterplot of the first three components among the samples for 25 dental traits. The first two components account for 75.844% of the total variance (43.386% on the x-axis, 32.548% on the y-axis). Methodological details and the sample abbreviations are defined in Chapter 5.

Mean measure of divergence

This multivariate statistic provides a quantitative estimate of divergence between samples based on degree of phenetic similarity for the suite of dental and osseous traits. All four samples were compared using the initial 25, 23 and final 20 dental and osseous traits. To determine whether the samples differ significantly, each MMD value was compared to its standard deviation. If the MMD is greater than two times its standard deviation, then the null hypothesis,

$P_1=P_2$ (where P_1 = one population and P_2 = a second population) is rejected at the 0.025 alpha level. Conversely, an insignificant MMD means it is impossible to distinguish between two samples because the samples are phenetically indistinguishable, or the size of one or both samples is small, which can result in an excessively large standard deviation (Sjovold, 1977). A 25-trait comparison was conducted to move beyond qualitative inspection of individual trait frequencies and gain an initial impression of intersample affinities (Green et al., 1979; Green and Suchey, 1976; Irish, 2010; Sjovold, 1977). The resulting distance matrix for all four samples is presented in Table 9. Overall heterogeneity is indicated, for all the sample pairs were significantly different at the .025 alpha level.

A 23-trait comparison excluding all traits that occurred at 0% across all samples and including those traits identified for removal by PCA (Carabelli's UM1, groove pattern, and cusp number LM1) included, was conducted to determine whether inclusion of these traits affected the overall dental phenetic relationships. The resulting distance matrix for all four samples is presented in Table 10. Heterogeneity among the samples was again indicated by this MMD analysis, all the samples are statistically significantly different from one another at the .025 alpha level (MMD is greater than two times its standard deviation). The inclusion of Carabelli's UM1, groove pattern, and cusp number LM1 did not affect the resulting dental phenetic relationships, although a difference in MMD values is evident this difference is due to differential trait weighting. A 20 trait comparison, with Carabelli's UM1, groove pattern, and cusp number LM1 removed, was conducted to determine the inter-sample affinities. The 20 trait MMD distance matrix for all samples is presented in Table 11.

Heterogeneity among the samples is again indicated by this MMD analysis, for all of the samples are statistically significantly different from one another at the .025 alpha level (MMD is greater than two times its standard deviation), although after deleting invariant and other largely noncontributory traits the sample pairs are slightly less distinct from one another than was the case for the analysis based on 25 traits. As heterogeneity was indicated by both the 23 and 20 trait MMD analyses, those traits indicated by the preceding PCA analysis (Carabelli's UM1, groove pattern, and cusp number LM1), need not be removed from subsequent analysis. The retention of these traits is further supported by the corresponding eigenvalue for component 3,

6.039, to which these traits contribute. While the varimax rotation indicated that Carabelli's UM1, groove pattern, and cusp number LM1 could be removed from subsequent analyses, the MMD matrices indicate that retention of these traits does not impact the dental phenetic relationships. However, additional MDS and cluster graphs were conducted with Carabelli's UM1, groove pattern, and cusp number LM1 removed and included, in order to determine whether the spatial patterning among the samples was affected. The MMD analyses support the PCA analysis indicating heterogeneity among the samples. The MMD analyses also suggest that there is greater diversity among the Iron Age samples associated with the Celts than previously established.

Table 9: MMD distance matrix for 25 traits among all samples. All traits with 0% across all samples removed

Samples	BRIT	MunRain	HalD	PON
BRIT	0.000	0.025	0.022	0.023
MunRain	0.064	0.000	0.024	0.025
HalD	0.059	0.060	0.000	0.022
PON	0.066	0.061	0.061	0.000

See Table 1 and text for sample details. The values above the diagonal are the standard deviations, and the values below are the MMD values.

All values are significantly different at the .025 level.

Table 10: MMD distance matrix for 23 traits among all samples.

Samples	BRIT	MunRain	HalD	PON
BRIT	0.000	0.021	0.021	0.021
MunRain	0.053	0.000	0.022	0.022
HalD	0.054	0.052	0.000	0.022
PON	0.060	0.053	0.058	0.000

See Table 1 and text for sample details. The values above the diagonal are the standard deviations, and the values below are the MMD values.

All values are significantly different at the .025 level.

Table 11: MMD distance matrix for 20 traits among all samples

Samples		MunRain	HalD	PON
BRIT				
BRIT	0.000	0.022	0.022	0.022
MunRain	0.050	0.000	0.023	0.023
HalD	0.051	0.049	0.000	0.023
PON	0.059	0.049	0.054	0.000

See Table 1 and text for sample details. The values above the diagonal are the standard deviations, and the values below are the MMD values.

All values are significantly different at the .025 level.

Multidimensional scaling

The MDS PROXSCAL procedure was used in place of the ALASCAL, as there were more traits than samples, to produce a graphical representation of the MMD values. MDS treats each of the MMD values as Euclidean distances, samples in close proximity in the MDS configuration have lower MMD scores than those that are farther apart. The MDS graph thus provides a visual representation of the MMD values, which is easier to comprehend than the MMD matrix. Two dimensional MDS proxscal graph of the MMD values are presented in Figures 11, 12 and 13. The MDS stress value is a measure of the “goodness of fit” of the scaled data compared to the unscaled data in reduced space, the lower the stress value the better the fit. Kruskal’s stress formula 1 value is .05. The r^2 value is a measure of variance of the scaled values accounted for by their corresponding MMDs; in this analysis, r^2 is 0.94. The .94 in this analysis indicates that 94% of the variance is explained by these distance values. The correlation coefficient r between the MMD and MDS distance is produced by taking the square root of r^2 (Kruskal and Wish, 1978).

Thus in this analysis the two data matrices are highly correlated, $r=.97$. In this case, the two dimensional solution is an accurate representation of the MMD derived dental relationships. The configurations of the 25, 23 and 20 trait MDS graphs (Figures 10, 11 and 12 respectively) share some patterning with the PCA graphs, including the relative positions of the Munsingen-

Rain and Hallstatt samples, yet the phenetic difference between the samples is evident (Figures 9 and 10 respectively). Inspection of Figures 11, 12 and 13 reveals a clear separation among the samples. In the 25 trait MDS graph (Figure 10) the Munsingen-Rain and Pontecagnano samples are identified as outliers. However, in the 23 and 20 trait MDS graphs (Figures 11 and 12 respectively) the British and Hallstatt D samples are identified as outliers. While the relative positions of the samples in the 25, 23 and 20 MDS graphs are switched (due to differential trait weighting), however, the distances between the samples remains the same. In all of the MDS graphs clear separation among the samples is evident. The 23 and 20 trait MDS graphs are identical, further supporting the inclusion of Carabelli's UM1, groove pattern, and cusp number LM1 regardless of their relatively low sample size and varimax rotation suggesting their potential removal from subsequent analyses. As the 23 and 20 trait MDS graphs are identical the removal of those traits indicated by varimax rotation was not sufficient to affect the overall phenetic dissimilarity.

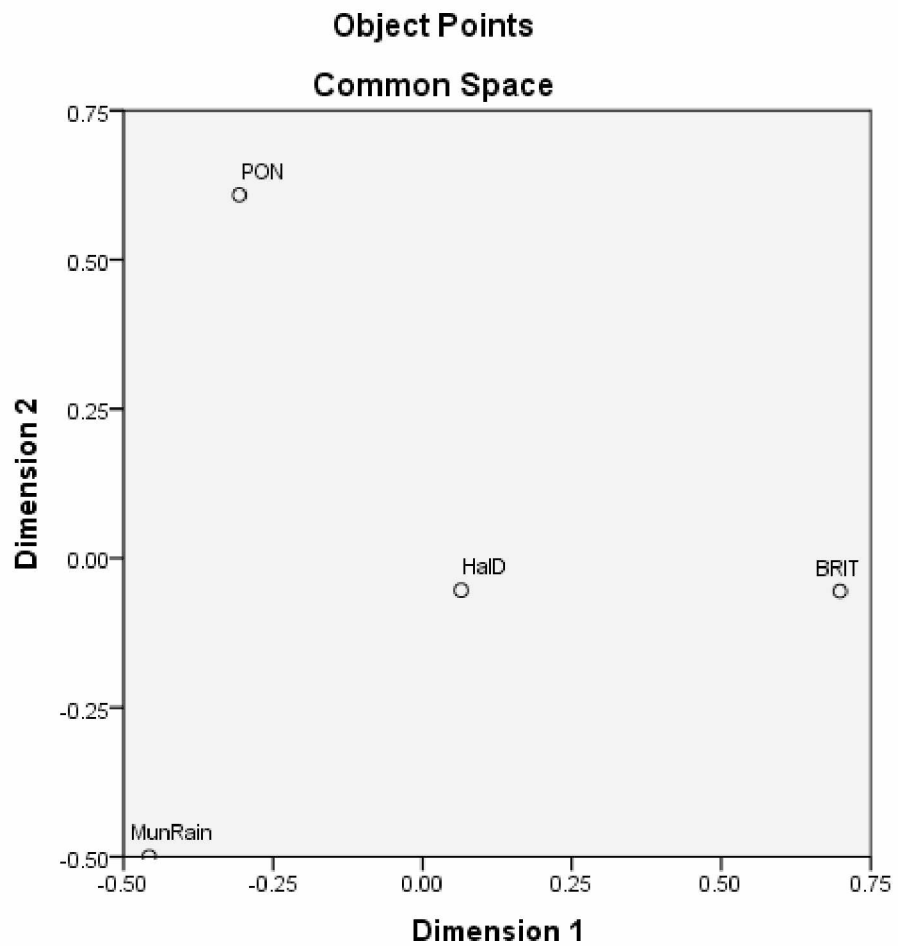


Figure 10: MDS graph of the 25 trait MMD distances among the four samples

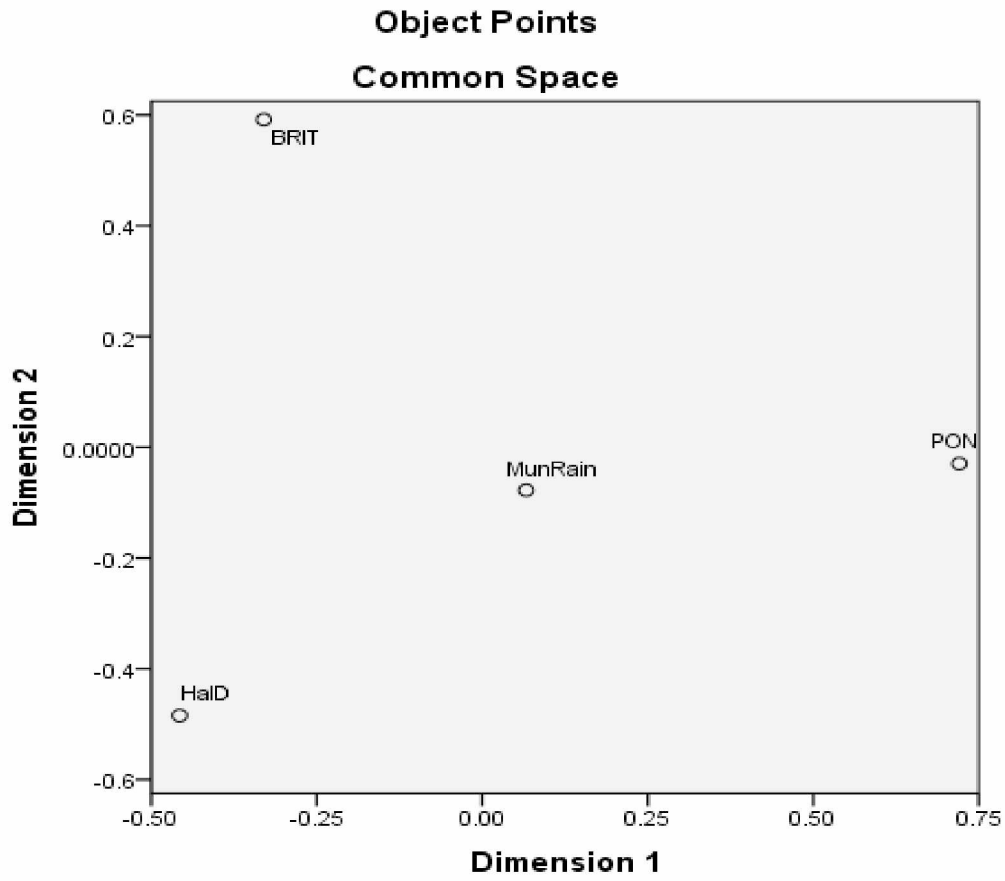


Figure 11: MDS graph of the 23 trait MMD distances among the four samples

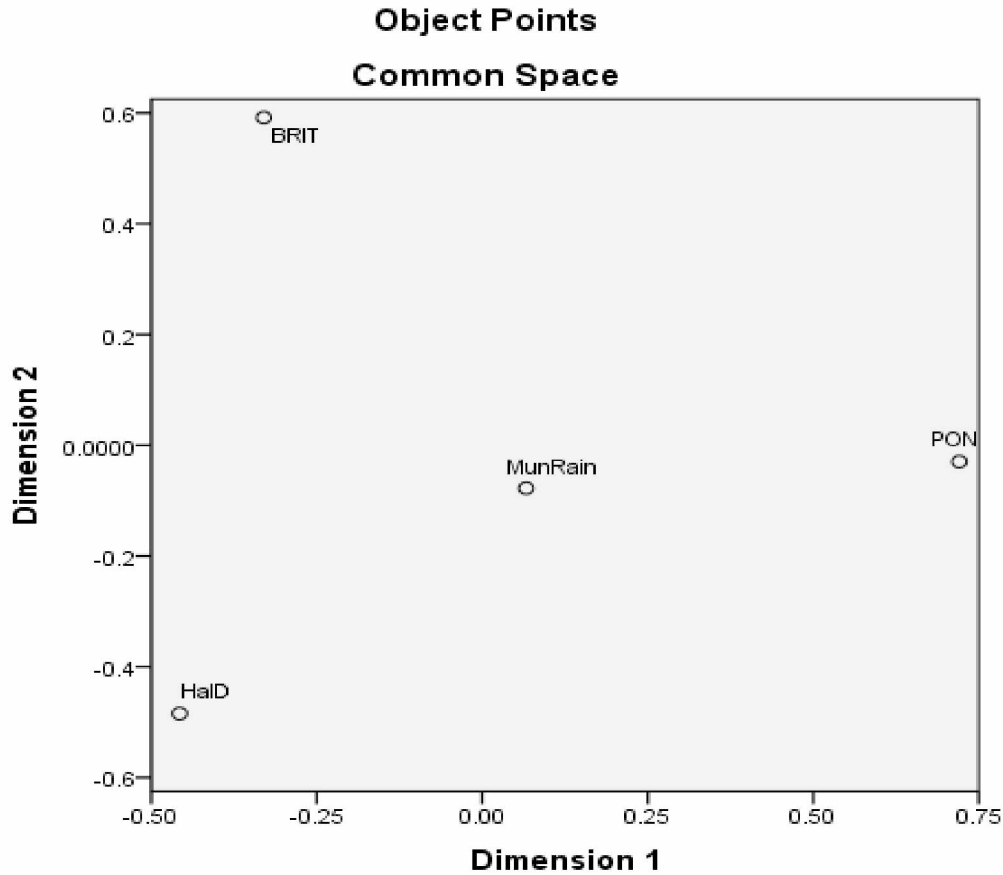


Figure 12: MDS graph of the 20 trait MMD distances among the four samples.

Hierarchal cluster analysis

Hierarchical cluster analysis with average linkage was used to provide a further illustration of among-sample affinities based upon the triangular matrix of the pairwise MMD distance values, based on the 25, 23 and 20 trait batteries and is presented in Figures 13, 14 and 15 respectively. All of the dendrograms identify the same broad grouping as depicted in the MDS configuration. In the 25 trait dendrogram, a dichotomy between the British and Hallstatt D samples is indicated while the Munsingen-Rain and the Pontecagnano samples are separated from the other samples. However, the Munsingen-Rain sample is identified as an outlier compared to the other Celtic samples in the 25 trait dendrogram. The British and Hallstatt D samples are clustered at the top and the Munsingen-Rain and Pontecagnano samples are at the bottom.

In the 23 trait dendrogram the Munsingen-rain and Hallstatt D samples are clustered at the top while the British and Pontecagnano samples are clustered at the bottom. The British sample is identified as an outlier compared to the other Celtic samples, however, the British sample is clustered closer to the Munsingen-rain and Hallstatt D samples than to the Pontecagnano sample. In the 20 trait dendrogram, a dichotomy between the Munsingen-Rain and Hallstatt D samples is indicated while the British and Pontecagnano samples are separated from the other samples. However, the British sample is identified as an outlier compared to the other Celtic samples. The Munsingen-Rain and Hallstatt D samples are clustered near the top and the British and Pontecagnano samples are clustered at the bottom. While in the 23 and 20 trait dendrograms the samples are clustered in a similar pattern, the separation of the British and Pontecagnano samples is different.

In both the 23 and 20 trait dendrograms the British sample is an outlier relative to the other Celtic samples, however, the degree of separation is different. In the 23 trait dendrogram the British sample is clustered closer to the Munsingen-rain and Hallstatt D samples. While in the 20 trait dendrogram while the British sample is clustered close to the Munsingen-Rain and Hallstatt D samples it is farther separated from the other Celtic samples than in the 23 trait dendrogram. The British and Pontecagnano samples are further separated from the other samples in the 20 trait dendrogram, suggesting that the removal of the traits indicated by the PCA analysis may have slightly impacted the among sample groupings. However, in both the 23 and 20 trait dendrograms there is a clear separation among the samples. The slight difference in the separation among the samples indicated by comparison of the 23 and 20 trait dendrograms may be related to differential trait weighting. Alternatively the slight difference in the separation among the samples indicated by comparison of the 23 and 20 trait dendrograms may be related to differential gene flow, and/or micro and macroevolutionary forces. The composition of the British sample may also be related to the slight difference in the 23 and 20 trait dendrograms, the British sample is pooled from five different Iron Age cemeteries and as such may not adequately represent the range of variation present among the diverse cemeteries in Yorkshire during the Iron Age.

In all cases, the Pontecagnano sample is removed from the rest, supporting the difference between the continental, non-continental Celtic and proto-Celtic samples and this European sample. While there is a minor change within the clusters, the overall division between the samples is maintained. Heterogeneity is once again indicated among the continental and non-continental Celts and the Proto-Celts. Inspection of the 23 and the 20 trait dendrograms (Figures 14 and 15) reveals some similarities with the perceived linguistic trends observed among the proto-Celts and the continental and non-continental Celts (as the Hallstatt and Munsingen-Rain samples are clustered together with the British sample and Pontecagnano samples clustered at the bottom). While the 25 trait dendrogram (Figure 13) does not reveal any specific known linguistic patterning the overall heterogeneity among the samples is maintained. Furthermore, as the linguistic relationships among the proto-Celts and the continental and non-continental Celts may never be adequately determined (due to lack of written records), it is difficult to determine which clusters adequately represent linguistic patterning among the samples. However, the lack of understanding as to the linguistic relationships among the proto-Celts and the continental and non-continental Celts may skew the interpretation, as any spatial relationships among Celtic groups not following the perceived linguistic patterns may be interpreted erroneously (i.e., not interpreted to represent regional diversity among Celtic groups). As discussed throughout this chapter, there is significant heterogeneity among the samples analyzed. The intra-regional clusters may reflect the actual dental patterns and trends among the samples. Although further analyses should be conducted into the differentiation among dental phenetic relationships during the La Tène period to further document the differences between this period and the preceding Hallstatt period.

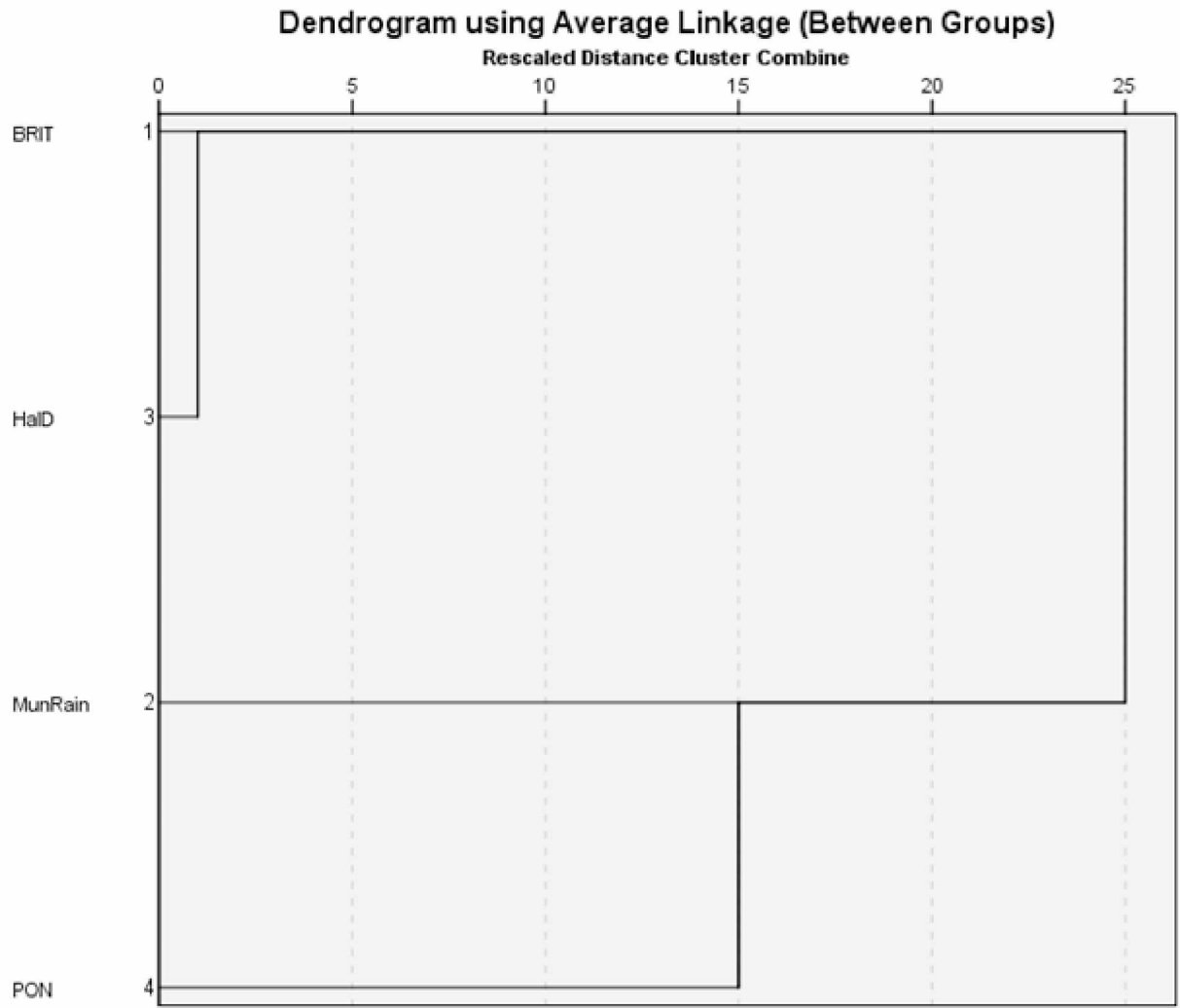


Figure 13: 25 traits dendrogram between groups for all the samples

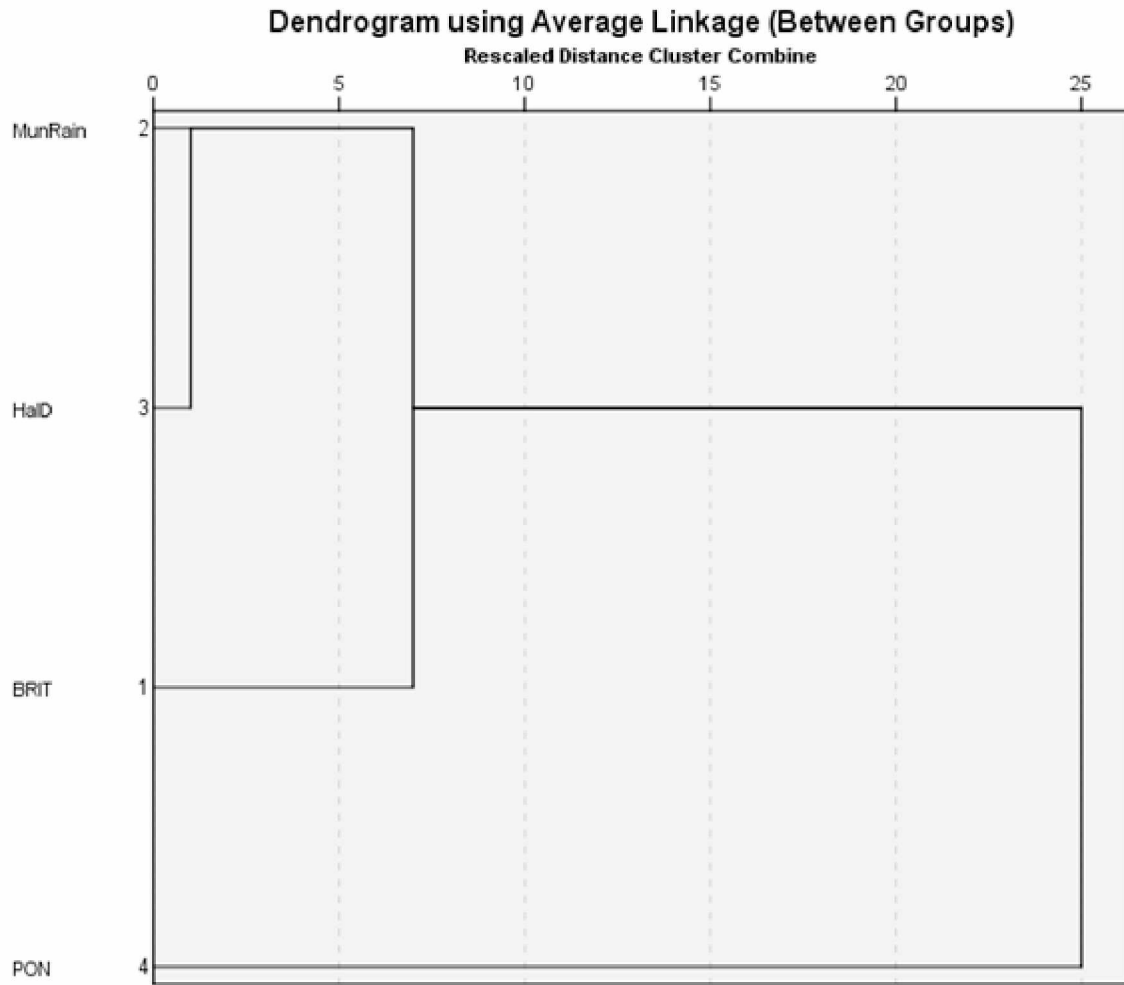


Figure 14: 23 traits dendrogram between groups for all the samples

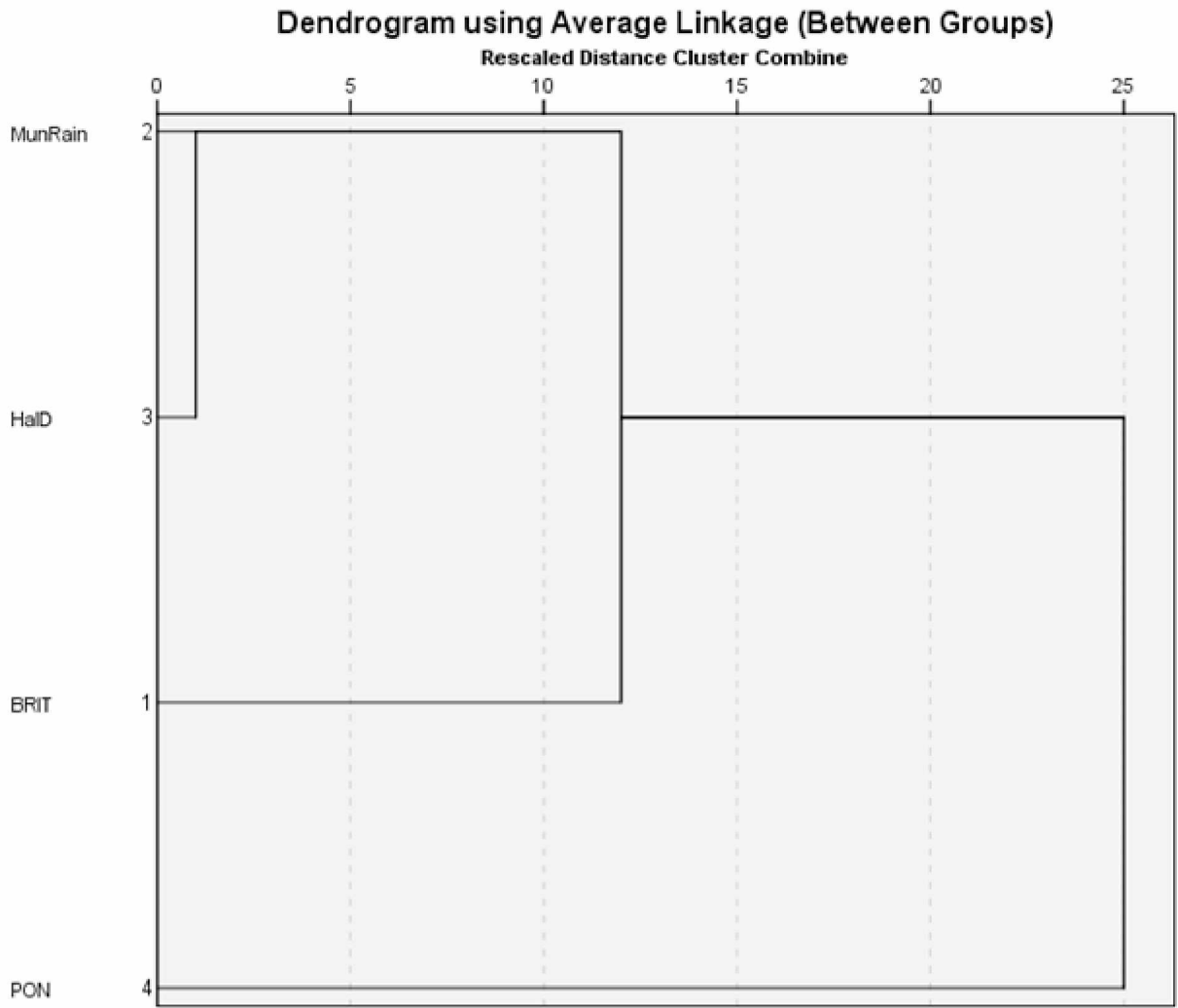


Figure 15: 20 traits dendrogram between groups for all the samples

Chapter 7: Discussion, conclusions and future research

Discussion

Based on the preceding dental analysis, dental heterogeneity is indicated among the proto-Celtic, continental and non-continental Celtic, and comparative samples analyzed. The samples analyzed display distinctly different suites of dental traits. The dental nonmetric traits observed at high frequencies are characteristic of morphologically simple, mass-reduced dentitions which are often associated with European populations, although some samples have high frequencies of mass-additive traits including Tuberculum Dentale UI2. While it is tempting to draw the conclusion that the proto-Celts and the continental and non-continental Celts were distinct populations and that the Celts were not a distinct biological population, further research is required into the phenetic variation among the diverse populations associated with the Celts prior to reaching this conclusion with any degree of certainty. However, the results of the preceding dental study indicate the presence of significant variation in the dental nonmetric traits among the samples analyzed.

While the samples have distinctive dental features and the dental nonmetric traits observed at high frequencies are characteristic of morphologically simple, mass-reduced dentitions, the degree of variation among the samples is not sufficient at this stage to determine the presence of specific dental complex's associated with each sample and/or region. When compared to the other samples the Hallstatt sample has high frequencies of root traits, although the frequencies of some crown traits are high, suggesting that the dental complex associated with the Hallstatt D sample is significantly different from the other samples analyzed. Although further analysis into the dental nonmetric trait variation among the populations associated with the Hallstatt culture is necessary to determine if this pattern is evident in other populations or if it is specific to the Hallstatt D period.

There is an increase in the high frequency of mass-additive traits and crown traits evident in the Hallstatt D sample when these traits are compared individually to the other samples. The Hallstatt D sample has high frequencies of several root traits including root number LM1 and root number LM2 as well as some mass-additive traits including cusp number LM1 and LM2, and other crown traits such as hypocone UM2 and deflecting wrinkle LM1.

The few genetic studies that have attempted to examine the degree of genetic variation among the continental and non-continental Celtic populations and/or tribes have been limited predominantly to the so-called modern six Celtic nations. Those focusing on populations in continental Europe have predominantly examined Y chromosome haplogroups, specifically the R1b haplogroup and associated sub-types. Moreover, these previous genetic studies have not been conducted on the specific populations directly associated with the continental and non-continental Celts, rather they have analyzed populations in regions where Celtic languages are believed to have been spoken and where Celtic material culture is evident. Discussion of the mtDNA haplogroups associated with the Celts as restricted geographically to those haplogroups present in the British Isles. While the few previous genetic studies have determined the presence of some specific haplogroups and sub-types in the regions associated with the Celts, the extent of the genetic variation throughout the diverse regions associated with Celtic languages and material culture remains largely unknown. However, since the conditions of the skeletal and dental remains associated with the continental and non-continental Celts may preclude genetic analysis in several cases (as with the samples used in this analysis), identification of further haplogroup and sub-types associated with the Celts may be difficult. Although the dental phenetic evidence can be used as a proxy for genetic boundaries among the diverse populations and/or tribes associated with the Celts. The presence of different haplogroup and sub-types in the regions associated with the Celts suggests that the population history of these groups is more diverse than previously assumed, and that small-scale rather than large-scale migration is likely responsible for the haplogroup distribution. The dental phenetic evidence suggests that there were more genetic boundaries among the populations and/or tribes associated with the Celts than previously assumed.

While the classical authors describe several large-scale population movements of Celtic populations and/or tribes, either through military raids or complete movement of settlements, the archaeological and isotopic evidence do not support these descriptions. While some studies have focused on the migrations associated with the Celts, they are limited to specific regions. An exception is Scheeres' (2013) analysis concerning population movement from the Celtic core to expansion area. However, such studies are uncommon. The previous isotopic analyses of the

La Tène populations in Yorkshire have indicated small scale population movement, on the order of a few people, which is in line with the archaeological evidence and the dental phenetic evidence (indicating the separation of the British sample from the other Celtic samples indicated by the MMD analyses, although further analysis is necessary to determine if this pattern is evident with other Celtic populations) (Jay et al., 2013; Montgomery et al., 2007; Scheeres et al., 2013; Scheeres, 2014).

The archaeological evidence supports cultural diffusion and assimilation, although small scale population movement cannot be ruled out at this stage, throughout the regions associated with the Celts. While it is tempting to suggest that cultural assimilation was the likely process that resulted in the distribution of Celtic material culture throughout the Celtic core area, whereas cultural diffusion was the more likely process throughout the expansion area, further populations will need to be analyzed in order to determine the population history throughout both regions. In the field of Celtic studies the presence of Celtic material culture, either Hallstatt or La Tène, has been interpreted to indicate the presence of a Celtic population. However, as the social elites are believed to have derived their wealth through control of trade routes with the Mediterranean and throughout Central Europe it is difficult to determine if the presence of a Celtic object, or a burial practice common in a Celtic region (such as a chariot burial) signifies the presence of a Celtic population. The presence of Celtic material objects (and their regional variations), in diverse regions throughout continental and non-continental Europe, may represent extensive trade and demic diffusion of Celtic material culture or cultural assimilation by the local populations. Celtic La Tène culture spread throughout much of continental Europe and into the British Isles and was incorporated into diverse cultures throughout this vast region (Chadwick, 1970; Collins, 1997a, 1999; Cunliffe, 1984, 1991, 1994, 1997; De Marinis, 1977; Dietler, 1994; Dunham, 1995; Giles, 2012; Karl, 2010; Royrvik, 2012; Koch, 2003, 2006, 2007, 2009a, 2013; Kruta, 2004; Maier, 2003; McCone, 2008; Meid, 2008; Oppenheimer, 2007; Poppi, 1991). However, the presence of Celtic material culture need not indicate the presence of a Celtic population, rather the presence of Celtic material culture may reflect the cultural diffusion of ideas and practices and/or the cultural assimilation of surrounding cultures and languages into the Celtic La Tène culture. Because the regions associated with the Celts were dominated by trade during the Iron Age, it is

possible that native residents of the surrounding cultures (i.e., the Cagnate culture) became culturally dominated by the La Tène culture.

The regional variation in Celtic material objects suggests differential incorporation and/or cultural assimilation of new cultural norms or art styles into an existing local population, rather than indicating large-scale population movement. The samples used in this analysis are associated with the proto-Celts and the continental and non-continental Celts archaeologically and linguistically. While the samples share key archaeological cultural elements (e.g., chariot burials) they also possess several distinct regional differences. It may seem readily apparent that regional differences in archaeological culture are present throughout the large region associated with the Celts, especially if the intra-and inter-regional trade is taken into account; however, the modern view of the Celts as a possessing a shared identity (whether biological or cultural), predominates the field of Celtic studies. This view of the Celts is accepted but not challenged. The archaeological and genetic diversity within these regions suggests the presence of diverse populations and/or tribes, thus differences in dental nonmetric trait frequencies should be observed. However, the skeletal and dental remains associated with the Celts are rarely utilized to their full potential.

The Celts are defined differently in relation to modern populations compared to how they were defined classically. The modern Celts are believed to be represented by the so-called six Celtic nations, Brittany, Cornwall, Wales, Scotland, Ireland, and the Isle of Man, each of which has a specific insular Celtic language that is still spoken or was spoken into modern times (Charles-Edwards, 1995; Eska, 1998; Evans, 1986, 1992; Glanville, 1995; Isaac, 2010; Karl, 2010; Matasovic, 2008). The belief that much of Europe was dominated by Celtic culture has persisted into modern times due to perceived linguistic and archaeological similarities. Moreover, this belief has led to the interpretation of the Yorkshire burials as Celtic, and the belief that the modern six Celtic nations are Celtic in culture rather than purely through perceived linguistic and archaeological similarities.

The description of the insular languages as Celtic, by Edward Lhuyd, began the association between the inhabitants of the British Isles and the Celts (Lhuyd, 1707). This

association was subsequently strengthened by the excavation of the cemeteries in the East Riding of Yorkshire, and the discovery of similar artifact types between this region and regions in continental Europe which the Celts are also believed to have inhabited. The view of the Celts as a people who inhabited much of Central Europe and subsequently spread into the Iberian Peninsula, Asia Minor (Anatolia), and eventually the British Isles has been a pervasive theory in Celtic studies and has been based on perceived linguistic and archaeological similarities combined with similarities in art style and burial practice (Caulfield, 1981; Chadwick, 1970; Collins, 1997b, 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 1997; De Marinis, 1977; Dietler, 1994; Dunham, 19915; Evans, 1986; Fitzpatrick, 1993; Giles, 2012; Karl, 2010; Royrvik, 2012; Sims-Williams, 1998b; Koch, 2003, 2006, 2007, 2009b, 2013; Kruta, 2004; Lloyd and Liang, 1992; Maier, 2003; McCone, 2008; Meid, 2008; Oppenheimer, 2007; Poppi, 1991). Descriptions of the Celts by the classical Greek and Roman authors have also been used to place the Celts in much of Europe; however, the descriptions of the inhabitants of the British Isles as being distinctly not Celtic are often ignored in favor of the perceived linguistic and archaeological similarities.

While the insular Celtic languages are similar to one another it is difficult to determine whether and to what extent these languages were similar to the continental Celtic languages, as none are extant, and it is unknown how diverse these languages were. Although there are several inscriptions from continental languages believed to be Celtic, including Leptonic, Gaulish and Tartessian the insular Celtic inscriptions do not appear until around 400 BC, near the end of the Hallstatt period (Ball and Fife, 1993; Bergsland and Vogt, 1962; Brainerd, 1970; Campbell, 1988; Dyen, 1962, 1963; Gray and Atkinson, 2003; Haarmann, 1990; Hoijer, 1956; Holm, 2003; Kirk et al., 1985; Koch, 1992, 2007, 2010; Korolec, 1995; Eska, 1998; Sankoff, 1970; Sjoberg and Sjoberg, 1956; Swadesh, 1952; Thomason and Kaufman, 1988). However, the split between the insular and continental Celtic languages is believed to have occurred between 3,200 and 2,500 BC (Forester and Toth 2003; Gray and Atkinson, 2003). The insular Celtic languages are believed to have arrived in the British Isles early, around 5,200 BC, evident by the deep split between Gaulish and the other insular Celtic languages. The dates given by Gray and Atkinson (2003) and Forester and Toth (2003) for the arrival of the insular Celtic languages in the British Isles are consistent with a Neolithic/Bronze Age migration or diffusion of languages.

Although the linguistic dates suggest an early introduction of insular Celtic languages in the British Isles; the archaeological evidence for the spread of Celtic material culture (during the Iron Age), is at odds with this perspective (Caulfield, 1981; Chadwick, 1970; Collins, 1997a, 1999; Cunliffe, 1984, 1991, 1994, 1997, 2009; Charles-Edwards, 1995; Evans, 1986, 1995; Fortson, 2004; Giles, 2012; Greene and Piggott, 1983; Greenwell, 1906; Halkon, 2013; Hodson, 1964; James, 1999; Koch, 2003, 2006, 2007, 2009b, 2013; Kruta, 2004; Maier, 2003). If the Celtic languages moved into the British Isles during the Neolithic/Bronze Age, their movement cannot be connected to the movement of La Tène material culture into the region during the Iron Age. Evidence for a degree of cultural continuity from the Bronze Age to the Iron Age (i.e., settlement patterns and house structure), suggests the arrival of the La Tène material culture into Yorkshire was the result of demic diffusion and/or assimilation supplemented by small-scale population movement (as evident by the isotopic analyses, although the effect of small-scale migration in the region cannot be ruled out at this stage). The insular Celtic languages were likely already established in the British Isles prior to the movement of the La Tène culture into Yorkshire. Cultural contact, through trade for example, may have brought some insular Celtic linguistic elements, such as place names, into the region prior to immigration of people (Collis, 2003; Cunliffe, 1984, 1991, 1994, 1997, 2009; Fortson, 2004; Giles, 2012; Halkon, 2013; James, 1999; Koch, 2007, 2009b, 2013; Kruta, 2004; Maier, 2003). Considering that the Celtic place name evidence associated with the British Isles and in other regions were assigned by the Romans and not the local inhabitants. However, the presence of insular Celtic languages in the British Isles is used to designate the inhabitants as Celtic, regardless of the gap in the movement of the insular Celtic languages and material culture, and the regional differences between the La Tène material culture in Yorkshire and in continental Europe.

The issue with applying the term Celt as an ethnonym and designating a specific population as Celtic complicates any subsequent analysis. The application of the term Celt as an ethnonym is further complicated by the general consensus in the field of Celtic studies that there is some degree of shared identity among the diverse groups associated with Celtic material culture. Because the nature of this identity, either biological or cultural, is not elaborated on it is difficult to determine how the term has been utilized previously. Moreover, the term Celt is used

interchangeably to refer to either a biological or cultural relationship among the diverse groups associated with either Celtic material culture or languages (Collins, 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 1997; Dietler, 1994; Dunham, 1995; Fitzpatrick, 1993; Giles, 2012; Royrvik, 2012; Koch, 2003, 2006, 2007, 2009b, 2013; Kruta, 2004; Maier, 2003; Meid, 2008; Oppenheimer, 2007; Poppi, 1991). The perception of a shared Celtic identity is derived from the linguistic and archaeological similarities attributed to diverse groups in Iron Age Europe during the 19th century. The term Celt has been defined through perceived similarities in archaeological culture, and linguistics in previous studies. While these studies have attempted to establish the presence of the continental and non-continental Celts, they were operating under the premise that the term Celt is biological as well as cultural. However, the pejorative definitions associated with the term Celt in antiquity, the interchangeable modern application and the inherent linguistic nature of the modern term, make applying either to a specific population and/or tribe difficult.

The modern concept of the Celts is intrinsically linked with linguistics, to the extent that any region in which a Celtic language was spoken is believed to be inhabited by a Celtic population and/or tribe. Regional differences in the archaeological cultures associated with the Celts have not been the focus of much research, nor has the population history within the regions these cultures spread. Although, genetic studies have indicated the presence of diversity throughout the regions associated with the continental and non-continental Celts, the similarities in archaeological culture and language have been sufficient to label these diverse groups as Celtic. However, the cultural changes from the proto-Celtic to Celtic period and the subsequent spread of Celtic material culture throughout continental Europe and into the British Isles may have been predominantly cultural. In the field of Celtic studies there is a general consensus that there is some degree of shared identity among the diverse groups associated with Celtic material culture, however, the nature of this identity whether biological or cultural is not often elaborated on. This perception of shared identity is derived from the linguistic and archaeological similarities attributed to diverse groups in Iron Age Europe during the 19th century.

While the biological nature of the term Celt is beginning to be questioned, it is still used to intrinsically link diverse groups together. As the MMD results have indicated the term Celt has little biological meaning if the diverse populations associated with it are not phenetically

similar. However, the term Celt has not been relegated to a strictly cultural application, due in part to the lack of research into the biological relationships among the diverse groups associated with the Celts and to the popular view of the Celts as an Iron Age population that spread over much of central Europe and into the British Isles. As the modern field of Celtic studies focuses almost exclusively on linguistic and archaeological similarities and dissimilarities to determine the extent of the interactions among the Celts and other European populations; determining the degree of phenetic similarity among these populations is necessary to obtain a better understanding of the diverse populations in continental and non-continental Europe during the Iron Age and to relegate the term Celt to a purely cultural application.

Was population movement from continental Celtic populations (i.e., from Munsingen-Rain) outside Gaul responsible for the diachronic changes in material culture in Yorkshire during the Iron Age?

There is no evidence for population continuity between La Tène population at Munsingen-Rain and those from Yorkshire. Based on the 25, 23 and the 20 trait MMD comparisons (Tables 9, 10 and 11), the null hypothesis, $P_1=P_2$ (where P_1 = one population and P_2 = a second population) is rejected at the 0.025 alpha level. There is a significant difference between the continental, Munsingen-Rain, and non-continental Celtic, Yorkshire, dental samples. Instead the patterning of dental phenetic affinities supports the presence of biologically distinct continental (Munsingen-Rain) and non-continental Celtic (Yorkshire) populations. While it is unknown to what extent the diverse continental and non-continental Celtic populations interacted biologically, the La Tène material culture in Yorkshire is not likely related to any substantial population movement from the continental Celtic Munsingen-Rain population. However, the continental and non-continental Celtic populations did not develop in total isolation from another. The presence of biologically distinct continental and non-continental Celtic populations, represented by the Yorkshire and Munsingen-Rain, samples respectively, is also supported by the archaeological, genetic evidence and linguistic evidence, which suggests that there was a degree of isolation among these continental and non-continental Celtic populations and that cultural contact was a primary factor in the spread of cultural ideas and practices associated with the Celts.

Thus it appears that the La Tène culture arrived in the British Isles through a series of waves of cultural influence from continental Europe, each affecting and changing the native population in different ways (Anthoons, 2007, 2011; Arnold, 1995, 2005; Collins 1973, 1999; Cunliffe, 1984, 1991, 1994, 2009; Dent, 1982, 1985, 1995; Giles, 2012; Halkon, 2013; Hodson, 1964; James, 1999; Koch, 2006, 2007; Kruta, 2004; Stead, 1965b, 1976, 1979, 1984, 1988, 1991). While some of these influences can be attributed to trade, others involved the movement of people into the British Isles. Although a few individuals have been identified as non-locals in Yorkshire, they did not come from regions with similar strontium isotopic signatures as those in Munsingen-Rain; instead the closest comparable isotopic signature is from the Yorkshire Moors. The low incidence of non-local individuals suggests migration within the Yorkshire Wolds regions, such as inter-marriage systems, rather than from without (Jay et al., 2013; Montgomery et al., 2007; Scheeres et al., 2013; Scheeres, 2014; Stead, 1991). However, the migration of La Tène groups from the Champagne region into Yorkshire cannot be ruled out at this stage, as relatively few isotopic analyses have been conducted on the Yorkshire skeletal collections, nor has a biological affinity study examining both regions been conducted. However, second generation incomers would have a local strontium isotope profile, and it is possible that the low sample sizes used for previous isotopic analyses missed a first generation immigrant group (Jay et al., 2013; Montgomery et al., 2007; Scheeres et al., 2013; Scheeres, 2014; Stead, 1991). The extent of the regional variation between the La Tène cultures in the Yorkshire Wolds and in continental Europe suggest demic diffusion and/or cultural assimilation and subsequent incorporation of different material culture into an existing local framework, supplemented by small-scale migration. At this stage cultural diffusion and/or assimilation were likely responsible for the incorporation of La Tène culture into the Yorkshire region. Small-scale migration may have also brought the La Tène culture into the British Isles, however, further samples from non-Celtic regions in Britain will need to be analyzed in order to determine whether the low incidence of non-local individuals indicated by the isotopic analyses reflect population movement or whether the Yorkshire chariot burials represent a secondary immigrant population (Scheeres et al., 2013; Scheeres, 2014).

In spite of the documented regional variation the similarities in material culture throughout the regions associated with the continental and non-continental Celts have been used to link diverse populations regardless of the presence of trade, population movement or genetic

isolation. While the archaeological evidence suggests the La Tène Arras culture in Yorkshire was regionally restricted and developed primarily through cultural diffusion and the subsequent integration of continental burial practices into local cultural traditions the concept of the Celts that has predominated since the early 19th century (Anthoons, 2007, 2011; Collins, 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 2009; Dent, 1982, 1985, 1995; Giles, 2012; Halkon, 2013; Hodson, 1964; James, 1999; Karl, 2010; Koch, 2006, 2007; Kruta, 2004; Maier, 2003; McCone, 2008; Stead, 1965b, 1976, 1979, 1984, 1988, 1991). The archaeological evidence indicates similarities between the Munsingen-Rain population and the Yorkshire population in relation to grave goods, specifically brooch and jewelry type, however, there are several key differences between the two regions that suggest that this similarity is the result of trade and/or cultural diffusion rather than cultural assimilation from the Munsingen-rain region.

Burial position and burial practice between Yorkshire and the Munsingen-Rain and other continental Celtic populations are strikingly different, as no chariot burials are associated with the Munsingen-Rain cemetery (Falileyev, 2007; Hodson, 1968; Joseph, 2010; Sims-Williams 1998a, 2006; Parsons, 2012; Stead, 1965b, 1976, 1979, 1984, 1988, 1991). The characteristic features used to link the non-continental Celts to the continental Celts include, square barrows, chariot burials, similarities in metalwork, and art style. However, the distribution of these features does not suggest population movement from outside Gaul (i.e., Munsingen-Rain) or from Gaul into Yorkshire. The burial positions in Yorkshire are crouched or flexed, while those in continental Europe are extended. Furthermore, the chariot burials in continental Europe are predominantly buried complete while those in Yorkshire are predominantly dismantled (Anthoons, 2011; Collis, 2003; Cunliffe, 1997, 2009; Halkon, 2013; Hodson, 1968; Stead, 1965b, 1976, 1979, 1984, 1988, 1991). Furthermore, in the continental Celtic chariot burials the body of the chariot was interred complete, while in the Yorkshire burials the body is dismantled and placed over the individual (Anthoons, 2007, 2011; Arnold, 1995, 2005; Brewster, 1971; Collins 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 2009; Dent, 1982, 1985, 1995; Fitzpatrick, 1984, 2007; Giles, 2012; Greene and Piggott, 1983; Greenwell, 1906; Halkon, 2013; Hodson, 1964; James, 1999; Kruta, 2004; Maier, 2003; McCone, 2008; Poppi, 1991; Raftery, 1981; Stead, 1965b, 1976, 1979, 1984, 1988, 1991; Stillingfleet, 1846). No region in continental Europe has a chariot burial practice similar to those in Yorkshire. The difference in chariot

burials and burial practice in regions associated with the continental and non-continental Celts have been interpreted to indicate a difference in the social class of the individual buried with chariots. However, as this burial practice differed between and within regions associated with the continental and non-continental Celts, it is difficult to determine whether the differences were designating social class or reflect the adoption of non-local burial practices by the local community (Collis, 2003; Stead, 1965b, 1976, 1979, 1984, 1988, 1991; Stillingfleet, 1846).

It has been argued that the chariot burials in Yorkshire represent a secondary insular development, derived from an initial burial tradition imported from continental Europe. However, the differences in chariot burials throughout the Yorkshire region (e.g., chariot placement, burial position and type of grave goods), combined with the lack of archaeological evidence supporting a migration prior to the Roman arrival in the British Isles does not support this interpretation (Brewster, 1971; Collins 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 2009; Dent, 1982, 1985, 1995; Greenwell, 1906; Halkon, 2013; Hodson, 1964; James, 1999; Kruta, 2004; Stead, 1965b, 1976, 1979, 1984, 1988, 1991; Stillingfleet, 1846). Furthermore it is not known whether the act of dismantling the chariot prior to burial was consistent with the same practice or ritual as not dismantling it prior to burial, nor can we determine whether the social status was the same for both individuals. The differences between chariot burials in Yorkshire and continental Europe, within and outside Gaul, support the cultural diffusion of Celtic La Tène culture into the region.

The non-continental Celtic burials in Yorkshire are further distinguished from those in Munsingen-Rain, and other La Tène populations in continental Europe, by the absence of weapons, the presence of speared burials in conjunction with chariot burials, and differences in grave goods (King, 2010; Stead, 1965b, 1991; Stillingfleet, 1846). Comparison of grave goods between the continental and non-continental Celtic burials is difficult as there is little information (i.e., beyond typological), as to the diversity of grave goods associated with the continental Celts. The majority of the information regarding grave goods is typological and descriptive rather than comparative (Anthoons, 2007, 2011; Collis, 2003; Giles, 2012; Stead, 1965b, 1976, 1979, 1984, 1988, 1991; Stillingfleet, 1846). Furthermore, the majority of the descriptions of continental and non-continental Celtic grave goods are vague, rendering an in

depth comparison difficult beyond generic features and style. However, despite of the vague nature of the description the grave goods, it appears that similarities may be found in the artifact assemblages recovered from Yorkshire and Munsingen-Rain, especially with regard to jewelry and, to some extent, pottery (Anthoons, 2007, 2011; Collis, 2003; Giles, 2012; Stead, 1991). The similarities in pottery and jewelry styles in Yorkshire and Munsingen-Rain suggest trade, either between the regions, or the presence of a trade route connecting them (Anthoons, 2007, 2011; Collis, 2003; Giles, 2012; Stead, 1991).

Although the Yorkshire metalwork was inspired by continental designs and some was locally produced, the few quality pieces were undoubtedly trade items, as the decoration, inlay materials and manufacture is markedly different and appears to be regional copies of continental styles (Anthoons, 2007, 2011; Collis, 2003; Giles, 2012; Stead, 1991). Furthermore, La Tène art and metalwork, in contrast to the large number of burials and rich grave goods, are not common in Yorkshire (compared to continental Celtic regions such as Munsingen-Rain). The few examples are associated with sword burials rather than chariot burials (Anthoons, 2007, 2011; Collis, 2003; Cowen, 1968, 1970; Giles, 2012; Piggott, 1950; Pleiner, 1993; Rapin, 1991; Stead, 1965b, 1979; Stead et al., 2006). The locally produced Yorkshire ornaments belong to a distinctly British tradition and include features derived from continental styles no earlier than the La Tène B period (Anthoons, 2007, 2011; Collis, 2003; Cunliffe, 1997, 2009; Giles, 2012; Stead, 1965b, 1991). However, in spite of these differences, the metalwork associated with the Yorkshire burials is still believed to be Celtic, as are its inhabitants. The differences in metalwork, grave goods, and burial practice in Yorkshire support cultural diffusion, although small-scale migration cannot be ruled out at this stage.

The surviving La Tène archaeological material in Britain is difficult to relate to that from continental Europe (Anthoons, 2007, 2011; Collins 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 1995b, 2009; Dent, 1982, 1985, 1995; Fitzpatrick, 1984, 2007; Greene and Piggott, 1983; Halkon, 2013; James, 1999, 2005; Karl, 2010; Koch, 2006, 2007; Kruta, 2004; Maier, 2003; Raftery, 1981; Stead, 1965b, 1988, 1991; Stillingfleet, 1846). In spite of the archaeological evidence suggesting the presence of a trade network connecting Munsingen-Rain and Yorkshire,

the non-continental Celts are still intrinsically linked with the continental Celts through perceived similarities in linguistics, archeological culture and Roman tribal names.

Cultural diffusion of the continental Celtic La Tène culture into the British Isles is further supported by the distribution of Y chromosome and mtDNA haplogroups, and sub-types, associated with the continental and non-continental Celts (De Beule, 2009, 2011; Di Giacomo et al., 2004; Faux, 2008; Lucotte, 2015; McEvoy et al., 2004; Oppenheimer, 2007, 2012; Richards et al., 2002; Rosser et al., 2000; Royrvik, 2012; Scheeres, 2014; Scheeres et al., 2013; Semino et al., 2004; Simoni et al., 2000; Sykes, 2006; Torroni et al., 1998, 2001; Wilson et al., 2001). However, the Y chromosome and mtDNA variation is not tied to specific Celtic populations. Furthermore, the few studies that has attempted to link the non-continental Celts to specific haplogroups have been predominantly centered on the Y chromosome R1b haplogroup.

These previous studies compare the broad geographic distribution of the Y chromosome and mtDNA haplogroups and sub-types throughout the regions inhabited by the continental and non-continental Celts. The distribution of these haplogroups throughout regions associated with the non-continental Celts indicates the presence of genetic diversity variation among the non-continental Celts. The genetic diversity among the continental and non-continental Celts indicates the presence of distinct continental and non-continental Celtic populations. However, further genetic analysis into the Celtic populations in the Champagne region is necessary to determine the extent of the genetic similarity between this region and the non-continental Celts. The presence of different mtDNA and Y chromosome haplotypes in the British Isles suggests that the continental and non-continental Celts were diverse populations, and that the presence of the La Tène culture in the British Isles is not the result of a large-scale Celtic migration into the region, but through cultural diffusion and small-scale population movement. The differences in haplogroup frequency and sub-type within Gaul and the Hallstatt and La Tène regions indicate a difference in the populations associated with Celtic material culture and those described by Caesar as referring to themselves as Celts, although these differences are likely related to differential migration rates throughout the region.

The Celts, as defined by the Munsingen-Rain population, were not present in Yorkshire during the Iron Age. While the possibility of population continuity between Celtic Gaul and the British Isles cannot be ruled out, there is no archaeological, genetic or linguistic evidence for the presence of the continental Celts (from Munsingen-Rain) in Yorkshire. If the Munsingen-Rain population is interpreted to represent the continental Celts, as a biological population in place of the type site for the La Tène culture, then their absence in Yorkshire supports the presence of multiple biologically distinct populations and/or tribes linked with the continental and non-continental Celts. Supporting the application of the term Celtic to the La Tène culture in Yorkshire is purely a cultural designation, and has no biological meaning. While it has been argued that the burial practices evident in Yorkshire are the result of the implantation of continental ideas into the local population primarily through the movement of people, this argument is not supported by the dental phenetic evidence. The Yorkshire Munsingen-Rain Celtic populations are significantly different from one another at the 0.25 alpha level, indicating that if continental burial practices and/or people did move into Yorkshire neither moved from the Munsingen-Rain region. However, the Munsingen-Rain sample was pooled by period, in order to obtain a large enough sample for analysis, as such the difference by time period in this cemetery may not be evident. Although it is possible that the continental burial practices and/or people moved into Yorkshire from other Celtic regions in continental Europe, or from Gaul, further analyses are necessary to determine whether the non-continental Celts in Yorkshire represent a purely cultural phenomenon.

The MMD analyses indicate that there was population discontinuity between the British and Munsingen-Rain regions indicating that the transition to La Tène culture in the British region was likely a cultural transition. The distribution of dental nonmetric traits in the British and Munsingen-Rain samples supports a degree of isolation, as neither sample shares any high frequency traits. The Munsingen-Rain sample has high frequencies of tuberculum Dentale UI2, canine distal accessory ridge UC, rocker jaw, deflecting wrinkle LM1, C1-C2 crest LM1, protostylid LM1, and cusp 7 LM1. While the British sample has high frequencies of Carabellis cusp UM1, lingual cusp LP2, anterior fovea LM1, molar cusp number LM1, root number LC, and root number LM1. The population discontinuity evident between the British and Munsingen-Rain cemeteries indicates that the non-continental Celts were a distinct population compared to

the continental Celtic populations possessing La Tène culture. A further analysis of the population diversity between continental Celtic populations compared to the non-continental Celts is necessary to determine whether this pattern is evident in relation to other continental Celtic groups (e.g., in the Champagne region).

Is there evidence for population continuity or discontinuity between the Hallstatt D (i.e., Hallstatt D) and La Tène (i.e., Munsingen-Rain) samples?

There is no evidence for population continuity between the Hallstatt D and La Tène populations at Munsingen-Rain. Based on the 25, 23 and the 20 trait MMD comparisons (Tables 9, 10 and 11), the null hypothesis, $P_1=P_2$ (where P_1 = one population and P_2 = a second population), is rejected at the 0.025 alpha level. There is a significant difference between the continental, Munsingen-Rain, and proto-Celtic, Hallstatt D dental samples. While there is evidence for continuity between the Hallstatt D and early La Tène burials in some regions (i.e., in the Champagne and Hunsruck Eifel regions) this continuity may be the result of the movement of ideas, through cultural diffusion and/or assimilation rather than the large-scale population movement. However, further analyses are required in order to adequately determine whether this pattern is also evident in the Champagne and Hunsruck Eifel regions. The population structure in both the Hallstatt D and La Tène regions has not been previously examined through a biodistance analysis.

The dental phenetic affinity analysis provided in the current study supports biological discontinuity from the proto-Celtic Hallstatt D period to the Celtic La Tène period, at the Hallstatt and Munsingen-Rain sites. While it is unknown to what extent these populations interacted, the proto-Celtic and Celtic populations did not develop in total isolation from another. However, the observed archaeological similarity between the two cultures is likely the result of cultural diffusion, assimilation and trade rather than population movement. Although there is regional variation within the Hallstatt and La Tène cultures, the application of the Hallstatt and La Tène cultural labels by modern researchers follows the same line as the application of the term Celt by Greek and Roman historians. These archaeological cultures are still described as Celtic, with no explanation given for the regional variation. In spite of the modern recognition that the Celts were not a cohesive population, or ethnic group, regions possessing a La Tène

cultural elements are assumed to be Celtic (a viewpoint which is not challenged). Furthermore, the Hallstatt and La Tène cultures are regarded differently; the Hallstatt culture is divided into different zones, based on variations in burial practice and grave goods, while the La Tène culture is not in spite of its presence across much of central Europe.

While La Tène cultural material has been found throughout much of Europe, only the inhabitants of Celtic Gaul were described as Celtic in antiquity. However, the spread of the La Tène culture through Europe and into the British Isles is still regarded as the result of Celtic migrations. The Celtic migrations were not viewed by classical authors as invaders replacing indigenous people; instead they were viewed as the domination of the indigenous people by Celtic elite (Bretz-Mahler, 1971; Caulfield, 1981; Chadwick, 1970; Collins, 1991, 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 1997; De Marinis, 1977; Dietler, 1994; Dunham, 1995; Evans, 1986; Fitzpatrick, 1993; Giles, 2012; James, 2005; Karl, 2010; Maier, 2003; Stead, 1991). If the La Tène culture was spread throughout Europe by small-scale movements of Celtic elite, then the similarities and differences in archaeological culture throughout these regions are likely the result of a cultural rather than demic diffusion and cultural assimilation. The similarities in material culture and burial practices between the Hallstatt D and Early La Tène periods have been used to link both cultures to the Celts and to form a continuum of Celtic culture across Europe. While the dissimilarities have been attributed to extremal cultural influence (e.g., Etruscan), the prevalence of trade across these regions has not been cited as a driving force behind the regional differences and similarities in material culture. The presence of certain key features, such as chariot or vehicle burials is cited as evidence of a degree of cultural continuity in spite of the differences in chariot burial practice and lack of strict ritual practice. However, the differential placement of vehicles in burials during the La Tène period, and the change from the four-wheeled vehicles of the Hallstatt D period, to two-wheeled chariots of the La Tène period, are not interpreted as indications of the presence of different populations or tribes. Instead the differences in burial practice are interpreted as the result of external cultural contact alone (Collins, 1991; Collis, 2003; Furger-Gunti, 1991; Giles, 2012; Harbison, 1969; Kuznetsov, 2006; Pare, 1991; Piggott, 1986; Stead, 1991). Previous research has focused on the similarities in the burial practice and material culture in the Hallstatt D and early La Tène periods, and the

continuation of Hallstatt D burials into the early La Tène period in the Champagne and Hunsrück-Eifel regions.

While the continuation of Hallstatt D burials into the early La Tène period in these regions may represent insitu development of the La Tène culture, alternatively the early La Tène burials may be of non-local individuals, the early La Tène burials may also represent the movement of Celtic elite as described by the classical authors, or may represent small-scale population movement into either the Champagne or Hunsrück-Eifel regions. However, as there are no dates (other than Hallstatt D or early La Tène), for these burials it is difficult to determine whether the burials in one region are diagnostically early or late compared to the other region. Moreover, it is not possible to examine these burials in depth, as only vague details have been presented (Bretz-Mahler, 1971; Collins, 1975, 1991; Cunliffe, 1999; De Marinis, 1977; Karl, 2010; Stead, 1991). Furthermore, if the early La Tène burials in the Champagne and Hunsrück-Eifel regions developed insitu around the same time, their presence supports the cultural diffusion and/or assimilation of the La Tène culture. While the occurrence of both Hallstatt D and early La Tène burials in the same region does not support large-scale population movement, the spread of the La Tène culture is still intrinsically linked to the movement of Celtic people.

The difference in vehicle burials associated with the Hallstatt D and early La Tène periods are still interpreted as characteristic of either archaeological culture, with little, if any, explanation as to their differences (Bretz-Mahler, 1971; Collins, 1975, 1997a, 1999; Cunliffe, 1997; De Marinis, 1977; Giles, 2012; James, 2005; Koch, 2013; Kruta, 2004; Maier, 2003; Meid, 2008; Poppi, 1991). The dissimilarities may be related to different cultural diffusion and assimilation rates in each region, France and Baden-Württemberg respectively, or to the differential adoption of so called Celtic burial practices by indigenous groups. The latter possibility may be more probable as it is assumed that specific burial practices, e.g., chariot or chariot burials, are associated with the Celts. These differences combined with the difference in grave goods associated with these burials supports cultural diffusion and assimilation, although small-scale migration cannot be ruled out at this stage.

Small-scale migration throughout continental Europe during the La Tène period is also supported by strontium isotopic evidence. However, few regions have been analyzed as the majority of skeletal remains associated with the continental Celts are not suitable for isotopic analysis. In spite of this limitation the migration rate from the Celtic core to the expansion area appears to have been low (Scheeres, 2014; Scheeres et al., 2013). Cultural diffusion and assimilation during the Hallstatt D to early La Tène period is further supported by the distribution of Y chromosome and mtDNA haplogroups, and sub-types, associated with the continental Celts. While only a few haplogroups, and sub-types, have been directly associated with the Celts, their distribution is in line with small-scale movement throughout the Hallstatt and La Tène regions (Capelli et al., 2003; De Beule, 2009, 2011; Faux, 2008; Lucotte, 2015; McEvoy et al., 2004; Oppenheimer, 2007, 2012; Rosser et al., 2000; Royrvik, 2012; Scheeres, 2014; Scheeres et al., 2013; Sykes, 2006). The distribution of these haplogroups throughout the regions in continental Europe associated with the Celts indicates the presence of genetic variation among the continental Celts.

These haplogroups are associated with the Celts based on their occurrence in regions where Celtic languages are believed to have been spoken, and archaeological evidence indicates the presence of a Celtic population. It is difficult to determine the validity of this association as the presence of a Celtic language does not necessarily equate the region with the Celts. Furthermore, it is not known whether a similar, or the same language was spoken during the Hallstatt D to La Tène transition, or by populations and/or tribes associated with either archaeological culture. Since the regional variation within the Hallstatt and La Tène cultures has not been the focus of much research, it is difficult to determine whether these haplotypes should be associated with the proto-Celts, the Celts, or with other populations inhabiting neighboring regions, e.g., the Belgae (Collis, 2003; Cunliffe, 1999; James, 2005). This association is further complicated by Caesar's description of the limits of the Celtic territory in Gaul. Because Caesar used geographic boundaries (e.g., rivers), to mark the limits of the respective territories of the Celts, Belgae and Aquitania, it can be argued that the slight similarities he described between these regions are the result of cultural diffusion and/or assimilation. Moreover, Caesar's description of Celts on both sides of the Rhine River further supports cultural diffusion and/or assimilation, and suggests that the rivers used as geographic boundaries between the different

groups inhabiting Gaul may have been more permeable than previously assumed (Anthony, 1997; Capelli et al., 2003; De Beule, 2009, 2011; Dunham, 1995; Faux, 2008; Lucotte, 2015; McEvoy et al., 2004; Oppenheimer, 2007, 2012; Rosser et al., 2000; Royrvik, 2012; Scheeres, 2014; Scheeres et al., 2013; Sykes, 2006). Although there is evidence for genetic diversity along linguistic lines, it cannot be determined whether the genetic differences among the continental Celts follow this pattern as the continental Celtic languages (and their relationships) cannot be reconstructed. Nevertheless, profound change is indisputable from the Hallstatt D to the La Tène period, and does not suggest population continuity.

The MMD analyses indicate that there was population discontinuity between the Hallstatt D and Munsingen-Rain regions indicating that the transition to La Tène culture in the Munsingen-Rain region was likely a cultural transition. The distribution of dental nonmetric traits in the Hallstatt D and Munsingen-Rain samples supports a degree of isolation, as neither sample shares any high frequency traits. The Munsingen-Rain sample has high frequencies of tuberculum Dentale UI2, canine distal accessory ridge UC, rocker jaw, deflecting wrinkle LM1, C1-C2 crest LM1, protostylid LM1, and cusp 7 LM1. While the Hallstatt D sample has higher frequencies of labial curvature UI1, interruption groove UI2, root number UP1, root number UM2, molar cusp number LM2, Tomes root UP1 and root number LM2. The discontinuity evident between the Hallstatt D and Munsingen-Rain cemeteries indicates that the proto-Celts, as they are defined archaeologically, were a distinct population compared to the Munsingen-Rain population possessing La Tène culture. However, further analysis of the population diversity between other La Tène and Hallstatt D populations is necessary to determine whether this pattern is evident in other proto-Celtic and Celtic transitions.

Is there sufficient evidence to suggest that the inhabitants of Yorkshire during the Iron Age were Celtic or is it a nominal association based on cultural diffusion?

There is no evidence for population continuity between the British (Yorkshire) and La Tène populations at Munsingen-Rain. Based on the 25, 23 and the 20 trait MMD comparisons (Tables 9, 10 and 11), the null hypothesis, $P_1=P_2$ (where P_1 =one and P_2 = a second population), is rejected at the 0.025 alpha level. There is a significant difference between the British (Yorkshire) continental, Munsingen-Rain, dental samples. While it is tempting to suggest that the

Yorkshire population (s) represent an indigenous population (s) that adopted the Celtic La Tène material culture through either diffusion, assimilation or trade, the sample will need to be compared to a non-Celtic British sample in order to determine whether there is evidence for population continuity. While there is no evidence for the presence of the continental Celts in Yorkshire during the Iron Age, it is difficult to determine whether the non-continental Celts should be associated with Britain (i.e., Yorkshire). The classical authors did not describe the inhabitants of the British Isles as Celts, instead the application of the term Celtic to the region is derived from perceived linguistic, archaeological, and artistic similarities, beginning with Edward Lhuyd's classification of languages in the British Isles as Celtic. Recent studies have shown that there was a degree of genetic variation between the continental Celts; however, no such analysis has been conducted on the non-continental Celts. Furthermore, while the La Tène burials in Yorkshire are similar, there are some inherent differences that have not been the focus of much research. The burial practices, grave goods, and chariot burials vary throughout Yorkshire. While these differences may be chronological the presence of different tribes in Yorkshire is a possibility that has not been examined.

The tribes inhabiting Iron Age Europe can therefore neither be described as Celtic nor as post-Celtic as it cannot be determined whether they no longer possess all the cultural traits that originally defined the Celts, nor can these traits be defined. It has been assumed that all the Celtic tribes possessed La Tène material culture, as it is found in nearly all the areas where evidence suggests that a Celtic language was spoken (Barth, 1969; Collins, 1999; Collis, 2003; Cunliffe, 1984, 1991, 1994, 1997; De Marinis, 1977; Dunham, 1995; Koch, 2003, 2006, 2007, 2009b, 2013; Kruta, 2004; Maier, 2003). However, the La Tène culture was not confined exclusively to Celtic-speaking people; aspects of La Tène material culture were incorporated into other cultures and regions including Dacia, Germany, Thrace, and the Roman and the Golasecca cultures which exhibited similarities to the Hallstatt and La Tène cultures. In spite of these associations the La Tène culture is intrinsically linked with the Celts. While the issues with the application of the term Celt to diverse populations, and archaeological cultures are beginning to surface in the field of Celtic studies, recent analyses are still placed into the antiquated framework of La Tène=Celtic.

Although it may seem readily apparent that regional differences in archaeological culture that are present in the large region associated with the Celts, especially if the intra-and inter-regional trade is taken into account; however, the modern view of the Celts as a possessing a shared identity (whether biological or cultural), still predominates the field of Celtic studies. This view of the Celts is accepted but not challenged. The archaeological and genetic diversity within these regions suggests the presence of diverse populations and/or tribes, thus differences in dental nonmetric traits should be observed. As the modern field of Celtic studies focuses almost exclusively on linguistic and archaeological similarities and dissimilarities to determine the extent of the interactions among the Celts and other European populations; determining the degree of phenetic similarity among these populations is necessary to obtain a better understanding of the diverse populations in central Europe during the Iron Age and to relegate the term Celt to a purely cultural application.

Is there a specific dental complex that can be identified among the Celtic populations that serves to unite the continental and non-continental Celts?

There is no single specific dental complex that can be identified among the Celtic populations analyzed that serves to unite the continental and non-continental Celts (i.e., Yorkshire and Munsingen-Rain, respectively). The non-continental and continental Celts (i.e., Yorkshire and Munsingen-Rain, respectively), share similar frequencies of certain traits, including interruption groove UI2, rocker jaw, cusp number LM2, and Tomes root LP1 but they are of insufficient influence to affect the overall phenetic dissimilarity. The continental Celtic and proto-Celtic samples (i.e., Munsingen-Rain and Hallstatt D, respectively), also share some similar trait frequencies, including lingual cusp LP2, anterior fovea LM1, and protostylid LM1, but they are also of insufficient influence to affect the overall phenetic dissimilarity. The non-continental Celts and the proto-Celts (i.e., Yorkshire and Hallstatt D, respectively), also share some similar trait frequencies, including interruption groove UI1, distal accessory ridge UC and root number LC, but they are also of insufficient influence to affect the overall phenetic dissimilarity. While the Hallstatt D sample has high frequencies of some mass additive and root traits, overall the traits observed in this sample are characteristic of a simplified mass-reduced dentition, which is also observed in the other samples.

The proto-Celts, continental and the non-continental Celts (i.e., Hallstatt D, Munsingen-Rain and Yorkshire respectively) are characterized by an overall simplistic dentition with some mass additive traits, although in different frequencies among the samples. Thus, a specific dental complex cannot be established that serves to unite any of the continental, non-continental, or proto-Celtic samples. Instead, these diverse groups are characterized by morphologically simple, mass-reduced dentitions, often associated with European populations, despite of high frequencies of some mass-additive traits (such as tuberculum dentale U12). However, further analyses of diverse continental, non-continental and proto-Celtic populations are necessary to determine whether other groups fit this pattern, and whether this pattern is restricted to Celtic populations.

Does the continental Celtic Munsingen-Rain population represent a biologically distinct population?

The Celts, as represented by the samples used in this analysis, represent biologically distinct populations from the comparative European population (i.e., Pontecagnano), as evident in the 25, 23 and 20 trait MMD analyses (Tables 9, 10 and 11). The continental, non-continental, and proto-Celtic populations are all distinct from the comparative sample used in this analysis, i.e. Pontecagnano. The Pontecagnano sample was chosen because it is located outside the region of known Celtic expansion and has no evidence of Celtic, La Tène, material elements in the population (Becker, 1993; Cencetti, 1989; D'Agostino and Gastaldi, 1988; De Natale, 1992; Fredericksen, 1974; Germana and Fornaciari, 1992; Petrone, 1995; Robb, 1994, 1997, 1998; Scarsini and Bigazzi, 1995; Serritella, 1995). The continental Celts, represented by the Munsingen-Rain sample, are biologically distinct from the continental proto-Celts, represented by the Hallstatt D sample, and from the British sample, represented by the pooled Yorkshire sample, and from other European populations, e.g. Pontecagnano. Confirming the presence of distinct populations associated with the continental Celts, i.e., Munsingen-Rain population, the proto-Celts, i.e., Hallstatt D population, and the non-continental Celts, i.e., the pooled British sample.

The archaeological and linguistic evidence also support the presence of a biologically distinct Munsingen-Rain population. While the burial practices and grave goods at Munsingen-Rain are similar to those in other continental and to some extent non-continental Celtic cultures

the key differences between these regions supports cultural diffusion and assimilation, such as burial practice, burial position and type and quantity of grave goods (Collis, 2003; Cunliffe, 1999; Hodson, 1968; James, 2005; Koch, 2003, 2006, 2007, 2009b, 2013; Kruta, 2004; Maier, 2003; Scheeres et al., 2013). However, other continental and non-continental Celtic populations will need to be analyzed and compared to the Munsingen-Rain population in order to determine how biologically distinct the Munsingen-Rain populations is from other European and Celtic populations.

The Celtic samples analyzed in this thesis all represent biologically distinct populations from one another and from the comparative European population, establishing the presence of biological diversity among the Celts. However, further Celtic samples will need to be analyzed in order to determine whether this pattern is evident in other Celtic populations. The biological diversity among the continental, non-continental, and proto-Celts as presented through the 25, 23 and 20 trait MMD analyses provides evidence for the degree of biological diversity among proto-Celtic, and the continental Celtic and non-continental Celtic populations. While the Celts are not recognized as a cohesive population, the archaeological and linguistic similarities among the diverse populations associated with the Celts are still used to link these groups to a form of shared Celtic identity. The presence of biological diversity among the continental Celts has been indicated through differences in haplogroup and sub-type distribution; however, the Celts are regarded as possessing a degree of shared identity. Because the diverse populations and/or tribes associated with the Celts are viewed as sharing either a biological or cultural identity, the majority of research into the Celts is focused on archaeological and linguistic similarities and differences rather than genetic and biological affinity. However, the archaeological, linguistic, and genetic evidence, and descriptions from classical sources do not support the presence of a shared biological identity among the diverse groups associated with the Celts, rather they suggest that there was more biological differentiation in Continental and non-continental European populations during the Iron Age than previously thought. The dental phenetic evidence indicates that the populations in these regions were more heterogeneous than previously assumed, and indicates the presence of diverse populations sharing Celtic La Tène culture, art styles, and languages. Furthermore, the dental phenetic evidence does not support a presence of a biological meaning with the term Celt, rather a purely cultural meaning is suggested.

The dental nonmetric traits observed at high frequencies in the proto-Celtic, continental and non-continental Celtic samples used in this analysis all display different high frequency traits. The Pontecagnano sample has high frequencies of hypocone UM2, C5 UM1, parastyle UM3, enamel extension UM1, groove pattern LM2, and Torsomolar LM3. The Munsingen-Rain sample has high frequencies of tuberculum Dentale UI2, canine distal accessory ridge UC, rocker jaw, deflecting wrinkle LM1, C1-C2 crest LM1, protostylid LM1, and cusp 7 LM1. While the Hallstatt D sample has higher frequencies of labial curvature UI1, interruption groove UI2, root number UP1, root number UM2, molar cusp number LM2, Tomes root UP1 and root number LM2. The British sample has high frequencies of Carabellis cusp UM1, lingual cusp LP2, anterior fovea LM1, molar cusp number LM1, root number LC, and root number LM1. The distribution of dental nonmetric traits in the Hallstatt D, Munsingen-Rain, British and Pontecagnano samples supports a degree of isolation, as none of the samples share any high frequency traits. While the dental nonmetric traits observed at high frequencies are characteristic of morphologically simple, mass-reduced dentitions, often associated with European populations, overall phenetic dissimilarity is indicated.

The dental phenetic affinities are in line with the archaeological, linguistic and genetic differences evident in each region, and support population discontinuity between the proto-Celts (i.e., Hallstatt D), and the continental and non-continental Celts (i.e., Munsingen-Rain and Yorkshire respectively). The transition from the proto-Celtic Hallstatt culture to the Continental La Tène culture at the Hallstatt D and Munsingen-Rain sites was primarily a cultural transition, as was the transition between continental (i.e., Munsingen-Rain), and non-continental Celtic culture (i.e., Yorkshire), although the influence of small-scale migration cannot be ruled out. The presence of a biologically distinct continental Celtic population (i.e., Munsingen-Rain), further supports the lack of biological meaning associated with the term Celt.

Summary and conclusions

The primary goals of this study were to determine whether the continental Celts (i.e., Munsingen-Rain), represent a biologically distinct population, to investigate population continuity or discontinuity between continental proto-Celtic (i.e., Hallstatt D) and fully Celtic

populations (i.e., Munsingen-Rain), and to determine whether population movement from continental Celtic populations (i.e., Munsingen-Rain) outside Gaul were responsible for the diachronic changes in material culture in the British Isles during the Iron Age. Six principal conclusions were reached: 1) the La Tène=Celtic paradigm prevalent in the field of Celtic studies is not supported by the dental data; 2) there is notable heterogeneity among the samples; 3) there is population discontinuity from the proto-Celtic Hallstatt D period to the continental Celtic La Tène period at the Hallstatt and Munsingen-Rain sites; 4) the association between the inhabitants of Yorkshire during the Iron Age and the Celts is nominal; 5) there is no single specific dental complex that serves to unite the continental and non-continental Celts; and 6) the continental Celts represented by Munsingen-Rain represent a biologically distinct population.

These findings were effective for estimating the synchronic and diachronic biological relationships among the continental, non-continental and proto-Celtic samples. The dental phenetic affinities were compared to the archaeological, genetic and linguistic evidence for each sample region. Large-scale migration throughout the continental Celtic region is not supported, nor is large-scale movement into the Celtic expansion area. Based on the 25, 23 and the 20 trait MMD comparisons, the null hypothesis is rejected at the 0.025 alpha level for all the sample pairs. The null hypotheses proposed at the beginning of this thesis are rejected because statistically significant differences in dental nonmetric traits were found among the proto-Celtic, continental, non-continental Celtic, and the comparative samples. Notable differences are evident in individual trait frequencies across the samples, which influence the overall phenetic similarity. While the sample pairs share similar frequencies of some nonmetric traits, they are insufficient to affect overall phenetic dissimilarity. The continental, non-continental and the proto-Celts (i.e., Munsingen-Rain, Yorkshire and Hallstatt D respectively), are characterized by an overall morphologically simple, mass-reduced dentition often associated with European populations, in spite of high frequencies of some mass-additive traits (such as tuberculum dentale U12). As such, the similarities in material culture and language are likely the result of trade and cultural diffusion, assimilation and interaction and the subsequent incorporation of non-local traditions into the existing local community, rather than population replacement or substantial gene flow. Thus, these findings are in agreement with the archaeological, linguistic and genetic evidence for diversity among the continental, non-continental and proto-Celts. Because the linguistic

relationships among the diverse continental and non-continental Celtic populations are unknown the dental phenetic relationships indicated in this analysis can be used to approximate the linguistic and genetic boundaries among the samples analyzed.

The spread of the La Tène culture throughout continental Europe and into the British Isles may reflect trade interconnection, cultural assimilation and/or diffusion rather than the expansions and movement of people. The divergence between the archaeological, linguistic, genetic and dental lines of evidence does not constitute a basis for any single integrated entity or Celtic group or people. The phenetic affinities are also in line with low incidence of non-local individuals in the Yorkshire (those cemeteries that could be analyzed), and Munsingen-Rain samples. While population discontinuity is supported (among the samples analyzed), population continuity between the non-continental Celts and the populations from Celtic Gaul, and between and among the other diverse populations associated with the proto-Celts, and the continental and non-continental Celts cannot be ruled out at this stage.

Based on the preceding dental analysis, several inferences can be made about the Celtic dentition. The proto-Celts, continental, and non-continental Celts all display distinctly different suites of dental traits. The British, Munsingen-Rain, and Pontecagnano samples share morphologically simple mass reduced dentitions they do display some mass-additive traits, such as tuberculum dentale and distal accessory ridge. However, the Hallstatt sample stands out as having higher frequencies of mass additive traits compared to the other samples. The higher frequencies of root traits and some mass additive traits, such as cusp number LM1 in the Hallstatt D sample may be related to differential gene flow, genetic isolation and/or limited genetic contact with the other samples analyzed. There is notable intra-regional heterogeneity among the samples, indicating the presence of diverse populations within the regions sharing Celtic La Tène material culture, art style, and languages. However, the British and Munsingen-Rain samples are pooled by cemetery and time period (see Chapter 5 for description), and may not adequately demonstrate the differences between the samples in each individual Yorkshire cemetery or La Tène time period.

The results of this analysis provide evidence for the extent of the biological diversity among the continental and non-continental Celtic populations and between continental proto-Celtic and fully Celtic populations. If the term Celt can be applied to a population rather than to a language family, an art style, or an archaeological culture then the populations used in this analysis are representative of the Celts. The application of the term Celt to a specific population or to a diverse group of tribes is difficult, as the term was not applied consistently by the classical Greek and Roman authors, nor has it been applied consistently by modern authors and has been used to subsume various similarities and interconnections among the diverse populations throughout continental and non-continental Europe during the Iron Age. Moreover, it is unknown if the term Celt was applied to specific groups by the Greek and Romans or if it was a self-applied ethnonym. The term Celt is better suited to a linguistic or cultural application, as the presence of a Celtic language was, and is, used to designate a population as Celtic. Since the term Celt has not biological meaning it is not possible to speak of the Celts independently of the Celtic languages. Without language there are no Celts, ancient or modern, there are only populations bearing certain genetic markers and who were carriers of certain Bronze and Iron Age material cultures. Thus the term Celtic cannot be reliably used as a pan-European label for populations inhabiting continental and non-continental Europe during the Iron Age. While the results of this study indicate that the spread of the transition from proto-Celtic culture in these regions and the subsequent spread of Celtic culture to Britain during the La Tène period was primarily cultural, supported by small-scale population movement in the regions analyzed, the composition and degree of diversity among the numerous Hallstatt and La Tène Celtic tribes is still uncertain.

The populations and/or tribes that possessed Celtic material culture are believed to have been Celtic, in spite of the fact that trade likely accounted for the presence of Celtic cultural objects in regions where the populations were not Celtic. The accepted convention that all populations possessing Celtic culture were Celtic and spoke Celtic languages is still prevalent in the field of Celtic studies in spite of the growing awareness of the genetic differences between the Celtic regions in continental Europe. In order to fully understand the level of biological diversity among the Celts, it is necessary to move beyond this convention. Researchers have argued since the 19th century about the validity of the term Celt as an ethnic and biological

designation. Several studies have addressed the population history of the Celts; however, they rely on archaeological and linguistic data predominantly, with few attempts at data synthesis. Furthermore, in the field of Celtic studies the Celts are presumed to be linked through archaeological and linguistic similarities, and are still viewed as possessing a shared identity. The concept of the Celts as an Iron Age people who spoke Celtic languages and had similar cultural and burial practices resulted in the creation of a homogenous population with a shared single ethnic identity. This view of the Celts has predominated since the discovery of the archaeological cultures that later became associated with them during the 19th century. The essence of being Celtic, as applied to Iron Age populations in Europe, is based on diverse lines of evidence including, language, art, classical texts, and archaeology.

The interpretations of the Celts and their place in Iron Age European society based on this evidence have been inextricably linked and jumbled, creating a situation in which the ensuing view of Celtic Iron Age Europe has been perceived as timeless and traditional, yet has little explanatory value. Because this concept of the Celts predominates in the field of Celtic studies, the term Celt has still been interpreted to have some biological meaning rather than purely cultural. The regional differences in the material culture, genetics and linguistics in the regions associated with the Celts, have not been interpreted to reflect the presence of diverse of populations and/or tribes, rather these differences when discussed, are predominantly examined typologically or chronologically. While the Celts are no longer recognized as a cohesive group the term Celt is still used to designate specific biological populations. The terminology that has been associated with the Celts since the 19th century has created a field characterized by assumptions about a people and a culture. Research into the Celts has been conducted in three main areas, genetics, linguistics and material culture. Reassessment of these three fields has revealed regional nature of the evidence within the vast interconnected trade network that developed in Iron Age Europe. Therefore the unitary phenomenon identified with the term Celt is actually a trade network, connecting diverse populations and/or tribes who came to possess Celtic material culture through cultural diffusion, assimilation and small scale migration. The term Celt should be redefined as a label for a trade network, a language family, and a material culture rather than defining a population (or populations). Few previous studies have attempted to conduct bioarchaeological analyses on the populations associated with the Celts; as such the

degree of variation among the diverse populations possessing Celtic material culture is largely unknown. Results obtained from the 25, 23 and 20 trait MMD analyses indicate that there is a degree of variation among the proto-Celts and the continental and non-continental Celts, suggesting the term Celt/Celtic has no biological meaning and is purely a cultural phenomenon.

The archaeological evidence also supports small-scale population movement through the regions associated with the Celts as well as cultural diffusion and assimilation of Celtic material culture. In the field of Celtic studies the presence of Celtic material culture, either Hallstatt or La Tène, has been interpreted to indicate the presence of a Celtic population. However, as the social elites are believed to have derived their wealth through control of trade routes with the Mediterranean and throughout Central Europe it is difficult to determine if the presence of a Celtic object signifies the presence of a Celtic population. Cultural assimilation and diffusion are equally viable hypotheses to explain the wide geographic distribution and incorporation of the La Tène culture into diverse populations throughout continental and non-continental Europe. The vast interconnected trade network that existed in Iron Age Europe brought diverse populations and/or tribes into contact with one another and enabled the La Tène material culture and the Celtic languages to spread throughout continental and non-continental Europe. The differential incorporation of La Tène cultural elements into populations and/or tribes in the Celtic core and periphery regions suggests differential rates of cultural assimilation and diffusion of Celtic culture throughout these regions. Changes in material culture from the Hallstatt D to La Tène period and subsequently during the La Tène period throughout continental Europe were both gradual and rapid, suggesting that the so-called Celtic core region may have experienced more cultural assimilation as trade was more prevalent in this region, while the so-called Celtic periphery region experienced more cultural diffusion of the La Tène culture. However, cultural assimilation and diffusion resulted in the spread of La Tène culture throughout continental and non-continental Europe and the incorporation of the La Tène culture into diverse populations throughout these regions. Although the effects of small-scale migration and diasporas cannot be ruled out at this stage, as the degree of biological affinity among the diverse populations associated with the continental and non-continental Celts during the Iron Age is not documented.

The samples used in this analysis are associated with the proto-Celts and the continental and non-continental Celts archaeologically and linguistically. While the samples share key archaeological cultural elements (e.g., chariot burials) they also possess several distinct regional differences. While it may seem readily apparent that regional differences in archaeological culture are present in the large region associated with the Celts, especially if the intra-and inter-regional trade is taken into account; the modern view of the Celts as a possessing a shared identity (whether biological or cultural), that predominates the field of Celtic studies. This view of the Celts is accepted but not challenged. The archaeological and genetic diversity within these regions suggests the presence of diverse populations and/or tribes, thus differences in dental nonmetric traits should be observed. The description of the samples used in this analysis have been described as Celtic based on the La Tène=Celtic framework. In order to fully understand the level of biological diversity among the Celts, it is necessary to move beyond this convention and identify the Celts as diverse groups and/or tribes through analysis of morphological traits rather than through archaeological culture and language. Despite the fact that the archaeological and genetic diversity among the continental and non-continental Celts is recognized, the significance of the regional diversity is largely ignored. The biological affinity of the Celts needs to be examined irrespective of the pre-established paradigm that the presence of La Tène cultural material or the assumption of a spoken Celtic language designates a population as Celtic.

Future work

My primary concern in future dental investigations will be to address the biological affinity among the tribes in Celtic Gaul, and to establish whether these tribes are phenetically similar to those used in this analysis. There are several avenues for future work in including: 1) comparison the Hallstatt D sample in this analysis, to others from the same time period; 2) comparison on the La Tène sample used in this analysis to others from the same time period; 3) comparison of the different Yorkshire cemeteries to one another; 4) comparison of diverse proto-Celtic and La Tène cemeteries; 5) comparison of the La Tène populations in the Champagne region to those in Yorkshire; 6) comparison to other non-Celtic populations; and 7) Comparison of La Tène populations from the core and expansion areas. The above comparisons will help to establish the level of biological diversity among the diverse continental, non-continental and

proto-Celtic populations during the Iron Age, and will establish the how applicable the term Celt is to these diverse populations.

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Appendix

Maxillary traits

Winging UII

Upper central incisors may be rotated mesiolingualward, giving a V-shaped appearance when viewed from the occlusal surface. No reference plaque. Four possible grades may occur:

- 1) Bilateral winging
- 2) Unilateral winging
- 3) No expression
- 4) Counter winging

Labial Curvature UII

Labial surface of the tooth may display a notable convex curvature. Reference plaque ASU UII labial curvature grades scored as:

- 0) No expression
- 1) Trace curvature
- 2) Weak curvature
- 3) Moderate curvature
- 4) Strong curvature

Palatine Torus

Linear bony exostosis that may develop along the palatine suture (in adults only) No reference plaque. Five possible ASU grades are:

- 1) No expression
- 2) Trace (1-2 mm elevation)
- 3) Medium (2-5 mm)
- 4) Marked (>5 mm)
- 5) Very marked (may be as high as 10 mm)

Shovel UII

Possible presence of mesial and distal vertical ridges on lingual surfaces, giving the tooth a shovel-like appearance. Six grades may be scored with reference plaque ASU UII shovel:

- 0) No expression
- 1) Faint expression
- 2) Trace ridges

- 3) Semi-shovel shaped
- 4) Shovel shaped
- 5) Marked shoveling

Double shovel UI1

Mesial and distal marginal ridges may be present on the labial surface. Six possible grades have been established on reference plaque ASU UI1 double-shovel:

- 0) No expression
- 1) Trace ridges on one margin
- 2) Trace ridges on both margins
- 3) One moderate and one trace ridge
- 4) Two moderate ridges
- 5) One large and one moderate ridge
- 6) Two large ridges

Interruption Groove UI2

Groove on lingual borders of teeth. No reference plaque Graded as absent or present (and location).

Tuberculum Dentale UI2

Ridging or cusp formation may occur on the mediolingual surface. There are eight possible grades using reference plaques ASU UC tuberculum dentale (grades 1-4), and ASU UC distal accessory ridge (grades 5-6):

- 0) No expression
- 1) Faint ridging
- 2) Trace ridging
- 3) Strong ridging
- 4) Pronounced ridging
- 5) A weakly developed cuspule
- 5) Weakly developed cuspule with free tip
- 6) Strong cusp with free tip

Mesial Ridge UC (Bushman Canine)

Mesiolingual ridge which may be notably larger than the distolingual ridge, may incorporate the tuberculum dentale. Called “Bushman Canine” after Morris (1975). Four Possible grades may be scored with reference plaque ASU UC mesial ridge:

- 0) No expression
- 1) ML ridge larger than DL, and weakly attached to the tuberculum dentale
- 2) ML ridge larger than DL, and moderately attached to the tuberculum dentale
- 3) ML ridge is much larger than the DL, and is fully incorporated into the tuberculum dentale

Distal Accessory Ridge UC

Anterior to upper canine distal marginal ridge, another distolingual ridge can be found. This feature can be very pronounced. The six possible ASU grades on reference plaque DAR UC are:

- 0) No expression
- 1) Ridge is very faint
- 2) Ridge is weakly developed
- 3) Ridge is moderately developed
- 4) Ridge is strongly developed
- 5) Ridge is very large

Hypocone UM2

Cusp 4 may range from absent to large and developed. Seven possible grades exist on reference plaque ASU UM hypocone:

- 0) No expression
- 1) Faint ridge present
- 2) Faint cuspule present
- 3) Small cusp present
- 3.5) Moderate-sized cusp present
- 4) Large cusp present
- 5) Very large cusp present

Cusp 5 (Metaconule) UM1

Possible presence of a fifth cusp between the third and fourth cusps. There are six possible grades on reference plaque ASU UM cusp 5:

- 0) No expression
- 1) Tiny round cusp
- 2) Tiny wedge-shaped cusp
- 3) Small cusp
- 4) Medium-sized cusp
- 5) Large cusp

Carabelli's Trait UM1

If present, the Mesiolingual aspect of upper molars may display a range of variation from a furrow to a large free cusp. An eight-grade classification, originated by Dahlberg (1956), is used with reference plaque Zoller Laboratory UM Carabelli cusp:

- 0) No expression
- 1) Furrow
- 2) Pit
- 3) Double furrow
- 4) Small attached cusp
- 5) Large attached cusp
- 6) Small free cusp
- 7) Large free cusp

Parastyle UM3

If present, the buccal surface may display variation from a pit to a free cusp. There are six grades on the reference plaque ASU UM parastyle:

- 0) No expression
- 1) Pit
- 2) Small attached cusp
- 3) Small free cusp
- 4) Medium-sized free cusp
- 5) Large free cusp

Enamel extension UM1

An extension of the enamel border may be present and extend toward the root apex. No reference plaque. Four possible ASU grades may be scored:

- 0) No expression
- 1) A short extension (up to 1 mm)
- 2) A medium extension (up to 2 mm)
- 3) A lengthy extension (up to 4 mm +)

Root Number UP1

Number of free roots. No reference plaque. Graded according to number of roots present.

Root number UM2

The tooth may be very reduced in size and display very simple typology. No reference plaque. This trait is graded as normal or peg-shaped

Odontome P1-P2

Any pin sized, spike-shaped enamel and dentine projection occurring on occlusal surface. No reference plaque. Scored as either present or absent.

Congenital Absence UM3

Tooth may not be formed in adult individuals. No ASU reference plaque. Scored as tooth present or absent.

Midline Diastema

In addition to the Arizona State University dental anthropology system traits, the occurrence of the UI1 midline diastema was also recorded. Previous research by the author suggests that a present/absent level of dichotomization is sufficient to record this metric feature, which is based on a measurement between the upper central incisors:

- 0) No diastema (space < .5 mm)
- 1) Diastema (space ≥ .5 mm)

The midline diastema has been shown to occur in high frequencies in many aboriginal African populations, yet is unusual outside Africa (Dervall, 1949; Jacobson, 1982; Massanali, 1982; Shaw, 1931; Sperner, 1958; Van Reenen, 1954). Thus, this feature may prove to be a useful African marker.

Mandibular traits

Lingual Cusp Number LP2

The number of lingual cusps present are recorded. Four possible grades exist on reference plaque ASU LP2: 0-3 cusps

Anterior Fovea LM1

A depression that can occur anterior to cusps 1 and 2. It can range in expression from absent, to a large depression with a ridge connecting the mesial margins of the two cusps. There are five possible grades on reference plaque ASU LM1 anterior fovea:

- 0) No expression
- 1) Faint depression anterior to cusps
- 2) Small depression
- 3) Medium depression
- 4) Large depression

Mandibular Torus

A nodular bony exostosis that may develop on the lingual side of the mandible in region of the canine and premolars. No reference plaque. Four possible ASU grades exist:

- 0) No expression
- 1) Traces elevation
- 2) Elevation between 2 to 5 mm
- 3) Elevation greater than 5 mm

Groove Pattern LM2

Pattern created on the occlusal surface from cusps. No reference plaque. There are three possible grades:

- Y: Cusps 2 and 3 touch
- X: Cusps 1 and 4 touch
- +: Cusps 1 through 4 touch

Rocker Jaw

Inferior surface curvature of the mandibles horizontal ramus. This age-dependent feature occurs only in adults. No reference plaque. There are three possible ASU grades:

- 0) No expression
- 1) Slight curvature of the Jaw

2) Extreme curvature, allowing the jaw to rock back and forth when placed on a flat surface

Cusp Number LM1

Number of cusps present, excluding the metaconulid (cusp 7). No reference plaque.

Three possible grades (4-6 cusps).

Cusp Number LM2

Number of cusps present excluding the metaconulid. No reference plaque. Three possible grades (4-6 cusps).

Deflecting Wrinkle LM1

Medial ridge on occlusal surface may be present and vary on cusp 2. Expression can range from absent, to a large ridge which may make contact with cusp 3. There are four possible grades on reference plaque ASU LM deflecting wrinkle:

- 0) No expression
- 1) Ridge extends ½ way across the cusp
- 2) Ridge extends completely across the cusp
- 3) Ridge extends into the central groove

C1-C2 (Distal Trigonid) Crest LM1

A ridge or loph may connect the distal borders of cusps 1 and 2. This trait is scored as present or absent with the aid of a reference plaque developed by Hanihara (1963) for deciduous teeth.

Protostylid LM1

A paramolar cusp that may occur on the mesiobuccal surface of cusp 1. The trait is often associated with the buccal groove, and can range from a pit to a free cusp. Eight possible ASU grades exist using the reference plaque Zoller Laboratory LM protostylid:

- 0) No Expression
- 1) Buccal pit
- 2) Distal deviation of the buccal groove
- 3) Secondary mesial groove occurs
- 4) Secondary groove is larger than 3

5) Secondary groove is larger than 4

6) Small cusp

7) Large cusp

Cusp 7 (Metaconulid) LM1

Cusp may be present in the lingual groove between cusps 2 and 4. Six possible grades can be scored with reference plaque ASU LM1 cusp 7:

0) No expression

1) Faint cusp

1A) Faint bulge on the lingual surface of cusp 2

2) Small cusp

3) Medium-sized cusp

4) Large cusp

Tome's Root LP2

Condition when the mesial and distal root surfaces may be deeply grooved. There are six possible grades on reference plaque ASU LP Tome's root:

0) No expression

1) Shallow groove is present

2) Moderate groove is present

3) Deep groove is present

4) Very deep groove is present

5) Two free roots are present

Root Number LC

Number of free roots. No reference plaque. Graded according to number of free roots present.

Root Number LM1

Number of free roots. No reference plaque. Graded according to number of free roots.

Root Number LM2

Number of free roots. No reference plaque. Graded according to number of roots present.

Trosomolar Angle LM3

The tooth may be rotated to a line drawn through the middle of the first and second molars. No reference plaque. Three possible ASU grades exist: straight, buccal rotation, and lingual rotation. The degree of rotation is noted.