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Population variation within the Iron Age of southern Africa

An assessment using dental anthropological and cranio-mandibular metric techniques

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Plagiarism Declaration

I know the meaning of plagiarism and declare that all of the work in the dissertation (or thesis), save for that which is properly acknowledged, is my own.

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ABSTRACT

Evidence for iron smelting, agriculture, elaborate pottery styles and increased sedentism appears abruptly in areas previously inhabited by hunter-gatherers and herders during the Early Iron Age (EIA) of southern Africa from around 250CE. Ceramic evidence connects these (cultural) populations to the second millennium Iron Age sites in eastern Botswana. This material culture differs from second millennium Late Iron Age (LIA) sites in South Africa which are attributed to migrations from east Africa and are connected, via the material culture, to modern Sotho-Tswana and Nguni speakers. Although the material culture of this period is well-studied, there is a gap in correlating Iron Age biological identity with the established cultural identity. Here I present an analysis of metric and non-metric dental and cranial variation to better understand biological relationships among these samples. Specimens from the LIA, EIA and Eastern Botswana are compared with each other, and to specimens from Iron Age Zambian sites, modern Bantu-speakers and a historic Ndebele site from the mid-nineteenth century. This research indicates few differences between the EIA and LIA groups, although surprisingly a sample from eastern Botswana is more similar to the LIA group than the EIA group. The Iron Age samples are significantly different from the modern sample, while the historic sample lies intermediate to the Iron Age and modern samples, indicating that Iron Age peoples had a pattern of dental and cranio-mandibular variation that differs from what is seen in modern (admixed?) descendants. This research has important implications for our understanding of the sub-Saharan African dental complex, showing population differences within this complex (between Khoesan and Iron Age peoples) as well as variation over time (between Iron Age peoples and modern Bantu-speakers). This indicates that, while farmers within the Iron Age of southernmost Africa are generally homogenous, there are important differences between populations in sub-Saharan Africa that reflect complex and differing histories.

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CONTENTS

ABBREVIATIONS

Teeth

I1	Frontal incisors
I2	Lateral incisors
C	Canines
P1	First premolar
P2	Second premolar
M1	First molar
M2	Second molar
M3	Third molar

U	Before tooth abbreviation: Upper/ maxillary tooth
L	Before tooth abbreviation: Lower/ mandibular tooth
R	After tooth abbreviation: Right tooth
L	After tooth abbreviation: Left tooth

Population samples

EIA	Early Iron Age: first millennium sample (does not include Toutswe)
TOU	Toutswe (Eastern Botswana) sample
EIA-T	The combined Early Iron Age and Toutswe samples
LIA-E	Late Iron Age south-eastern sample: KwaZulu Natal and Free State
LIA-W	Late Iron Age north-western sample: northern parts of South Africa,

	Botswana and Zimbabwe (excludes the Toutswe sample)
LIA	Late Iron Age: combined LIA-E and LIA-W specimens
ZAM	All specimens north of the Zambezi (all from Zambian sites)
HC	Historic Cave sample
MOD	Modern cadaver sample (Bantu-speakers)
KHO	Khoesan sample

Institutions

A	University of Witwatersrand
A*	University of Pretoria
UB	Gaborone Museum
D	Ditsong Museum
PMB	Natal Museum
NMB	National Museum of Bloemfontein

CHAPTER 1: INTRODUCTION

The main purpose of this thesis is to assess phenotypic identity within the Iron Age of southern Africa. This is achieved by looking at the dental anthropological and the 3-dimensional cranio-mandibular metrics of human Iron Age specimens that can be spatially, chronologically and culturally given a position within the Iron Age sequence. While archaeological studies have focussed on cultural and typological identity or on the genetic and linguistic identities of Bantu-speakers (the likely descendants from these populations), little work has focussed on assessing phenotypic or morphological variation within the Iron Age itself. This thesis also will focus on comparing the Iron Age samples with Khoesan (hunter-gatherer) specimens and modern cadaver material of Bantu-speakers.

The "Iron Age" in southern-most Africa begins in the first millennium AD, with the introduction of Chifumbaze ceramics, permanent or semi-permanent settlements, iron smelting and agriculture (Huffman, 1982; Parkington and Hall, 2010; Vogel, 1995). The abrupt introduction of all these elements is largely supported by the linguistics in areas south of the Zambezi and correlates with the migration of Bantu-speakers south-wards into these areas (Gramly, 1978). The archaeology shows growth in economic and political power towards the end of the first millennium, leading to an evident change in world-view and the value of cattle as wealth (Phillipson, 2005; Hall, 2010; Mitchell and Whitelaw, 2005). The value added to interior political systems by international trade goods created increasingly hierarchical political systems in eastern Botswana, associated with the *Toutswe* ceramics, and in the Shashe/Limpopo region culminated in the first class based political system with Mapungubwe as the capital of the Mapungubwe state in the 13th century AD (Hall, 2010). In the second millennium (or Late Iron Age), ceramic styles which have been classified and linked to modern language-groups appear in the southern African archaeology (Mitchell and Whitelaw, 2005; Hall, 2010). These links are with Sotho-Tswana and Nguni-speakers and archaeological analysis indicates that their appearance also implicates migration, and demographic additions to the established Early Iron Age gene pool.

These first and second millennium Iron Age agriculturalists differ economically from the hunter-gatherers (San) and herders (Khoe) who also inhabited the landscape and whose descendants continue to do so today. The relationships between these identities have long been of great interest to ethnographers and archaeologists (see Parkington & Hall, 2010; Hall, 2010; Reid and Segobye, 2000; Denbow, 1990; Hall and Smith, 2000). Trade between hunter-gatherers and agriculturalists are evident from the beginning of the first millennium or Early Iron Age (EIA). Spiritual and trade relationships have been recorded in the ethnography between modern and historical hunter-gatherers and agriculturalists. Genetic analysis of modern Bantu-speakers has shown much interaction between the two groups and the linguistics of southern Bantu-speakers supports this (Pereira, 2002; Wood *et al.*, 2005; Jones, 2003).

Additionally, these agriculturalists were also subjected to external pressure from colonial influence along the south east African coast and from the Cape by slaving and trading, especially for elephant ivory. By the end of the eighteenth century, significant political and economic changes are evident as a result, and evident in the massive increase in the size of Tswana towns, the establishment of the Zulu state and the events of the *Mfecane*/*Difaqane.* With the introduction of new dynamics and pressures, and the appearance of new population groups on the landscape (specifically Europeans) comes a change in social, cultural and genetic identities (Wood, 2008; Hall *et al.,* 2008; Maggs, 1976b; Hall *et al.,* 2008; Wright, 1989 and 2008; Boeyens, 2003; Esterhuysen, 2008; Esterhuysen *et al.,* 2009; Beleza *et al.,* 2005; Berniell-Lee *et al.,* 2009; Pereira, 2002: 376).

It is against this background that this thesis will explore Iron Age phenotypic identities using two well-known techniques. Studies using quantitative and qualitative dental anthropology have been successful in exploring gene flow in many modern and archaeological contexts. Dental anthropology has been shown to be successful in analysing gene flow on a population level, yet is underexplored in African contexts. Similarly, cranio-mandibular metrics has been shown to be useful in understanding geographic variation, with 3-dimensional images allowing for novel ways of analysing this data.

This thesis will then use these techniques to identify variation within Iron Age populations and use the archaeological sequence to assess variability, especially between EIA and LIA populations. The interpretation of population variation will be extrapolated from the information extracted from the samples selected. Statistically significant differences in measurements and dental non-metric data will be compared between samples. Samples with few significant differences will be seen as more homogenous or similar. It will also explore the variation between these people and historic and modern southern Bantu-speakers to look at whether, and if so how, colonialism has contributed to this variation. It will also look at the variation between Iron Age people and precolonial Khoesan people, to better assess similarity in morphology as an indication for interaction between the two economic/ linguistic identities.

In the following chapter I begin by reviewing what is known about these Iron Age populations, by focussing on archaeological, linguistic and some genetic research. In Chapter 3 I then explore how physical anthropology has helped in our understanding of the Iron Age as well as look at how the techniques that will be used in this thesis have been used in similar situations. Chapter 4 includes the materials and methods that I have used in this study, to look at variation between and within populations, and discuss the samples used. In Chapter 5 I present and discuss the results and they are summarised in Chapter 6 with suggestions for future work. .

CHAPTER 2: ARCHAEOLOGY AND IDENTITY IN THE SOUTHERN AFRICAN IRON AGE

2.1 Introduction

This thesis addresses morphological identity in the southern African Iron Age. It does this by using the archaeologically defined sequence as the pivotal structure through which samples can be assigned to a spatial, chronological and cultural position and assessed in relation to the morphological and demographic implications of that sequence. This approach acknowledges that studying a precolonial history in southern Africa has been an interdisciplinary endeavour that requires a collection/collation of data from several disciplines to reconstruct past identities. An "emerging synthesis" based upon interdisciplinarity in precolonial studies is clearly important for a better understanding of questions around population change and continuity (Jones, 2003: 502). It does, however, always confront the well-known caveat that language, morphology (race) and economy (cultural structure) do not necessarily covary, hand in hand. Table 2.1 (at the end of the chapter) is adapted from Table 1.3 in Blench (2006: 30). It shows how a number of disciplines have been used in southern and eastern Africa. Consequently, a lack of congruence between 'identities', differently defined, does not invalidate their disciplinary integrity and acknowledges the complexity of historical processes in the past are no different from the complexity seen in the present (Diamond and Bellwood, 2003). This chapter will outline linguistic and archaeological data used to establish the advent and development of Iron Age food production within southern Africa. It is within this sequence that questions about morphological identity, population change and variation can be asked.

Table 2.1 Table showing the fields used to reconstruct the past of eastern and southern Africa (adapted from Blench, 2006: pg. 30)

Elements	**Linguistics**	**Archaeology**	**Iconography**	**Textual**	**Oral Traditions**	**Genetics**	**Ethnography/ ethnoscience**
Samples	Very large number	Small number of point samples	Highly variable sample	Very small sample, chronologically limited	Extensive	Large number	Very small number
Precision	Low	High	High	Medium	Low	High	Very low
Dating	Low	High	Low	High	Medium	Medium	None
Degree of exploitation	Medium	Medium	Medium	Medium	Medium	Low	Medium

The term, “Iron Age”, for southern African food production over the last 2000 years is contested. This period is not comparable to that of Europe, from whence the term was borrowed, because it is not premised upon earlier copper and bronze ages (Maggs, 1992; Parkington and Hall, 2010; Mitchell, 2002). Additionally, an emphasis on iron neglects the cultural and technological complexity of this time (Mitchell, 2002). Most authors refer to these populations as food producers or agropastoralists (Maggs, 1992) instead of “Early” and “Late” Iron Age, as distinct from hunter-gatherers (San) and herders (the Khoe) with whom they shared the landscape (although interaction and shared occupation between these groups will also be discussed). In other words the emphasis is on economic labels, although as a short-hand term, it is understood that ‘Iron Age’ stands for much more than technology (Parkington and Hall, 2010; Mitchell, 2002; Mitchell and Whitelaw, 2005; Hall, 2010). The term “Iron Age”, however, emphasises time period and the technology, the other terms are more empathetic with the idea of people and, particularly important for this thesis, and the biological interactions between them.

Consequently, “Iron Age”, is used for convenience, with a full understanding that the term stands for considerably more complexity at this time. Although hunter-gatherers had been on the landscape for thousands of years, evidence for herding and non-Bantu-ceramics also predates the arrival of farming. The distinction between these hunter-gatherers and herders within the archaeology has long been debated, but an archaeological farmer identity seems more clear (Hausman, 1984; Parkington and Hall, 2010). These identities are defined by economic, cultural and linguistic distinctions. Hunter-gatherers (or foragers or San), herders (or Khoe) and farmers (Bantu-speakers), begin sharing the landscape in the first millennium CE. While foraging, herding and farming distinguish these groups from an economic point of view, San, Khoe and Bantu-are the linguistic classifications. Culturally, these groups appear to differ as well, with ceramics only appearing with the arrival of herders and permanent and semi-permanent settlements, agriculture and iron-smelting only appearing with the introduction of farmers. Within this thesis, the foragers and herders will often be referred to, collectively, as Khoesan.

2.2 Advent and origins: Cultural and archaeological Identity

Iron Age archaeology in Southern Africa only systematically started in the 1960s. Up to that point the majority of archaeologists focused on Stone Age studies. Significantly excavations and material culture from the complex state capital of Mapungubwe as early as the 1930s unsettled notions of a simple, savage and recent Bantu-speaking presence, despite the 'genetic' denialism based on a framework of racial typology (Hall, 1984a). Ironically, Iron Age studies, and the establishment of radiocarbon dating, took off during the height of Apartheid, disproving the myths of a coeval arrival of the Dutch and Bantu-speakers. While Iron Age studies had a late start compared to countries north of the Limpopo, they have made significant advances over the last 40 years (Hall, 1984b; Maggs, 1994/1995). A basic sequence has been established through the combination of dating, ceramic and settlement classification, and this has been supplemented by increasingly detailed interrogations of life-ways, environmental relationships and identity through the use of isotopic studies, faunal and floral remains, and the analysis of other climatic and environmental proxies. More sophisticated use of the ethnography has opened up important insights and debates around social structure, social process and the complexities of identity. I review some of this work on cultural identity, temporal variation and change by broad period; namely the Early Iron Age (EIA, 1st millennium AD) and the Late Iron Age (LIA, 2nd millennium AD).

First, however, I briefly outline issues to do with the archaeological definitions of identity. The introduction of farming is considered "the single most significant development which occurred in Africa south of the Equator in the two to three millennia before 1000AD" (Vansina, 1994/1995: 15). Archaeologically, EIA sites have abundant evidence for semi-permanent settlements based on mixed farming (pole and daga huts and granaries, underground cereal storage pits, cattle byres) and specialised expertise in the production of metal (iron and copper in the EIA and gold, tin and bronze from the 12th century AD onwards) and large-scale ceramic production (Huffman, 1982). Few doubt that these attributes and their sudden appearance in southern Africa early in the 1st millennium AD are the material remains of Bantu-speakers. On the basis of ceramic style there is significant homogeneity throughout eastern and southern Africa, and radiocarbon dates show that the best explanation for this common style and the appearance of this archaeological "package" was a rapid movement of Bantu-speaking mixed farmers into a resident hunter-gatherer population (Parkington and Hall, 2010). While each of these elements has a complex history within the continent (Vansina, 2005), their sudden introduction into southern Africa within the first millennium AD does indicate the arrival of a relatively intact economic and cultural package that was established in the savannah summer rainfall areas from 400AD based on radiocarbon dates (Vogel, 1995: 109). The contrast with the material residues of hunting and gathering is marked and abrupt.

As indicated, the idea of EIA mixed farmer cultural homogeneity over East and southern Africa is suggested by similar ceramic style (Huffman, 2005, 2007:111-122). Ceramic classification therefore is important for the archaeological identification of group identity in this period. It has been suggested that the identification of discontinuous stylistic clusters is underpinned by linguistic or dialect difference and within the Late Iron Age (LIA), ceramic style has been used to identify linguistic groups that can be directly linked with historic groups (e.g. Loubser, 1989; Katanekwa, 1994/1995). Shared ceramic style is about communication among Bantu-speakers, and ethnography shows ceramic designs reflect social meaning about gender and sexuality, death and life (Pikirayi, 2007). Changes in ceramics would therefore reflect social change.

This is important because the distinction between the EIA and the LIA is made on the basis of a change in style structure over a large area and in this case, absolute disjunct style is a useful indication of further population movement. Some LIA ceramic styles do not appear to be derived in any way from local EIA styles and this is a second important cusp for this project, because it highlights the possibility of new demographic shifts and interactions from the 12th century AD (see Huffman, 2007:118, 317-320). Qualitative stylistic shifts within the EIA and the LIA reflect smaller scale local processes driven by political, ecological and social factors that may also have had demographic consequences within a region. Although culture is not inherited in the same sense as genes, it may impose barriers or constraints on gene flow (Hall and Morris, 1983; Hausman, 1984).

Ceramic classification for the definition of identity, however, does have its problems. It is suggested that there is too much emphasis placed on pottery classification, somewhat ignoring other kinds of material culture (Parkington and Hall, 2010; Pikirayi, 2007). While this is true, ceramic classification has established a robust structure for ordering time and space that, despite this criticism, most archaeologists use to frame their higher order questions. The distinction, for example, between the EIA and LIA noted above is well established. However, there is notable overlap between styles throughout much of the second millennium AD. It is on smaller scale degrees of stylistic difference that debate around the mechanics of those differences hinge. Consequently, despite historical evidence that shows that change can occur because of population movement, one should not ignore other explanations (Mitchell and Whitelaw, 2005). In this regard it useful to remember that language spread is not dependant on migration, and diffusion is equally important as a mechanism for cultural change. However, while it is good to remember that the sequence outlined below is based on ceramic style and the typologies could be misleading in relation to the entangled complexity of contextual cultural, social, political and economic processes (Hall, 1984a), it does identify two scales of demographic process important for this project. One scale focuses on the appearance of mixed farmers early in the 1st millennium AD and the EIA/LIA change between the end of the 1st millennium and the start of the 2nd millennium AD. A second scale focuses on the smaller shifts within the EIA and LIA that may or may not have involved local demographic movement. It is to this sequence that I now turn.

The Early Iron Age

The homogeneity of eastern and southern African EIA ceramic style has been lumped into a category known as the Chifumbaze Complex (Huffman, 2007:117-122, 331-359; Parkington and Hall, 2010). The Chifumbaze complex is subdivided into a western Kalundu Tradition and an Eastern Urewe Tradition (although this is not universally agreed upon by archaeologists; Huffman and Herbert, 1994/1995; Huffman, 2007:122). Urewe is further divided into the Nkope and Kwale branches. The different facies and phases (or temporal and spatial styles) within these Traditions and Branches are indicative of change, migration and interaction of cultural identities.

The *Silver leaves* facies of the Kwale Branch in Limpopo, Swaziland, Mozambique and Zimbabwe (250-430AD) is the earliest expression of the EIA in southern Africa (Mitchell and Whitelaw, 2005). *Mzonjani* (420-580AD) is a second facies, found at the *Silver Leaves* site in Limpopo Province at Broederstroom in Gauteng and eastern Botswana, dating to 550-650AD, but not further south than Durban (Mitchell, 2002; Parkington and Hall, 2010). Sites are near iron ore sources and occur in areas of high rainfall, ≥800mm a year (Mitchell and Whitelaw, 2005; Parkington and Hall, 2010; Whitelaw and Moon, 1996). Many *Mzonjani* sites are located within 6km of the coast, allowing for the exploitation of shellfish and for short periods of slash and burn agriculture (Parkington and Hall, 2010).

The Nkope Branch appears in Zambia and Zimbabwe from 400AD. The *Zhizo* phase of the Nkope Branch is present in the Shashe/Limpopo Basin, eastern Botswana and western Zimbabwe between the seventh to tenth century, and gives rise to the *Toutswe* facies in eastern Botswana until the thirteenth century (Mitchell, 2002; Parkington and Hall, 2010; Mitchell and Whitelaw, 2005).

The Kalundu Tradition (Western Stream) is characterised by ceramic decoration that emphasises multiple bands on the neck (Huffman, 1982, Huffman, 2007:212 ff.). In this attribute and jar profile Kalundu is stylistically distinctive from Kwale and Nkope Branch ceramics. Additionally, most of the founding facies of the Kalundu Tradition are younger than Kwale Branch facies and consequently while Kalundu dominates the EIA after AD 600, interaction results in some shared attributes.

The replacement of Kwale Branch ceramics by Kalundu is most evident in KwaZulu Natal (KZN). *Msuluzi* pottery is the first Kalundu facies there (AD 650-700) and these sites extend further south than the preceding Urewe (*Mzonjane*) sites. There is considerable stylistic continuity in the KZN sequence where *Mzuluzi* locally changes into *Ndondonwane* (to 900AD) and then to the *Ntshekane* phase (900-1000AD). These phases extend to the Kei region of Eastern Cape but not further south (Binneman, 1996). This marks the southern limits of viable sorghum and millet agriculture determined by suitable summer rainfall. In the summer rainfall savannah landscapes to the west of the escarpment there are a number of Kalundu phases and facies. The terminal phases end between the 12th and 14th centuries i.e. *Broadhurst* (derived from *Eiland*), in Botswana, continues well into the 2nd millennium (1400AD) and the *Maguga* phase in Swaziland and the Kruger National Park (1450 AD) (Mitchell and Whitelaw, 2005; Mitchell, 2002; Parkington and Hall, 2010).

The EIA stylistic sequences raise questions that have possible genetic and morphological implications. One, as indicated above, is that the appearance of the Chifumbaze Complex in southern Africa is relatively rapid as shown by a geo-referenced radiocarbon database on EIA sites. Suitable climate and environmental conditions may have encouraged this expansion as well as the possession of iron technology for the production of tools to clear land, plant and harvest. This rapid spread of the Iron Age package through migration is mostly uncontested, (Russell and Steele, 2009; 2011), compared with the spread of the European Neolithic where there is a suggestion of cultural diffusion. Despite debates over degrees of migration versus diffusion, in southern Africa the appearance of the agropastoralist package marks the arrival of Bantu-speakers and consequently there was significant gene flow.

Second, is that EIA farmers only settled within the savannah regions of the summer rainfall zone and the database suggests certain criteria that could account for the rapid spread of the Iron Age into Southern Africa. One focuses on pioneer farmers locating and settling on very specific landscapes and their preferred ecologies (niche hopping). Most EIA villages are found on pockets of deep iron rich and fertile red soils close to major perennial drainages and within mixed tree and grassland savannah habitats where annual rainfall ranges from 400mm to 700 and 900mm (Russell and Steele, 2009: 337). These conditions supported sorghum and millet production and cattle management in the grassland component of these environments (Carrión *et al.*, 2000). Most EIA sites produced their own iron and proximity to iron ore deposits was also important.

The settlement preferences of EIA farmers have a third implication. Within this area, farmer occupation was patchy and along the smaller and larger frontier margins may have encouraged a range of interactive opportunities with resident hunter-gatherers, from avoidance to intermarriage. Khoesan populations continued in the drier interior regions, the year round rainfall areas and the winter rainfall areas of the Cape, where mixed cereal and cattle farmers did not settle (see Parkington & Hall, 2010; Hall, 2010). Once established, EIA farmers may have changed the environment (Prins, 1994/1995; Vansina, 1994/1995; Carrión *et al.*, 2000) and settlement data show an increase in the number of Iron Age settlements after 400 AD, that despite contractions at times in certain areas due to climatic deviations and rainfall variation, would have resulted in increased farming populations (Vogel, 1995; see for example Huffman, 2008 and 2009).

In addition to identity based upon ceramic style and ceramic sequence, different scales of cultural identity can also be discerned based upon settlement organization. This is premised on spatial organisation as a sensitive expression of social structure and worldview. The key here is the strong correlation between the spread of the Chifumbaze complex and people who spoke forms of Eastern Bantu, as opposed to the other major linguistic division, referred to as Western Bantu (Huffman and Herbert, 1994/1995). Based on historic and ethnographic evidence Eastern Bantu-speakers have a patrilineal ideology, have male hereditary leaders, use cattle as bride wealth (*lobola*) and have a particular belief in the role of patrilineal ancestors (Huffman, 1986). All historic southern African Bantu-languages are classified as Eastern Bantu- and this linguistic identity and associated worldview is spatially expressed in the layout of homesteads. Consequently, a spatial model known as the Central Cattle Pattern (or CCP), has been ethnographically derived from Sotho-Tswana and Nguni ethnography and which spatially ‘captures’ Eastern Bantu-ideology where a central cattle pen is dominated by men, is the place for high status burials, is associated with the male assembly area or court where prestige male craft production takes place. In contrast there is the residential zone surrounding the central area. This is the domestic domain of households and of women and child rearing. The women and children are commonly buried in the domestic middens or under hut floors or in the courtyards around the huts. The houses are each divided into male and female sides, surrounding a central hearth (Whitelaw, 1994/1995; Huffman, 1982, 1986).

In contrast, Western Bantu-speakers have a matrilineal ideology about procreation; bride service is to the father-in-law as marriage payment and they have a different belief about the role of ancestors. These cultural principles are spatially expressed in a different village layout characterised by a street pattern and where attitudes to ancestors contributes to burial in cemeteries outside the boundaries of the village (Huffman and Herbert, 1994/1995; Huffman, 1989a).

Huffman shows that the CCP model is congruent with and explains most of the spatial organisation in southern African EIA sites, and significantly it straddles all the ceramic Traditions and Branches of the Chifumbaze Complex (see for example Whitelaw, 1994/1995; Huffman, 1998, 2007; Mitchell, 2002). It is for this reason that the archaeologically defined Chifumbaze Complex is all about Eastern Bantu-speakers, that this cultural and linguistic identity is continuous throughout the southern African Iron Age, and that this worldview was integral to the EIA 'package'.

This interpretation is, however, not universally accepted. Hall (1984b) and Lane (1994/1995) point out the ahistoric implications of using an ethnographic model to account for 2000 years of structural similarity. It implies cultural stasis and a lack of development within societies. While the relevance of the CCP for 2nd millennium spatial interpretation is not in doubt, its use to interpret social organization in the EIA is problematic. For example, as a process of transformation, iron smelting ethnographically is associated with the 'liminal' domain of the bush, outside of homesteads. Some claim that there is evidence for iron smelting associated with the male centre and therefore differs from ethnographic predictions (Mitchell, 2002). However, this material can be linked to forging, a secondary stage of metal production that does take place within male areas.

On methodological grounds others are suspicious that the historical and colonial processes have influenced the ethnography and that it has limited deeper time relevance. Badenhorst (2010) suggests that the spatial pattern seen in the EIA reflects matrilineal societies. He suggests that because the remains of goats and sheep outnumber cattle the CCP cannot be supported and that small stock herding and extensive horticulture often indicate that women had more power in a matrilineal system and that this changed to a patrilineal system in the second millennium, when cattle-dominated livestock are evident and different agricultural groups entered the landscape. Huffman argues that the social significance of cattle need not only be determined by herd size, and that the Shona upheld bride-wealth with small numbers of cattle (1998: 61).

Despite these criticisms, however, it is clear that there is no competing model that provides an alternative to the CCP and that the CCP makes sense of a significant amount of EIA spatial data. What is frequently misunderstood is that Huffman's CCP model addresses structure and broad cultural principles and not the variability in how those principles are contextually expressed. Consequently, there is variability in the material expressions of initiation and rites of passage. For example, where ceramic sculpture and figurines in the EIA sites of Ndondondwane and Kwagandaganda in KZN and at early and later 2nd millennium sites is comparable to some contemporary Bantu-speakers such as Venda, Shona and some Sotho-speakers (Whitelaw, 1994/1995), Nguni and Sotho-Tswana-speaking peoples do not use figurines (Mitchell, 2002). More specific to the Early Iron Age is the skeletal evidence for dental modification, which is supported by the Lydenburg Heads, and seen in many sites associated with the Chifumbaze Complex (Whitelaw, 1994/1995; Mitchell, 2002; Mitchell and Whitelaw, 2005). These ceramic sculptures clearly show dental modification, and indicate variability in EIA and LIA initiation practices. There is cultural continuity in some of these smaller scale expressions but not in others.

This variability may indicate differences in worldview between EIA and LIA populations. This discussion continues with a consideration of the archaeology after the end of the stylistically defined EIA. I first briefly outline the importance of the sequence in the Shashe/Limpopo Basin between 1000 and 1300 AD for this discussion and then go on to outline the LIA sequence.

The Middle Iron Age

The Middle Iron Age (MIA) in South Africa is a period between about 1000 AD and 1350 AD that is geographically constrained to the Shashe/Limpopo area north of the Soutpansberg. It culminates at Mapungubwe from AD 1250, which was the capital of a state in the region and which was the forerunner of the even larger capital centred at Great Zimbabwe that developed after Mapungubwe collapsed around AD 1300. These developments were based on an intensification of international trade links with the East African coast and the wider Indian Ocean region that contributed to wealth, political centralisation and social complexity evident at Mapungubwe.

This sequence in the Shashe/Limpopo River Basin (SLRB) starts at Schroda, the largest settlement (and likely capital) in the SLRB from 900 to 1000 AD (Phillipson, 2005; Hall, 2010). The SLRB is a marginal area for mixed farming but this did not deter settlement there at 900 AD and the establishment of a chiefdom centred at Schroda. This occupation was basically the first farmer settlement of the region and was part of the *Zhizo* facies that in turn was part of the larger Nkope Branch of the Urewe Tradition. Initially it was thought to correlate with increased rainfall at that time. However, it is more reasonable to conclude that this chiefdom saw the potential of the region to satisfy the growing demand for trade in elephant ivory coming from the south east African trade entrepots, such as Sofala (Mitchell and Whitelaw, 2005). The size of Schroda indicates it was the capital and relied on deep trade connections through “down-the-line trade” (Hall, 2010: 119).

At 1000 AD the appearance of *Leopard’s Kopje* ceramics (Kalundu Tradition) from the EIA areas to the south marks the arrival of a competing chiefdom that in part displaced the *Zhizo* chiefdom. Evidence of *Zhizo*-style ceramics continues in eastern Botswana with a significant increase in *Toutswe* phase sites, which are closely related to *Zhizo* as a facies of the Nkope Branch, from the 11th century AD. The appearance of *K2* ceramics (Kalundu ceramics) signifies the rise of the site of K2 as the regional capital that took over and intensified international trade upon which the rise in political power was based.

The change from *Zhizo* to *K2* ceramic style in the SLRB is critical for the discussion of change and continuity between the EIA and LIA stated above. Two points are important. First is that the *K2* ceramic style is derived from EIA Kalundu phases from the south. Second is that the *K2* ceramic style has clear continuities into the Zimbabwe Tradition of the second millennium AD and into the historic period (Huffman, 1989a). The implications of this stylistic continuity between the southern African EIA and LIA is that people who made *K2* ceramics spoke Shona, and consequently Shona (Eastern Bantu) was spoken in the EIA.

Additionally, ceramic evidence shows that some *Zhizo* people stayed on in the SLRB until the thirteenth century where their ceramic style (*Leokwe*) was contemporary with *K2*. However, while they lived side by side, archaeological evidence indicates that they were subordinate to *K2* elites (Mitchell and Whitelaw, 2005; Hall, 2010). This is also important because interaction was underpinned by close cultural similarities and, settlement evidence aside, it indicates that facies derived from both the EIA Kalundu Tradition and the Nkope Branch of the Urewe Tradition were both Eastern Bantu-speakers.

The Eastern Bantu-continuity into the second millennium AD is further supported by the settlement pattern that develops out of K2 and which is fully expressed at Mapungubwe from AD 1250. Mapungubwe is less than one kilometre from K2 and this change in settlement focus marks the full establishment of a class based system, where for the first time elite rulers separated themselves from the rest of the settlement, and lived on top of Mapungubwe Hill, while commoners in the town lived on the flats below the hill. This new spatial expression elaborated the ever increasing power of rulers, based as it was on the wealth generated by east coast trade. High status burials are evident on the hill and isotopic signatures show varying diets (possibly indicative of status; Mitchell, 2002: 303). Bronze and gold were worked in Mapungubwe (Mitchell and Whitelaw, 2005: 239) and there were other innovations that marked status and control of trade goods such as glass beads, and cotton cloth from around the Indian Ocean rim that were exchanged for ivory and gold, among other commodities. While these items exceeded the wealth and political power that could be generated by cattle, commoner homesteads within the Mapungubwe state but outside of the capital and other elite centres, continued to be organised along the principles of the CCP. In Eastern Botswana Toutswe sites that are contemporary with the K2 and Mapungubwe sequence only attain a three-tier political hierarchy based on cattle and CCP settlements.

Despite evidence for extensive trade westwards into the Kalahari and Botswana (Calabrese, 2000), these chiefdoms could not fully take advantage of the international trade because this was blocked by the Mapungubwe state to the east.

Mapungubwe was the first *Zimbabwe Culture Pattern* (ZCP) settlement and Great Zimbabwe state elaborated these principles at the capital of Great Zimbabwe itself. When it collapsed around AD 1450, the Great Zimbabwe state split into the *Khami* period, also associated with the ZCP and ceramics. It dates from 1450 AD and shares much continuity with the sites mentioned previously (Hall, 2010). *Khami* period sites include Khami and Danagombe and the Mutapa dynasty in north east Zimbabwe, which was recorded by the Portuguese and continued well into the nineteenth century (Mitchell, 2002).

As indicated above, the implications of the MIA sequence is that it emphasises cultural continuity from the EIA and that these changes were not wrought by population change, but rather by internal social changes brought about through trade (Huffman, 1982). The ZCP from its inception has been associated with Eastern Bantu-speaking Shona, and overall, the archaeology and ethnography, oral traditions and the Portuguese documents all support this identity (Huffman, 1986).

Mapungubwe ceramics continue in eastern Botswana and the north-eastern Soutpansberg and eventually dominate the regions (Hall, 2010). Further to the north *Ingombe Ilede* sites found around the Zambezi at this time, result from Western Bantu-movement from the north early in this period and the population is culturally unrelated to Shona-speakers (Mitchell, 2002;

Huffman, 1989a). This is seen in the oral records, 16th century historic documents and ceramic style (Huffman, 1989b). The Iron Age sequence of southern Zambia, in general, however, alternates between Eastern and Western Bantu (Huffman, 1989b).

The LIA and the origins of Sotho-Tswana and Nguni-speakers

The advent of Sotho-Tswana and Nguni-speakers can be identified archaeologically and marks the start of the LIA outside the smaller geographic focus of the MIA. The evidence for these origins are best explained by migration because there is an absolute and complete stylistic disjunction between any South African EIA ceramic styles and those associated with the LIA. The LIA ceramic styles cannot be derived from any South African EIA ceramic style. In KwaZulu Natal (KZN) this disjuncture is marked by the appearance of *Blackburn* ceramics from 1100AD. The association with Nguni-speakers is made because there is stylistic continuity all the way through into the present-day. Similarly, the appearance of *Moloko* ceramics from 1300 AD in the area north of the Soutpansberg cannot be stylistically linked to any EIA or MIA (Middle Iron Age) style and stylistic continuity into the historic period establishes the link with Sotho-Tswana-speakers (Mitchell and Whitelaw, 2005; Hall, 2010). The origins of both these ceramic styles may reside in the East African EIA (Hall, 2010; Huffman, 1989a). This connection is strengthened by ethnographic similarities that draw attention to similar kinship terminology, congruent beliefs in pollution concepts and pollution practices and, most importantly, linguistic classification that shows a close historical link between Swahili and Chaga and Nguni and Sotho-Tswana (Mitchell, 2002; and see summary in Huffman, 2007). The importance of these connections is that while significant population movement (and potentially gene flow) is indicated at the start of the

LIA, the origins reside within the Chifumbaze Complex and this reinforces the general cultural continuity of Eastern Bantu-speakers between the EIA and the LIA. This continuity in a patrilineal worldview emphasises the relevance of the CCP for the interpretation of EIA settlement organisation (Huffman, 1998; 2007). While not an explanation for this significant demographic shift, it may have been facilitated by climatic conditions (see Tyson *et al.*, 2002: 129; Smith *et al.* 2007). Compared with the apparent scale of demographic shift implied by the appearance of the LIA, the subsequent sequence is one of small scale cultural and demographic change within a relatively homogenous continuous change.

Moor Park, the second phase after Blackburn, is also associated with Nguni-speakers and dates from 1300 to 1700 AD (Hall, 2010). They expanded into the KwaZulu Natal interior and into higher altitude grasslands, as well as southwards into the Eastern Cape near present-day Grahamstown, and were likely the ancestors to the Xhosa (Hall, 2010). It is during this phase that the first Late Iron Age stone walls were constructed to mark homestead boundaries, cattle enclosures and activity areas. Drier conditions at the beginning of the Little Ice Age (1300 to 1800 AD; Tyson *et al.*, 2002) may have threatened food security, and as a result Moor Park sites were located on defendable hilltops.

To the west of the escarpment, from the mid-fifteenth century, Sotho-Tswana-speaking communities expanded into eastern Botswana and the North-West Province (Hall, 2010: 129), and from 1500AD had crossed the Vaal River and settled the Highveld. This was the first exploitation of these grasslands by mixed farmers and set up new frontiers between them and Khoesan populations. These farmers made extensive use of stone walls to define homesteads, possibly influenced by the earlier stone wall building traditions of Moor Park farmers and by the lack of wood in the Highveld at this time (Maggs, 1976a; Huffman, 2007). Despite the abrupt stylistic break between the EIA ceramic style and LIA Moloko ceramic style (ancestral Sotho-Tswana), in south-eastern Botswana there is a clear chronological overlap between the terminal EIA phase and early Moloko populations. They were therefore co-resident for a short while and subsequent interaction imposed a Moloko cultural identity; part of this process must have been through intermarriage, resulting in genetic continuity across the stylistically define EIA and LIA boundary.

Homesteads defined by stone walls had quickly become a feature of this period south of the Zambezi and aerial photography has allowed archaeologists to define settlement types that, through oral histories, link specific historical Sotho-Tswana identities to them (Mason, 1968; Maggs, 1976b). These include the eastern settlement types (N and V) associated with Kwena and Fokeng identities and the north-western Type Z settlements associated with southern Tswana identities (Rolong). Significant movement of Nguni-speakers from east of the escarpment to the west is indicated in settlement type and in the oral histories of so-called southern and northern Ndebele and in Koni settlements from the 17th century on the Mpumalanga escarpment (Huffman, 2007). These developments are attributed to two separate Moor Park movements from KwaZulu Natal between 1630 and 1670 AD (Hall, 2010), prompted perhaps by severe climatic conditions within the Little Ice Age. The introduction of maize may have also impacted population dynamics, prompting relative and absolute population shifts (Boeyens, 2003; Huffman, 2007). Nguni groups (Ndebele) adopted other pottery styles, showing interaction between Nguni and Sotho-Tswana-speakers.

In the second half of the 18th and early 19th centuries regional demographic shifts and political change intensified as European expansion into interior African societies from the Cape and the south east African coast intensified. One well known response was the establishment of the Zulu state in KwaZulu Natal, while a chronologically equivalent response by Tswana-speakers in North West Province was a rapid shift to high density town living, that in part reflected increasing concerns about defence and security (Boeyens, 2003; Hall, 2010). In the context of these early colonial encounters and the Mfecane there were further Nguni and Sotho-Tswana-speaking diasporas. In the early 19th century, for example, the Ndebele state in present-day North West Province was established, but under continued threat from Dutch expansion from the Cape eventually settled in south western Zimbabwe from the 1840s. Additionally, there was an extensive Nguni diaspora from northern KwaZulu Natal up to Northern Malawi and Southern Tanzania over the same period.

Whether these 18th and 19th century processes can be accounted for by the end of the Little Ice Age, or the increased stress of colonialism, the significance for this project is that there was considerable demographic movement during which social and political identities were continually being renegotiated. Much more recently, political interference such as the 1913 Land Act and the control of people within specific homelands during Apartheid must have had an influence on populations. This archaeological and historic perspective highlights that the constitution of contemporary populations has a complex history and consequently, the relationship between contemporary identities and their links to the prehistoric past is complex and not straightforward.

Oral records have been useful for understanding the identities of Tswana speakers (Boeyens, 2003). Dates based on genealogical lists of rulers of western Tswana-speaking communities point to two migrations: the arrival of the Rolong (between the thirteenth and mid-fourteenth century AD) and the arrival of the Kwena-Hurutshe (between mid-fourteenth and mid-fifteenth century AD) (Boeyens, 2003: 67). The archaeology seems to support the date for the Hurutshe migration in the Marico region. The creation myth of the original Tswana ancestor arriving from a hole in the ground can be traced to eastern Botswana, the waterhole of Matsieng (Hall, 2010: 139; Boeyens, 2003). The myth includes the idea of hunter-gatherers as the first people because of footprints of humans and animals emerging from the hole were clearly San petroglyphs that were incorporated into Tswana mythology.

Oral traditions are more often employed in the LIA studies. "Rather as science fiction tells a reader more about authors' present preconceptions and the shape of the future, so oral traditions reflect recent political and social preoccupations rather than objective historical narrative" (Blench, 2006: 27; Phillipson, 2005). Considering Loubser's (1989) comparison of Venda oral traditions, where the Singo claim to Venda language and tradition was not supported by the archaeology, it is good to keep in mind the limitation of using these records for historical reconstruction. Oral records, however, supported the Khami incursion that was evident in the archaeology.

2.3 Linguistics, interactions and genetics

Linguistic identity

As indicated above, there is no necessary correlation between archaeological, linguistic and genetic identities, and in order to maintain this distinction I briefly consider linguistic evidence separately. Wilhelm Bleek clearly saw differences between Bantu-and Khoesan languages from the mid 1800's (Blench, 2006) and the hypothesis of a Bantu-expansion premised on this distinction and the close similarity in Bantu-languages northwards into East and West Africa "has been current ever since" (Parkington and Hall, 2010: 69; Blench, 2006, 1994/1995; Nurse, 1994/1995). The important point is that the idea of Bantu-migration was first based on linguistic evidence and an archaeological contribution to this only came later in the 20th century. While the linguistics has been useful for archaeology, in establishing the connection between Bantu-speakers and the spread of the Iron Age into southern Africa (Gramly, 1978), historical linguistics shows the complexity of the spread, sharing and changing of language. A branching tree model of Bantu-language history is simplistic; more appropriate is the model of an entangled thicket, and consequently connecting linguistics and material culture is difficult and, of course, "pots do not speak" (Nurse, 1997: 361, 1994/1995).

More relevant here for the southern African Early Iron Age is the linguistic division within Bantu-languages which classifies Bantu into Eastern Bantu and Western (or non-Eastern) Bantu, both of which have their origins in West Africa (Mitchell and Whitelaw, 2005; Huffman and Herbert, 1994/1995; Nurse, 1994/1995). These distinctions are conventionally based on lexicostatistics (using comparative statistics on a standard word list) and glottochronology (using sound shifts to infer rate of change and to create a time-scale) (Nurse, 1994/1995:67, 1997). However, change in vocabulary is not constant and “family trees” of languages, often produced in this way, do not take into account the complex social and political contexts within which languages do or do not change (Ehret, 2001; Nurse, 1997). Consequently, other methods that compare historical relationships through morphology, phonology and syntax are also considered (Blench, 2006). This is not to say that these phylogenetic trees are useless (Mace and Holden, 2004), and it has been shown that some cultural traits do map onto linguistic (and genetic) trees, but it is useful to remember that these attributes should be dealt with independently.

In this regard Bantu-language classification/s should not be forced to fit the archaeology, especially when migration and the routes of EIA farmers are concerned (Vansina, 1994/1995). Few historical linguists use lexicostatistics and glottochronology now and there is debate, depending on method of classification, as to whether there is a coherent “Western” Bantu-group. Importantly for this thesis, however, is that Eastern Bantu is a clear and coherent linguistic subgroup (Ehret, 2001). While the relative homogeneity in Bantu within the Niger-Congo phylum over a very large area is evidence for a recent expansion (between 2 and 4 kya) and that this “homeland” developed in what is now Cameroon (Blench, 2006:84), the initial spread of Bantu seems not to have been part of food production (Blench, 2006:126).

In contrast, the more recent Bantu-expansion into southern Africa is based on linguistic evidence, associated with agro-pastoralists, and the correlation between archaeologically defined EIA streams, branches and traditions are the material expressions of this movement and spread of Eastern Bantu-speakers (Huffman, 2007; Blench, 2006:137). While Vansina (1994/1995) has proposed multiple expansions, at the scale of Eastern Bantu and the Chifumbaze ceramic complex, this correlation is secure. As noted above, ceramic continuities more securely indicate that the MIA comprised Shona-speakers, and that Shona was part of the EIA linguistic make-up. Additionally, the linguistic/archaeological correlations during the LIA are secure and this archaeological sequence is about Nguni and Sotho-Tswana-speakers and the history of the majority of present-day South Africans. Cultural evidence also supports the view that the LIA has its origins within Eastern Bantu-speakers in East Africa. This is supported by kinship terminology (Hammond-Tooke, 2004), where it has been noted that Nguni-speakers have similar terms for cousin and a structure of cross-cousin marriage with interlacustrine groups. Linguistically, Sotho is also more similar to Tanzanian groups (Hammond-Tooke, 2004:77).

Another contribution of linguistics is to our understanding of the interaction between Bantu-speaking farmers and Khoesan-speakers, and I briefly turn to this issue below.

Farmer interaction

The summary provided above makes mention of frontiers and boundaries between Bantu-speaking agropastoralists and Khoe and San people. I briefly review these boundaries and evidence for interaction across them. Although the thesis looks specifically at farmers it is useful to remember that Khoesan groups had varying histories of contact with farmers and consequently identities certainly changed throughout this period. Sometimes interactions may be fluid, positive and culturally bi-directional or negative in terms of force and marginalisation. The material culture changes to reflect these relationships (Reid and Segobye, 2000). Here I only consider some of the evidence for interaction and not the social and economic structures within which interaction took place (see Parkington & Hall, 2010; Hall, 2010).

With the advent of systematic anthropological and archaeological research it became increasingly evident that in the western and central parts of Southern Africa there had been economic and cultural interaction from early in the 1st millennium AD between farmers and foragers who shared these landscapes (Denbow, 1990). Even in areas such as the Kalahari, deemed hostile to farming, there is clear evidence for interaction with Early Iron Age communities (Denbow, 1990), disproving that harsh environments buffered Khoesan-speakers from contact. Khoe words for cattle and sheep have been adopted by southern Bantu-speakers but the geography of these loans, their chronology, and the implications for the acquisition of livestock in southern Africa is not so straightforward (Smith, 2000).

In prime farming habitats such as the Thukela Basin where the EIA has been relatively well studied (Parkington and Hall, 2010) there is evidence for wide trade networks between farmers and hunter-gatherers where the presence on EIA sites, for example, of ostrich egg shell (OES) beads indicate geographically extensive networks of acquisition and exchange, underpinned by the presence of Kalundu pottery in local LSA sites and in Lesotho. The "social dynamic" (van Schalkwyk, 1994/1995: 197) was not simply one of displacements.

EIA farmers were selective in the habitats they settled and presumably hunter-gatherers would not have changed mobility or settlement patterns too much. Despite this hunter-gatherers intensified their occupation in the Thukela, possibly to take advantage of exchange relationships with EIA farmers settled there. Formal LSA tools, especially scrapers, are found in EIA farmer sites, and the implication is that hunter-gatherer technology or hunter-gatherers themselves prepared hides there (Parkington and Hall, 2010).

In the Limpopo Basin, research has shown that relationships between hunter-gatherers, herders and farmers were complex (Hall and Smith, 2000). The sequence suggests that hunter-gatherers up to about 1000 AD interacted intensively with farmers, but with the rise of farmer political complexity, they were progressively pushed into a subordinate status. Early in the second millennium hunter-gatherer occupation declines and it seems that rock shelters were appropriated by farmers for their own ritual purposes; this sequence is further supported by the rock art (Hall and Smith, 2000). In the Waterberg, Blaauberg, Magabeng and Soutpansberg, for example, “Late White” rock art associated with North Sotho initiation is commonly found in rock shelters (Hall and Smith, 2000). Furthermore, socially marginal people of mixed Khoesan and farmer descent, historically known as “Vaalpense”, were at the bottom of Tswana and Ndebele social hierarchies and are described from the second half of the 19th century. These groups may have their origins in these deeper time processes.

In Eastern Botswana there is evidence at Toutswe farmer sites (700 to 1300 AD) for long distance trade with the Shashe/Limpopo region to the east (Calabrese, 2000), and across the

Kalahari and into the Okavango region to the west and northwest in which hunter-gatherers and Khoe were included. Unworked chert caches at Bosutswe and OES beads in many Toutswe sites indicate hunter-gatherer involvement in long distance trade (Reid and Segobye, 2000). Obviously, the decreasing viability of farming to the west created a frontier beyond which hunter-gatherers and Khoe could exploit, supply and transport trade goods (Segobye, 1994/1995; Reid and Segobye, 2000).

In the second millennium, there is less evidence of San material culture within farmer areas and intensification of farmers would have disrupted mobility and access to resources. Furthermore, intermarriage, usually of San women into farmer societies, could have also led to a fragmentation of San identity (Hall, 2010).

Despite the decline in conventional San material signatures the continued presence of San hunter-gatherers is powerfully expressed in their rock art, particularly in the Drakensberg and escarpment areas. The arrival of Nguni-speakers and the expansion of Nguni- and Sotho-Tswana-speakers throughout the second millennium affected both San and farmer alike. Rock art in the Drakensberg depicting cattle show a change in San social relations both within and without their bands, while the extensive adoption of Khoesan clicks by Nguni-speakers indicates intensive social interaction and exchange (Hall, 2010). While southern Nguni-languages have extensively incorporated San clicks this is not the same for Sotho-Tswana (Hall, 2010), despite being on the landscape since 1300AD. The linguistic evidence therefore supports the archaeological and ethnographic evidence for intensive San-Nguni interactions. This is not to say that these same interactions did not occur within the Moloko/ Sotho-Tswana sequence; they clearly did (see Hall and Smith, 2000). Clearly Nguni-speaking social structure facilitated a specific form of interaction with San that may have been driven by exogamy in which Nguni wives and women, as deep outsiders, were the conduits for cultural exchange with San, who similarly were also ‘outsiders’ (Hammond-Tooke 2004).

Clearly, San could and did influence the linguistics and spirituality of farming communities; most well-known is that Nguni-speakers consulted San shamans as powerful controllers of the weather and consequently important for rainmaking. These relationships and changes in San social structure are powerfully expressed in the rock art of the region. Furthermore, around the Riet River stone wall settlements show that some San kept and managed livestock (Maggs, 1976a) and Fokeng farmers a little further to the north (associated with Type N stone-walling) had “easy relations with the San” (Maggs, 1976a: 308).

Genetic Identity

The use of DNA studies is becoming increasingly important in our understanding of identity and our ability to interpret the past (Wood *et al.* 2005). Modern DNA studies have focussed on haplotype diversity, tracing sets of genes that are inherited together and explaining ancestral ties between populations. It can then be used to explain genetic relationships, population histories and even migrations.

The interest in African history based upon genetic analysis and interpretation is steadily growing, particularly concerning foundational Bantu-expansion events that have clearly impacted genetic variation in southern Africa (Wood *et al.*, 2005). The “overall genetic homogeneity" of Bantu-speakers supports migration from an early Bantu-'homeland', although enough Y chromosome (passed on by males) haplotype-sharing between Eastern and Western Bantu-speakers could indicate movements after an initial migration (de Filippo *et al.*, 2011: 1266). This is expected as total isolation between these two groups is unlikely. In Western Central Africa, Y chromosome analysis shows that the situation is more complex and unlikely to have been attributed to only a single migration event (Montano *et al.*, 2011). However, there are Y chromosome haplogroups (or genetic units with shared ancestry) in East Africa that are specific to Eastern Bantu-speakers. The genetics also shows that Western Bantu-speakers displaced the local Khoesan in areas such as Angola, and genetic markers in populations in Angola show that there is clear gene flow from the Eastern to Western Bantu-speakers in southern populations (Beleza *et al.*, 2005). Because the likelihood of these populations being completely isolated is small, this is expected.

Mitochondrial DNA (mtDNA) analysis, important for understanding maternal genetic contributions, has linked Bantu-speakers in southern Africa to origins in both West or East Africa (Parkington and Hall, 2010). But the study of mtDNA in understanding linguistic identities is limited. Studies have shown that males (through the study of Y chromosomes) immigrating into a populated area may induce language change more successfully than females (Forster and Renfrew, 2011). Therefore, in Bantu-speakers, the Y chromosomes better correlate with languages than mtDNA (Wood *et al.*, 2005). While there is weak correlation between mtDNA and language, there is more (albeit weak) correlation between mtDNA and geography than in Y-chromosome. Language change could therefore easily come about by an expansion of farming males. This may have to do with larger numbers of viable children or the language of choice of these children, or the adoption of languages by females in an area.

More geographically specific studies have also supported interaction (or admixture) between Bantu-speakers and Khoesan.7.3% of Mozambique Bantu-speakers shared Haplogroup L0d with Khoesan (Pereira, 2002). Similarly, Xhosa and Zulu speakers showed even higher frequencies of Khoesan mtDNA, at 25% and 50% respectively. However, studies on Bisa and Kunda farmers from the Luangwa Valley in Zambia show low levels of admixture, with no difference between mtDNA and Y chromosomes, despite a deep time coexistence with hunter-gatherers (de Filippo *et al.*, 2010). These findings support much ethnographic and historical evidence, where intermarriage is biased towards Khoesan females but also varies between different Bantu-speaking populations. Genetics has also shown that Bantu-speaking females were not so readily incorporated into Khoesan populations. The sex-biased admixture has obviously influenced genetic variation within Bantu-speakers (Wood *et al.*, 2005). Polygyny or more extensive movement of males could account for this. Only a few populations deviate from this genetic-linguistic model (Jones, 2003:508)

These genetic studies have concerned mostly modern populations, and therefore it is not surprising that European admixture is also evident due to recent colonization. Mozambique Bantu-populations show a high proportion of European male genetic influence (5.9%), while no European mtDNA has been observed (Pereira, 2002: 376). This means that gene flow is almost completely between male Europeans and female Bantu-speakers. This is not surprising given Portuguese involvement in Mozambique from early in the 16th century.

Although useful in understanding living populations in southern Africa, genetics is often treated with some skepticism within certain fields in archaeology. “Genetics has been the subject of great hopes and even greater claims” (Blench, 2006: 6). Both the hypothesis of the migration of Bantu-speakers into southern Africa and the amount of Khoesan-Bantu-“admixture” has been addressed in a variety of genetic studies. However, from an archaeological point of view, many of these studies pose difficulties when applied for deeper time reconstructions. These difficulties include questions about sample provenance, sample representativeness, and a tendency for many studies to ignore archaeological data or use non-archaeological sources for archaeological information (Mitchell, 2010).There are also known limits to the accuracy of molecular clocks. Molecular dates track genes, not people, making correlations between these dates and past events suspect. Although studying the genetics of modern populations permits reconstruction of past relationships and migrations, it also involves assumptions about the history of those populations. Also, sampling is often based on linguistic identity, which is highly changeable.

In conclusion, while genetics studies have given us insight into the genetics of modern populations in southern Africa and have assessed the kinds of gene flow that may have occurred, it is in danger of underplaying the complexity of these populations’ histories. Genetics has, however, shown that gene flow between western and eastern Bantu-speakers, and between Khoesan and Bantu-speakers is evident.

2.4 Questions

In this chapter I have highlighted some of the issues concerning the Iron Age of southern Africa. The archaeology highlights different scales of cultural change and continuities that in turn emphasise different scales of demographic shifts underpinned by significant migration of Bantu-speakers into southern Africa early in the first millennia AD, and another Bantu-speaking population migrating into southern Africa marked by the advent of the LIA from the start of the second millennia AD. Within the EIA and LIA sequences, however, there were smaller scale demographic shifts within the established population. The archaeology also emphasises that all of the southern African Iron Age can be placed within the Chifumbaze complex and that this correlates linguistically with people who were Eastern Bantu-speakers and consequently, who shared a common ideology and worldview. This broad correlation emphasises a general cultural homogeneity. Clearly, this general picture and the smaller scale shifts that occurred once the Iron Age was established within southern Africa invite critical comparison with alternative sources that may be interpreted from a historical viewpoint and it is with this in mind that I focus on dental variation.

To this end, the next chapter looks at the contribution of physical anthropology to Iron Age studies, and discusses how various techniques have been used to explore past populations. I will also consider the contribution of physical anthropology to our understanding of this period. The focus in this thesis is on populations: how are they changing and how can we account for this change? Does morphological variation in populations correlate well with our multi-disciplined understanding of the Iron Age, in particular cultural variation? If so, why? If not, can this be explained? To what degree is it possible to look at population change? Are only large-scale populations useful, i.e. between Khoesan and farmers, or can we account for changes between the EIA and LIA, or even smaller-scale regional variation?

This is not to say that external forces are solely responsible for change. Although we have looked at migration and interaction in some depth, gene flow is not the only explanation for population change. Bottlenecking, for instance, could bring about change in population variation without external populations being involved.

CHAPTER 3: SKELETAL STUDIES OF THE SOUTHERN AFRICAN IRON AGE

In Chapter 2 the focus was largely on how identity through the Iron Age has been assessed, looking at the material culture of these samples, in addition to the genetics and linguistics of their modern-day descendants. The purpose of this thesis is to look for evidences of morphological variation within Iron Age populations and compare it to what is already known about the period. This chapter will summarise previous studies of Iron Age skeletal remains in southern Africa, and assess the value of these studies for understanding Iron Age population identities. Analyses of human skeletal material have contributed substantially to our understanding of the southern African past, including the Iron Age. This chapter will also introduce the methodologies that will be used in this thesis, discussing how they have been used in other studies and whether they will adequately assess statistical variability and inter-sample differences within the Iron Age.

3.1 Human skeletal material and the southern African Iron Age

Southern African skeletal analysis

In the first half of the nineteenth century, physical anthropology in South Africa (as well as much of the rest of the Western world) focussed heavily on race, variation within and between races and “racial origins” (Morris, 2012: 2; Morris, 2008). The focus was on the “primitive” nature, both cultural and biological, of Bantu-speakers and Khoesan. Intermixture was used to explain physical variations that were not “pure” (Hall and Morris, 1983). In the 1950’s, physical anthropologists were seeing more and more pitfalls in this typological approach, and the focus turned to biological variation and clinal models for explaining the distribution of diversity. These approaches were supplemented by a better understanding of genetics and more rigorous quantitative approaches (Hall and Morris, 1983).

Research now shows that there is much more genetic variability within populations than between neighbouring populations and even other “races” (Lewontin, 1972; Keita *et al.,* 2004; Royal and Dunston, 2004; Rosenberg *et al.,* 2002; Nei and Roychoudhury, 1974). Lewontin (1967 and 1972) identified genes responsible for blood types and calculated the variation within and between groups. He calculated that within-group variation accounted for the majority of the variation (with a mean of 85.4%; therefore less than 15% accounts for between-group variation). Later research showed that within-group variation accounts for as much as 95% of genetic variation (Rosenberg *et al.,* 2002). This is particularly so for African groups (Tishkoff *et al.,* 2009). Relethford (1994) showed that craniometric variation indicated low between-group variation, reflecting genetic studies.

The typological focus of the early part of the nineteenth century also affected collections of skeletal material in museums and universities. Interest in Khoesan, because of their distinctive “physical type”, led to large collections of Khoesan crania. Although these specimens were labelled “Khoesan”, very few can be verified (Morris, 1987). Also, many of these individuals were donated, with donor perceptions of their identities or with the perceptions of analysts (Morris, 1987).

Similarly, skeletons of Bantu-speaking people housed in the Dart Collection at the University of Witwatersrand were initially collected to study the “Negro physical type” (Hall and Morris, 1983: 32). The specimens are further classified into “tribes” after their deaths, without adequate understanding of the culture of the individual in life or how the individual would identify himself or herself (Hall and Morris, 1983; Dayal *et al.*, 2009). The allocation of “tribe” to these specimens is misleading. Some of these individuals were classified according to surname on death certificates (Dayal *et al.*, 2009). Prior to 1959, many of these individuals were unclaimed bodies from Provincial hospitals. Other factors also make it harder to use the identities classified in the Dart Collection. The political, academic and ethical atmosphere around classification of tribal identities has changed, and detribalization and the movement of migrant workers into the Witwatersrand area have occurred over the last century (Dayal *et al.*, 2009; De Villiers, 1968). In 1959, the basement at the Wits Medical School (where the collection was kept) flooded. Many of the individual bones were unmarked and mixing occurred. When the bones were laid out to dry and later put back into boxes, further mixing of specimens occurred (Dayal *et al.*, 2009; Tobias, 2005). It is estimated that a large proportion of the current collection was already present at the time and therefore affected by the flood (Dayal *et al.*, 2009).

This collection has often been used to estimate variation within and between groups of Bantu-speaking South Africans (De Villiers, 1968; Jacobson, 1982; Nurse *et al*., 1984; Tobias, 1985; Dubow, 1995; Legassick and Rassool, 2000; Morris, 2005). Hertha De Villiers (1968) studied the skulls of South African “negro” individuals, looking at inter-tribal variation based on cranial metric and non-metric analyses. There was a low degree of inter-tribal variation. Although the thesis accounts for detribalisation in Gauteng at the town of the study, it insists that the cadavers used were “unhybridized” (De Villiers, 1968:5), ignoring the historic effects of colonialism on gene flow and migration mentioned in the previous chapter. Her results were likely to also be affected by the concerns discussed in the previous paragraph (about the Dart Collection itself). However, it was pioneering work in assessing South African morphological variation. The study was made on a large sample size, looking at multiple variables and taking into account sexual differences (where possible). The study also showed that many features are similarly seen in the Khoesan, implying historic admixture (De Villiers, 1968; which is also supported by the genetic literature: Tishkoff *et al.,* 2009). Franklin *et al.* (2007) used geometric morphometrics to show some dissimilarity between Khoesan and Bantu-speakers; however, the research implies more admixtures between the southern-most Bantu-groups (Xhosa, Zulu and Sotho) and Khoesan.

Work on archaeological skeletal remains in South Africa

The biggest problem regarding the study of variation in the Iron Age is the limited number of human specimens available. This is partially historical: the socio-political background in southern Africa led to a late start in Iron Age studies (Hall, 1984a). However, it also remains difficult to build up a database of Iron Age skeletons because of a lack of distinct burial grounds (Steyn, 2003 and 2010). Burials often occur throughout a site, based on the individual's status in society. Because it is rare for an entire site to be excavated, the chance of finding all of the burials per site is low. Mapungubwe and Bambanyalo were the exceptions to this rule (Steyn and Nienaber, 2000). Excavations resulted in a large sample of specimens, but these have since been reburied or lost (Nienaber *et al.,* 2008; Steyn and Nienaber, 2000; Steyn, 1997). These skeletons were assessed by Rightmire (1973) and later Steyn (1997), using multivariate analyses, craniometry and dental metrics, and were shown to be within the range of Bantu-speakers, although previous (more dubious) studies did not concur (Gardner, 1955 and 1963).

Because of the nature of Iron Age burials, often only a couple of specimens in each site are excavated. It was thus tempting for archaeologists to fit these specimens into this range of variation among Bantu-speakers, with little scrutiny of its validity (eg. Abrahams, 1983; Brothwell, 1963; Rightmire and van der Merwe, 1976; De Villiers, 1990; Gramley and Rightmire, 1973; Mason, 1974; Rightmire, 1970; Fagan, 1964). This fitting of individual specimens into Bantu-speakers ("Negro"), Khoesan, hybrids or even "proto-negro" (Brothwell and Shaw, 1971: 227) does not take into account interaction and variability between these people and it is therefore difficult to make historic interpretations. Other articles (Steyn and Nienaber, 2000; Pistorius *et al.*, 2002; Steyn *et al.*, 1998) are mostly descriptions of burials.

However, the study of archaeological human remains in South Africa is gaining momentum. Some studies have looked at or are currently looking at variation within Khoesan samples over space and time in some detail (Hausman, 1984; Smith *et al.*, 1992; Stynder, 2006 and 2009; Stynder *et al.*, 2007; W Black, PhD in progress). Additionally, isotopic work has greatly improved our knowledge of diet and environment in the South African precolonial period (eg. Sealy, 2010; Sealy *et al.*, 1992; Balasse *et al.*, 2002; Balasse *et al.*, 2003; Sealy and van der Merwe, 1985; Lee-Thorpe *et al.*, 1989; Sealy, 1986; Cox and Sealy, 1997; Mosothwane, 2010).

The Iron Age has not been neglected. Research by Maryna Steyn and her students, and Alan Morris and his students, has greatly broadened our knowledge of the physical anthropology of this period (Dlamini, 2006; Mosothwane and Steyn, 2004 and 2009; Ohinata and Steyn, 2001; Pistorius *et al.*, 2002; Ribot *et al.*, 2010; Steyn, 2003; Steyn and Henneberg, 1996; Steyn and Nienaber, 2000; Steyn *et al.*, 1998; Morris, 1992; L'Abbe *et al.*, 2008). Many of these studies focus on health, demography and diet, or describe individual burials in the context of the archaeology (Morris and Steyn, 2012).

Dlamini (2006) looked at the health of prehistoric farmers in Sub-Saharan Africa in different ecological areas and over time. Her study includes specimens from as far North as the Congo to South Africa. She noticed that early farmers in dry Savannah areas were healthier, on average, that those from wetter environments. Population health of Mapungubwe/ K2 specimens has been assessed by Steyn (1997). Mosothwane and Steyn (2009) looked at the health of Toutswe populations in eastern Botswana. Farmers generally have poor health, with a larger proportion of hyploplastic teeth in farmer populations compared with those studied from a hunter-gatherer site in Oakhurst (Steyn, 1997). Both studies noted generally healthy populations (for prehistoric farmers) although the eastern Botswana specimens were healthier on average with reduced levels of stress, possibly due to micro-climatic conditions being more favourable or to more political stability. This is supported by the paleodemography, which shows better chances of surviving to older age in eastern Botswana communities (Mosothwane and Steyn, 2004). However, high infant mortality rates and low life expectancy in general was seen for both K2/Mapungubwe specimens and eastern Botswana samples, typical of prehistoric farming communities (Mosothwane and Steyn, 2004; Steyn, 1997). Health was also compared between pre- and post-colonial populations (Steyn, 2003). This study found that health may have stayed the same, but life expectancy reduced after colonialism. Signs of trauma, however, notably increased, possibly as the result of increasing historic tensions (increased population size) and violence (such as during the Anglo Boer War and the *Difaqane*; Steyn, 2003). All these studies looked at dental health, for signs of infectious diseases, cribra orbitalia and trauma.

Diet within the Iron Age has also been assessed. Mosothwane (2010) used carbon isotopes from human skeletons in eastern Botswana. These individuals relied on C4 based proteins, although there is a large C3 component (30%). Comparing bone apatite to enamel isotopes showed that a few (four out of 81) individuals even shifted diet during their lives, implying the incorporation of hunter-gatherers into farming communities. The $\delta^{13}C$ values also suggested that Xaro adults (an early Iron Age site) relied on freshwater fishing. Ribot *et al.*

(2010) looked at carbon and nitrogen isotopic variation of populations in KwaZulu Natal over the last two millennia. The results showed that individuals before 400AD ate more marine food (a more hunter-gatherer diet) while individuals dated post-400AD ate a diet indicative of farming. This paper will also be discussed in the next section.

Cranial and mandibular metrics on southern African populations

Craniometric distances have been shown to reflect genetic and molecular distances (Smith, 2009). Cranial variation among populations has been used frequently for assessing modern human variation (Lahr, 1996). Variation within and between living southern African samples has also been assessed using cranial morphometrics, with work by De Villiers (1968; mentioned earlier), Hiernaux (1963, 1974 and 1976) and Ribot (2004). These studies have been used to fit archaeological specimens into a cranial range of variation, but have also been used to answer historic questions such as the migration of Bantu-speakers into southern Africa. Franklin *et al.* (2008) used geometric morphometrics to compare male and female Bantu-speakers, confirming high levels of sexual dimorphism on the mandible.

Some studies have also focussed on Khoesan archaeological specimens in Southern Africa. Recently Stynder (2006; and Stynder *et al.*, 2007) has looked at cranio-facial variation (in size and shape) within South African Holocene skeletons (the Late Stone Age). He used a large sample size (n=153) of Later Stone Age archaeological human crania to investigate morphological variation over time and between geographic regions in the south-western regions of South Africa. He showed that there was variability in size throughout the

Holocene, but that this period was dominated by individuals with larger, more robust crania. His data also showed similarity in form between early Holocene archaeological populations and more recent Khoesan populations, possibly due to isolation from other populations during the Holocene. Furthermore, he indicated that Holocene cranial variatiability had more to do with human plasticity (and the morphological changes expected in samples from populations with malnutrition or high levels of stress) than gene flow. His research also showed that there was no major change in morphological craniofacial form between populations before and after the introduction of herding into the area. Although there was a (small but significant) difference in metric variability this may be due to the different kinds of resources being exploited (Stynder, 2006).

Morris and Ribot (2006) looked at the craniometrics of Later Stone Age populations in South Central Africa and compared them to known populations. The study showed these specimens fit well within the range of variation of Bantu-speakers, suggesting little biological discontinuity with the introduction of agriculture. Although the sample size is very small, these results are not unexpected in the context of the region. In southern Africa, morphological discontinuity with the introduction of agriculture was observed by Ribot *et al.* (2010). The study looked at cranial variation of Holocene specimens from KwaZulu Natal, comparing those pre-400AD and post-400AD with modern human samples. The study showed that specimens pre-400AD were more similar to Khoesan, while the later specimens were more like Bantu-speakers. Although the study was well conducted and also looked at stable isotopes for indications of change, the sample size was very small. This supports the archaeology: that the Iron Age "package" is the result of a migration, at least into southern-most Africa. It suggests a population change along with the cultural change seen in the archaeology.

Three dimensional images of crania and mandibles (e.g. laser scans, CT scans) have been used in a number of fields: for medical use (e.g. Adaskevicius *et al.*, 2011), to look at functional morphology (e.g. Friess *et al.*, 2002) and as a tool for assessing hominids and primates (e.g. Harvati *et al.*, 2004; Harvati *et al.*, 2010). Measuring cranial and mandibular landmarks/distances of modern humans off of 3D scans has been achieved with good success (e.g. Garvin and Ruff, 2012; Williams and Richtsmeier, 2003; Hennessee and Stringer, 2002). These approaches successfully illuminate sexual dimorphism as well as inter- and intra-population variation, and can be a useful tool for understanding the relationships among populations. To date such techniques have not been applied to investigating cranial and mandibular variation in southern African Holocene peoples.

3.2 Dental Anthropology

What is dental anthropology

Dental anthropology is a subfield of physical anthropology. Teeth possess many traits that make them useful for anthropological studies: they are adaptable; heritable; vary within and between populations; can indicate health, age and diet of individuals; and even show certain cultural practices (Scott and Turner, 1988 and 1997). They are also durable within the archaeological record. Tooth size has been used to assess the genetics of a population (Mayhall, 1992). Change in tooth size, on a population level, is often used as an indication of genetic change.

Many dental measurements and techniques have been described in the literature (Hillson *et al.*, 2005; Mayhall, 1992), but a large proportion of research focuses on only two: mesiodistal and buccolingual diameters, both of which require the use of callipers and will be described in the methodology. Although standardized measurements are useful for accurate comparisons of teeth within and between populations (Mayhall, 1992), dental metrics, more generally, can be difficult to acquire and/or evaluate. Firstly, tooth size has great variability even within a single population. Comparisons between populations, especially populations represented by only small samples (likely in archaeology), may therefore be biased. Second, teeth are often impossible to measure due to wear, caries or post/ante-mortem loss. This can greatly reduce an overall sample size. Finally, variation in tooth size could be a reflection of other factors such as sexual dimorphism and asymmetry, skewing results that are used to make genetic interpretations. There is a small, but significant degree of sexual dimorphism between the sexes, especially in the adult canines. Fluctuating asymmetry has also been studied as an indication of stress, thereby implying an environmental effect on tooth size.

Dental non-metric traits have been compared to inherited traits, such as blood groups and fingerprints, which can be observed within and between populations (Scott and Turner, 1997). Dental trait frequencies (non-metric) are easily observable in both living and archaeological populations. It may also be that there are fewer non-genetic factors which affect non-metric (qualitative) traits than there are those that affect tooth size, allowing for group specificity with low levels of sexual dimorphism (Smith, 1977).

A problem with dental non-metric analysis in the past is a general lack of standardization (Mayhall, 1992), but a number of dental plaques, articles and books have been produced to address these issues (Turner *et al.*, 1991; Scott and Turner, 1997; ASU Dental Anthropological System). None of these traits has a simple mode of inheritance, but on a population level, trait frequencies are not significantly affected by environmental factors (Scott and Turner, 1997). One last point is that many non-metric dental traits have continuous or quasi-continuous phenotypic distributions (in size). This makes it difficult to score as simple qualitative traits. Also, although standardization within dental anthropology has greatly improved, classifying traits as “present” or “absent” can be arbitrary.

Dental anthropology and identity

Both dental metric and non-metric analyses show variability between populations groups over large geographic areas. Studies have shown that in some instances differences in dental morphology correlates with genetics, linguistics and geography (Scott and Turner, 1988). Some studies have compared dental non-metrics and metrics of very large populations divided along broad geographic areas (Hanihara, 2008; Hanihara and Ishida, 2005; Scott and Turner, 1997). These studies show that sub-Saharan African populations indicate one extreme, reflecting low levels of inter-regional variation and high levels of intra-regional variation, supporting a sub-Saharan African origin for modern humans (Hanihara, 2008).

Dental anthropology has been used to identify various aspects of population genetics (Scott and Turner, 1988). For example, selection for the increase or reduction of tooth size can occur in modern humans, possibly as a result of increased food processing or to select for a reduction in caries. Gene flow can also be studied, comparing the dental anthropology of populations through time or over geographic distances. Genetic drift can also be used to explain changes within a population (such as bottlenecks or founder affect causing reduced variation) and is thus important in generating patterns of traits that differ from the original population. The Uto-Aztecan premolar is a good example of a mutation (Morris *et al*., 1978; Scott and Turner, 1988). By comparing morphological traits and patterns among archaeological samples, it is possible to answer historical/evolutionary questions about process; this is considered more accurate than relying on the genetics of living populations, and more easily available than using ancient DNA (Jackes *et al.*, 2001).

Using dental anthropology to assess the presence of gene flow in the archaeological record is not a new concept (Scott and Turner, 1997). Jackes *et al.* (2001) looked at the dentition of populations in the European Mesolithic/ Neolithic transition period, focussing on Portuguese and North African archaeological samples and comparing them to 20th century Portuguese skeletal samples. The study did not support morphological similarity between the Portugal post-Mesolithic populations. Smith (1977) looked at dental metrics and morphology of Habbanite lineages. Inter-lineage variation was found to be relatively high even though they were closely related. Tooth size reduction in populations in the Oaxaca Valley in Mexico, coincident with the development of agriculture, shows selective pressures that were also seen in European and Asian populations (Christensen, 1998). Dental anthropological techniques have also been used in conjunction with linguistic and genetic data, although some studies are controversial. Greenberg *et al.* (1986) used all three methods to support the hypothesis of three migrations responsible for the populating of the Americas. Despite subsequent research refuting this claim (Lorenz and Smith, 1996; Bortolini *et al.*, 2003; Mulligan *et al.*, 2004) the largest genetic study to date has recently vindicated it (Reich *et al.* 2012).

Prehistoric and historic teeth from East Asia, Southeast Asia, Australia and Melanesia have been used to show two migrations into southeast Asia in the early Neolithic (Matsumura and Hudson, 2005). Similarly, dental non-metrics have shown that the transition from the Late Bronze Age to the early Iron Age in the near East was not the result of a population change even though there was much cultural change (Ullinger *et al.*, 2005). Dental anthropology has been used to test for variability among samples of Neolithic Jomon hunter-gatherers in Japan (Matsumura, 2007). The dental anthropology suggests that the samples were similar and possibly ancestral to the Ainu (Turner, 1976). It has also shown a sinodont (Asian) origin for pre-colonial Argentinian archaeological humans remains (Bollini *et al.,* 2008). Dental anthropology has also proved useful in analysing Iron Age populations in Italy, showing that the Apennine Mountains were not a geographic barrier to gene flow, and more variability is seen between samples over time than between geographically separated samples (Coppa *et al.*, 1998). Dental metric and non-metric variability shows phenotypic differences between samples at different Maya sites (between 250 and 900AD; Scherer, 2004). This was unrelated to geographic distance. Dental anthropology has also been used to look at variation in Ancient Egyptian samples (Irish, 2006). This has shown similarity in samples from pre-dynastic Egyptian communities through to the Ptolemaic period.

The use of dental anthropology in southern Africa

Dental anthropology had a relatively early start in South Africa. Works by Shaw (1931a, 1931b and 1927) were mostly descriptive of modern Bantu-speakers, and comparing Africans to Australian aboriginals or Europeans. A more recent dental anthropological technique was used by Jacobson (1982), who used both metric and non-metric data to compare Bantu-linguistic groups (or tribes). Later works also looked at modern Bantu-South African teeth. Haeussler *et al.* (1989) compared San and Central Sotho dental traits and measurements. They concluded that the two populations were significantly different from one another. Although this is a much needed comparative study, it does not investigate these differences further, and moreover the use of modern individuals ignores a very complex historical sequence within the region. Also, the use of casts limits the number of traits (especially in the roots of the teeth) that may be observed, although the uniform matte colour may make scoring easier. Other works have asked more specific questions relating to modern Bantu-speakers (Kieser *et al.*, 1987; Kieser and Groeneveld, 1988).

Many researchers have grouped living human populations based on dental traits that represent large-scale geographic areas. These include Sinodonts (south east Asia and Micronesia) and Sundadonts (northerly East Asian and Native American populations; Scott and Turner, 1997). The Sub-Saharan African complex is defined by higher frequencies of cusp 7, “Bushman’s canine”, a LM2 Y pattern, two-rooted UP1, three-rooted UM2, Tome’s root and two-rooted LM2 (Scott and Turner, 1997; Irish, 1997, 1998a, 1998b). This complex also includes low frequencies of small cusp numbers on all molars, UI1 winging, shovelling, double shovelling, interruption grooves, odontomes and enamel extensions (Scott and Turner, 1997; Irish, 1998a). Elucidating the patterns seen in the Sub-Saharan dental complex has largely been the work of Joel Irish (1993, 1997, 1998a, 1998b). He noted that although sub-Saharan African populations were characterized by general homogeneity, they differed from other world populations. He also noted a general lack of sexual dimorphism. A few researchers have looked at modern human origins in sub-Saharan Africa, comparing modern human cadaver or cast material and comparing sub-Saharan African groups to other large modern human geographic populations (Hanihara, 2008; Hanihara and Ishida, 2005; Irish and Guatelli-Steinberg, 2003).

Despite this research, considerable work remains to be done on sub-Saharan African populations; compared with studies of Asian, Australian and American populations sub-Saharan Africa is poorly studied.

In particular, there is a lack of application of dental anthropology (specifically non-metric traits) to southern African archaeological contexts. Steyn (1997) compared the dental size of K2 and Mapungubwe specimens to Khoesan and “South African Negro” populations (1997:

18). The teeth were notably larger than the San and more similar to South African Bantu-speakers. However, there was still a significant difference between the archaeological population and the modern Bantu-speakers. She suggested this was due to a small sample size. Other dental research on variability across time and space among Khoesan Holocene peoples is also currently in progress (W Black, PhD in progress), as is dental anthropological research on biological variation in the Congo Iron Age (N Dlamini, PhD in progress).

3.3. The project in context

Comparing phenotypic or morphological identity with cultural identity in the southern African Iron Age is in its infancy. While research has been done on health and demography and deductions have been made concerning gene flow based on archaeological material, considerable work remains to be done. Cranio-mandibular and dental studies have been shown to be useful in understanding population dynamics around the world. These studies have been employed, to some extent, on modern and, to a lesser extent, archaeological South African samples. These methods will be used in this thesis to assess morphological variation and population affinities for Iron Age archaeological human remains.

This thesis will therefore look at the following issues:

1. Is there phenotypic change within the Iron Age (variability)? I will look at samples that are seen in the archaeological record as typologically (based on ceramic evidence) or temporally variable. I will compare specimens from the first millennium (Early Iron Age) to those in the second millennium (Late Iron Age). When sample size is large enough, these larger samples will be split into geographically and typologically different groups. Furthermore, specimens from southernmost Africa (Botswana, Zimbabwe and South Africa) will be compared with archaeological Iron Age specimens from north of the Zambezi (Zambia) to test for gene flow across this geographic region.
2. Have historical circumstances affected gene flow? To what extent are modern populations a useful analogue for genetic interpretations of pre-history, specifically the Iron Age? This may have further implications on current interpretations about the

morphological similarities and differences of Bantu-speakers and on interpretations of African pre-history using the sub-Saharan Dental Complex.

3. Are samples representing the Iron Age different from Khoesan populations? Archaeology, anthropology and history have suggested close but ambiguous relationships between Late Stone Age and Iron Age peoples. Mitochondrial genetic research has shown generally a high level (but differential levels) of genetic interaction between Khoesan and southern African Bantu-speakers. Is this reflected in the comparisons between Iron Age and Khoesan samples?
4. How does the archaeological sample compare with the literature on the sub-Saharan Dental Complex and why? If there are statistically significant differences, are these large, or do the general trends nonetheless agree with that of the complex?
5. How do dental health and cultural practices (i.e. traits that are not genetically pre-determined) affect the dentition of Iron Age samples? This will not be the focus of the thesis, but will hopefully provide some insight into how culture, diet and the environment also affected the teeth of Iron Age peoples.

CHAPTER 4: MATERIALS AND METHODS

4.1. Cranial, mandibular and dental samples

The study consists of 142 human specimens (Table 4.1.1). These specimens were selected primarily based on their association with Iron Age material. Many of these specimens are therefore from Iron Age agricultural burials, with good association. Those that are less well-understood are also included but are indicated as such. In order to reduce the possibility of genetic input from both recent colonial and deeper hunter-gather populations, skeletons were limited to the period between 150 and 1600 BP. Different subsets of these specimens were used for the dental anthropological analysis and the cranial analysis, depending on the condition of the material. For the dental anthropology analysis, individuals had to have at least one adult tooth. Considering eruption of permanent dentition can occur from the age of 5, many individuals were available (n=158). If only one tooth was present, it needed to be in good enough condition to see at least three features. This could include which tooth it was (e.g. upper premolar), root number and status (wear and cavities). Deciduous teeth were not analysed. For the cranial analysis, only adult crania and mandibles were scanned, as indicated by the full eruption of third molars or status of second versus first molars (when third molars are missing or do not erupt). Additionally, enough landmarks needed to be visible to justify the scans (at least three for the mandible or facial/basicranial areas of the crania). Finally, specimens where landmarks were separated by elements that were glued together were rejected. The final sample consisted of 71 mandibular and 71 cranial scans.

Table 4.1.1 List of Iron Age archaeological specimens

	Specimen	Site	Age	Sex	Reference	Date
EIA	A4143	Broederstroom	17-25	?	Mason, 1981	AD460±50 (UCLA-1791B)
	A4151	Eiland	adult	M	Evers, 1975	1260±90BP (RL-207)
	A*1	Happyrest	adult	M	Steyn *et al*., 1994; Steyn and Nienaber, 2010	1310±50BP (Pta-2692)
	A*88	Ha-Matshata	adult	M		EIA- according to institution
	A*90	Ha-Matshata	adult	M		EIA- according to institution
	A*91 (1)	Ha-Matshata	young adult	?		EIA- according to institution
	A*91 (2)	Ha-Matshata	14-16	M?		EIA- according to institution
	A*92	Ha-Matshata	15-18	M		EIA- according to institution
	A*94	Ha-Matshata	adult	M		EIA- according to institution
	A*97	Ha-Matshata	adult	M		EIA- according to institution
	PMB2001/02 Burial 2	Eastern Shores State Forest	17-20	M		dental mutilation
	PMB80/2 Burial 1	Mhlopeni	5 to 7	?	Ribot *et al*., 2010; Maggs and Ward, 1984	EIA
	PMB84/5	Wosi	12 to 15?	?	Ribot *et al*., 2010; Morris, 1993a; van Schalkwyk, 1994/1995	EIA
	PMB86/1 144	Nanda	young adult	F	Ribot *et al*., 2010; Morris, 1993a; Whitelaw,1993-	EIA
	PMB86/1 BOX 147	Nanda	young adult	M	Ribot *et al*., 2010; Morris, 1993a; Whitelaw,1993	EIA
	PMB86/1.146	Nanda	7 to 9	?	Ribot *et al*., 2010; Morris, 1993a; Whitelaw,1993	EIA
	UB-N!oma 2	N!oma	14-15	?	Mosothwane, 2010; Morris, 1996	600-1000AD
	UB-N!oma 3	N!oma	middle aged	F	Mosothwane, 2010; Morris, 1996	600-1000AD
	UB-Xaro 1	Xaro	middle aged	M	Mosothwane, 2010; Morris, 1996	550-900AD
	UB-Xaro 2	Xaro	middle aged	M	Mosothwane, 2010	550-900AD
Toutswe	UB-Kgaswe 2	Kgaswe	adult	F	Mosothwane, 2010	1000-1200AD
	UB-Kgaswe 5	Kgaswe	17-23	M	Mosothwane, 2010	1000-1200AD
	UB-Kgaswe 9	Kgaswe	middle aged	M	Mosothwane, 2010	1000-1200AD

UB-Kgaswe 14	Kgaswe	middle aged	F	Mosothwane, 2010	1000-1200AD
UB-Kgaswe 15	Kgaswe	10 to 12	?	Mosothwane, 2010	1000-1200AD
UB-Kgaswe 16	Kgaswe	young adult	M	Mosothwane, 2010	1000-1200AD
UB-Thataganyane 1	Thataganyane	?	?	Mosothwane, 2010	100-1200AD
UB-Bonwapitse 1	Bonwapitse	15-18	M?	Mosothwane, 2010	800-1200AD
UB-Bonwapitse 2	Bonwapitse	middle aged	M	Mosothwane, 2010	800-1200AD
UB-Bonwapitse 3	Bonwapitse	middle aged	M	Mosothwane, 2010	800-1200AD
UB-Taukome 1	Taukome	middle aged	M	Mosothwane, 2010; Denbow, 1983	710-995AD
UB-Taukome 2	Taukome	middle aged	F	Mosothwane, 2010; Denbow, 1983	710-995AD
UB-Taukome 6	Taukome			Mosothwane, 2010; Denbow, 1983	710-995AD
UB-Thatswane 4	Thatswane	8 to 10	?	Mosothwane, 2010; Denbow, 1983	925±80 - 1110±75AD
UB-Toutswe 2	Toutswe	5 to 7	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 3	Toutswe	6 to 8	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 4	Toutswe	6 to 8	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 6	Toutswe	9 to 11	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 9	Toutswe	7 to 9	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 13	Toutswe	7 to 9	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 14	Toutswe	5 to 7	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 16	Toutswe	10 to 12	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 17	Toutswe	10 to 12	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 25	Toutswe	young adult	F	Mosothwane, 2010	1000-1200AD
UB-Toutswe 29	Toutswe	6 to 10	?	Mosothwane, 2010	1000-1200AD
UB-Toutswe 30	Toutswe	adult	?	Mosothwane, 2010	1000-1200AD
UB-Bosutswe 3 (2010)	Bosutswe			Mosothwane, 2010	800-1700AD
UB-Bosutswe 3	Bosutswe	adult	M	Mosothwane, 2010	800-1700AD
UB-Bosutswe 4	Bosutswe	7 to 9	?	Mosothwane, 2010	800-1700AD
UB-Bosutswe 5	Bosutswe	17-20	M	Mosothwane, 2010	800-1700AD

	UB-Bosutswe 6	Bosutswe	7 to 9	?	Mosothwane, 2010	800-1700AD
	UB-Bosutswe 11	Bosutswe	13 - 15	?	Mosothwane, 2010	800-1700AD
	UB-Bosutswe 12	Bosutswe	older adult	M	Mosothwane, 2010	800-1700AD
	UB-Bosutswe 13	Bosutswe	12 to 15	?	Mosothwane, 2010	800-1700AD
LIA western	A4209	Klipsriviersberg	15-17	?	Mason,1974	AD1723±46 (Pta-136)
	A4221	Olifantspoort	older adult	F	Mason, 1986	1820AD- according to institution
	A4226	Rooikrans - RO	older adult	M	Hall, 1985	mid 1600s
	A4227	Rooikrans - RO	older adult	F	Hall, 1985	mid 1600s
	A4229	Thavatshena	young adult	M?	Loubser, J.H.N. 1991	LIA
	A4230	Rooikrans - RO	older adult	M	Hall, 1985	LIA
	A4260	Vhunyela - VH	15-17	F?	Loubser, J.H.N. 1991	LIA
	A*7	Rooiberg	10 to 12	F	Steyn and Broekhuizen, 1993	LIA
	A*31	Pilanesburg	adult	F	L'abbe *et al*., 2008	LIA
	A*37	Pilanesburg	adult	?	L'abbe *et al*., 2008	300 ± 35BP (Sta-8944)
	A*42	Pilanesburg	adult	?	L'abbe *et al*., 2008	LIA
	A*51	Pilanesburg	young adult	M	L'abbe *et al*., 2008	LIA
	A*51(UP151)	Pilanesburg	18-25	M	L'abbe *et al*., 2008	LIA
	A*51(UP81)	Pilanesburg	young adult	F	L'abbe *et al*., 2008	LIA
	A*68	Willowglen II	young adult	F	Laidler, 1935; Steyn And Nienaber, 1997	LIA
	A*79	Pilanesburg	adult	F	L'abbe *et al*., 2008	AD1692, AD1726, AD1814
	A*99	Ben Alberts Thabazimbi	young adult	?	Mason, 1974; Steyn and Nienaber, 1997	C14 dates: AD 1485-1628 Pta. 7848
	A*100	Ben Alberts Thabazimbi	adult	f?	Mason, 1974; Steyn and Nienaber, 1997	C14 dates: AD 1485-1628 Pta. 7848
	A*103	Pilanesburg	young adult	M	L'abbe *et al*., 2008	AD 1433 (1451) 1487
	A*108	Pilanesburg	9 to 11	?	L'abbe *et al*., 2008	LIA
	D-Welgegund B3/B2	Welgegund	older adult	M	Voigt and de Villiers, 1972	LIA
	D-Skutwater E13.9 B3	Skutwater	adult	?	Van Ewyk, 1987	830±40BP (Pta-3734); 820±45BP (Pta-3715)

	D-Skutwater F7.5 B9	Skutwater	older adult	M	Van Ewyk, 1987	830±40BP (Pta-3734); 820±45BP (Pta-3715)
	D-Asskopies	Vredefort Dome	older adult	F	Pelser, 2003	LIA- according to institution
	D-6271 21.5	Rooiberg	adult	?	AW Rogers (1921)	LIA- according to institution
	D-Skutwater (NAS 27)	Skutwater	10 to 12	?	Van Ewyk, 1987	830±40BP (Pta-3734); 820±45BP (Pta-3715)
	D-Skutwater (NAS 28)	Skutwater	adult	M	Van Ewyk, 1987	830±40BP (Pta-3734); 820±45BP (Pta-3715)
	D-MK3 (Schroda?)	Magoeba's Kloof Districs	young adult	F	Klapwijk, 1989	LIA- according to institution
	D-Rietfontein	Rietfontein	young adult	F	Pelser *et al.*, 2007	LIA- according to institution
	D-Rietfontein?	Rietfontein	adult	F	Pelser *et al.*, 2007	LIA- according to institution
	D-Rietfontein "10"	Rietfontein	15-17	M?	Pelser *et al.*, 2007	LIA- according to institution
	D-Rietfontein "7"	Rietfontein	adult	F	Pelser *et al.*, 2007	LIA- according to institution
	D-TSW1/1 BURIAL	Skutwater	young adult	?	Van Ewyk, 1987	830±40BP (Pta-3734); 820±45BP (Pta-3715)
	D-BGL1/1 C24	Glennel	middle aged	F	de Villiers, 1980; Steyn and Nienaber, 2000	No firm dates
	D-BGL1/1 A26.1 BOKS458	Glennel	young adult	?	de Villiers, 1980; Steyn and Nienaber, 2000	No firm dates
	D-BGL1/1 A25/1.1 BOKS456	Glennel	adult	M	de Villiers, 1980; Steyn and Nienaber, 2000	No firm dates
	D-BGL1/1 BOKS 457	Glennel	17-20	?	de Villiers, 1980; Steyn and Nienaber, 2000	No firm dates
	D-BGL1/1 BOKS455	Glennel	16-20	?	de Villiers, 1980; Steyn and Nienaber, 2000	No firm dates
	UB-Dikgathlong 1	Dikgathlong Dam				LIA- according to institution
	UB-Dikgathlong 1 (S088)	Dikgathlong Dam				LIA- according to institution
	UB-Dikgathlong 2	Dikgathlong Dam				LIA- according to institution
	UB-Dikgathlong 3	Dikgathlong Dam				LIA- according to institution
	UB-Mowana	Mowana			Mosothwane, 2010	LIA- according to institution
	UCT330	Klip River Valley	7 to 9	?	Maggs, 1976a	LIA
	UCT326	Makgwareng	young adult	M?	de Villiers, 1972; Maggs, 1976a	LIA
	UCT327	Makgwareng	adult	?	de Villiers, 1972; Maggs, 1976a	LIA
	UCT328	Makgwareng	12 to 15	?	de Villiers, 1972; Maggs, 1976a	LIA
LIA	PMB-AMAFA	Inhlanhla Game Ranch	11 to 13	?	Ribot *et al.*, 2010	LIA

eastern						
	A*80 (1)	Phalaborwa	middle aged	F	Steyn, 2003	LIA
	A*80 (2)	Phalaborwa	adult	F	Steyn, 2003	LIA
	UCT430	Nagome Terrace	young adult	?	Rightmire and van der Merwe, 1976	LIA
	UCT431	Phalaborwa	16-18	F	Rightmire and van der Merwe, 1976	LIA
	PMB91/45	Venus Substation	young adult	F	Ribot *et al.*, 2010	140±40 (pta-5780)
	PMB2001/02 B 1	Eastern Shores State Forest	adult	F		360±60BP (Pta-8676)
	A*6	Simunye	15-17	M	Ohinata and Steyn, 2001	LIA
	A*24	Simunye	juvenile		Ohinata and Steyn, 2001	LIA
	A*25	Simunye	sub adult	F	Ohinata and Steyn, 2001	LIA
	PMB2009/006	Fynnlands	adult	M	Ribot *et al.*, 2010	LIA
	PMB2009/11	King's View	adult	?	Ribot *et al.*, 2010	Early Nguni
	PMB-S*K2*	Kings View	adult	F	Ribot *et al.*, 2010	LIA
	PMB2009/4 B1	Umdloti	young adult	M		LIA
	PMB87/12	Santorini Thomsons Bay	young adult	M	Ribot *et al.*, 2010	110±45BP
	PMB90/11	Mhlanga Lagoon	adult	M	Ribot *et al.*, 2010	20±45 (Pta-5780)
Zambia	A4140	Kala Ranch, Kalomo	adult	M	Fagan *et al.*, 1969	
	A4142	Behrens site	12 to 15		Fagan *et al.*, 1969	
	A4149	Dambwa	adult	M	Fagan *et al.*, 1969	
	A4156	Isamu Patu Mound (IP)	young adult	F	Fagan *et al.*, 1969	
	A4158	Isamu Patu Mound (IP)	older adult	M?	Fagan *et al.*, 1969	
	A4159	Isamu Patu Mound (IP)	older adult	M	Fagan *et al.*, 1969	
	A4160	Isamu Patu Mound (IP)	adult	F	Fagan *et al.*, 1969	
	A4161	Isamu Patu Mound (IP)	adult	?	Fagan *et al.*, 1969	
	A4163	Isamu Patu Mound (IP)	17-20	F?	Fagan *et al.*, 1969	
	A4164	Isamu Patu Mound (IP)	adult	?	Fagan *et al.*, 1969	
	A4165	Isamu Patu Mound (IP)	young	F?	Fagan *et al.*, 1969	

			adult			
	A4166	Isamu Patu Mound (IP)	young adult	F	Fagan *et al.*, 1969	
	A4168(1)	Ingombe Ilede Mound	adult	?	Fagan *et al.*, 1969	
	A4168(2)	Ingombe Ilede Mound	young adult	?	Fagan *et al.*, 1969	
	A4169	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4170	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4171	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4172	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4174	Ingombe Ilede Mound	middle aged	M	Fagan *et al.*, 1969	
	A4175	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4177	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4178	Ingombe Ilede Mound	adult	F	Fagan *et al.*, 1969	
	A4180	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4183	Ingombe Ilede Mound	adult	M	Fagan *et al.*, 1969	
	A4192	Ingombe Ilede Mound	middle aged	M	Fagan *et al.*, 1969	
	A4195	Ingombe Ilede Mound	young adult	F	Fagan *et al.*, 1969	
	A4199	Ingombe Ilede Mound	older adult	M	Fagan *et al.*, 1969	
	A4203	Ingombe Ilede Mound	older adult	M	Fagan *et al.*, 1969	
	A4205	Ingombe Ilede Mound	15-17	F	Fagan *et al.*, 1969	
	A4272	Makoli	older adult	M	Inskeep, 1962	LIA- according to institution
	A4273	Makoli	young adult	M	Inskeep, 1962	LIA- according to institution
	A4274	Makoli	middle aged	M	Inskeep, 1962	LIA- according to institution
	A4275	Makoli	adult	M	Inskeep, 1962	LIA- according to institution
	A4276M	Makoli	older adult	?	Inskeep, 1962	LIA- according to institution
	A4276M/K	Makoli	adult	M	Inskeep, 1962	LIA- according to institution

The specimens all come from southern Africa. This includes South Africa, Zimbabwe and Botswana (because farmers were restricted to summer rainfall areas, this only includes the eastern part of southern-most Africa). Specimens from Zambia are also included, for comparative purposes. Although geography and time alone does not restrict relatedness, these specimens are divided into categories based on archaeological inferences and sample size (to increase the probability of detecting significant differences). Therefore the categories for comparison are: Zambia (ZAM: North of Zambezi), Early Iron Age (EIA-T: South of Zambezi before 1000BP, but includes the Toutswe specimens because of evidence for ceramic continuity) and Late Iron Age (LIA: South of Zambezi after 1000BP). The samples were further split up into Toutswe (TOU: Middle Iron Age, Botswana) and Early Iron Age exclusively (EIA: excluding the Toutswe specimens), while the Late Iron Age was further split into east (LIA east: within 250km of the eastern coast) and west (LIA west: non-coastal specimens). Although these categories are broad, these comparisons should nonetheless provide interesting results and can be compared with current archaeological understanding of identity. The sites are categorized and shown in Figure 4.1.1.

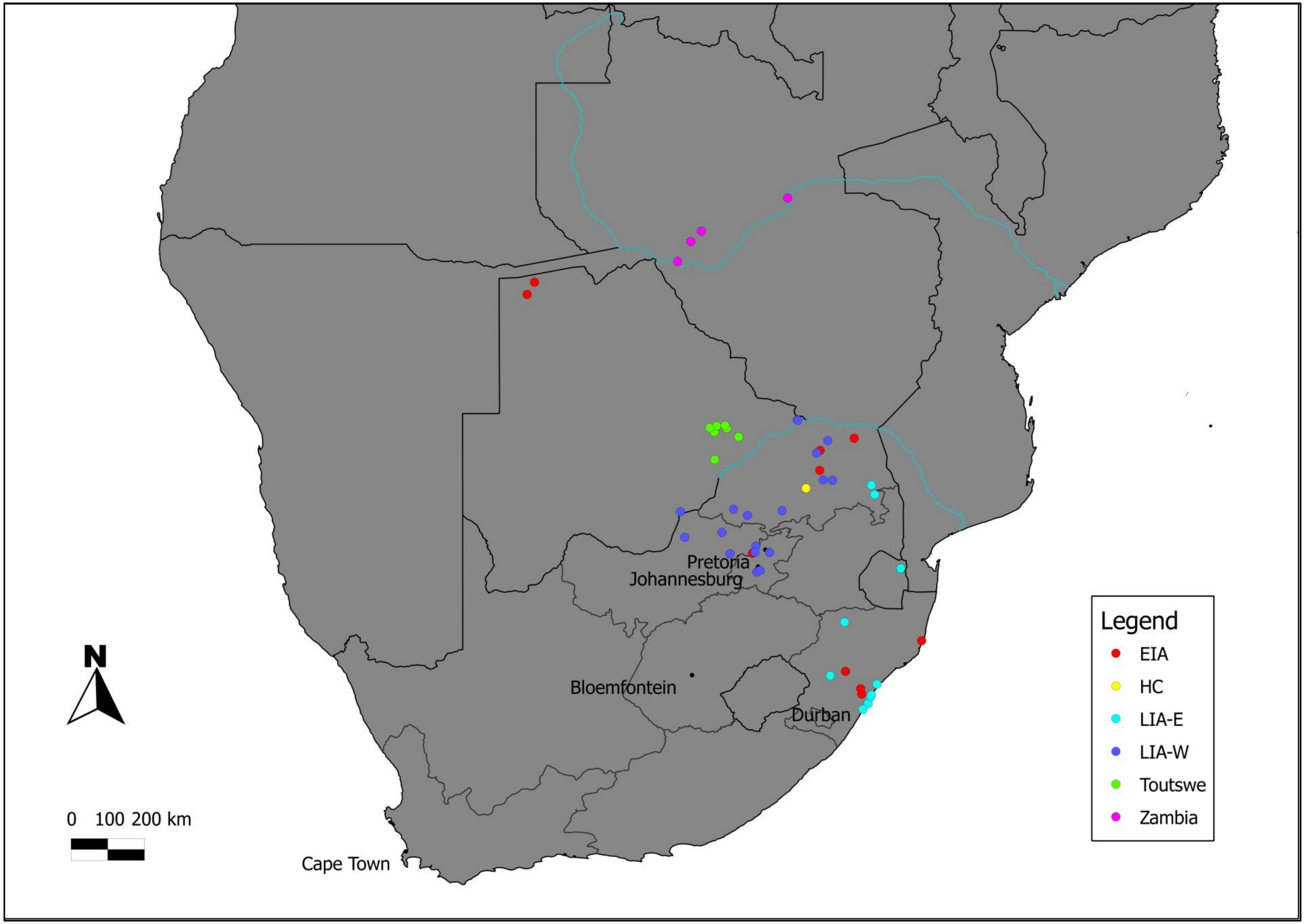

Figure 4.1.1 Map showing the distribution of Iron Age sites used in this thesis.

The specimens all come from the following institutions: the University of Witwatersrand (A), the University of Pretoria (A*), the Gaborone Museum (UB), the National Museum of Cultural History (Ditsong Museums of South Africa) (D), the Natal Museum (PMB) and the University of Cape Town (UCT). Additional specimen information (e.g. site, location, dating) was provided, when available, by the museum. References are included in the table. Age and sex were assessed independently. Age was assessed by the teeth and sex was based on the pelvis, cranium and mandible, when available.

Specimens from Historic Cave (HC- the yellow dot; Esterhuysen *et al.*, 2009) were also included in this study as a useful historical comparative. (Historic Cave is also shown in Figure 4.1.1). The sample consists largely of individual teeth, housed at the University of Witwatersrand. There were no adult mandibular or cranial features to compare with the scanned material. The dentition of modern Bantu-speakers skeletons from the University of Witwatersrand were also examined for additional comparison. Similarly, Khoesan dental data were donated by Ms Wendy Black as a further comparative sample. Table 4.1.2 lists these comparative samples. For comparisons with Iron Age scanned material, cranial and mandible scans of Khoesan and modern cadavers of Bantu-speaking individuals was donated by Ms Lauren Schroeder (Table 4.1.3). The Khoesan material largely comes from the University of Cape Town (UCT) and Iziko Museum (SAM-AP). The modern cadaver material comes from the University of the Witwatersrand (A).

Table 4.1.2 Dental comparative samples

		Language/ Site	Sex
Bantu-sample	A22	Xhosa	F
	A380	Zulu	M
	A398	Zulu	M
	A439	Xhosa	M
	A453	Soto	M
	A496	Soto	M
	A617	Zulu	F
	A650	Xhosa	M
	A741	Soto	M
	A746	Zulu	F
	A787	Xhosa	F
	A847	Soto	M
	A863	Xhosa	F
	A973	Xhosa	M
	A1280	Zulu	M
	A1281	Soto	M
	A1424	Xhosa	M
	A1434	Zulu	M
	A1435	Zulu	M
	A1499	Zulu	F
	A1513	Zulu	M
	A1525	Soto	M
	A1576	Zulu	F
	A1630	Soto	F
	A1875	Zulu	F
	A1967	Soto	M
	A1971	Zulu	M
	A2018	Zulu	M
	A2114	Zulu	M
	A2322	Zulu	M
	A2431	Soto	M
	A2848	Zulu	F
	A2849	Zulu	F
	A3358	Zulu	M
	A3416	Xhosa	M
	A3538	Xhosa	M
	A3784	Zulu	M
	A3806	Soto	M
	A3924	Soto	F
Khoesan sample	UCT 60	Saldahna	M
	UCT 62	Philipi, Cape Flats	M
	UCT 66	Taung	F

	UCT 97	Kommetjie	
	SAM-AP 6332	Melkbosstrand	M
	SAM-AP 6334	Melkbosstrand	F
	SAM-AP 1143	Port Elizabeth	F
	SAM-AP 1154		
	SAM-AP 1162	Coldstream Cave, Humansdorp	
	SAM-AP 1240	Richtersveld, Namaqualand	
	SAM-AP 1259	Cape Town	
	SAM-AP 1275	Matjies River	
	SAM-AP 1442	Gordon's Bay	
	SAM-AP 1449	Clanwilliam	
	SAM-AP 1451	Knysna	
	SAM-AP 1452	Fourcade	
	SAM-AP 1132	Robberg, Knysna	
	SAM-AP 1277	Kannemeyer?	
	SAM-AP 1274	Matjies River	F
	SAM-AP 1273	Jackalswater (Namaqualand?)	F
	SAM-AP 1440	Matjies River	M
	SAM-AP 1455	Richtersveld	M
	SAM-AP 1450	Knysna	
	SAM-AP 1448	Knysna	
	SAM-AP 3043	Coast, "Pondoland"	
	SAM-AP 3044a	Heatherton, near Blaauwberg	
	SAM-AP 3044b	Heatherton, near Blaauwberg	
	SAM-AP 3058	Prince Albert, Haughton	
	SAM-AP 3700	Welgemoed farm, Ceres	F
	SAM-AP 3027	Knysna	
	SAM-AP 3024	Robberg	M
	SAM-AP 3457	Kruidfontein, Prince Albert	F
	SAM-AP 3691	Upington	
	SAM-AP 3697	RooiEls, Hottentots Holland	M
	SAM-AP 4293	Van der Walt's Cave, Humansdorp	

Table 4.1.3 Comparative digitized specimens (names “Xosa” and “Soto” derived from the catalogue)

Specimen number	Language Category	Sex	Age
A22	XOSA	F	30
A80	ZULU	M	38
A96	SOTO	F	75
A182	TSWA	F	32
A244	TSWA	M	39
A250	ZULU	M	43
A252	XOSA	M	30
A263	SHAN	F	30
A267	TSON	M	49
A381	ZULU	F	29
A395	ZULU	M	
A396	XOSA	M	60
A399	ZULU	M	39
A400	XOSA	M	36
A437	ZULU	M	68
A465	ZULU	M	30
A591	XOSA	M	28
A700	SOTO	F	45
A702	NDEB	M	25
A740	ZULU	M	72
A761	XOSA	F	37
A787	XOSA	F	22
A799	ZULU	F	54
A863	XOSA	F	20
A865	SOTO	M	49
A866	SOTO	F	30
A883	SOTO	F	27
A900	SWAZ	F	26
A1228	ZULU	F	62
A1256	ZULU	F	32
A1276	XOSA	M	39
A1324	ZULU	M	58
A1338	TSWA	M	39
A1370	XOSA	F	52
A1423	ZULU	M	40
A1429	ZULU	F	49
A1451	ZULU	F	39
A1464	XOSA	M	25
A1532	NDEB	F	69

A1549	NDEB	F	28
A1551	**XOSA**	**M**	**51**
A1653	VEND	F	29
SAM-AP278G	Khoesan		
SAM-AP1145	Khoesan		
SAM-AP1146	Khoesan		
SAM-AP1268	Khoesan		
SAM-AP1441	Khoesan		
SAM-AP1473	Khoesan		
SAM-AP1871	Khoesan		
SAM-AP1878A	Khoesan		
SAM-AP3700	Khoesan	F	
SAM-AP4300	Khoesan		
SAM-AP4790	Khoesan		
SAM-AP4840	Khoesan		
SAM-AP4844	Khoesan		
SAM-AP4867	Khoesan		
SAM-AP4920A	Khoesan		
SAM-AP4942	Khoesan		
SAM-AP5035A	Khoesan		
SAM-AP5048	Khoesan		
SAM-AP5050	Khoesan		
SAM-AP5069	Khoesan		
SAM-AP5083	Khoesan		
SAM-AP6044	Khoesan		
SAM-AP6074	Khoesan		
SAM-AP6252	Khoesan		
SAM-AP6260A	Khoesan		
SAM-AP6319	Khoesan		
SAM-AP6331	Khoesan		
UCT373	Khoesan		
UCT421	Khoesan		
UCT427	Khoesan		
UCT582	Khoesan		

4.2. Dental non-metric traits

Scoring procedures followed the Arizona State University Dental Anthropological System (Turner *et al.*, 1991), where rank-order classification of features is used. To reduce error, a set of Dental Plaques, approved by ASUDAS, were initially used and calibration with Ms Wendy Black was done to 93% accuracy. Both Scott and Turner (1997) and Turner *et al*. (1991) were constantly referred to throughout data collection. When a trait could not be seen (due to wear or large cavities), it was left out. Table 4.2.1 lists all the examined and scored traits, the teeth to which they refer, and the references for quantifying the degrees of expression.

Table 4.2.1 Table showing the traits scored

Trait	Teeth	Degrees of expression
Status/ Wear	All	Smith, 1984
Caries	All	Researcher's own*
Winging	UI1s	Turner *et al.*, 1991: 14
Labial curve	UI1s	Turner *et al.*, 1991: 15
Shovel	UIs, UCs, LIs	Turner *et al.*, 1991: 14
Double Shovel	UIs, UCs, UP1s	Turner *et al.*, 1991: 15
Interruption Groove	UIs	Turner *et al.*, 1991: 16
Tuberculum Dentale	UIs, UCs	Turner *et al.*, 1991: 16
Canine Mesial Ridge	UCs	Turner *et al.*, 1991: 16
Canine Distal Accessory Ridge	UCs,LCs	Turner *et al.*, 1991: 17
Premolar Mesial and Distal Ridge	UPs	Turner *et al.*, 1991: 17
Metacone	UMs	Turner *et al.*, 1991: 18
Hypocone	UMs	Turner *et al.*, 1991: 18
Cusp 5	UMs	Turner *et al.*, 1991: 18
Carabelli's Trait	UMs	Turner *et al.*, 1991: 19
C2 Parastyle	UMs	Turner *et al.*, 1991: 19
Enamel Extention	UPs, UMs, LPs, LMs	Turner *et al.*, 1991: 19
Root Number	All	Turner *et al.*, 1991: 20, 24, 25

Hypoplasia	All	Orner and Putchar, 1981
Peg/ Reduced Tooth	UI2s, UM3s	Turner *et al.*, 1991: 21
Congenital Absence	UI2s, UP2s, UM3s, LI1s, LP2s, LM3s	Turner *et al.*, 1991: 21
Premolar Lingual Cusp Variation	LPs	Turner *et al.*, 1991: 21
Anterior Fovea	LM1s, LM2s	Turner *et al.*, 1991: 22
Molar Cusp Number	LMs	Turner *et al.*, 1991: 23
Groove Pattern	LMs	Turner *et al.*, 1991: 22
Deflecting wrinkle	LMs	Turner *et al.*, 1991: 23
C1-C2 Distal Trigonid Crest	LMs	Turner *et al.*, 1991: 23
Protostylid	LMs	Turner *et al.*, 1991: 23
Cusp 5	LMs	Turner *et al.*, 1991: 24
Cusp 6	LMs	Turner *et al.*, 1991: 24
Cusp 7	LMs	Turner *et al.*, 1991: 24
Torsomolar angle	LM3s	Turner *et al.*, 1991: 26
Torus	Maxilla and mandible	Turner *et al.*, 1991: 26
Rocker Jaw	Mandible	Turner *et al.*, 1991: 26
Abscesses	Maxilla and mandible	Turner *et al.*, 1991: 26
Periodontitis	Maxilla and mandible	Turner *et al.*, 1991: 26
Chipping	All	Turner *et al.*, 1991: 28
Other Cultural Treatment	All	Turner *et al.*, 1991: 27
TMJ damage	Maxilla	Turner *et al.*, 1991: 28
Extra Teeth	Maxilla and mandible	Ortner and Putchar, 1981

Taken together, all the these traits provide a picture on non-metric trait diversity – i.e. a "dental complex" – for all the Iron Age skeletal specimens, which can then be compared to the Modern Bantu-cadaver specimens and the Khoesan sample. For better accuracy and easier comparison, the degrees of expression scored were separated into "present" and "absent" based on previous research. Table 4.2.2 shows how this was done. Furthermore, if the trait was "present" on either tooth (left or right), it was scored as "present" for that specimen, showing phenotypic potential for that trait.

Table 4.2.2 "Present" "Absent" distinctions

Trait	**Present**	**Reference**
Winging	ASU1,2,4	Turner II *et al.*, 1991
Labial curve	ASU2-4	Turner II *et al.*, 1991
Shovel	ASU3-6	Irish, 1998a
Double Shovel	ASU2-6	Irish, 1998a
Interruption Groove	ASU+	Irish, 1998a
Tuberculum Dentale	ASU3-	Turner II *et al.*, 1991
Canine Mesial Ridge	ASU1-3	Irish, 1998a
Canine Distal Accessory Ridge	ASU2-5	Turner II *et al.*, 1991
Premolar Mesial and Distal Ridge	ASU+	Turner II *et al.*, 1991
Metacone	ASU3-5	Turner II *et al.*, 1991
Hypocone	ASU3-5	Hanihara, 2008
Cusp 5-upper	ASU1-5	Irish, 1998a
Carabelli's Trait	ASU3-7	Hanihara, 2008
Parastyle	ASU2-6	Turner II *et al.*, 1991
Enamel Extention	ASU2-3	Irish, 1998a
Root Number	(ASU3+ for UM; 2+ for LM)	Irish, 1998a
Peg/ Reduced Tooth	ASU P, R	Irish, 1998a
Congenital Absence	ASU1	Turner II *et al.*, 1991
Premolar Lingual Cusp Variation	ASU2-9	Turner II *et al.*, 1991
Anterior Fovea	ASU1-4	Turner II *et al.*, 1991
Molar Cusp Number	ASU 4	Irish, 1998a
Groove Pattern	ASU Y	Turner II *et al.*, 1991
Deflecting wrinkle	ASU2-3	Hanihara, 2008
C1-C2 Distal Trigonid Crest	ASU1-	Hanihara, 2008
Protostylid	ASU2-7	Hanihara, 2008
Cusp 5-lower	ASU2-5	Turner II *et al.*, 1991
Cusp 6	ASU1-	Hanihara, 2008
Cusp 7	ASU1-4	Irish, 1998a
Torsomolar angle	>0	Turner II *et al.*, 1991
Tomes root	ASU3-5	Irish, 1998a

Once the degrees of expression have been simplified, Chi-squared tests were performed in Microsoft Excel, using the following formula:

n*((ad-bc)^2)/((a+b)(c+d)(a+c)(b+d))

Where:

n= number of specimens;

a= number of specimens where the trait was present in sample 1;

b= number of specimens where the trait was absent in sample 1;

c= number of specimens where the trait was present in sample 2;

d= number of specimens where the trait was absent in sample 2.

When sample sizes were too small (less than n=5), Yate's Chi-Squared equation was used instead:

N*(abs(ad-bc)-(N/2))^2/((a+b)(c+d)(a+c)(b+d)), where a, b, c and d are as above.

These tests are used to compare traits between the Iron Age population with the Historic Cave sample, Khoesan sample and Cadaver sample. Comparisons are also made within the Iron Age sample, i.e. between the Zambian, EIA, LIA east, LIA west and Toutswe categories.

4.3. Dental metrics

This thesis makes use of the two most common forms of tooth measurements (mesiodistal and buccolingual lengths of the crown). Mesiodistal length was measured by holding the dental callipers parallel to the occlusal surface of the tooth and measuring the maximum diameter of the crown in the mesiodistal plane (Mayhall, 1992). Attrition, however, will always affect this distance, especially in the anterior dentition. Similarly, the buccolingual length was measured holding the callipers parallel to the occlusal surface of the tooth, perpendicular to the mesiodistal plane, and measuring the widest distance. This measurement can be difficult to take because the most protruding buccal surface may not be along the same plane as the most protruding lingual surface of the tooth (Mayhall, 1992; Hillson *et al.*, 2005). Often a small degree of rotation was necessary to ensure a maximum diameter. This is consistent with other research and ensures repeatability (Hillson *et al*., 2005). This measurement is highly affected by wear and for teeth with wear of grade 3 or greater it was not taken at all.

All the measurements were measured three times and an average was taken. Although measurements were taken for every tooth, only the measurements for teeth on the left were used for comparison, unless the left was absent and only the right's measurements were available. The samples were compared using T-TESTS in Microsoft Excel. Comparisons were made between the Iron Age, Historic Cave, Cadaver and Khoesan samples. Comparisons between the groups within the Iron Age sample was also made using T-TESTS. Principal Components Analysis (PCA) is used to examine the distribution of variation among the Iron Age, Cadaver and Khoesan sample using the programme, PAST (archaeological statistics programme downloaded online). This will be done by creating a matrix of distances (mesiodistal and buccolingual of each tooth on each individual). The matrix was then reduced to get an adequate sample size (by deleting distances which were not as frequent) with an adequate number of comparative distances (by deleting specimens with too few measurements). This accounted for missing data. PAST will then evaluate the principal components with the greatest variability between the samples and produce a PCA graph.

4.4. 3D scanning and cranial and mandibular metrics

The use of scans increases the number of viable landmarks that may be used for measurements, by reducing the error on constructed and “fuzzy” landmarks on the mandible (Williams and Richtsmeier, 2003: 499). Good cranio-mandibular analyses need, firstly, adult specimens that have reached maturity (a problem in the Iron Age). Secondly, the analysis needs a face and/or mandible as complete as possible (without being glued together). Thirdly, while these necessities greatly reduce the number of viable specimens, a large sample size is needed for statistical accuracy. Also, while taking direct measurements may take time, the scanning process can take longer.

Scans were made using Next Engine Scan Studio HD (version 1.1.0). The mandibular and cranial specimens chosen were each scanned twice (on different planes) using 360° rotations, seven divisions (sets of scans) and wide distance settings (to include the full object within the scan). The two scans were then trimmed, aligned (to within 0.01 inch accuracy) and fused. The final scans were saved as both .scn and NZIP files. The NZIP files were then exported to Meshlab where landmarks were placed on to the scans. 57 cranial landmarks and 20 mandibular landmarks were chosen as described in Table 4.4.1. Both left and right landmarks were taken where possible.

Table 4.4.1 Cranial and mandibular landmarks chosen

	Mandibular	
Midline		
GNA	Gnathion	Williams and Richtsmeier, 2003
POG	Pogonion	Williams and Richtsmeier, 2003
INFRA	Infradentale	Williams and Richtsmeier, 2003
MSPIN	Superior Mental spine	Williams and Richtsmeier, 2003
MNS	Mandibular symphysis	Franklin *et al.*, 2008
Bilateral		
MEN	Mental foramen	Williams and Richtsmeier, 2003
ALV	Alveolar border of body	Williams and Richtsmeier, 2003
IBB	Inferior border of body	Williams and Richtsmeier, 2003
GON	Gonion	Williams and Richtsmeier, 2003
PGA	Inferior posterior ramus	Williams and Richtsmeier, 2003
AJUNC	Inferior anterior ramus	Williams and Richtsmeier, 2003
LAT	Lateral mandibular condyle	Williams and Richtsmeier, 2003
PSC	Posterior mandibular condyle	Williams and Richtsmeier, 2003
COR	Coronoid process	Williams and Richtsmeier, 2003
MC	Medial mandibular condyle	Williams and Richtsmeier, 2003
MN	Mandibular notch	Franklin *et al.*, 2008
AR	Anterior ramus	Franklin *et al.*, 2008
SA	Superior anterior ramus	Williams and Richtsmeier, 2003
MFO	Mandibular foramen	Williams and Richtsmeier, 2003
	Cranial	
Midline		
ALV	Alveolon	von Cramon-Taubadel and Smith, 2012
B	Bregma	von Cramon-Taubadel and Smith, 2012
BA	Basion	von Cramon-Taubadel and Smith, 2012
G	Glabella	von Cramon-Taubadel and Smith, 2012
I	Inion	von Cramon-Taubadel and Smith, 2012
INC	Incisivon	von Cramon-Taubadel and Smith, 2012
L	Lambda	von Cramon-Taubadel and Smith, 2012
N	Nasion	von Cramon-Taubadel and Smith, 2012
O	Opisthion	von Cramon-Taubadel and Smith, 2012
PR	Prosthion	von Cramon-Taubadel and Smith, 2012
NS	Subspinale	von Cramon-Taubadel and Smith, 2012

Bilateral		
A	Alare	von Cramon-Taubadel and Smith, 2012
AST	Asterion	von Cramon-Taubadel and Smith, 2012
D	Dacryon	von Cramon-Taubadel and Smith, 2012
MXT	Maxillary tuberosity	Ackermann *et al.*, 2006
FMO	Frontomalar orbital	von Cramon-Taubadel and Smith, 2012
FMT	Frontomalar temporale	von Cramon-Taubadel and Smith, 2012
FM	Foramen magnum	von Cramon-Taubadel and Smith, 2012
FMN	Frontal-maxillary-nasal junction	Ackermann *et al.*, 2006
J	Jugale	von Cramon-Taubadel and Smith, 2012
KR	Krotaphion	von Cramon-Taubadel and Smith, 2012
MF	Mandibular fossa	von Cramon-Taubadel and Smith, 2012
MMC	Max maxillary curve	von Cramon-Taubadel and Smith, 2012
MAS	Mastoidale	von Cramon-Taubadel and Smith, 2012
OCA	Occipitocondyle (ant)	von Cramon-Taubadel and Smith, 2012
OCL	Occipitocondyle (lat)	von Cramon-Taubadel and Smith, 2012
ORI	Orbitale (inf)	von Cramon-Taubadel and Smith, 2012
ORB	Orbitale (sup)	von Cramon-Taubadel and Smith, 2012
POR	Porion	von Cramon-Taubadel and Smith, 2012
SPH	Sphenion	von Cramon-Taubadel and Smith, 2012
TF	Temporal fossa (pos)	von Cramon-Taubadel and Smith, 2012
JRI	Jugular ridge inferior	
ZY	Zygion	von Cramon-Taubadel and Smith, 2012
MAX	Maxillary foramen	

The landmarks acted as points within a 3 dimensional matrix ([x, y, z] coordinates) from which Euclidean squared distances between two points ((x_1, y_1, z_1) to (x_2, y_2, z_2)) were calculated using the following theorem:

$$d^2 = (x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2$$

Euclidean distances (d) were then calculated in Microsoft Excel.

Table 4.4.2 shows the distances calculated; distances were chosen to limit redundancy while ensuring good coverage of the cranium and mandible. On the cranium, emphasis should be placed on the upper-facial and basicranium regions and the cranium as a whole where possible, to best estimate genetic relationships (Smith, 2009). However, this was subject to the preservation of these regions within the sample. Although some measurements focus on the lower maxilla, variation in this region may be influenced by environmental factors (Smith, 2009).

Table 4.4.2 Chosen cranial and mandibular measurements

	Measurement
Mandibular	GNA-POG
	POG-MNS
	POG-INFRA
	GNA-IBB_L
	GNA-IBB_R
	IBB_L-MEN_L
	IBB_R-MEN_R
	MEN_L-ALV_L
	MEN_R-ALV_R
	INFRA-ALV_L
	INFRA-ALV_R
	ALV_L-AJUNC_L
	ALV_R-AJUNC_R
	IBB_L-GON_L
	IBB_R-GON_R
	GON_L-PGA_L
	GON_R-PGA_R
	PGA_L-PSC_L
	PGA_R-PSC_R
	PSC_L-LAT_L
	PSC_R-LAT_R
	LAT_L-MC_L
	LAT_R-MC_R
	LAT_L-COR_L
	LAT_R-COR_R
	LAT_L-MN_L
	LAT_R-MN_R
	COR_L-MN_L
	COR_R-MN_R
	COR_L-SA_L
	COR_R-SA_R
	SA_L-AR_L
	SA_R-AR_R
	AR_L-AJUNC_L
	AR_R-AJUNC_R
	MSPIN-MFO_L
	MSPIN-MFO_R
	MFO_L-MN_L
	MFO_R-MN-R
	MFO_L-GON_L
	MFO_R-GON_R
Cranial	G-N
	N-FMN_L

	N-FMN-R
	N-D_L
	N-D_R
	N-NS
	NS-PR
	NS-A_L
	NS-A_R
	D_L-FMO_L
	D_R-FMO_R
	ORB_L-ORI_L
	ORB_R-ORI_R
	D_L-ORI_L
	D_R-ORI_R
	D_L-ORB_L
	D_R-ORB_R
	FMO_L-FMT_L
	FMO_R-FMT_R
	ORI_L-MMC_L
	ORI_R-MMC_R
	MMC_L-JRI_L
	MMC_R-JRI_R
	A_L-MMC_L
	A_R-MMC_R
	J_L-MAX_L
	J_R-MAX_R
	FMT_L-J_L
	FMT_R-J_R
	SPH_L-KR_L
	SPH_R-KR_R
	J_L-MF_L
	J_R-MF_R
	ZY_L-JRI_L
	ZY_R-JRI_R
	ZY_L-MF_L
	ZY_R-MF_R
	MF_L-POR_L
	MF_R-POR_R
	SPH_L-B
	SPH_R-B
	KR_L-AST_L
	KR_R-AST_R
	AST_L-MAS_L
	AST_R-MAS_R
	POR_L-MAS_L
	POR_R-MAS_R
	AST_L-L

	AST_R-L
	L-B
	L-I
	I-O
	PR-NS
	NS-ALV
	I-AST_L
	I-AST_R
	NS-MXT_L
	NS-MXT_R
	BA-O
	FM_L-O
	FM_R-O
	FM_L-BA
	FM_R-BA
	FM_L-FM_R
	OCA_L-FM_L
	OCA_R-FM_R
	OCA_L-OCL_L
	OCA_R-OCL_R
	OCL_L-FM_L
	OCL_R-FM_R
	BA-NS

The distances were compared between the Iron Age, Khoesan and modern Bantu-samples using ANOVA tests (between all three) and T-tests (between each pair) in Microsoft Excel. Similar to the dental metrics, a PCA was performed in PAST to show the covariance relationship between the groups. A matrix was created, eliminating missing data (either specimens with too few distances or distances that were too rare) and the uncorrelated principal components were represented visually.

4.5. Dental health and cultural practices

Dental anthropologists also take into account a number of factors that are not genetically determined (Scott and Turner, 1997 and Turner *et al.*, 1991). This accounts for other factors (such as health or cultural practices) that may interfere with the visibility of traits. However, it also provides a lot of information about the samples being studied. The majority of these non-genetic traits take into account diet (such as tooth status and caries), health (abscesses, periodontitis, TMJ damage and hypoplasia) and cultural changes to teeth (chipping and other cultural treatment). Those traits were analysed for each specimen and they are also included in Table 4.2.2.

Smith (1984) was used to score wear. This scoring pattern takes into account different wear patterns which may result from differences in diet and food preparation within farming societies. Some of the traits have a better connection to environmental factors such as the health of the individual specimens studied. These include caries, hypoplasia, temporo-mandibular joint damage, abscesses and periodontitis. Although health is well-studied within Iron Age populations, this might help with further assessment of the connection between environment and morphology in other traits. Chipping and cultural treatment were also scored. These may not only cover other-wise visible traits, but can also give us an indication of how these populations used teeth for group affiliation and aesthetics, or even indicate certain behaviours (such as pipe-smoking).

When occurring on the occlusal surface of the tooth, caries were scored on a scale of 1 to 5. On this scale, 1 is an un-obtrusive small caries, often within grooves on the occlusal surface of the tooth (Ortner and Putchar, 1981). Two is where the caries either follows a short distance along the groove or where multiple small caries occur. Three is a larger caries (=1mm) that will hide trait information. Four (>1mm) is where an entire cusp or two is lost to caries. Five is where the caries engulfs more than half the tooth surface. When the caries was large enough to cover one or more traits, those traits were left unscored. While even the smallest caries may hide trait information, traits 3 and above are seen as the most obstructive and those teeth were not used.

CHAPTER 5: RESULTS

This chapter initially focuses on the non-metric dental data, presenting the results of comparisons between Iron Age samples, a contemporary cadaver sample (Bantu-speakers) and comparative (externally sourced) Khoesan data. Results are then presented for similar comparisons made for the dental metric data. Indicators of dental health and cultural modification as seen on the dentition are also presented. Finally, the cranio-mandibular metric results are presented.

5.1 Non-metric dental description

Appendix 7.1 lists the dental trait frequencies of the samples studied in this thesis. This includes the larger samples separated chronologically into Early Iron Age (which includes the Toutswe specimens; EIA-T), and the Late Iron Age (LIA). The specimens from Zambia (ZAM) represent Iron Age samples just north of the Zambezi. The table also includes the samples separated geographically and temporally: Toutswe (TOU), Early Iron Age (without the Toutswe specimens; EIA), Late Iron Age specimens from the Free State and KwaZulu Natal (LIA East) and Late Iron Age specimens found in the more North-West regions of southern Africa (LIA West). The table includes the modern cadaver specimens (MOD) collected from the University of Witwatersrand and the Historic Cave specimens (HC) as well as the grouped Iron Age specimens from Zambia, LIA and EIA.

All Iron Age samples show low frequencies of the following: winging (UI1), labial curvature (UI1), shovelling (UI1, UI2, UC and LI), double shovelling (UI1, UI2, UC and UP1), interruption grooves (UI1 and UI2), tuberculum dentale (UI1 and UI2) pegging (UI2 and UM3), premolar mesial and distal cusps (UP1 and UP2), Carabelli's trait (UM1, UM2 and UM3), parastyle (UM1, UM2 and UM3), enamel extension (UM1), root number (LC and LM1), Tome's root (LP1), deflecting wrinkle (LM1, LM2 and LM3), DT crests (LM1, LM2 and LM3), protostylid (LM1, LM2 and LM3), cusp 6 (LM1 and LM2) and torsomolar angle (LM3). Similarly, all Iron Age samples have high frequencies of the following: canine mesial ridge (UC), canine distal accessory ridge (UC and LC), premolar lingual cusp variation (LP1 and LP2), metacones (UM1, UM2 and UM3), hypocones (UM1, UM2 and UM3), cusp 5 (UM1, UM2 and UM3), root number (UM1, UM2, UM3, LM2 and LM3), anterior fovea

(LM1 and LM2), Y groove pattern (LM1, LM2 and LM3), large cusp numbers (LM1, LM2 and LM3), cusp 5 (LM1, LM2 and LM3) and cusp 7 (LM1, LM2 and LM3).

Appendix 7.1 and Table 5.1.1 shows the sample size of each group of specimens for which the traits could be observed. This is important, because the numbers of specimens for each trait is not uniform for each sample. In other words, sample size may vary, depending on preservation, health, wear (some traits cannot be seen even after minimal wear, while some can), tooth eruption (when the sample includes juveniles, there will be fewer available M3s) and dental modification. Within the modern cadaver sample, sample size varies from n=6 (LM3 root number) to n=39 (metacone UM1, hypocone UM1, cusp 5 UM1, Carabelli's trait UM1, LP1 premolar lingual cusp variation and LM2 anterior fovea). The Historic Cave sample, specifically, includes very small sample sizes, ranging from n=0 (torsomolar angle; which is likely because the sample was dominated by isolated teeth and the adult teeth of juveniles) to n=25 (lower incisors; a large number of juveniles). The Early Iron Age sample (EIA, excluding the Toutswe specimens) was also a small sample, ranging from n=3 to n=16.

Table 5.1.1 Table showing the sample size for each traits within each sample. This includes the Historic Cave (HC), modern cadaver (MOD), Khoesan (KHOE), Zambian (ZAM), Early Iron Age (EIA-T, which is divided into Toutswe and other EIA samples) and the Late Iron Age (LIA; which is divided into east and west) samples.

Trait	HC	MOD	KHO	ZAM	EIA-T		LIA	
	HC (n)	MOD (n)	KHO (n)	ZAM (n)	TOU (n)	EIA (n)	LIA-east (n)	LIA-west (n)
Winging- UI1	2	25	7	10	15	3	5	14
Labial Curve-UI1	12	21	13	15	15	4	7	24
Shovel- UI1	12	23	12	9	15	3	7	20
Double Shovel UI1	12	22	13	15	15	4	7	22
Int. Groove UI1	12	23	12	14	15	4	7	22
I and C td UI1	12	24	10	11	14	4	7	21
Shovel UI2	8	33	14	15	20	3	8	25
Double Shovel UI2	8	33	18	17	20	5	8	26
Int Groove UI2	10	33	18	18	18	6	8	28
I and C td UI2	9	31	15	15	19	6	8	27
Peg UI2	11	—	—	21	24	9	10	32
Shovel UC	10	35	12	17	17	9	8	25
Double Shovel UC	10	35	22	19	19	11	10	29
I and C td UC	10	36	15	17	19	10	8	26
C mesial ridge UC	9	34	14	14	16	8	8	22
CDAR UC	7	34	14	10	14	7	7	20
Double shovel UP1	7	37	16	22	18	14	10	27
P m and d cusps UP	16	37	15	22	18	15	11	27
Metacone UM1	6	39	36	20	20	14	11	31
Metacone UM2	9	38	31	23	21	16	12	34
Metacone UM3	5	37	22	20	17	12	8	30
Hypocone UM1	7	39	33	19	20	15	11	32
Hypocone UM2	8	38	30	22	19	11	12	29
Hypocone UM3	4	35	19	20	13	11	10	26
Cusp 5 UM1	6	39	30	14	18	7	11	20
Cusp 5 UM2	6	38	28	16	15	10	11	23
Cusp 5 UM3	2	36	20	20	14	8	10	18
Carabelli UM1	7	39	28	22	21	14	10	32
Carabelli UM2	9	38	22	24	19	12	12	32

Carabelli UM3	5	31	18	21	14	11	10	30
Parastyle UM1	7	37	37	24	23	16	10	35
Parastyle UM2	9	38	23	25	20	16	11	31
Parastyle UM3	5	32	19	21	18	13	9	30
Root no. UM1	8	24	—	21	27	14	9	29
Root no. UM2	6	12	—	26	17	13	10	31
Root no. UM3	4	10	—	20	14	12	8	23
Shovel LI	25	34	9	16	19	12	9	32
CDAR LC	11	33	4	15	17	10	8	29
P ling cusp LP1	8	39	24	15	20	15	10	34
P ling cusp LP2	4	37	21	14	16	12	8	30
Tome root LP1	4	7	11	3	18	9	8	17
Ant Fovea LM1	10	19	26	7	15	7	9	19
Ant Fovea LM2	11	39	—	13	15	13	8	25
Ant Fovea LM3	1	37	15	21	15	11	10	27
Groove pattern LM1	10	34	45	18	20	14	9	23
Groove pattern LM2	11	38	41	19	19	15	10	30
Groove pattern LM3	3	35	25	15	14	11	10	29
Cusp no. LM1	11	35	42	16	20	13	9	27
Cusp no. LM2	11	35	36	18	19	15	10	31
Cusp no. LM3	2	33	27	17	13	12	9	26
Def Wrinkle LM1	9	34	32	6	13	6	6	18
Def Wrinkle LM2	9	37	4	13	12	12	7	28
Def Wrinkle LM3	1	34	—	12	8	9	8	19
DT crest LM1	10	35	22	8	15	5	5	17
DT crest LM2	10	37	19	14	15	13	9	25
DT crest LM3	1	34	21	14	9	9	9	22
Protostylid LM1	10	37	54	18	23	14	8	31
Protostylid LM2	9	37	37	18	19	15	11	32
Protostylid LM3	1	31	26	17	14	12	10	28
Cusp 5 LM1	11	36	40	17	20	13	9	27
Cusp 5 LM2	11	35	36	18	19	15	10	31
Cusp 5 LM3	2	34	28	17	13	12	9	25

Cusp 6 LM1	11	35	40	16	20	14	9	27
Cusp 6 LM2	11	35	36	18	19	15	10	31
Cusp 6 LM3	2	33	28	17	13	12	9	25
Cusp 7 LM1	11	36	46	17	20	12	9	26
Cusp 7 LM2	11	38	39	19	16	15	8	32
Cusp 7 LM3	2	32	28	17	11	12	9	27
Torso. Angle	0	36	25	16	12	10	10	30
Root no. LM1	11	20	—	18	26	15	8	40
Root no. LM2	7	12	—	18	23	13	9	35
Root no. LM3	1	6	—	12	13	10	8	26
Enamel extension UM1	10	—	—	23	28	16	9	37
Root no. UP1	10	14	—	23	21	15	10	38
Peg, reduced absent UM3	7	38	—	23	18	13	11	35
Root no. LC	9	38	—	19	19	12	8	37

5.2 Non-metric dental comparisons

Non-metric dental comparisons between the Iron Age samples

Table 5.2.1 shows the Chi-squared p-values for the comparisons between the Early Iron Age sample (EIA-T: which includes the Toutswe material), the Late Iron Age sample (LIA), and the Zambian sample (ZAM). P-values that are significant at $p<0.1$ are indicated in bold. When both samples compared had no presentation of a trait, and therefore it was impossible to calculate the Chi-squared values, a dash is inserted. This indicates that the samples had the same proportion of traits and are not significantly different in that trait (making the p-values 1.0). It is important to note that this does not imply biological distance, merely varying levels of significance.

Results indicate that all three of the samples (EIA-T, LIA and ZAM) are not significantly different from each other for the vast majority of traits. For the comparison between the Early Iron Age and Late Iron Age samples, eight traits (out of 76) showed significant differences at $p<0.1$. These include interruption groove (UI2), tuberculum dentale (UI2), hypocone (UM2), cusp 5 (UM1), parastyle (UM3), anterior fovea (LM2), cusp 7 (LM3) and enamel extension (UM1). Three of these traits showed significant differences at $p<0.05$ (UI2 tuberculum dentale, UM3 parastyle and UM1 enamel extension). UM1 enamel extension showed significant difference at $p<0.01$.

When comparing the Early Iron Age sample to the Zambian sample (Table 5.2.1), seven out of 76 traits showed significant difference at $p<0.1$. UM2 cusp 5, UM1 parastyle and LM2 groove pattern showed significance at $0.05<p<0.1$. UI1 tuberculum dentale, LM2 anterior fovea, LM3 cusp 7 and UM1 enamel extension showed significant differences at $p<0.05$. There were no significant differences where $p<0.01$. Similarly, comparing the Late Iron Age to the Zambian sample, nine traits showed significant difference at $p<0.1$. UI1 shovelling, UM2 hypocone, UM2 root number and LP1 premolar lingual cusp variation were significantly different where $0.05<p<0.1$. UP1 double shovelling, UM1 and UM2 cusp 5 and LM2 groove pattern showed significant difference where $0.01<p<0.05$. UI1 tuberculum dentale was significantly different where $p<0.01$. UI1 tuberculum dentale, UM2 cusp 5 and LM2 groove pattern differ significantly within both comparisons (EIA-T versus ZAM and LIA versus ZAM).

Table 5.2.1 Table showing the p-values for non-metric comparisons between the larger archaeological groups within the Iron Age Sample: The Early Iron Age (including the Toutswe specimens; EIA-T), the Zambian (ZAM) and the LIA samples.

	EIA-T / LIA	EIA-T / ZAM	LIA/ ZAM
Winging- UI1	0.324	—	0.460
Labial Curve-UI1	0.407	0.841	0.336
Shovel- UI1	0.768	0.194	**0.082**
Double Shovel UI1	—	—	—
Int. Groove UI1	—	—	—
I and C td UI1	0.747	**0.012**	**0.002**
Shovel UI2	0.144	0.428	0.677
Double Shovel UI2	0.217	—	0.308
Int Groove UI2	**0.091**	—	0.142
I and C td UI2	**0.012**	0.414	0.153
Peg UI2	—	—	—
Shovel UC	0.644	0.217	0.109
Double Shovel UC	0.950	0.363	0.375
I and C td UC	0.673	0.604	0.349
C mesial ridge UC	0.684	0.253	0.402
CDAR UC	0.327	0.813	0.325
Double shovel UP1	0.489	0.127	**0.040**
P m and d cusps UP	0.560	0.137	0.284
Metacone UM1	—	—	—
Metacone UM2	—	—	—
Metacone UM3	0.379	—	0.464
Hypocone UM1	—	—	—
Hypocone UM2	**0.055**	0.956	**0.080**
Hypocone UM3	0.285	0.507	0.773
Cusp 5 UM1	**0.062**	0.436	**0.012**
Cusp 5 UM2	0.867	**0.050**	**0.050**
Cusp 5 UM3	0.913	0.227	0.163
Carabelli UM1	0.775	0.243	0.164
Carabelli UM2	0.678	0.711	0.457
Carabelli UM3	0.426	0.115	0.228
Parastyle UM1	0.349	**0.067**	0.236
Parastyle UM2	0.512	0.783	0.405

Parastyle UM3	**0.044**	0.208	0.651
Root no. UM1	0.602	1.000	0.665
Root no. UM2	0.405	0.325	**0.061**
Root no. UM3	0.707	0.762	0.975
Shovel LI	0.247	0.468	—
CDAR LC	0.272	0.542	0.114
P ling cusp LP1	0.171	0.558	**0.086**
P ling cusp LP2	0.605	0.469	0.718
Tome root LP1	0.186	0.858	0.196
Ant Fovea LM1	0.276	0.397	1.000
Ant Fovea LM2	**0.057**	**0.033**	0.767
P m and d cusps UP2	0.834	0.240	0.293
Groove pattern LM1	0.139	0.165	0.920
Groove pattern LM2	0.551	**0.079**	**0.036**
Groove pattern LM3	0.975	0.869	0.838
Cusp no. LM1	—	—	—
Cusp no. LM2	—	—	—
Cusp no. LM3	—	—	—
Def Wrinkle LM1	0.248	0.160	0.361
Def Wrinkle LM2	0.177	0.874	0.177
Def Wrinkle LM3	0.950	0.706	0.632
DT crest LM1	0.197	0.701	0.148
DT crest LM2	0.498	0.350	0.634
DT crest LM3	0.185	0.854	0.132
Protostylid LM1	0.301	0.482	—
Protostylid LM2	0.439	0.187	0.352
Protostylid LM3	0.672	0.217	0.114
Cusp 5 LM1	0.950	0.626	0.580
Cusp 5 LM2	0.473	0.356	0.726
Cusp 5 LM3	0.216	0.322	1.000
Cusp 6 LM1	0.888	0.726	0.639
Cusp 6 LM2	0.423	0.326	0.122
Cusp 6 LM3	0.346	0.858	0.311
Cusp 7 LM1	0.298	0.539	0.135
Cusp 7 LM2	0.377	0.273	0.698
Cusp 7 LM3	**0.092**	**0.012**	0.219

Torso. Angle	0.188	0.235	0.869
Root no. LM1	0.652	0.504	0.379
Root no. LM2	0.363	0.153	0.507
Root no. LM3	0.711	0.975	0.742
Enamel extension UM1	**0.005**	**0.025**	0.672
Root no. UP1	0.944	0.458	0.404
Peg, reduced absent UM3	—	0.241	0.154
Root no. LC	—	—	—

In order to consider whether differences exist within subdivisions of the Iron Age samples, further comparisons were made. Table 5.2.2 shows the Chi-squared p-values for the comparisons between the following groups: Toutswe (TOU), Early Iron Age (EIA: First Millennium specimens from South of the Zambezi, excluding the Toutswe specimens), Late Iron Age east (LIA east: second millennium specimens from the Free State and KwaZulu Natal) and Late Iron Age west (LIA west: second millennium specimens north and west of the Free State and KwaZulu Natal but south of the Zambezi). The Toutswe specimens (TOU) overlap temporally with Late Iron Age samples, although the ceramics are typologically linked to the Early Iron Age (EIA). Similarly, the LIA was divided into LIA east and LIA west, as described in the methodology section. The table shows the same traits, abbreviations and layout as Table 5.2.1.

Out of the 76 traits that are listed, eleven of those traits are significantly different between the Toutswe and Early Iron Age samples at $p<0.1$. UC double shovelling, UC distal accessory ridge and LM1 deflecting wrinkle show significant differences where $0.05<p<0.1$. Significant difference where $p<0.05$ was seen for the following traits: UM3 cusp 5, Hypocone UM2, UM2 and UM3 root number, LM3 cusp 5 and LM2 cusp 6. Only 2 traits showed significance below 0.01 (UM1 enamel extension and UP1 root number). When comparing the Late Iron Age to the Toutswe sample, only seven total traits showed significant differences with p-value less than 0.1. Only premolar lingual cusp variation (LP1) showed significance where 0.05<p<0.1. UM3 parastyle, LM1 and LM2 deflecting wrinkle, LM3 cusp 7 and UM1 enamel extension are significantly different where 0.01<p<0.05. Only one trait is significantly different, with a p-value less than 0.01 (UI1 tuberculum dentale). Toutswe differs from both other samples only in LM1 deflecting wrinkle and UM1 enamel extension.

When comparing the LIA along the East Coast and Free State to the more north-western LIA sample, eight of the 76 traits showed significant difference with p-value less than 0.1. UI1 labial curvature, UI2 tuberculum dentale, UM3 Carabelli's trait and LM1 deflecting wrinkle had p values where 0.05<p<0.1. Carabelli's trait (UM2) and LM2 root number showed significant difference at 0.05<p<0.01. LC canine distal accessory ridge and LM1 root number had P-values less than 0.01.

Table 5.2.2 Table showing the p-values for non-metric comparisons between the divided groups within the Iron Age Sample: The Early Iron Age (excluding the Toutswe specimens; EIA), the Toutswe (TOU) and the LIA east (LIA east) and west (LIA west) samples.

	EIA/ TOU	**LIA/ TOU**	**LIA west/ LIA east**
Winging- UI1	—	0.367	0.581
Labial Curve-UI1	0.840	0.336	**0.076**
Shovel- UI1	0.357	0.665	0.547
Double Shovel UI1	—	—	—
Int. Groove UI1	—	—	—
I and C td UI1	0.492	0.608	0.556
Shovel UI2	0.679	0.141	0.763
Double Shovel UI2	—	0.269	0.419
Int Groove UI2	—	0.142	0.888
I and C td UI2	0.629	**0.009**	**0.062**
Peg UI2	—	—	—
Shovel UC	0.779	0.594	0.315
Double Shovel UC	**0.087**	0.375	0.160
I and C td UC	0.187	0.733	0.916
C mesial ridge UC	0.317	0.408	0.149
CDAR UC	**0.070**	0.933	0.711
Double shovel UP1	0.568	0.780	0.636
P m and d cusps UP	0.510	0.388	0.126
Metacone UM1	—	—	—
Metacone UM2	—	—	—
Metacone UM3	—	0.499	0.601
Hypocone UM1	—	—	—
Hypocone UM2	**0.029**	0.676	0.247
Hypocone UM3	0.219	0.879	0.763
Cusp 5 UM1	0.169	0.255	0.350
Cusp 5 UM2	0.656	0.706	0.956
Cusp 5 UM3	**0.021**	0.242	0.410
Carabelli UM1	0.324	0.815	0.746
Carabelli UM2	0.245	0.858	**0.025**
Carabelli UM3	—	0.550	**0.079**
Parastyle UM1	—	0.471	0.589

Parastyle UM2	0.872	0.541	0.210
Parastyle UM3	0.278	**0.015**	0.579
Root no. UM1	0.628	0.805	0.572
Root no. UM2	**0.037**	0.354	0.410
Root no. UM3	**0.049**	0.146	0.319
Shovel LI	0.201	—	—
CDAR LC	0.562	0.208	**0.004**
P ling cusp LP1	0.207	**0.062**	0.865
P ling cusp LP2	0.483	0.411	0.419
Tome root LP1	0.701	0.158	0.484
Ant Fovea LM1	0.15	0.137	0.741
Ant Fovea LM2	—	0.159	0.227
P m and d cusps UP2	0.446	0.557	0.703
Groove pattern LM1	—	0.254	0.477
Groove pattern LM2	0.240	0.924	0.361
Groove pattern LM3	0.346	0.608	0.225
Cusp no. LM1	—	—	—
Cusp no. LM2	—	—	—
Cusp no. LM3	—	—	—
Def Wrinkle LM1	**0.077**	**0.067**	**0.075**
Def Wrinkle LM2	0.132	**0.038**	0.546
Def Wrinkle LM3	0.929	0.913	0.233
DT crest LM1	1.000	0.153	0.787
DT crest LM2	0.751	0.448	0.201
DT crest LM3	0.303	—	—
Protostylid LM1	0.429	0.189	—
Protostylid LM2	0.738	0.385	0.418
Protostylid LM3	0.759	0.865	0.584
Cusp 5 LM1	0.208	0.452	0.558
Cusp 5 LM2	0.447	0.843	0.278
Cusp 5 LM3	**0.047**	0.686	0.944
Cusp 6 LM1	0.307	0.671	0.120
Cusp 6 LM2	**0.031**	0.710	0.480
Cusp 6 LM3	0.319	0.184	0.975
Cusp 7 LM1	0.581	0.520	0.128
Cusp 7 LM2	0.605	0.310	0.342

Cusp 7 LM3	0.221	**0.043**	0.563
Torso. Angle	—	0.328	0.298
Root no. LM1	0.442	0.950	**0.001**
Root no. LM2	—	0.466	**0.046**
Root no. LM3	0.194	0.739	0.944
Enamel extension UM1	**0.003**	**0.033**	0.389
Root no. UP1	**0.009**	0.193	0.103
Peg, reduced absent UM3	—	—	—
Root no. LC	—	—	—

Non-metric dental comparisons between the Iron Age sample and modern and historical samples

Table 5.2.3 shows the Chi-squared values for the non-metric comparisons between the Late Iron Age sample, the Toutswe sample and the Historic Cave and modern cadaver sample. The table shows the same traits, abbreviations and layout as Table 5.2.1 and Table 5.2.2.

Relative to the within-Iron Age comparisons, comparisons between Iron Age and modern/historical samples indicate more substantial differences. When comparing the modern cadaver sample to the Late Iron Age sample fifteen traits (out of 76) showed significant differences where P-value less than 0.1. Torsomolar angle, LM1 protostylid, UM3 metacone and UM3 Carabelli's trait show significance where $p<0.01$. UI2 and C double shovelling, UI2 tuberculum dentale, UP2 mesial and distal cusps, UM1 Carabelli's trait, UM2 root number, protostylid LM2 and LM1 root number are also significantly different (where $0.01<p<0.05$). UM2 parastyle, LM3 cusp 7 and LM1 deflecting wrinkle show significant differences where $0.05<p<0.1$.

Eleven out of the 76 traits showed significant difference (P-value less than 0.1) between the Toutswe and modern samples. Torsomolar angle and UM3 metacone show significant difference where p<0.01. Double shovel (UI2 and UC), UM2 and LM1 root number and LM3 cusp 6 are significantly different where 0.01<p<0.05. LM2 deflecting wrinkle, UM1 and UM3 Carabelli's trait and UM1 cusp 5 show significant difference where 0.05<p<0.1. Eight of those differences are the same between the modern and both the LIA and Toutswe comparisons (UI2 and C double shovel, UM3 metacone, UM1 and UM3 Carabelli's trait, UM2 and LM1 root number and torsomolar angle).

Comparing these results to Appendix 7.1 can show how these traits differ between the modern cadaver and Iron Age samples. The modern cadaver sample shows statistically higher frequencies of double shovel (UI2 and UC), tuberculum dentale (UI2), Upper molar cusp 5 (UM1), Carabelli's trait (UM1), LM1 root number, deflecting wrinkle (LM1compared to LIA and LM2 compared to Toutswe), protostylid (LM1 and LM2), cusp 6 (LM2 and LM3), cusp 7 (LM3) and torsomolar angle (LM3). The samples also show a lower frequency for UM2 root number.

The Historic Cave sample was compared to the Late Iron Age sample and the modern cadaver sample. Nine traits were significantly different between the Historic Cave and LIA samples (P-values less than 0.1). No traits were significantly different where p<0.01. UI2 shovelling, UI2 and UC tuberculum dentale, LC distal accessory ridge, LM1 groove pattern, LM2 cusp 6 show significant difference where 0.01<p<0.05. UM2 cusp 5, LP1 Tome's root and LM2 cusp number show significant difference, where 0.05<p<0.1. However, LM2 cusp number and cusp 6 may be reflecting the same trait difference.

Ten traits were significantly different between the Historic Cave and modern cadaver sample. UM2 cusp 5 and LM1 groove pattern show significant difference where p<0.01. UI2 shovel, LC distal accessory ridge and LM1 deflecting wrinkle show significant difference where 0.01<p<0.05 and UM3 and LM1 root number, LM2 cusp number and LM1 cusp 6 show significant difference where 0.05<p<0.1. Five of those involve the same trait as the differences between the HC and LIA sample. This includes UI2 shovelling, canine mesial ridge, UM2 cusp 5, LC distal accessory ridge, LM1 groove pattern and LM2 cusp number.

The Historic Cave sample shows higher frequencies, compared with the Iron Age sample, of the following traits: UI2 shovelling, UI2 and UC tuberculum dentale, Cusp 6 (LM1) and Tome’s root (LP1). Low frequencies (as above) for the following traits were also seen: Cusp 5 (UM2) and canine distal accessory ridge (LC). However, the trait frequencies representing the Historic Cave sample is based on a small sample size and many of these traits are unlikely to be accurate reflections of the actual population frequencies. Traits observable on three or fewer teeth were left out of this list.

Table 5.2.3 Table showing the p-values for non-metric comparisons between second millennium Iron Age samples (Late Iron Age-LIA- and Toutswe-TOU), the Historic Cave sample (HC) and the modern cadaver sample (MOD).

	LIA / MOD	**TOU / MOD**	**HC / LIA**	**HC / MOD**
Winging- UI1	0.266	0.102	0.158	0.673
Labial Curve-UI1	0.556	0.172	0.206	0.107
Shovel- UI1	0.459	0.821	0.499	0.293
Double Shovel UI1	—	—	—	—
Int. Groove UI1	—	—	—	—
I and C td UI1	0.228	0.604	0.507	0.201
Shovel UI2	0.769	0.226	**0.021**	**0.037**
Double Shovel UI2	**0.035**	**0.017**	0.482	0.121
Int Groove UI2	0.457	0.287	0.270	0.425
I and C td UI2	**0.030**	0.564	**0.040**	0.850
Shovel UC	0.779	0.450	0.120	0.179
Double Shovel UC	**0.015**	**0.011**	0.808	0.102
I and C td UC	0.116	0.141	**0.010**	0.185
C mesial ridge UC	0.959	0.423	**0.061**	**0.063**
CDAR UC	0.376	0.522	0.251	0.494
Double shovel UP1	0.106	0.128	0.516	0.149
P m and d cusps UP	0.333	0.956	0.597	0.813
Metacone UM1	—	—	—	—
Metacone UM2	—	—	—	—
Metacone UM3	**0.000**	**0.005**	0.226	0.280
Hypocone UM1	—	—	—	—
Hypocone UM2	0.236	0.590	0.624	0.815
Hypocone UM3	0.929	0.933	1.000	0.964
Cusp 5 UM1	0.425	**0.053**	0.401	0.119
Cusp 5 UM2	0.212	0.542	**0.080**	**0.005**
Cusp 5 UM3	0.428	0.510	0.956	0.713
Carabelli UM1	**0.015**	**0.085**	0.451	0.534
Carabelli UM2	0.557	0.776	0.257	0.492
Carabelli UM3	**0.008**	**0.053**	0.211	0.565
Parastyle UM1	0.362	—	0.690	—

Parastyle UM2	**0.051**	0.164	0.335	—
Parastyle UM3	0.216	0.209	0.218	0.867
Root no. UM1	0.123	0.244	0.643	0.294
Root no. UM2	**0.036**	**0.029**	0.580	0.180
Root no. UM3	0.124	0.754	0.329	**0.076**
Shovel LI	—	—	—	—
CDAR LC	0.779	0.318	0.015	**0.030**
P ling cusp LP1	0.788	0.111	0.218	0.301
P ling cusp LP2	0.944	0.446	0.588	0.612
Tome root LP1	0.320	0.885	**0.055**	0.565
Ant Fovea LM1	0.325	0.383	0.731	0.632
Ant Fovea LM2	0.112	0.531	0.784	0.329
P m and d cusps UP2	**0.030**	0.284	0.269	0.736
Groove pattern LM1	0.519	0.439	**0.043**	**0.009**
Groove pattern LM2	0.694	0.823	0.401	0.290
Groove pattern LM3	0.159	0.124	0.796	0.773
Cusp no. LM1	—	—	—	—
Cusp no. LM2	—	—	**0.051**	**0.071**
Cusp no. LM3	—	—	—	—
Def Wrinkle LM1	**0.082**	0.693	0.266	**0.048**
Def Wrinkle LM2	0.748	**0.067**	0.363	0.302
Def Wrinkle LM3	0.475	0.725	0.196	0.377
DT crest LM1	0.129	0.893	0.646	0.482
DT crest LM2	0.825	0.557	0.505	0.609
DT crest LM3	—	—	—	—
Protostylid LM1	**0.009**	0.164	—	0.173
Protostylid LM2	**0.022**	0.305	0.450	0.476
Protostylid LM3	0.615	0.593	0.517	0.621
Cusp 5 LM1	0.314	—	0.576	—
Cusp 5 LM2	0.425	0.646	0.666	0.916
Cusp 5 LM3	0.690	0.903	0.640	0.520
Cusp 6 LM1	0.177	0.128	0.259	**0.056**
Cusp 6 LM2	**0.028**	0.163	**0.034**	0.609
Cusp 6 LM3	0.109	**0.013**	0.623	0.298
Cusp 7 LM1	0.547	0.242	0.394	0.194
Cusp 7 LM2	0.165	0.964	0.138	0.557

Cusp 7 LM3	0.009	0.796	0.564	0.109
Torso. Angle	**0.000**	**0.003**	—	—
Root no. LM1	**0.010**	**0.035**	0.491	**0.070**
Root no. LM2	0.598	—	0.687	—
Root no. LM3	0.376	0.310	0.300	0.270
Enamel extension UM1	1.000	1.000	0.397	—
Root no. UP1	0.753	0.486	0.592	0.830
Peg, reduced absent UM3	—	—	—	—
Root no. LC	—	—	—	—

Non-metric dental comparisons between the Iron Age and small sub-set of Wendy Black's Khoesan sample

When comparing the total Iron Age sample with the Khoesan sample (Table 5.2.4), 22 out of the 63 non-metric traits that were compared showed significant difference (P-value less than 0.1; ten of those traits had P-values less than 0.01). UI1 winging, UI2 tuberculum dentale, UC distal accessory ridge, UM1 Carabelli's trait, LP1 lingual cusp variation, Antereor Fovea LM1, LM2 cusp 5 and LM1, LM2 and LM3 cusp 7 show significant difference where $p<0.01$. UI1 double shovelling, UC mesial ridge, UM1 cusp 5, LM2 and LM3 groove pattern, LM1 disto-trigonid (DT) crest and LM1 protostylid show significant difference where $0.01<p<0.05$. UI2 interruption groove, UC and UP1 double shovelling, LM2 DT crest and LP1 Tome's root are at $0.05<p<0.1$.

When comparing the Khoesan to the modern cadaver sample, 24 of the 63 traits showed significant difference (P-value less than 0.1; 16 of those traits had p-values less than 0.01).

UI2 tuberculum dentale, UC and UP1 double shovelling, UC distal accessory ridge, UM3 metacone, UM1 cusp 5, LP1 lingual cusp variation, LM1 anterior fovea, LM1 disto-trigonid crest, LM2 protostylid, LM2 cusp 5, LM3 cusp 6, LM1, LM2 and LM3 cusp 7 and torsomolar angle are significantly different where $p<0.01$. UI1 winging, UC mesial ridge, UC shovelling, UP2 mesial and distal cusps and LM2 cusp 6 show significant difference where $0.01<p<0.05$. UI2 double shovelling, UM2 cusp 5 and LM2 disto-trigonid crest show significant difference where $0.05<p<0.1$. Fifteen of these differences are the same as those comparing Khoesan to the Iron Age sample. They include UI1 winging, UI2 tuberculum dentale, UC and UP1 double shovelling, UC mesial ridge, UC distal accessory ridge, UM1 cusp 5, LP1 lingual cusp variation, LM1 anterior fovea, LM1 and LM2 disto-trigonid crests, LM2 cusp 5 and LM1, LM2 and LM3 cusp 7.

Table 5.2.4 Table showing the p-values for non-metric comparisons between the pooled Iron Age sample (IA), Wendy Black's Khoesan sample (KHO) and the modern cadaver sample (MOD).

	IA / KHO	KHO / MOD
Winging- UI1	**0.000**	**0.026**
Labial Curve-UI1	0.699	0.249
Shovel- UI1	0.913	0.975
Double Shovel UI1	**0.027**	0.187
Int. Groove UI1	—	—
I and C td UI1	0.270	0.573
Shovel UI2	0.278	0.446
Double Shovel UI2	0.526	**0.094**
Int Groove UI2	**0.090**	0.223
I and C td UI2	**0.000**	**0.000**
Shovel UC	0.105	**0.043**
Double Shovel UC	**0.097**	**0.001**
I and C td UC	0.352	0.933
C mesial ridge UC	**0.018**	**0.025**
CDAR UC	**0.000**	**0.000**
Double shovel UP1	**0.063**	**0.002**
P m and d cusps UP	0.491	0.197
Metacone UM1	—	—
Metacone UM2	—	—
Metacone UM3	0.614	**0.002**
Hypocone UM1	—	—
Hypocone UM2	0.624	0.651
Hypocone UM3	0.628	0.465
Cusp 5 UM1	**0.023**	**0.000**
Cusp 5 UM2	0.803	**0.055**
Cusp 5 UM3	0.518	0.551
Carabelli UM1	**0.006**	0.660
Carabelli UM2	0.666	0.284
Carabelli UM3	0.169	0.318
Parastyle UM1	0.306	—
Parastyle UM2	0.198	—
Parastyle UM3	0.710	0.597
Shovel LI	0.748	—

CDAR LC	0.869	0.718
P ling cusp LP1	**0.003**	**0.002**
P ling cusp LP2	0.344	0.381
Tome root LP1	**0.092**	0.518
Ant Fovea LM1	**0.000**	**0.001**
P m and d cusps UP2	0.552	**0.036**
Groove pattern LM1	0.806	0.729
Groove pattern LM2	**0.017**	0.427
Groove pattern LM3	**0.016**	0.337
Cusp no. LM1	—	—
Cusp no. LM2	—	—
Cusp no. LM3	—	—
Def Wrinkle LM1	0.933	0.113
Def Wrinkle LM2	0.909	0.845
DT crest LM1	**0.012**	**0.003**
DT crest LM2	**0.095**	**0.093**
DT crest LM3	0.409	—
Protostylid LM1	**0.040**	0.187
Protostylid LM2	0.153	**0.003**
Protostylid LM3	0.716	0.221
Cusp 5 LM1	0.232	—
Cusp 5 LM2	**0.000**	**0.000**
Cusp 5 LM3	0.513	0.802
Cusp 6 LM1	0.836	0.165
Cusp 6 LM2	0.417	**0.036**
Cusp 6 LM3	0.432	**0.006**
Cusp 7 LM1	**0.000**	**0.000**
Cusp 7 LM2	**0.000**	**0.000**
Cusp 7 LM3	**0.000**	**0.000**
Torso. Angle	0.235	**0.004**

Additional non-metric comparisons (Torus, midline diastema, rocker jaw)

Other non-metric traits can also be compared between the Iron Age populations: midline diastema, torus on the mandible, torus on the maxilla and rocker jaw. Table 5.2.5 shows the total number of specimens where it was possible to measure the trait in each sample and the proportion of each sample this trait is present. There are a low proportion of specimens with rocker jaw (17% of total specimens). Twenty-one of the 84 specimens (25%) had a medium or marked mandibular torus and 2 of the 69 specimens (3%) had a marked or medium maxillary torus. A large number of midline diastema between the frontal incisors was seen in the Iron Age samples. Although the Iron Age sample size for this trait is small, 17 of the 35 specimens (49%) show a midline diastema.

Table 5.2.5 Table showing other non-metric traits for the Iron Age samples

		Midline diastema	**Torus (Lower)**	**Torus (Upper)**	**Rocker jaw**
EIA	Total	2	12	6	7
	Present	50%	33%	17%	14%
Toutswe	Total	8	16	14	10
	Present	25%	25%	0%	10%
Zambia	Total	9	18	15	9
	Present	44%	28	0%	33%
LIA E	Total	1	8	12	5
	Present	100%	12.5%	0%	20%
LIA W	Total	15	30	22	15
	Present	60%	23%	5%	13%

5.3 Metric dental comparisons

T-tests

Comparisons were made between buccolingual and mesiodistal measurements for each tooth. T-tests conducted to test the statistical significance of these differences are shown in Appendix 7.2. This meant a total of 32 measurements for all groups, except the Historic Cave sample. Table 5.3.1 to Table 5.3.6 presents a summary of those T-tests in the form of a matrix, where the total number of T-tests per sample and the number of T-tests where the samples were significantly different is recorded (where p<0.1, p<0.05 and p<0.01).

Table 5.3.1 Table showing proportion of significantly different T-tests per comparison (where p<0.1). All values are number of p-values where p<0.1 out of the total measurements (32 for all populations except Historic Cave, which is out of 30 measurements). This includes the EIA-T (EIA including the Toutswe specimens), LIA, ZAM (Zambian), Historic Cave (HC), modern cadaver (MOD) and Khoesan (KHOE) samples.

0.1	EIA-T	LIA	ZAM	HC	MOD	KHOE
EIA-T	—	1	3	4	13	16
LIA	—	—	2	5	13	15
ZAM	—	—	—	3	4	12
HC	—	—	—	—	6	6
CAD	—	—	—	—	—	11

Table 5.3.1 presents the matrix where the number of measurement which were significantly different ($p<0.1$) between the larger Iron Age groups (EIA-T, LIA and ZAM), the Historic Cave sample, the modern cadavers and the Khoesan sample are shown. Comparisons between the Iron Age groups show relatively few significant differences. When the Early Iron Age (including the Toutswe specimens; EIA-T) metric data was compared with the Late Iron Age metric data, only one of the 32 measurements was shown to be statistically significantly different ($p<0.1$). Similarly, comparing the Zambian sample to the EIA-T and the LIA samples, only three and two of the 32 t-tests are significantly different, respectively. Compared with the Historic Cave specimens, relatively more differences are seen, but there are still only a few. There are only 30 measurements when comparing to the HC sample. There are four significantly different variables between HC and the EIA-T, five between HC and LIA and 3 between HC and the Zambian sample. There are more significantly different measurements comparing the modern cadaver sample with the Iron Age samples south of the Zambezi. There were 13 total significantly different measurements between the modern sample and both the EIA-T and LIA samples. However, there are only four significant differences between the Zambian sample and the modern sample and six significant differences between the HC and modern samples.

The Khoesan sample differs even further from the Iron Age sample, with 16, 15 and 12 significant differences seen when compared with the EIA-T, LIA and Zambian samples, respectively. There are 11 significant differences seen between the Khoesan and cadaver samples. There are fewer significant differences between the Khoesan and HC sample (6 out of 30). While few significant differences are seen between the Iron Age samples, a larger proportion of differences are seen between the modern cadavers and Iron Age samples, and between the Iron Age and Khoesan samples. The LIA sample differs more from the Historic

Cave sample than the other Iron Age samples but less than the cadaver sample. The Historic Cave sample is much more similar to the cadaver sample than the Iron Age samples south of the Zambezi are to the cadaver sample. The Zambian sample seems the most similar to the HC and modern samples.

Table 5.3.2 Table showing number of significantly different T-tests different T-tests per comparison (where p<0.1). All values are number of p-values where p<0.1 out of the total measurements (32). This includes the divided samples: LIA east (LIA-E), LIA west (LIA-W), EIA (excluding Toutswe) and Toutswe (TOU).

0.1	LIA-E	LIA-W	TOU	EIA
LIA-E	—	0	1	2
LIA-W	—	—	3	0
TOU	—	—	—	2

Table 5.3.2 shows a smaller matrix, showing the significant differences between only the smaller Iron Age groups, where p<0.1 (32 total measurements). It separates the LIA into an eastern sample and western sample. It also includes the EIA group without the Toutswe specimens and the Toutswe sample. The LIA samples show no significant differences (where p<0.1) when compared with each other. The LIA eastern sample is significantly different from the Toutswe and EIA sample by one and two measurements, respectively. The LIA western sample differs by 3 metric traits when compare with the Toutswe sample, but does not differ in any of the measurements when compared with the EIA sample. The EIA and Toutswe comparisons showed two significant differences.

Table 5.3.3 and Table 5.3.4 show the significant differences between the samples, where p<0.05, showing the same structure as Tables 5.3.1 and 5.3.2, respectively. It indicates only one significant difference between the LIA and EIA-T samples, no significant differences between the Zambian and LIA samples and three significant differences between the Zambian and EIA+T samples. The HC sample shows no significant differences between the Zambian sample, and three each for the EIA-T and LIA samples. The comparatives with the modern sample reflect the trend seen in Table 5.3.1. The EIA-T is significantly different in 11 measurements, the LIA by 9 and the Zambian and HC samples only differ by 3 and 4 measurements, respectively. The Khoesan show the most differences between the Iron Age samples, with 12 significantly different measurements between the EIA-T, 13 with the LIA and 7 with the Zambian sample. Eight significant differences are seen between the Khoesan and modern samples. Only 3 significant differences are seen between the Khoesan and HC (out of 30).

Table 5.3.3 Table showing proportion of significantly different T-tests per comparison (where p<0.05). All values are number of p-values where p<0.05 out of the total measurements (32 for all populations except Historic Cave, which is out of 30 measurements. This includes the EIA-T (EIA including the Toutswe specimens), LIA, ZAM (Zambian), Historic Cave (HC), modern cadaver (MOD) and Khoesan (KHOE) samples.

0.05	EIA-T	LIA	ZAM	HC	CAD	KHOE
EIA-T	—	1	3	3	11	12
LIA	—	—	0	3	9	13
ZAM	—	—	—	0	3	7
HC	—	—	—	—	4	3
CAD	—	—	—	—	—	8

Table 5.3.4 reflects the trends seen in Table 5.3.2. There is only one significant difference between the LIA eastern sample with both the Toutswe and EIA samples; 3 significant differences between the LIA western sample and the Toutswe sample and 2 significant differences between the EIA and Toutswe samples. There are no significant differences between both the LIA samples and the LIA western sample and EIA sample.

Table 5.3.4 Table showing proportion of significantly different T-tests per comparison (where p<0.05). All values are number of p-values where p<0.05 out of the total measurements (32). This includes the divided samples: LIA east (LIA-E), LIA west (LIA-W), EIA (excluding Toutswe) and Toutswe (TOU).

0.05	LIA-E	LIA-W	TOU	EIA
LIA-E	—	0	1	1
LIA-W	—	—	3	0
TOU	—	—	—	2

Tables 5.3.5 and 5.3.6 are also similar to Tables 5.3.1and 5.3.2, respectively, but include all P-values for the T-tests that were less than 0.01. Although the number of significantly different T-tests is smaller in general (only by one or two t-tests per comparison) the general pattern is the same as that discussed for Tables 4.3.3 and 4.3.4. There are no significant differences (p<0.01) between the Iron Age groups (EIA-T, LIA and Zambian samples). Only one significant difference occurs between HC and both EIA-T and LIA, but none between HC and the Zambian sample. The modern sample differs more between the EIA-T (four differences) and LIA (three differences) than the Zambian sample (one difference) and the HC sample (two differences). The Khoesan sample differs by 8 and 9 measurements between the EIA-T and LIA samples, respectively, and by one measurement when compared with the

Zambian sample. Only two significant differences are calculated between the modern sample and the Khoesan sample, and no significant differences between the Khoesan and HC samples. Table 5.3.4 shows no significant differences between the LIA samples (east and west) to each other or to both the Toutswe and EIA samples. There is only one significant difference between the Toutswe and EIA samples, where p<0.01.

Table 5.3.5 Table showing proportion of significantly different T-tests per comparison (where p<0.01). All values are number of p-values where p<0.01 out of the total measurements (32 for all populations except Historic Cave, which is out of 30 measurements. This includes the EIA-T (EIA including the Toutswe specimens), LIA, ZAM (Zambian), Historic Cave (HC), modern cadaver (MOD) and Khoesan (KHOE) samples.

0.01	EIA-T	LIA	ZAM	HC	CAD	KHOE
EIA-T	—	0	0	1	4	8
LIA	—	—	0	1	3	9
ZAM	—	—	—	0	1	1
HC	—	—	—	—	2	0
CAD	—	—	—	—	—	2

Table 5.3.6 Table showing proportion of significantly different T-tests per comparison (where p<0.01). All values are number of p-values where p<0.01 out of the total measurements (32). This includes the divided samples: LIA east (LIA-E), LIA west (LIA-W), EIA (excluding Toutswe) and Toutswe (TOU).

0.01	LIA-E	LIA-W	TOU	EIA
LIA-E	—	0	0	0
LIA-W	—	—	0	0
TOU	—	—	—	1

Principal Components Analyses on dental measurements

Table 5.3.7 shows the Principal Components calculated in PAST. The following measurements were used to construct the PCA: Buccolingual lengths of UM1L, UM2L, LP1L, LM1L and LM2L; and mesiodistal lengths of UM1L, UM2L, LP1L, LM1L and LM2L. The EIA-T (n=19), LIA (n=21), ZAM (n=15) and modern cadaver (n=34) samples were compared. The first Principal Component (PC1) reflects 67.150% of the variance (Table 5.3.7). PC2 and PC3 reflect 6.892% and 6.481% respectively.

Table 5.3.7 Table showing the eigenvalue and percentage variance for each of the principal components (PC) based on the dental measurements.

PC	Eigenvalue	% variance
1	2.973	67.150
2	0.305	6.892
3	0.287	6.481
4	0.198	4.477
5	0.182	4.121
6	0.154	3.472
7	0.114	2.564
8	0.097	2.194
9	0.075	1.692
10	0.042	0.957

Figure 5.3.1 represents a graph of PC1 versus PC2. It is based on a between-group V/CV matrix. The 95% ellipses are indicated. The component loadings for each of the measurements are seen in Table 5.3.8, but are also presented graphically in Figure 5.3.2

(PC1). All of the loadings are positive and comparable in magnitude, with the buccolingual UM2L measurement being weighted the highest (0.423), closely followed by the mesiodistal LM2L (0.398) and buccolingual UM1L (0.339). Mesiodistal LP1L has the lowest weighting (0.174). These results indicate that that there is no discernible inter-population difference in this size variation.

Table 5.3.8 Table showing the loadings for each of the dental measurements used to calculate the principal components (PC). Buccolingual (BL) and Mesiodistal (MD) measurements were used.

	Axis 1	**Axis 2**	**Axis 3**	**Axis 4**	**Axis 5**	**Axis 6**	**Axis 7**	**Axis 8**	**Axis 9**	**Axis 10**
BL-UM1L	0.339	-0.361	-0.204	-0.273	0.342	0.282	-0.115	-0.202	0.493	0.381
BL-UM2L	0.423	-0.168	-0.503	-0.018	-0.187	0.292	0.033	-0.075	-0.227	-0.601
BL-UM1L	0.288	0.118	0.530	-0.054	0.139	0.265	-0.621	-0.174	-0.331	-0.073
BL-UM2L	0.302	0.783	-0.186	-0.209	0.357	0.054	0.200	0.205	-0.027	0.067
BL-LP1L	0.208	0.016	0.205	0.770	0.257	0.201	0.380	-0.253	0.082	-0.014
MD-LM1L	0.308	-0.220	0.230	-0.121	0.382	-0.669	0.063	0.075	0.135	-0.411
MD-LM2L	0.343	-0.146	-0.321	0.353	-0.016	-0.343	-0.248	0.272	-0.389	0.478
MD-LP1L	0.174	-0.044	0.211	0.168	-0.205	0.250	-0.120	0.773	0.407	-0.119
MD-LM1L	0.295	-0.242	0.375	-0.344	-0.208	0.128	0.578	0.112	-0.357	0.251
MD-LM2L	0.398	0.291	0.088	0.017	-0.636	-0.280	-0.047	-0.358	0.355	0.095

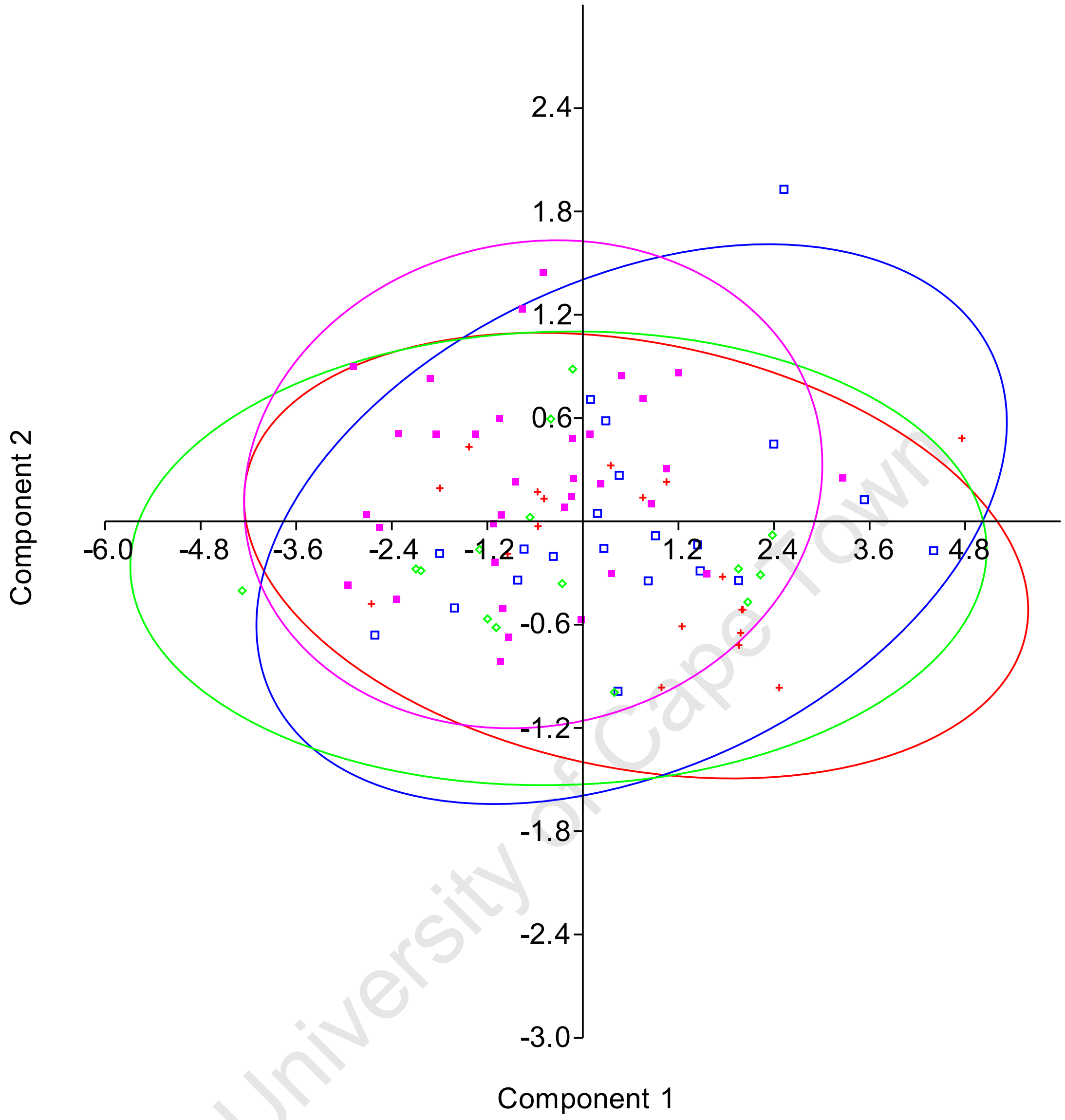

Figure 5.3.1 Graph plotting individuals on component 1 (PC1) and component 2 (PC2) for dental measurements. The pink specimens are the modern cadaver individuals, the blue is the LIA individuals, the red is the EIA individuals and the green are the Zambian individuals. The 95% ellipses are shown.

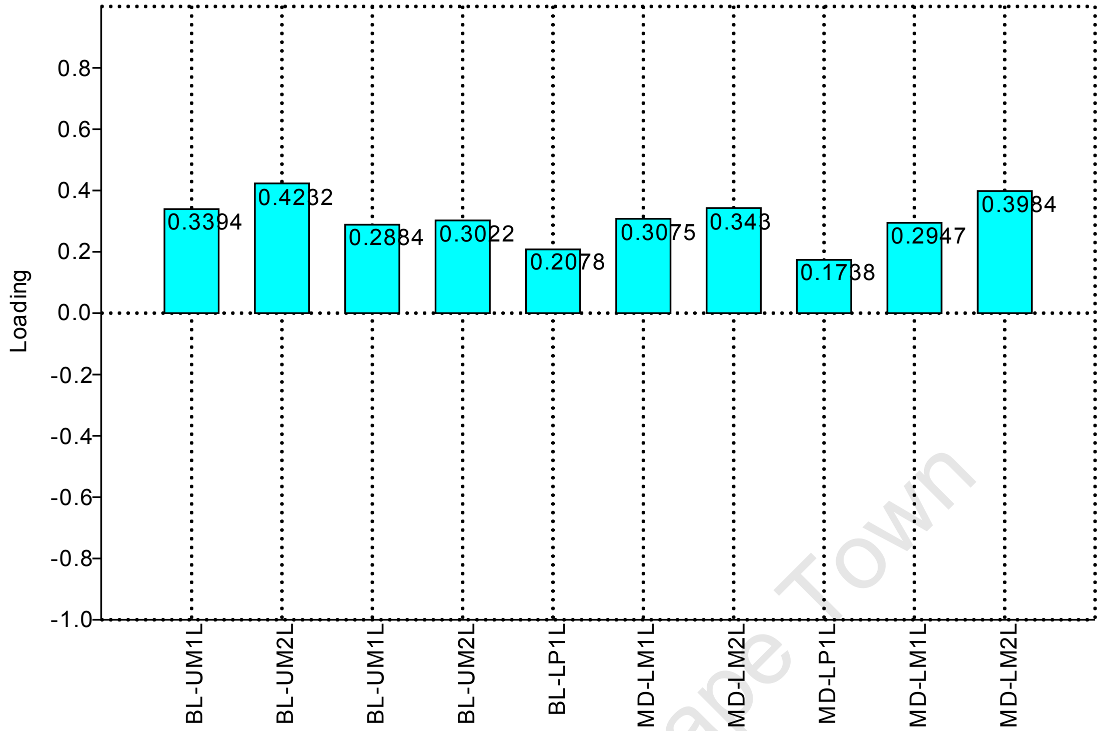

Figure 5.3.2 Principal component 1 loadings for dental measurements.

5.4: Non-metric dental comparisons between the Iron Age sample and the literature

In order to compare the Iron Age sample with the existing literature on sub-Saharan dental variation, the data presented above are compared with sub-Saharan dental data from Irish (1993 and 1997) and Hanihara (2008) (Table 5.4.1). Certain traits show similar frequencies: UI1 double shovel, Carabelli's trait (UM1), root number (UM2, LM1, LM2 and LC), protostylid (LM1), enamel extension (UM1) and pegging, reduction or absence in UM3. Other trait frequencies differ substantially: canine mesial ridge (or bushmen's canine), cusp 5 (UM1), LM2 groove pattern and cusp number, DT crest (LM1) and root number (UP1).

Table 5.4.2 shows the p-values of these non-metric comparisons, calculated using Chi-squared tests. It includes comparisons between Irish (1993 and 1997) and the Iron Age, modern and Historic Cave samples. The majority of the trait frequencies are significantly different between Irish's data and the Iron Age sample (15 out of 20 traits; where $p<0.1$; 12 where $0.01<p<0.05$ and 9 where $0.05<p<0.01$).). These include UI2 interruption groove, canine mesial ridge, hypocone UM2, UM1 cusp 5, Tomes's root LP2, LM2 groove pattern, LM2 cusp number, LM1 deflecting wrinkle, LM1 DT crest, LM1 cusp 6, LM1 cusp 7, LM2, UP1 and LC root number and UM1 enamel extension. Figure 5.4.1 shows the proportions of traits graphically.

Table 5.4.1 Table showing the percentage comparisons between the whole Iron Age sample, Hanihara (2008) and Irish (1993 and 1997). In this table, the dashes indicate that there was no data for that trait.

	Hanihara (%)	Irish, 1993 (%)	Pooled Iron Age sample (%)
Shovel- UI1	41.7-53.1	5.3	7.4
Double Shovel UI1	0-0.9	1.1	0
Shovel UI2	56.8-47.7	—	28.2
Int Groove UI2	—	13.4	5.1
C mesial ridge UC	—	18.1	69.1
P m and d cusps UP	4.6-5.0	—	12.9
Hypocone UM2	91.4-87.6	—	83.9
Cusp 5 UM1	—	32.8	81.4
Carabelli UM1	13.8-18.6	16.4	13.1
Root no. UM2	—	83.7	89.7
Groove pattern LM2	—	52.4	86.0
Cusp no. LM2	—	24.1	100
Def Wrinkle LM1	—	2.3	16.3
DT crest LM1	0.6-1.7	1.3	24.0
Protostylid LM1	0-2.1	—	1.1
Cusp 6 LM1	17.1-23.8	16.6	26.7
Cusp 7 LM1	32.5-34.6	38.5	59.5
Root no. LM1	—	1.7	2.8
Root no. LM2	—	93.3	98.0
Enamel extension UM1	—	0.3	3.5
Root no. UP1	—	58.9	29.0
Peg, reduced, absent UM3	—	5.4	1.0
Root no. LC	—	0	0

Table 5.4.2 Table showing the p-values for the non-metric comparisons between the whole Iron Age sample and Irish (1993 and 1997)

	Total Iron Age	**Modern**	**Historic Cave sample**
Shovel- UI1	0.531	0.491	0.412
Double Shovel UI1	0.394	0.614	0.709
Int Groove UI2	**0.039**	0.226	0.215
C mesial ridge UC	**0.000**	**0.000**	**0.000**
Hypocone UM2	**0.056**	0.223	0.791
Cusp 5 UM1	**0.000**	**0.000**	**0.009**
Carabelli UM1	0.407	**0.000**	0.388
Root no. UM2	0.134	0.423	0.280
Tome root LP1	**0.023**	0.607	0.479
Groove pattern LM2	**0.000**	**0.004**	**0.011**
Cusp no. LM2	**0.000**	**0.000**	**0.000**
Def Wrinkle LM1	**0.000**	**0.000**	0.644
DT crest LM1	**0.000**	**0.000**	**0.000**
Cusp 6 LM1	**0.022**	**0.000**	0.507
Cusp 7 LM1	**0.000**	**0.000**	0.278
Root no. LM1	0.466	**0.000**	0.662
Root no. LM2	**0.077**	0.354	0.479
Enamel extension UM1	**0.001**	1.000	**0.000**
Root no. UP1	**0.000**	**0.081**	0.228
Root no. LC	**0.020**	0.100	0.422

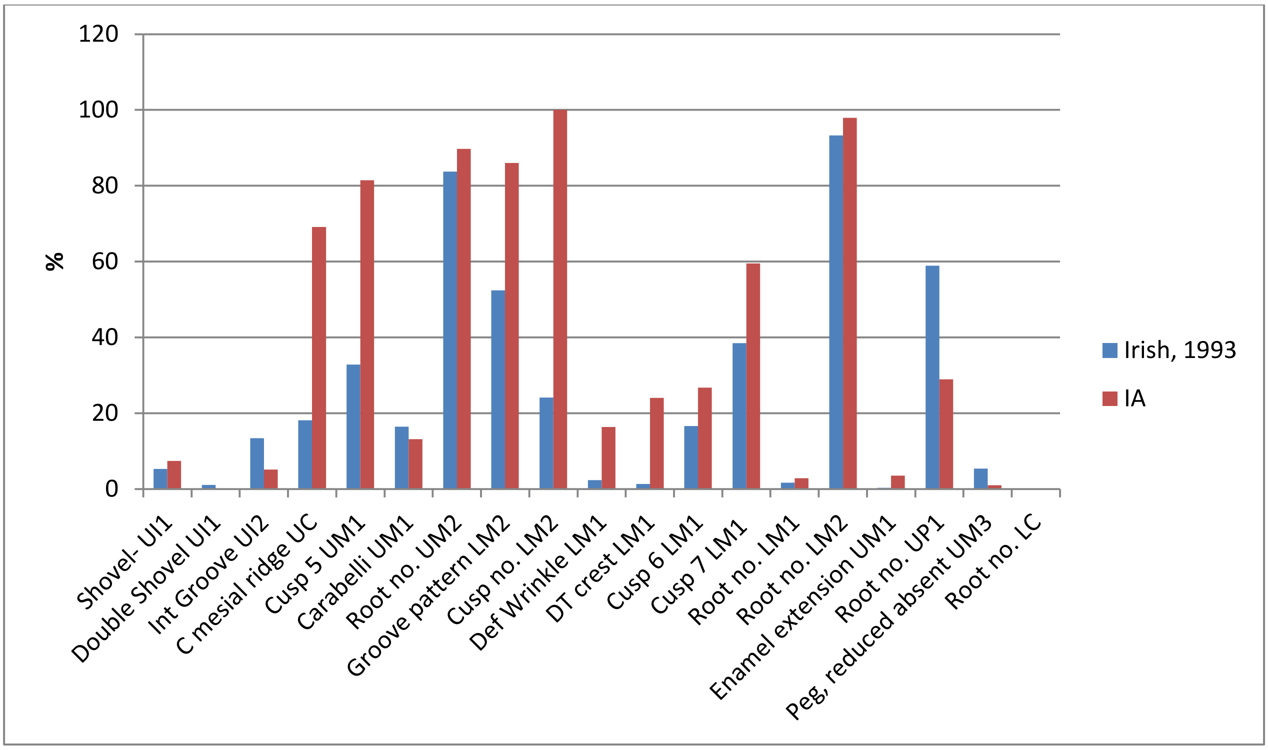

Figure 5.4.1 Graph comparing the proportions of dental traits of Irish (1993) and the Iron Age sample

Table 5.4.2 also shows the Chi-squared values for the comparison between the cadaver material and Irish (1993). Out of the 20 traits compared, eleven are significantly different, with P-values less than 0.1 (10 are significant where p<0.01). Similarly, Figure 5.4.2 shows the proportions of the two samples. Significantly larger proportions of canine mesial ridge (UC), Carabelli's trait (UM1), UM1 cusp 5, LM1 root number, cusp 6 (LM1), cusp 7 (LM1), LM2 groove pattern and cusp number, deflecting wrinkle (LM2) and DT crest (LM2) were recorded in the cadaver sample and a smaller proportion of UP1 root number. This is shown graphically in Figure 5.4.2.

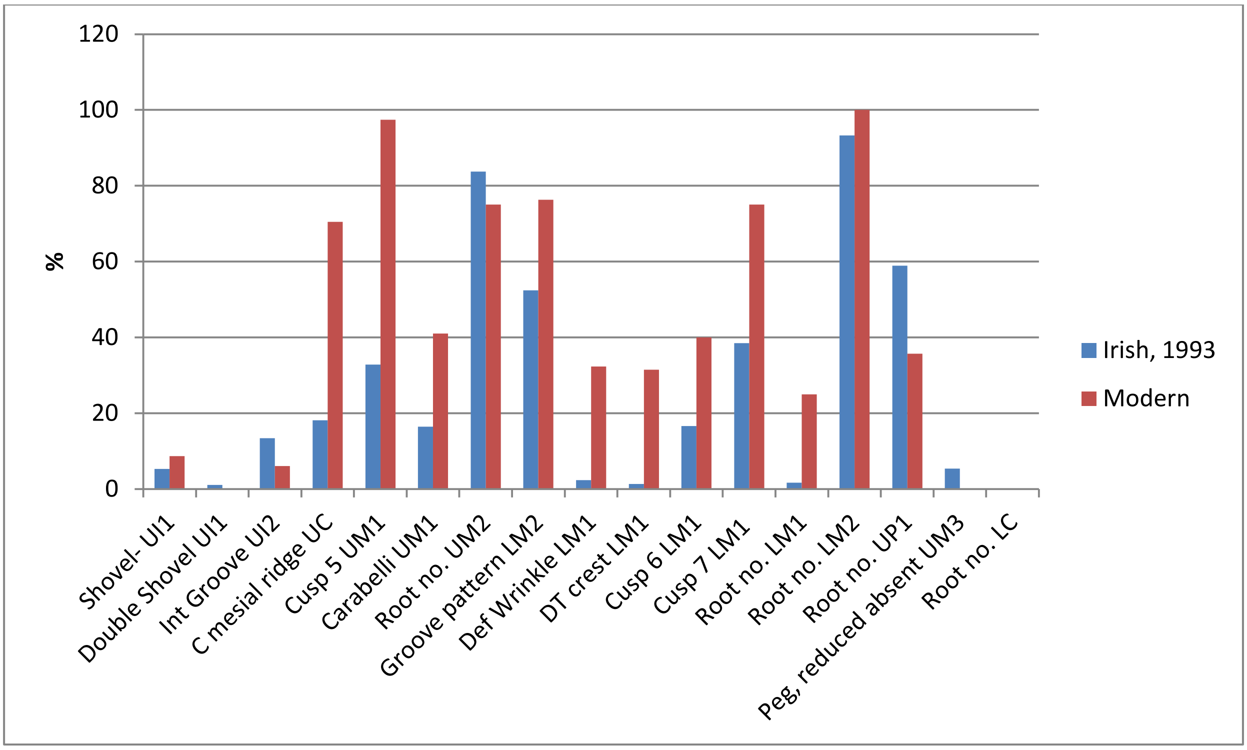

Figure 5.4.2 Graph comparing the proportions of dental traits from Irish (1993) and the modern sample

Six out of 20 compared traits differ significantly between the Historic Cave and Irish's sample ($p<0.05$; five where $p<0.01$). These include canine mesial ridge, UM1 cusp 5, LM2 groove pattern, LM2 cusp number, LM1 disto-trigonid crest and UM1 enamel extension. Canine mesial ridge, UM1 cusp 5, Y-groove pattern (LM2), LM2 cusp number and LM1 DT crest differ between Irish's data and all three samples (Iron Age, Historic Cave and modern cadaver).

Table 5.4.3 shows the chi-squared p-values of the comparisons between the sub-Saharan African dental trait frequencies from Hanihara (2008) and the pooled Iron Age sample. Out of the 13 traits compared, 7 are significantly different, with P-values below 0.05. Hanihara

(2008) has a significantly larger frequency of shovelling (UI1 and UI2) and hypocone (UM2); and significantly lower frequency of UP2 mesial and distal cusps, deflecting wrinkle (LM1), DT crest (LM1) and cusp7 (LM1).

Table 5.4.3 Table showing the p-values for the non-metric comparisons between the whole Iron Age sample and Hanihara (2008)

	Iron Age sample
Shovel- UI1	**0.000**
Double Shovel UI1	0.448
Shovel UI2	**0.000**
P m and d cusps UP1	**0.004**
Hypocone UM2	**0.022**
Carabelli UM1	0.189
P m and d cusps UP2	0.562
Def Wrinkle LM1	**0.000**
DT crest LM1	**0.000**
Protostylid LM1	0.531
Cusp 6 LM1	0.580
Cusp 6 LM2	0.694
Cusp 7 LM1	**0.000**

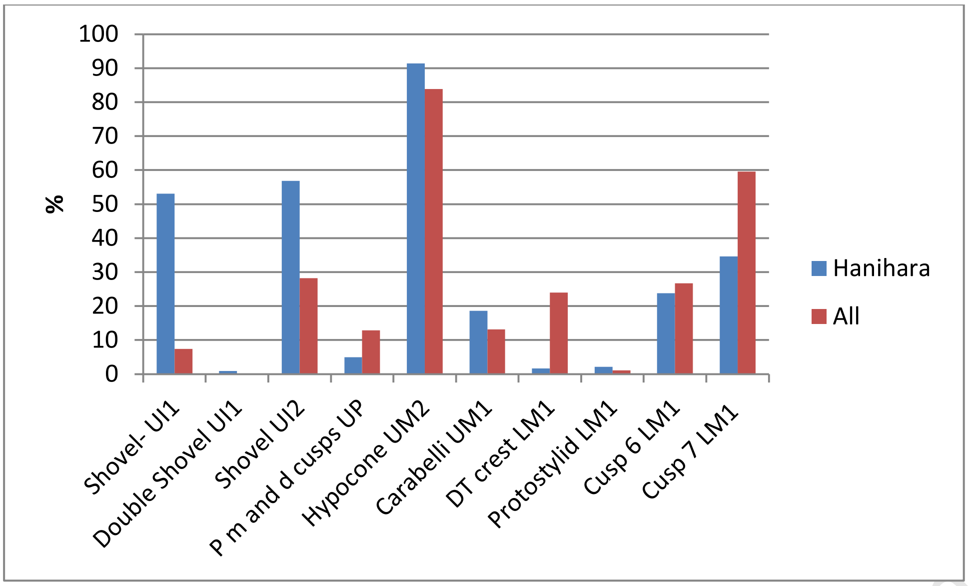

Figure 5.4.3 Graph comparing the proportions of dental traits from the sub-Saharan African sample from Hanihara (2008) and the Iron Age sample

5.5 Health and Dental modification

Dental health: hypoplasias, caries and periodontitis

Table 5.5.1 shows the number of specimens in which periodontitis and abscesses were visible. Within the samples, almost half of the specimens showed pitting and inflammation around the alveolus of the maxilla and mandible. Between 30% (Toutswe sample) and 55% (LIA western sample) of specimens had abscesses.

Table 5.5.1 Table showing the percentage of specimens with Periodontitis or Abscesses within the Iron Age samples

		Periodontitis	**Abscess**
EIA	N	9	11
	Present	78%	36%
Toutswe	N	25	23
	Present	48%	30%
Zambia	N	18	18
	Present	44%	44%
LIA E	N	10	11
	Present	20%	36%
LIA W	N	33	31
	Present	48%	55%

Table 5.5.2 shows the number of specimens and teeth with caries in the Iron Age samples. This includes the EIA (without Toutswe), LIA and Toutswe samples; the LIA has also been separated into east and west. Within each sample, the frequency of specimens with caries

ranges from 57% in the LIA east to 80% in the LIA west. The proportion of teeth with caries is much lower (all samples below 25%) indicating that while many individuals have caries, they only have them in some of their teeth. Tables 5.5.3 and 5.5.4 shows matrices of Chi-squared p-values where the five divided samples are compared with each other. In Table 5.5.3, the proportions of individuals with caries were compared. Only the comparison between the LIA samples (east and west) had a p-value<0.1. Table 5.5.4 (comparing the proportions of teeth with caries), however, shows that p<0.1 for LIA east versus west, for LIA east versus Toutswe, LIA east versus Zambia, LIA west versus EIA and LIA west versus Zambian samples.

Table 5.5.2 Table showing the proportions of specimens and teeth with caries in the Iron Age samples

Caries	Specimens (N)	Specimens with caries (%)	Teeth (N)	Teeth with caries (%)
EIA	21	62	332	16
Toutswe	34	70.5	580	18
Zambia	28	78.5	578	17
LIA E	14	57	264	12
LIA W	51	80	867	21

Table 5.5.3 Matrix showing the p-values of the comparison of proportions of individuals with caries in the divided Iron Age samples

individuals	Toutswe	Zambia	LIA E	LIA W
EIA	0.505	0.201	0.779	0.1
Toutswe	—	0.475	0.369	0.296
Zambia	—	—	0.147	0.847
LIA E	—	—	—	**0.074**

Table 5.5.4 Matrix showing the p-values of the comparison of proportions of teeth with caries in the divided Iron Age samples

teeth	Toutswe	Zambia	LIA E	LIA W
EIA	0.449	0.699	0.183	**0.05**
Toutswe	—	0.662	**0.033**	0.152
Zambia	—	—	**0.072**	**0.057**
LIA E	—	—	—	**0.001**

Figure 5.5.1 shows the proportion of teeth with caries within each of the Iron Age samples. While the LIA east sample has a lower proportion of carious teeth (11.7%), the LIA west sample has a high proportion of carious teeth (20.9%). The frequencies for the LIA, Toutswe and Zambian samples are similar (18.7%, 18.3% and 17.1%, respectively). The EIA sample showed a lower proportion of caries (16).

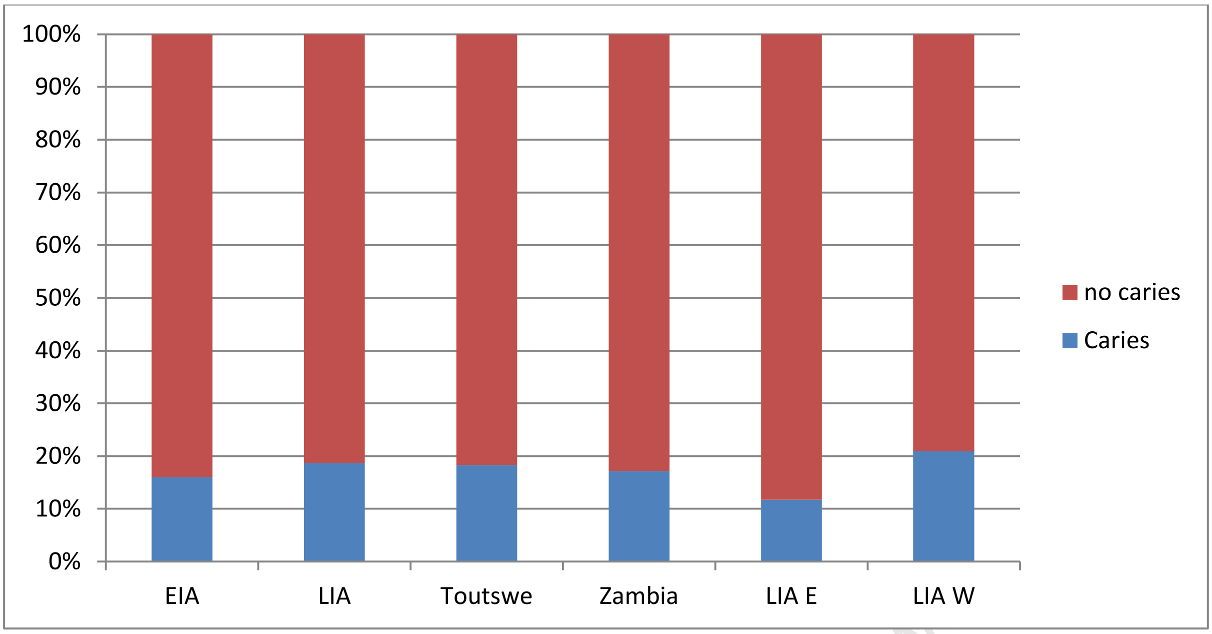

Figure 5.5.1 Graph showing proportion of teeth with caries in each of the Iron Age populations

Figure 5.5.2 shows the proportion of teeth with hypoplasia within the total Iron Age samples. Although 42.6% of teeth showed hypoplasia, incisors and canines (particularly mandibular) had a much higher frequency of hypoplastic teeth, while premolars showed a lower frequency of hypoplasia. The frequencies changed depending on tooth observed.

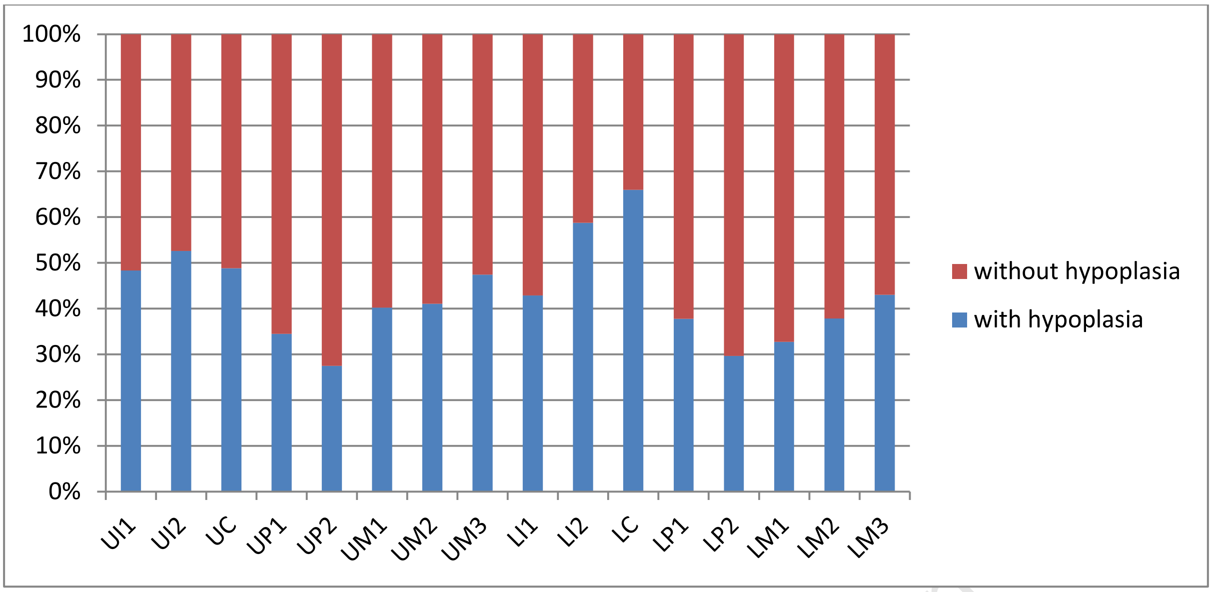

Figure 5.5.2 Graph showing proportion of teeth with hypoplasia on each tooth of total Iron Age specimens.

Cultural modification and interesting cultural features

Teeth can also show some cultural characteristics of a population. Within the Iron Age samples, three kinds of cultural features were visible. There was purposeful modification or filing of central maxillary incisors to produce a point (Figure 5.5.3 and Figure 5.5.6). There was medial wear of the central maxillary incisors, producing a V-shaped gap between the teeth (Figure 5.5.4). There was also lingual wear on the central incisors, with little or no wear on the labial surface, forming a spade-like shape (Figure 5.5.5). Specimens also showed pre-mortem incisor loss that may have been caused by dental extraction, but this is not always clear.

Figure 5.5.3 Photograph of A4143, indicating dental modification in the Early Iron Age (Upper left second incisor)

Figure 5.5.4 Photograph of A4170 (Zambian specimen) showing interesting wear pattern on upper incisors

Figure 5.5.5 Photograph showing lingual wear on A4180 (Zambian specimen)

Figure 5.5.6. Photograph showing maxillary central incisors of Late Iron Age specimen from Pilanesberg, the UI2s have been sharpened to points.

Table 5.5.5 shows the number of specimens within each sample with one of the above cultural traits. While the EIA and Zambian specimens have high frequencies of cultural modification/wear, these were lower in the LIA and Toutswe samples. Surprisingly, modification or dental filing was also noted on LIA (western) specimens (Figure 5.5.6). However no modification or filing was noted for LIA (eastern) specimens. One specimen from Pilanesberg shows I2s sharpened like those seen in the EIA. Four LIA specimens exhibit medial wear, possibly from cultural habits. These specimens were found in Skutwater, Pilanesberg and Phalaborwa.

Table 5.5.5 Table showing interesting features, created by direct or indirect dental modification within the divided Iron Age samples

		Dental modification	**Interesting features**
EIA	Total	14	
	Present	36%	Modification
Toutswe	Total	25	
	Present	8%	Medial wear
Zambia	Total	21	
	Present	33%	Lingual wearing and modification
LIA E	Total	13	
	Present	0%	
LIA W	Total	32	
	Present	16%	Modification and medial wear

Antemortem loss of the central maxillary incisors (sometimes including lateral incisors and even canines with alveolar loss) is noted in Table 5.5.6. The table does not indicate dental extractions, but does show the proportions of clear alveolar loss. However, the total number of specimens with which it is compared is only those where there is clear evidence for the retention of incisors until death. Considering that this may include juveniles and even loose teeth, this may skew the data. Juveniles may not yet have undergone initiation and loose teeth only indicates what is there, not what is missing and why. While the EIA, Zambian and LIA (western) samples indicated the most antemortem incisor loss (25%, 19% and 17% respectively), it is uncertain if this was cultural or due to lifestyle and diet.

Table 5.5.6 Table showing proportion of antemortem incisor loss (a potential indicator for dental pulling)

EIA	**N**	**8**
	I's missing pre-mortem	25%
Tou	N	20
	I's missing antemortem	10%
Zam	N	21
	I's missing pre-mortem	19%
LIA E	N	9
	I's missing pre-mortem	11%
LIA W	N	30
	I's missing pre-mortem	17%

5.6. ANOVA and T-tests for cranio- and mandibular-metrics

Differences between Iron Age, Khoesan and modern cadaver material

Table 5.6.1 is the summary of the Khoesan, modern cadaver and Iron Age samples cranio-mandibular distances. It includes the sample size for each measurement within each group, the mean for each measurement within each group, the ANOVA p-values and T-tests between the Khoesan and Iron Age, Iron Age and modern and Khoesan and modern samples (where ANOVA p<0.05). Out of 63 measurements, 41 had ANOVA p-values where p<0.05. The measurement where p>0.05 (i.e. the groups are not significantly different) include ORB-ORI, ORI-MMC, MMC-JRI, FMT-J, SPH-KR, ZY-MF, MF-POR, KR-AST, AST-L, L-B, L-I, I-AST, BA-O, FM-O, FM-BA, FM(L)-FM(R), OCA-FM, OCA-OCL, OCL-FM, POG-MNS, GON-PGA and COR-SA. Pairwise T-tests between the Khoesan and Iron Age groups show that 39 of these measurements are significantly different where p<0.1 (36 where p<0.05). Twenty seven of these measurements are statistically significant between the modern cadavers and the Iron Age group, where p<0.1 (21 where p<0.05). Thirty four significantly different measurements are calculated between Khoesan and modern Bantu-speakers, where p<0.1 (29 where p<0.05).

Table 5.6.1 Table showing the sample size (n), mean, ANOVA p-values and T-test p-values for the Khoesan (KHO), modern cadaver (MOD) and Iron Age (IA) samples for all of the cranio-mandibular measurements.

	KHO (n)	**MOD (n)**	**IA (n)**	**Mean KHO**	**Mean MOD**	**Mean IA**	**ANOVA**	**T-test(KHO-IA)**	**T-test(MOD-IA)**	**T-test(KHO-MOD)**
G-N	25	40	40	10.1	8.9	9.8	**0.049**	0.534	**0.067**	**0.017**
N-FMN	25	40	40	5.3	6.3	6.4	**0.013**	**0.002**	0.749	**0.023**
N-D	25	40	41	9.7	11.7	11.6	**0.000**	**0.000**	0.971	**0.000**
N-NS	23	38	33	46.4	50.2	49.3	**0.000**	**0.002**	0.288	**0.000**
NS-PR	21	34	25	15.3	17.7	18.9	**0.000**	**0.000**	**0.082**	**0.003**
NS-A	24	37	39	17.0	19.4	18.3	**0.000**	**0.001**	**0.004**	**0.000**
D-FMO	26	40	39	42.3	42.7	44.2	**0.002**	**0.001**	**0.006**	0.508
ORB-ORI	26	40	41	33.7	35.6	35.7	0.096	—	—	—
D-ORI	26	40	41	32.3	33.8	33.5	**0.043**	**0.055**	0.641	**0.018**
D-ORB	26	40	40	26.5	27.5	27.8	**0.049**	**0.014**	0.618	**0.051**
FMO-FMT	26	40	38	7.8	6.7	6.8	**0.005**	**0.004**	0.760	**0.003**
ORI-MMC	26	39	47	24.9	22.1	23.2	0.218	—	—	—
MMC-JRI	26	39	49	11.3	12.2	11.8	0.337	—	—	—
A-MMC	26	38	45	26.9	27.3	28.4	**0.027**	**0.020**	**0.058**	0.405
J-MAX	22	38	30	12.8	13.5	15.5	**0.010**	**0.009**	**0.020**	0.434
FMT-J	25	40	35	21.7	22.3	21.8	0.748	—	—	—
SPH-KR	22	36	43	9.1	9.1	8.9	0.954	—	—	—
J-MF	25	40	34	43.2	42.8	45.5	**0.006**	**0.026**	**0.003**	0.637
ZY-JRI	25	40	26	33.0	36.0	40.2	**0.000**	**0.000**	**0.010**	**0.045**
ZY-MF	25	40	26	25.5	24.8	25.4	0.856	—	—	—
MF-POR	26	40	51	13.5	13.7	14.1	0.486	—	—	—
SPH-_LB	16	37	40	88.4	92.4	91.3	**0.023**	**0.031**	0.280	**0.019**
KR-AST	25	36	41	83.0	84.0	86.4	0.112	—	—	—
AST-MAS	26	40	45	42.9	46.4	48.0	**0.001**	**0.000**	0.190	**0.021**
POR-MAS	26	40	52	27.2	31.3	31.6	**0.000**	**0.000**	0.603	**0.000**
AST-L	25	39	42	85.0	86.9	85.4	0.437	—	—	—
L-B	18	39	41	109.2	112.6	113.3	0.058	—	—	—
L-I	25	39	44	66.2	63.2	66.5	0.270	—	—	—
I-O	26	40	38	40.3	45.3	44.2	**0.049**	**0.095**	0.529	**0.015**
PR-NS	21	34	25	15.3	17.7	18.9	**0.000**	**0.000**	**0.082**	**0.003**
NS-ALV	17	35	27	43.1	45.3	46.6	**0.001**	**0.000**	**0.071**	**0.012**
I-AST	26	40	47	63.9	66.3	63.4	0.059	—	—	—
NS-MXT	22	35	34	51.9	54.4	55.8	**0.000**	**0.000**	**0.086**	**0.009**
BA-O	26	40	32	41.4	39.6	40.3	0.673	—	—	—
FM-O	26	40	33	28.8	27.1	30.2	0.571	—	—	—

FM-BA	26	40	34	24.6	24.4	27.5	0.333	—	—	—
FM_L-FM_R	25	40	33	31.3	31.8	34.8	0.292	—	—	—
OCA-FM	26	39	36	19.5	19.8	22.7	0.332	—	—	—
OCA-OCL	26	38	40	13.7	15.1	15.3	0.062	—	—	—
OCL-FM	26	39	36	12.8	13.0	16.7	0.211	—	—	—
BA-NS	24	38	25	87.1	92.2	94.5	**0.000**	**0.000**	0.104	**0.000**
GNA-POG	30	38	58	7.6	8.7	9.5	**0.000**	**0.000**	**0.000**	**0.002**
POG-MNS	24	37	56	15.2	14.7	14.3	0.446	—	—	—
POG-INFRA	19	34	30	21.4	22.6	24.0	**0.011**	**0.014**	**0.014**	0.160
GNA-IBB	29	38	52	23.8	25.6	25.5	**0.003**	**0.017**	0.427	**0.001**
IBB-MEN	30	38	65	12.1	13.8	14.0	**0.000**	**0.000**	**0.006**	**0.000**
MEN-ALV	25	37	52	14.5	15.5	16.3	**0.002**	**0.002**	**0.008**	**0.056**
INFRA-ALV	17	33	25	24.1	26.7	27.2	**0.000**	**0.001**	0.173	**0.000**
ALV-AJUNC	25	33	47	30.8	33.1	34.0	**0.003**	**0.000**	**0.002**	**0.024**
IBB-GON	30	38	60	56.0	59.5	61.9	**0.000**	**0.000**	**0.000**	**0.001**
GON-PGA	30	38	62	17.5	18.7	17.4	0.248	—	—	—
PGA-PSC	29	38	40	33.0	37.4	40.3	**0.000**	**0.000**	**0.000**	**0.000**
PSC-LAT	28	35	36	13.5	14.9	14.6	**0.016**	**0.058**	0.502	**0.002**
LAT-MC	27	34	31	17.7	19.0	20.1	**0.000**	**0.000**	**0.000**	**0.009**
LAT-COR	29	35	38	30.3	32.1	34.5	**0.000**	**0.000**	**0.000**	**0.039**
LAT-MN	29	35	37	19.1	20.5	21.6	**0.003**	**0.002**	**0.021**	**0.067**
COR-MN	30	38	52	18.2	19.6	20.7	**0.001**	**0.000**	**0.000**	**0.050**
COR-SA	30	38	58	12.5	12.4	13.8	0.138	—	—	—
SA-AR	30	38	61	9.2	10.4	13.8	**0.000**	**0.000**	**0.000**	0.101
AR-AJUNC	30	34	61	16.3	20.0	15.9	**0.000**	0.659	**0.007**	**0.003**
MSPIN-MFO	30	38	48	71.9	74.0	74.8	**0.024**	**0.001**	**0.008**	**0.057**
MFO-MN	30	38	52	17.7	21.9	22.7	**0.000**	**0.000**	**0.000**	**0.000**
MFO-GON	30	38	60	20.7	21.5	23.2	**0.012**	**0.003**	**0.002**	0.426

Differences between Iron Age samples

Table 5.6.2 is similar to 5.6.1 except it only shows the results for the Iron Age samples. These were split into Early Iron Age (EIA-T), Late Iron Age (LIA) and Zambia (Zam). Out of 63 measurements, 13 showed ANOVA where $p<0.1$. Seven of these (out of 21) were mandibular measurements. Between the EIA-T and Zambian samples, nine measurements showed significant differences where $p<0.1$, seven of which showed significant difference where $p<0.05$. Between the LIA and Zambian samples, five measurements were significantly different where $p<0.1$ (all of which were $p<0.05$). Between the EIA and LIA samples, six showed significant differences where $p<0.1$ and three significant differences where $p<0.05$. Although the sample sizes are generally much smaller, there appears to be a lot more overall homogeneity among the Iron Age samples than between the Iron Age, Khoesan and modern cadaver samples.

Table 5.6.2 Table showing the sample size (n), means, ANOVA p-values and T-test p-values for the EIA, LIA and Zambian (Zam) samples for all of the cranio-mandibular measurements.

	EIA (n)	LIA (n)	Zam (n)	Mean EIA	Mean LIA	Mean Zam	ANOVA	T-test (EIA-T-Zam)	T-test (LIA-Zam)	T-test (EIA-T-LIA)
G-N	12	20	7	9.0	10.1	10.3	0.289	—	—	—
N-FMN	13	20	6	6.3	6.2	6.6	0.775	—	—	—
N-D	13	20	7	11.9	11.4	11.7	0.663	—	—	—
N-NS	12	14	6	49.5	48.3	49.9	0.461	—	—	—
NS-PR	10	9	5	17.7	19.7	20.4	0.184	—	—	—
NS-A	16	14	8	18.2	18.3	18.5	0.891	—	—	—
D-FMO	13	19	6	44.8	43.8	44.0	0.504	—	—	—
ORB-ORI	11	20	8	34.2	35.7	37.2	**0.078**	**0.072**	0.117	0.176
D-ORI	14	19	7	33.4	33.4	34.1	0.798	—	—	—
D-ORB	12	19	7	27.9	28.0	26.7	0.394	—	—	—
FMO-FMT	13	17	7	7.1	6.5	6.7	0.524	—	—	—
ORI-MMC	16	20	10	22.7	23.9	22.6	0.265	—	—	—
MMC-JRI	16	22	10	12.2	11.9	11.2	0.689	—	—	—
A-MMC	17	19	8	28.2	28.3	29.3	0.616	—	—	—
J-MAX	11	10	8	14.8	18.3	13.0	**0.008**	0.171	**0.009**	**0.034**
FMT-J	10	17	7	24.4	21.8	18.7	**0.044**	**0.030**	0.139	0.120
SPH-KR	16	19	7	8.2	9.3	9.6	0.547	—	—	—
J-MF	11	16	6	45.8	44.4	47.8	0.187	—	—	—
ZY-JRI	7	11	6	39.1	39.0	43.1	0.164	—	—	—
ZY-MF	7	11	6	25.1	26.9	23.9	0.884	—	—	—
MF-POR	18	23	9	14.5	13.9	13.5	0.688	—	—	—
SPH-B	14	18	6	89.8	91.7	93.0	0.141	—	—	—
KR-AST	15	18	7	86.9	84.6	86.7	0.582	—	—	—
AST-MAS	17	20	7	48.2	49.1	43.4	**0.014**	**0.010**	**0.014**	0.508
POR-MAS	19	23	9	31.2	31.6	32.5	0.572	—	—	—
AST-L	18	17	6	85.1	85.3	88.5	0.480	—	—	—
L-B	14	18	7	113.1	113.8	112.2	0.803	—	—	—
L-I	18	18	7	65.5	68.2	64.6	0.679	—	—	—
I-O	15	15	7	44.7	43.8	45.8	0.880	—	—	—
PR-NS	10	9	5	17.7	19.7	20.4	0.184	—	—	—
NS-ALV	10	8	8	48.3	46.0	45.4	0.110	—	—	—
I-AST	18	20	8	63.0	64.7	64.1	0.703	—	—	—
NS-MXT	14	11	8	57.0	55.4	54.3	0.190	—	—	—
BA-O	14	12	6	40.4	40.0	40.7	0.703	—	—	—
FM-O	14	13	6	34.5	26.8	28.4	0.464	—	—	—
FM-BA	16	12	6	30.4	24.8	24.8	0.608	—	—	—
FM_L-FM_R	15	13	5	38.5	31.5	33.0	0.512	—	—	—
OCA-FM	16	14	6	26.2	20.3	19.1	0.520	—	—	—
OCA-OCL	17	17	6	15.4	16.0	12.8	**0.014**	**0.023**	**0.006**	0.434

OCL-FM	16	14	6	20.1	14.2	13.3	0.555	—	—	—
BA-NS	11	9	5	98.0	91.7	93.1	**0.039**	**0.099**	0.605	**0.025**
GNA-POG	19	25	14	9.3	9.6	9.4	0.881	—	—	—
POG-MNS	17	25	14	13.3	14.2	15.9	**0.063**	**0.022**	0.131	0.308
POG-INFRA	9	13	8	23.3	23.8	25.1	0.440	—	—	—
GNA-IBB	19	22	11	25.4	25.1	26.7	0.314	—	—	—
IBB-MEN	21	29	15	14.3	13.6	14.4	0.203	—	—	—
MEN-ALV	18	21	13	15.9	16.6	16.4	0.643	—	—	—
INFRA-ALV	8	10	7	25.8	27.8	27.8	0.174	—	—	—
ALV-AJUNC	17	19	11	34.5	33.5	33.8	0.711	—	—	—
IBB-GON	20	25	15	63.0	60.8	62.1	0.360	—	—	—
GON-PGA	20	27	15	18.0	18.1	15.5	**0.085**	0.050	**0.038**	0.960
PGA-PSC	14	16	10	41.8	38.3	41.5	0.141	—	—	—
PSC-LAT	13	13	10	14.5	14.9	14.5	0.901	—	—	—
LAT-MC	10	11	10	21.3	20.0	19.2	**0.049**	**0.020**	0.364	**0.099**
LAT-COR	13	16	9	35.1	34.2	34.1	0.771	—	—	—
LAT-MN	13	15	9	22.1	22.0	20.3	0.181	—	—	—
COR-MN	18	20	14	21.6	19.6	21.2	0.101	—	—	—
COR-SA	21	23	14	15.0	12.7	13.5	0.169	—	—	—
SA-AR	21	26	14	12.8	12.6	17.7	**0.004**	**0.010**	0.001	0.867
AR-AJUNC	21	26	14	17.6	15.4	14.5	**0.055**	**0.042**	0.468	**0.070**
MSPIN-MFO	17	21	10	76.3	72.8	76.5	**0.019**	0.886	**0.023**	**0.016**
MFO-MN	18	22	12	22.9	22.5	22.7	0.950	—	—	—
MFO-GON	20	26	14	24.0	21.9	24.6	**0.086**	0.711	0.035	**0.077**

5.7 PCAs for cranio- and mandibular metrics

The following distances were used to construct a PCA in PAST: GNA-POG (gnathion-pogonion), POG-MNS (pogonion- mandibular symphysis), IBB-GON (inferior border of ramus- gonion), GON-PGA (gonion- inferior posterior ramus), COR-SA (coronoid process-superior anterior ramus), SA-AR (superior anterior ramus- anterior ramus), AR-AJUNC (anterior ramus- inferior anterior ramus), MFO-MN (mandibular foramen- mandibular notch), MFO-GON (mandibular foramen to gonion), MF-POR (mandibular fossa-poronion), POR-MAS (poronion-mastoidale). These are mostly reflective of the mandible. Principal component scores of individuals from the modern cadaver sample (n=31), the Khoesan sample (n=21) and the Iron Age sample (n=26) are plotted in Figure 5.7.1, 5.7.2 and 5.7.3. Table 5.7.1 shows the eigenvalues and percentage variance for each of the 13 principal components. PC1 explains 28.17% of the variance. PC2 explains 19.837% of the variance and PC3 explains 13.698% variance. The PCAs are based on a V/CV matrix.

As can be seen from the graphs, there is considerable overlap between the Iron Age, cadaver, and Khoesan samples. This is expected considering these samples are close in age and geographic space. However, certain Iron Age specimens in particular are distinct from the range of variation shown in the other two groups. This is largely on components 1 and 3, indicating extreme size in a handful of individuals, and some degree of shape difference. The variables contributing to PC3 are mandibular variables, indicating some shape variation, especially in the gonial region, that distinguishes these individuals from the other specimens. These distinctive Iron Age individuals are from sites in Zambia (Four individuals from Ingombe Ilede), Botswana (two from Xaro) and one individual from Phalaborwa (right at the bottom of the ellipse). It is, however, important to note that the number of variables was limited by sample size. Given that many of the selected variables happened to be ones that were shown in the ANOVA to differ significantly among these groups (five out of eight of the selected measurements used for the PCA have ANOVA p values which are less than 0.1 (POG-MNS, GON-PGA, SA-AR, AR-AJUNC and MFO-GON), while only 13 out of the 63 total measurements had ANOVA $p<0.1$), it is important not to over-interpret these differences. It is not known how different or similar the groups might be in other, un-analysed, regions of the cranium.

Table 5.7.1 Table showing the eigenvalue and percentage variance explained for each of the principal components (PC) based on cranio-mandibular measurements.

PC	Eigenvalue	% variance
1	48.9732	28.171
2	34.4853	19.837
3	23.8129	13.698
4	16.7243	9.6203
5	12.641	7.2715
6	9.34309	5.3744
7	7.70022	4.4294
8	5.69128	3.2738
9	5.25914	3.0252
10	4.14472	2.3842
11	2.20751	1.2698
12	1.76678	1.0163
13	1.09421	0.62942

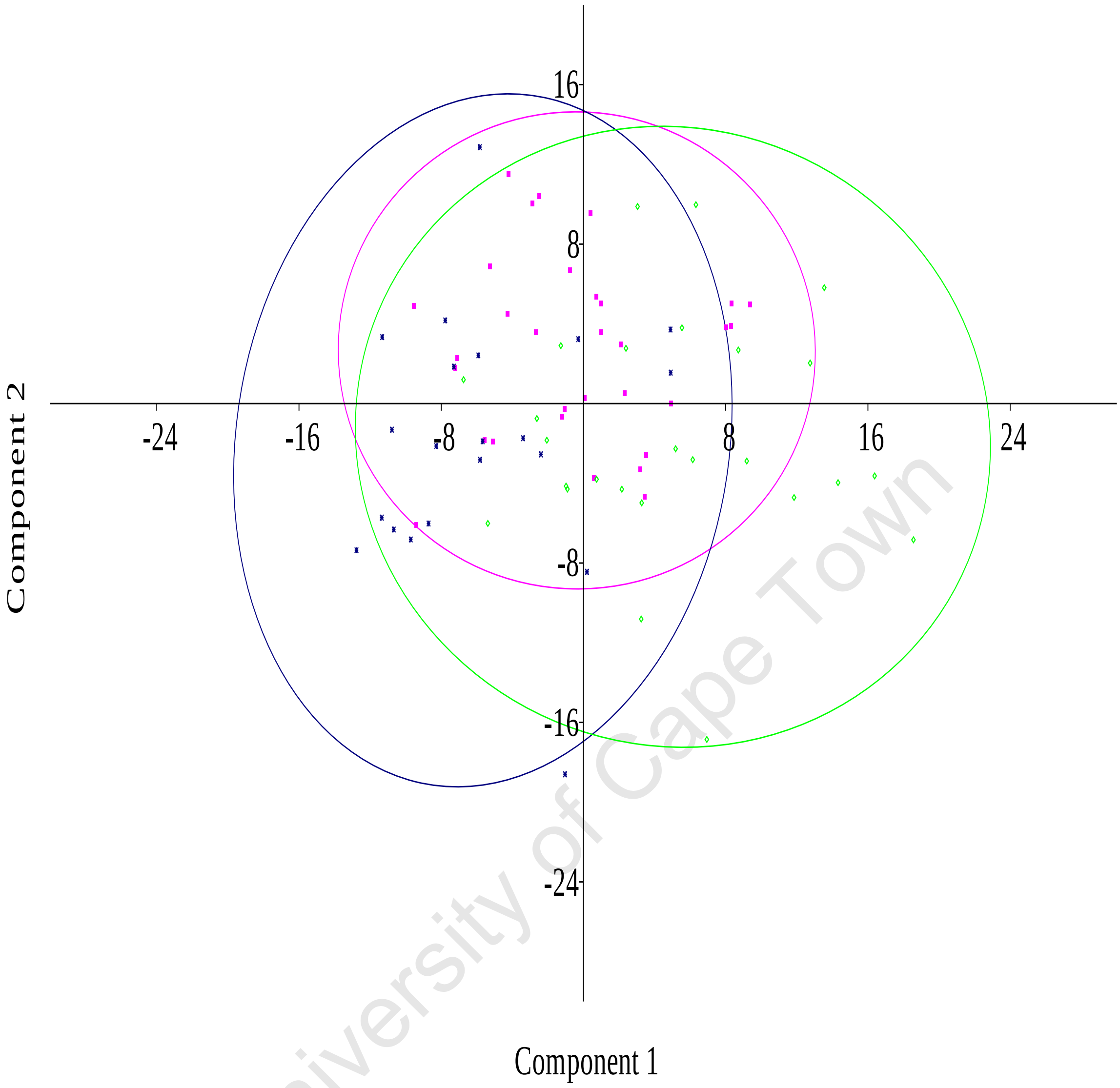

Figure 5.7.1. Graph plotting individuals against component 1 (PC1) and component 2 (PC2) for cranio-mandibular distances. The pink specimens are the modern cadaver individuals, the blue is the Khoesan individuals and the green are the Iron Age individuals. The 95% ellipses correspond to each group.

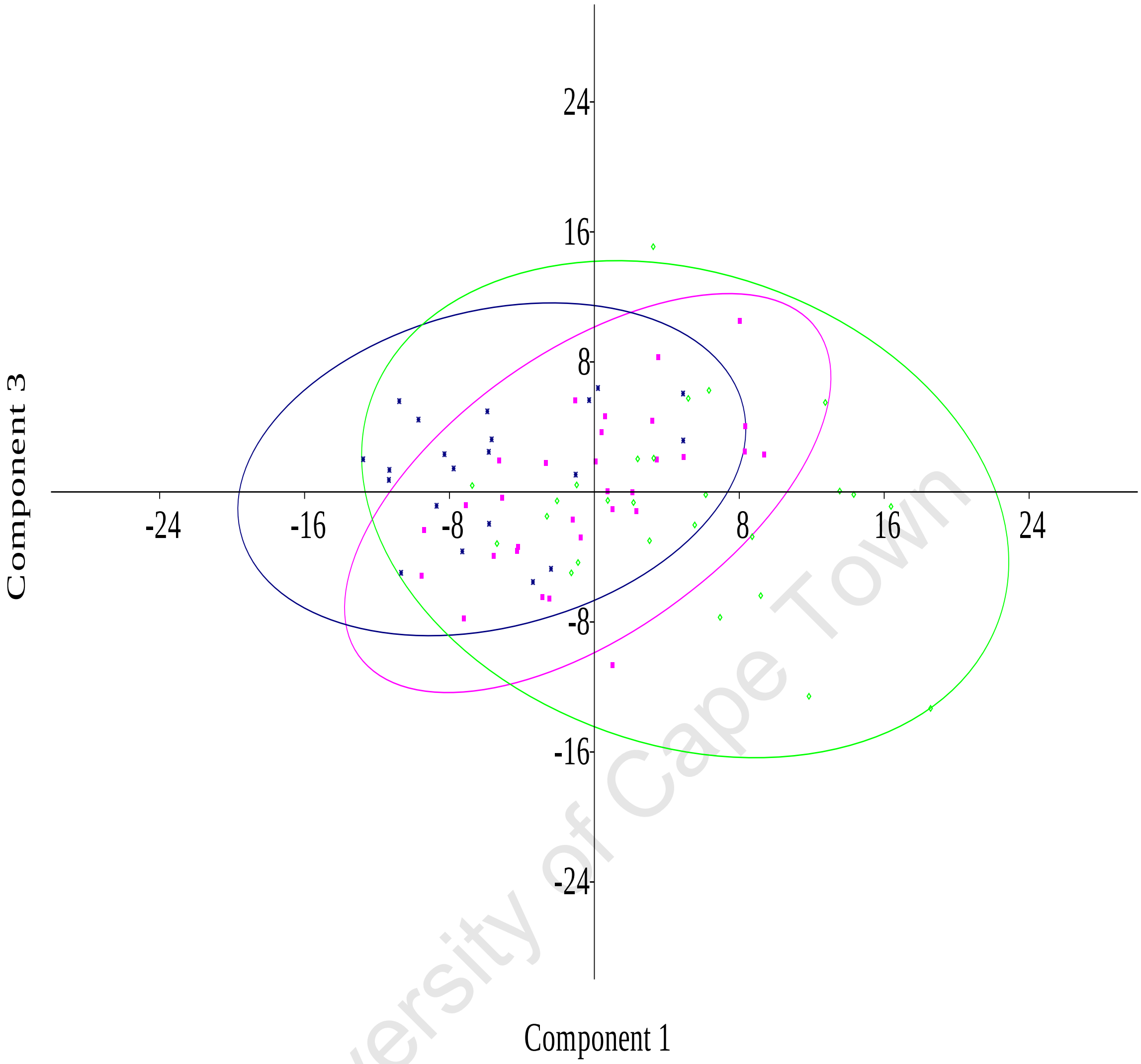

Figure 5.7.2. Graph plotting individuals against component 1 (PC1) and component 3 (PC3) for cranio-mandibular distances. The pink specimens are the modern cadaver individuals, the blue is the Khoesan individuals and the green are the Iron Age individuals. The 95% ellipses correspond to each group.

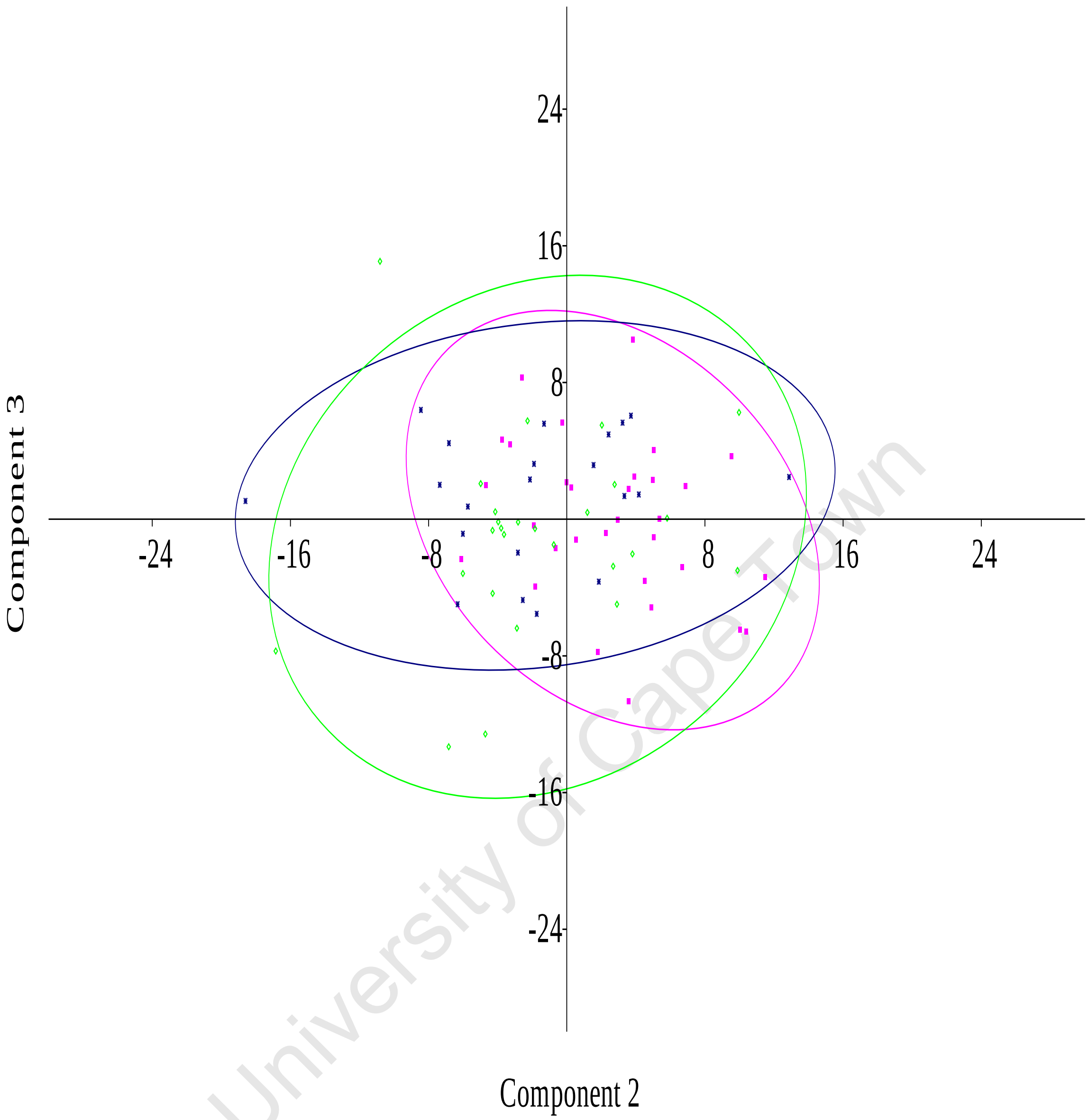

Figure 5.7.3. Graph plotting individuals against component 2 (PC2) and component 3 (PC3) for cranio-mandibular distances. The pink specimens are the modern cadaver individuals, the blue is the Khoesan individuals and the green are the Iron Age individuals. The 95% ellipses correspond to each group.

Table 5.7.2 shows the component loadings for each of the measurements. This is also shown graphically for the first three components in Figures 4.7.4, 4.7.5 and 4.7.6. PC1 was calculated with the majority of the weighting toward IBB-GON (0.568), which was shown to have an ANOVA p-value where p<0.001, SA-AR (0.488 weighting and ANOVA p<0.001), POR-MAS (0.348 weighting and ANOVA p<0.001) and MFO-GON (0.337 weighting and ANOVA p=0.012). The lowest weighting is AR-AJUNC (-0.053 weighting and ANOVA p<0.001). For PC2 measurements AR-AJUNC (0.75 weighting and ANOVA p<0.001) and IBB-GON (0.31 and ANOVA p>0.001) are the most weighted, while SA-AR is the least weighted (-0.432 and ANOVA p<0.001). For PC3 measurement MFO-GON (0.598 weighted and ANOVA p=0.012), GON-PGA (0.519 weighted and ANOVA p=0.248) and COR-SA (0.390 weighted and ANOVA p=0.138) are the most weighted, while SA-AR (-0.283 weighted and ANOVA p<0.001), MFO-MN (-0.238 weighted and ANOVA p<0.001) and IBB-GON (-0.214 weighted and ANOVA p<0.001) are the least weighted. In calculating the ANOVA p-values, distances between IBB-GON, SA-AR, POR-MAS, MFO-GON, AR-AJUNC and MFO-MN had ANOVA where p>0.05.

Table 5.7.2 Table showing the PC loadings for each of the dental measurements. Measurements from the following landmarks were used: Gnathion (GNA), pogonion (POG), inferior border of ramus (IBB), gonion (GON), inferior posterior ramus (PGA), coronoid process (COR), superior anterior ramus (SA), anterior ramus (AR), inferior anterior ramus (AJUNC), mandibular foramen (MFO), mandibular notch (MN), mandibular fossa (MF), poronion (POR) and mastoidale (MAS)

	GNA-POG	POG-MNS	IBB-MEN	IBB-GON	GON-PGA	COR-MN	COR-SA	SA -AR	AR - AJUNC	MFO - MN	MFO - GON	MF-POR	POR-MAS
Axis 13	0.637	0.151	-0.74	-0.01	-0.03	-0.02	-0.04	0.005	0.044	0.038	0.099	0.002	0.09
Axis 12	0.618	0.25	0.584	-0.18	-0.18	-0.27	0.044	0.07	0.011	-0.05	0.07	-0.19	-0.174
Axis 11	0.087	-0.17	-0.04	0.014	0.188	-0.16	0.393	0.499	0.207	-0.51	-0.39	0.185	0.064
Axis 10	-0.38	0.672	-0.18	-0.15	0.131	-0.43	0.15	0.211	0.147	0.2	0.038	-0.09	-0.099
Axis 9	0.084	0.22	0.13	0.195	0.229	-0.25	-0.35	-0.14	-0.13	-0.12	0.054	0.771	0.073
Axis 8	0.014	0.53	0.084	-0.04	0.071	0.411	0.013	-0.24	-0.16	-0.29	-0.38	-0.17	0.444
Axis 7	0.059	0.021	0.082	-0.56	-0.09	0.365	0.284	0.104	0.108	0.423	-0.05	0.486	0.1
Axis 6	0.095	0.198	-0.01	0.2	0.369	0.462	0.077	0.018	-0	-0	-0.06	0.036	-0.742
Axis 5	0.147	-0.19	0.076	-0.17	0.657	-0.1	-0.33	0.174	-0.11	0.383	-0.29	-0.23	0.166
Axis 4	-0.08	0.067	0.04	-0.23	0.029	0.269	-0.55	0.277	0.55	-0.29	0.305	-0.06	0.049
Axis 3	0.014	-0.08	0.038	-0.21	0.519	-0.02	0.39	-0.28	-0.05	-0.24	0.598	-0.07	0.15
Axis 2	0.095	-0.02	0.105	0.309	0.102	-0.07	0.154	-0.43	0.75	0.231	-0.17	0	0.111
Axis 1	0.076	0.127	0.169	0.568	0.024	0.228	0.159	0.488	-0.05	0.27	0.337	-0.01	0.348

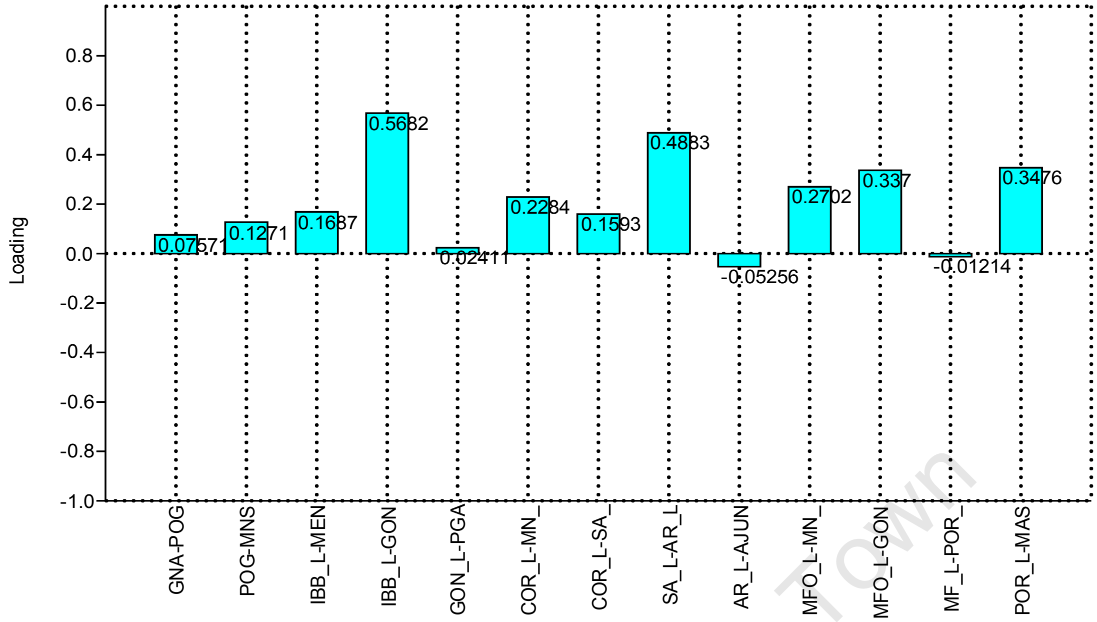

Figure 5.7.4 Principal component 1 loadings for cranio-mandibular distances.

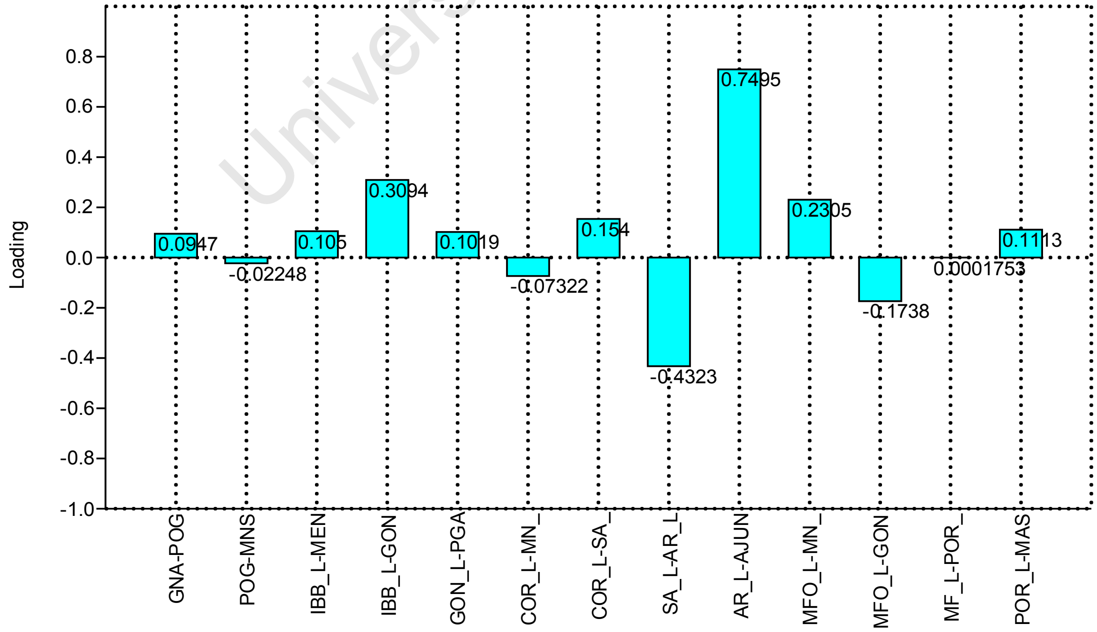

Figure 5.7.5 Principal component 2 loadings for cranio-mandibular distances.

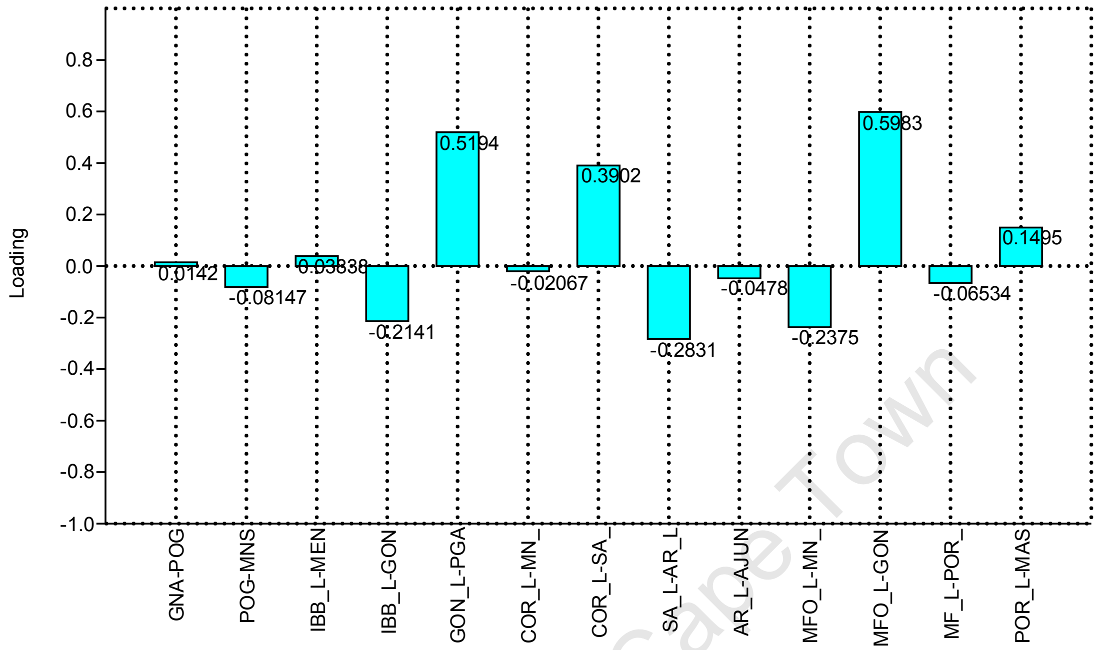

Figure 5.7.6 Principal component 3 loadings for cranio-mandibular distances.

CHAPTER 6: DISCUSSION

This chapter focuses on the relationship between biological identity and the cultural, typological or temporal identities that have been discussed in the literature. It looks at whether historic and prehistoric circumstances could have affected morphological changes. This is followed by a discussion of the dental and craniometric results in the context of previous dental anthropology studies of southern-most Africa. I will then briefly turn to non-genetic factors seen in the dentition: population health and cultural modifications or habits that are visible in the dentition. Finally the strengths and weaknesses of this thesis will be discussed, including commentary on how future research might support, use or fine-tune the generated data.

6.1 Comparisons among Iron Age peoples

Zambian Iron Age sample versus EIA and LIA samples from South of the Zambezi

When comparing the LIA and Zambian samples in this study, 6.5% of non-metric dental traits showed significant differences (at $p<0.05$ for everything discussed here). None of metric traits showed significant differences. Both of these tests support similarity between these groups. The non-metric data indicated that only a few traits differ significantly between the Late Iron Age vs. Zambian samples and the Early Iron Age vs. Zambian samples (5% of non-metric and 9% metric), indicating great dental similarities between these people. The metric dental results indicated comparable homogeneity. Similarly, only 13% of cranio-mandibular measurements were significantly different between the Early Iron Age, Late Iron Age and Zambian groups. Seven of these (11%) showed differences between EIA and the Zambian samples and five of these (8%) between the LIA and Zambian samples. This supports a high level of inter-population similarities during the Iron Age among Bantu-speakers in southern Africa. The cranio-mandibular PCA, however, shows a few outliers within the Iron Age sample. These individuals mostly came from Xaro (northern Botswana EIA site) and Ingombe Ilede (Zambia). This would be consistent with a Western Bantu-origin for Ingombe Ilede (Huffman, 1989b) as well as interaction between Eastern and Western Bantu-speakers within this broader area (Beleza *et al.*, 2005). Although this conclusion is based on a limited number of variables, this does provide interesting support for this connection; further analyses of cranio-mandibular variation between Eastern and Western Iron Age archaeological sites will be needed to support this claim.

The Iron Age of southern-most Africa has long been attributed to an expansion of populations from north of the Zambezi River. The “Bantu-expansion” has been supported within the archaeological literature, which focusses on ceramic typology, the presence of which is strongly correlated with eastern Bantu-speakers (Huffman, 1982 and 2005; Mason, 1974; Phillipson, 2005). There has been some disagreement by some archaeologists regarding the association of Bantu-and iron smelting in more north-eastern areas (e.g. Gramly, 1978, Chami and Kwekason, 2003 and Chami, 2007). Nonetheless into southern Africa, migration remains largely supported by the archaeological evidence. The earliest Iron Age sites in southern-most Africa show a number of attributes. These are semi-permanent settlements, cattle and sheep livestock management, crops, metal productions and Chifumbaze ceramics. These attributes make up an Iron Age package (Huffman, 1970, 1982 and 2005; Phillipson, 2005; Parkington and Hall, 2010). Iron Age skeletons younger than 400AD from KwaZulu Natal show dietary and morphological similarities to Sotho-Tswana and Nguni speakers (Ribot *et al.,* 2010), indicating skeletal morphology, along with culture, form part of the “package”.

Ethnography, linguistics and genetics of modern Bantu-speakers (Vansina, 1994/1995, Baleza *et al.*, 2005; Ehret, 2001; Huffman, 1982 and 1989a; Holden, 2002) have also provided substantial insight into the historical migration of Bantu-speaker peoples. Diamond and Bellwood (2003: 600) briefly discuss the Bantu-expansion: “Of particular interest… is the exceptionally detailed integration of linguistic evidence with other types of evidence (from genetics, archaeology and domesticated plants and animals) in this case”. In particular, the genetics shows similarities within the Y-chromosome of contemporary Bantu-speakers (de Filippo *et al.,* 2011; Forster and Renfrew, 2011).

A number of studies suggest that there were likely multiple migrations. Ceramic typology has linked a later migration in the Late Iron Age to populations in East Africa (Huffman, 1989a and 1998). This shows that within southern Africa, the “Iron Age” period is a dynamic one which is continuously culturally connected with more northern populations and this is confirmed by genetic analysis (Beleza *et al.,* 2005; de Fillipo *et al.,* 2011). Indeed, genetic research has shown that many short-duration migrations of Bantu-speakers from Eastern Africa to southern Africa seems to have occurred (Baleza *et al.,* 2005; Montano *et al.,* 2011; Wood *et al.,* 2005).

The dental and cranio-mandibular metric results in this thesis have therefore supported the idea of continuity and cultural connection. Taken together, the dental data indicate homogeneity among these Iron Age samples, suggesting close biological relationships between populations north and south of the Zambezi during the Iron Age. The large volume of evidence, from multiple disciplines, indicates morphological similarities between these populations, therefore this result is not surprising. Importantly, the results supports the evidence that the EIA of southern Africa is the result of a migration of closely related people, and that genes flowed between Iron Age populations North and South of the Zambezi.

Comparisons between the EIA and LIA in South Africa

Within this study, the frequencies of the vast majority of the non-metric dental traits (96%) were similar across the Early Iron Age and Late Iron Age samples. This was confirmed further in the metric dental analysis, where only 3% of dental measurements differed significantly between the samples. This indicates that dental traits in the EIA and LIA populations sampled were not significantly different, suggesting that they represent temporally successive but morphologically similar populations. Similarly, 95% of the cranio-mandibular traits were not significantly different between EIA and LIA samples. Therefore, despite the typological, political, social and economic changes one sees in the archaeological record, the results support a genetic link between EIA and LIA populations. This genetic link is likely due to continuous gene flow from East Africa throughout the Iron Age, a shared and recent ancestry and frequent gene flow between settled populations.

Within the literature, certain cultural differences between the EIA and LIA material culture have been argued for based on ceramics and other material culture observed in the archaeology (see chapter 2). Iron Age archaeologists often use ceramic typology to establish group or cultural identity, although all these groups are within or have origins within the Chifumbaze complex (e.g. Huffman, 1982 and 2005). Although there are many reasons for this (abundance, preservation, precedent), it is often used to the exclusion of other material or analyses for assessing identity (Pikarayi, 2007). While ceramic style is often used to classify group identity, the social meaning is often ignored (Pikarayi, 2007). “Ceramic style is key to social communication, rather than a mere reflection of group identity or a basis for explaining cultural change” (Pikarayi, 2007: 293). Therefore, it is reasonable to assume that change in ceramic style is not a direct indication of change in cultural identity.

Badenhorst (2010) has suggested a shift from matrilineal descent in the EIA to patrilineal descent in the LIA with the arrival of Nguni and Sotho-Tswana farmers. He argues that patrilineality is not as widespread in the first millennium as it is in the second millennium. This argument greatly revolves around the presence of cattle. When a central cattle pen is seen within a homestead, this is thought of as evidence for patrilineal descent within Bantu-communities (Holden and Mace, 2003; Hall, 1986; Huffman, 1982). Badenhorst (2010) argues that these communities were caprine herders. Although this is mostly a caution against using the ethnography too extensively for EIA populations, by encouraging an idea of little change between past and present populations, these potential cultural differences may have influenced gene flow from the EIA to LIA. However, the data within this thesis does not note much morphological differences between the EIA and LIA that could be used to support this.

Social, political and economic differences have also been observed between EIA and LIA communities (Hall, 2010). Dental modification, burying bottomless pots in pits, initiation figurines and the inclusion of fish in the diet decrease into the second millennium (Whitelaw, 1994/1995; Mitchell, 2002; Morris, 1993b; Badenhorst, 2010; Maggs, 1994/1995; Mitchell, and Whitelaw, 2005). Extensive trade, greater social hierarchies and dominant cattle keeping are widespread in the MIA and LIA, or second millennium (Hall, 2010; Badenhorst, 2010). LIA populations also settle further south and west than EIA populations had done (Vogel and Fuls, 1999, Maggs, 1984).

Within the LIA, studies of the archaeological histories of Bantu-speaking identities have primarily focussed on settlement organization and ceramic classification. While ancestral Shona was part of EIA identities and can be traced through the archaeology to modern-day Shona (and Venda) speakers (Huffman, 1982; Loubser, 1989), LIA Sotho-Tswana and Nguni identities are typologically (via ceramics) connected to movement from East Africa in the second millennium (Boeyens, 2003; Huffman, 1989a and 1998; Mitchell and Whitelaw, 2005; Mitchell, 2002; Hall, 2010; Loubser, 1989). The archaeology of these stylistic/linguistic identities indicates that, even within the LIA, dynamic interaction and change occurred.

The rise of a class based system at Mapungubwe (MIA) is often associated with a changing internal dynamic brought about by trade and production (Huffman, 1982; Maggs, 1984) and possibly by climatic changes (Tyson *et al.*, 2002). While these MIA communities exist in the second millennium, they clearly arise from EIA ceramic style, showing some continuity within this period. Similarly, *Zhizo*-style pottery in Eastern Botswana (*Toutswe*) at the beginning of the second millennium also shows some stylistic continuity with EIA (Calabrese, 2000). However, *Moloko* and *Blackburn* pottery culturally connected to Sotho-Tswana and Nguni-speakers respectively, are associated with a migration from southern Tanzania (Boeyens, 2003; Huffman, 1989a). This is further supported by the linguistic and cultural evidence (Hammond-Tooke, 2004).

Although archaeologists see considerable political, social and economic change from the EIA to the LIA, the data discussed here indicate much morphological/genetic similarity between the two millennia. There are several implications of this: 1) Clearly cultural/typological change does not reflect genetic change, 2) the "EIA" and "LIA" are stylistically constructed, and, while there is differences, the general structure is the same, and 3) cultural, political and economic changes can be created by a number of external and internal factors that are independent of gene flow (Huffman, 1982 and 1989a). Other factors are at play in the archaeological changes between the EIA and LIA, including environmental change, trading opportunities, and population growth/influx.

The concept that visible typological or cultural change may occur with little genetic change is not a new one in the context of southern African Iron Age archaeology. Schroda and K2 (in-between), sites with an emphasis on the Central Cattle Pattern and low level hierarchies differ in settlement pattern (and possibly worldview) from the Zimbabwe Culture Pattern evident at Mapungubwe and Great Zimbabwe (Calabrese, 2000). This transition is a gradual one which is visible in the archaeology of the Shashe/Limpopo. These changes in settlement pattern and even worldview are attributed to increasing political centralization and expansive trading networks throughout southern Africa (Denbow, 1990, Phillipson, 2005; De Fillipo *et al.*, 2011), rather than genetic change. Archaeology from the Shashe/Limpopo region yielded specifically significant evidence (such as trade beads) for large trading networks (Wood, 2000) and the transition from Schroda to K2, and then Mapungubwe, is clearly linked to this.

Fluctuations in climate and environmental change are also important factors in archaeological change as seen the Iron Age. While environmental change may simply lead to population movement or growth (and ultimately changes in patterns of gene flow with differential interaction), it also creates internal pressures within a society, which may lead to cultural adjustments. It is well established that Iron Age communities are only found in the eastern parts of southern-most Africa, in summer rainfall zones (Parkington and Hall, 2010). Agriculturalists are limited by where they can successfully grow crops. Climate and environment are therefore extremely important factors in determining the settlement range of agriculturalists (Mace *et al.*, 1993).

Climate and environmental changes have been studied in the context of the southern African Iron Age. Vogel and Fuls (1999) have shown that population increase in the southern African Iron Age over the last two millennia can be linked to increasing temperature and increasing precipitation. Smith *et al.* (2007) used nitrogen isotopes on fauna to compare rainfall patterns over time in the Shashe/Limpopo. The data indicated increased precipitation between the settlement of Schroda and the rise of political centralization in K2/ Mapungubwe. Although the decline in population in the Shashe/Limpopo cannot initially be attributed to a decrease in moisture levels, the Little Ice Age that occurred after this time very likely restricted population in that area (Vogel, 1995). After the Little Ice Age, Iron Age peoples began extensively occupying grasslands in the interior (Tyson *et al.*, 2002). However, the abandonment of Mapungubwe, once thought to have occurred because of climatic stress, occurred while moisture levels were still high.

Climate may affect gene flow (i.e. expansion and contraction of populations and its influence on local movement). Tyson *et al.* (2002: 129) have shown how East Africa and Southern African climates have been in “anti-phase” for at least the last millennium. This could likely explain migrations of people into southern Africa in the beginning of the LIA. If this trend can be extrapolated into the first millennium, it could possibly account for the rapid southerly migration into Southern Africa of the first Iron Age peoples. EIA sites are found in habitats suitable for growing crops such as sorghum (with origins in the Sahel), relaying the importance (and restriction) climate imposes on settlement, and therefore gene flow (Russell and Steele, 2009). The interconnectedness of Iron Age peoples between southern Africa and

East Africa could account for the degree of between-group homogeneity of populations observed in this thesis, both North and South of the Zambezi.

It must be remembered that there is visible morphological homogeneity, and very likely genetic continuity, between the EIA and LIA groups, but visible typological differences within the archaeological record. Loubser (1989) has shown the origins of Venda identity through ceramic style. He shows interaction between Mapungubwe peoples in the Shashe/Limpopo and established Sotho-Tswana speakers in the Soutpansberg. The ceramic styles over time show intense interaction, intermarriage and the cultural merger of Soto-Tswana and Shona-speakers to produce a distinct Venda identity. This is also evident from linguistics (Venda has both Sotho and Shona roots).

Finer scale inter-group comparisons

The Toutswe specimens were analysed separately from the other EIA specimens. This is because although ceramic typology links the Toutswe populations to EIA populations, these specimens overlap temporally with the second millennium MIA populations. Also, these specimens represent a population that is more easily defined (geographically and typologically, using ceramics), and the sample size is larger. When the Toutswe specimens were compared with other Iron Age specimens, both the dental metric and non-metric traits indicated few differences between them and the other EIA and LIA samples. Dental metric data shows 6% significant differences between EIA and Toutswe samples and between 3 and 9% between LIA and Toutswe samples. There were more dental non-metric differences between the Toutswe and the EIA sub-samples (10.5%) than between the Toutswe and LIA samples (8%). This was unexpected because the Toutswe ceramic style clearly stems from the EIA *Zhizo* phase of the Nkope Branch. Also, the increase in Toutswe settlements in eastern Botswana is contemporaneous with the arrival of Leopard's Kopje people (and a reduction of *Zhizo* ceramics) in the Shashe/Limpopo (Reid and Segobye, 2000; Mitchell and Whitelaw, 2005).

However, although Toutswe-style pottery stems from EIA *Zhizo* ceramics (Calabrese, 2000; Huffman, 1982), the Toutswe specimens mostly are from the second millennium: closer, temporally, to the LIA sample (Denbow, 1982 and 1983). Moreover, ceramic evidence indicates trade relations and general contact (possibly including inter-marriage) between Toutswe and the Shashe/Limpopo (MIA) peoples; the ceramics are also closely derived from the EIA (Calabrese, 2000; Denbow, 1990; Huffman, 1986; Mosothwane and Steyn, 2009), providing the means for gene flow among these groups. However, the dental differences are small and the EIA sample size is also very small when the Toutswe specimens are excluded, potentially affecting the comparison. Indeed, the Iron Age in general seems to have little genetic inter-population variation in southern Africa.

The dentitions of the LIA sub-samples, east and west of the escarpment, were also compared. Only 5% significant non-metric differences, and no metric differences, were found. This is similar to the level of difference seen between the EIA and LIA samples. The two are therefore extremely similar, with little inter-population variation. This is largely expected, given the variation seen in the Iron Age thus far. Culturally, the LIA includes the migrations of Sotho-Tswana and Nguni-speakers (*Moloko* and *Blackburn* phases) into southern Africa from eastern Africa (Huffman, 2004). The second migration is associated with ancestral Sotho-Tswana-speakers (*Moloko* ceramics) and appears in the Soutpansberg in the fourteenth century (Huffman, 2002). Both groups are associated with the central cattle pattern, patrilineality and compare well with East African linguistics and anthropology. Despite the demographic shifts at the start of the LIA, there was no introduction of genetic material that was any different from first millennium populations.

The Iron Age in general seems to have little inter-population morphological (and by extension genetic) variation in southern Africa. This is evident from comparisons over time and across space. The detailed cultural distinctions recognised by archaeologists and the changes and shifts through the sequences are clearly not matched biologically and the two are only correlated at the broadest scale.

6.2 Colonization and the effects of historical socio-economic changes

This section will discuss the comparisons between the Iron Age sample, the Historic Cave specimens and the modern cadaver sample. Before colonialism there is clearly historic and genetic complexity. More complexity arises in the archaeology of the second millennium where there was changing social structure, increasing political hierarchies and adaptations to international trade. From the 16th century this was further complicated by colonialism, which brought a new set of pressures, and one outcome was genetic exchange.

Not unexpectedly, the dental results show more significant metric and non-metric trait differences between the precolonial Iron Age samples and the modern Bantu-cadaver sample than was seen among between Iron Age samples. There are 14% of non-metric dental traits that showed significant differences between LIA and modern samples, while 10.5% significantly different traits were seen between Toutswe and modern samples (six of those traits were the same for both the LIA and Toutswe samples). This implies greater similarity between the modern sample and Toutswe than between the modern sample and second millennium LIA sample. This clearly has nothing to do with a European colonial presence. On the whole, however, the differences between the Iron Age samples and modern sample are greater than between each of the Iron Age samples. Dental metric results showed 28% significantly different metric traits between modern and Late Iron Age samples, and 34% metric trait differences between the EIA and modern samples. This supports the idea that there are more differences between the Iron Age samples and the modern sample than between each of the Iron Age samples, and moreover is important for establishing the power of these variables for indicating biological relationships in this context.

Similarly the cranio-mandibular metric results have shown some significant differences between the modern Bantu-speaking sample and the Iron Age sample. Out of 63 measurements, 33% were significantly different. This could also be seen visually in the PCAs (Figure 5.7.1 to 5.7.3). This will be discussed in more detail in the next section, when I compare this data with the Khoesan samples. Increasing differentiation between the dental anthropology of Iron Age populations and modern Bantu-speakers is to be expected. Genetic studies have shown sex-biased admixture with Europeans in southern African Bantu-speaking groups (Beleza *et al.,* 2005; Berniell-Lee *et al.,* 2009; Pereira *et al.,* 2002).

The comparison between the Iron Age groups and Historic Cave is interesting. In this regard, based on historical evidence, the specific group of Ndebele at Historic Cave were affected by the arrival of Trekboers in the region in the early nineteenth century (Esterhuysen, 2008; Esterhuysen *et al.*, 2009). The murder of a number of Trekboers by some Ndebele people set off a retaliation which led to the Ndebele retreating to Historic Cave where they were to be sieged. Many individuals died, possibly of thirst, and many the teeth in this study were of children with some adult teeth (many roots and even crowns were not fully developed).

The non-metric dental results show 8% significantly different traits between the Historic Cave and LIA sample and 6.5% between the Historic Cave and modern cadaver sample, showing much more similarity to both samples than the LIA and modern samples do to each other. The dental metric results illustrate that the Historic Cave specimens are more different from the Iron Age samples than the Iron Age samples are from each other (10% significantly different dental distances). Furthermore, the dental metric results show that the Historic Cave sample is the most similar of all the samples to the cadaver sample (13% significantly different dental distances).

This has great implications when compared with what we know about the effects of colonialism. The effects of colonialism impacted rapidly, from the arrival of new trading partners (the Portuguese) in the east in the sixteenth century to the expanding frontiers from the Cape Colony in the eighteenth/ nineteenth century (Wood, 2008). This gives rise to a whole host of political, economic and social changes (Hall *et al.*, 2008). Access to guns, slave labour and the intensification of the Ivory trade created a new set of dynamics between Bantu-speaking groups (Esterhuysen, 2008; Esterhuysen *et al.*, 2009). Increasing external pressures from expanding colonial borders played a role in a number of social, political and economic changes, including the aggregation of large Tswana towns, the adoption of maize, the Great Trek and the *Mfecane* (Maggs, 1976b; Hall *et al.*, 2008; Wright, 1989 and 2008; Boeyens, 2003). Although these changes were also a product of internal pressures, the effects of colonialism cannot be ignored: "The ethnographies, oral histories, anthropological and archaeological studies dating to [the 17th and 19th centuries] provided evidence for intensive mixing of peoples and associated material culture, and numerous and complex processes resulting in the fission, fusion and interaction of different players in the socio-economic landscape" (Esterhuysen, 2008: 210). More recent history shows potentially even greater effects on changing gene flow and the degree to which people interbred: the discovery of gold and diamonds in the interior, mining, the Anglo-Boer wars, the Land Act, Apartheid and the formation of homelands.

Physical anthropology between the colonial and precolonial periods has mostly focussed on health. Steyn (2003) shows that health status remained the same or even worsened after colonialism and that trauma was more evident more recently, possibly resulting from these historic scenarios. This can be seen as an indication for cultural change between these periods but are also seen on the bones.

The results presented in this thesis therefore show us that the pressures from colonialism must have had some impact on gene flow. Comparisons between the Iron Age, Historic Cave and modern cadaver samples indicate increasing differences with time, especially when noting the homogeneity of the Iron Age samples. However, these differences are still low and the implications do not include the displacement of Iron Age peoples, but rather a change in gene flow that is expected in light of the colonial and post-colonial pressures.

6.3 Comparisons with Holocene Khoesan

The thesis has thus far focussed on Iron Age peoples of southern Africa. But, as explained in chapter 2, these were not the only people on the landscape. Hunter-gatherers inhabited the area long before the arrival of the first Iron Age farmers and, only a few centuries before the arrival of the Iron Age package, herding was introduced into southern-most Africa. Ribot *et al.* (2010) shows that the earliest farmers were morphologically more like modern Bantu-speakers than Khoesan. This is also supported by the genetics (see Lane *et al.*, 2002). By the nineteenth century, hunter-gatherers (San) and herders (Khoe) were mostly occurring in the west, while farming was in the summer-rainfall eastern parts of the country (Parkington and Hall, 2010). However, the archaeological record clearly shows the presence of hunter-gatherers, herders and farmers sharing the same landscapes in the eastern parts of southern-most Africa throughout the Iron Age (Denbow, 1990; Hall and Smith, 2000; Reid and Segobye, 2000; van Doornun, 2007; Schoeman, 2006; Eastwood, 2003; Mason, 1974; Mazel, 1986; Wadley, 1996; Mosothwane, 2010).

The results of this thesis suggest two things with regards to the relatedness of these different cultural and economic groups. First, the low inter-population variability between Iron Age groups over time and space is surprising given that these "other people" also inhabited the landscape at this time, and suggests a degree of isolation within this group. Secondly, the differences between the Iron Age sample and the Khoesan sample for both dental metric (41% of measurements) and non-metric (22% of traits) analyses is comparable to that between the Khoesan and modern Bantu-speakers (19% of measurements; 27% of traits). These differences are greater than seen among the Iron Age samples, or between the Iron Age groups and historic/ modern samples. However, the general dental trends between the groups are similar (e.g. low frequencies of incisor shovelling, high frequencies of bushman's canine, etc).

The dental results are also supported by the cranio-mandibular metric results. While differences occur between the Iron Age samples and the modern samples, there are more significantly different measurements when compared with the Khoesan sample; 57% of measurements showed significant differences between the Khoesan and Iron Age samples. Similarly, 46% of the measurements differed significantly between the Khoesan and modern Bantu-speakers. Meanwhile, only 33% of measurements were significantly different between the Iron Age and modern samples. This further supports the idea that modern Bantu-speaking populations are more similar to the Iron Age populations compared to the Khoesan that lived within southern Africa at the time. However, the PCA charts do show considerable overlap between these groups. This may also indicate that while the Iron Age and modern samples are most similar and the Iron Age and Khoesan samples most different, this indicates some level of gene flow.

Farmers and Khoesan peoples were clearly interacting. The relationship between hunter-gatherers and farmers has been looked at in a number of different contexts (Hall and Smith, 2000; Denbow, 1990; Schoeman, 2006). The attitude of farmers toward hunter-gatherers, based on trade relations and the overlap of Late Stone Age and Iron Age material culture, differ in the archaeology between regions and over time. In general, however, the relationship reflects the ambivalent "first people/newcomer" principles seen in the ethnography (Parkington and Hall, 2010; Hall and Smith, 2000). The hunter-gatherers are simultaneously treated with great respect and suspicion. They are close to nature and powerful spiritually, but child-like and uncivilized (Parkington and Hall, 2010). It seems likely that these attitudes would have encouraged or even inhibited relationships (and therefore gene flow) between the Khoesan and other peoples.

Genetic studies on modern Bantu-speakers clearly show Khoesan admixture (Pereira *et al.,* 2001; Salas *et al.,* 2002; Wood *et al.,* 2005; Baleza *et al.,* 2005; Mitchell, 2010). Soodyall and Jenkins (1992) and Soodyall (1993) showed mitochondrial Khoesan L0d (L0 is a mitochondrial haplogroup, or ancestral group, of which L0d is one of the most divergent, or ancient, branches) as high as 50 % in Zulu-speakers. Studies of different Bantu-groups show different proportions of gene flow with hunter-gatherers (De Filippo *et al.,* 2010; Wood *et al.,* 2005). Mitochondrial and Y-chromosome genetic studies have shown that in most of sub-Saharan Africa, gene flow is sex-biased, with hunter-gatherer female gene flow into farmer groups and male farmer gene flow into hunter-gatherer groups (Wood *et al.,* 2005; Berniell-Lee *et al.,* 2009; Destro-Bisol, 2004; Pereira *et al.,* 2001; Soodyall, 1993; Montano *et al.,* 2011; Baleza *et al.,* 2005). It has been suggested that the extreme sex-bias admixture within Nguni-speaking groups may have only occurred after the *Mfecane/Difaqane* (Hamilton, 1995; Mitchell, 2010).

In light of these results (and from the literature) it is clear that Khoesan are more different from IA populations than IA populations are from each other (or even from current and historic populations), and that the levels of difference between Khoesan and IA populations, and Khoesan and modern Bantu-speakers, are comparable. This suggests that the amount of gene flow from Khoesan detected in modern Bantu-speakers from genetic studies may be similar to what existed between IA/Khoesan peoples. This could also be due to the age of the Khoesan specimens, which are more comparable to Iron Age populations than current or historical populations.

6.4. Results in the context of the greater dental anthropological literature

As has been indicated throughout this thesis, dental anthropology is a useful tool for studying gene flow within and between populations (Scott and Turner, 1988 and 1997). However, within sub-Saharan Africa very little standardized dental anthropology has been done. Earlier non-metric dental anthropology by Shaw (1931a, 1931b and 1927) and Jacobson (1982) were largely unstandardized and only focussed on modern individuals, making them difficult to compare to the data used in this thesis. While the dental anthropology of modern Bantu-speakers has been studied, looking at asymmetry and metrics (Kieser *et al.*, 1987; Kieser and Groeneveld, 1988), Haeussler *et al.* (1989) has also shown significant differences between modern Sotho and San using dental metrics and non-metrics. All of these studies have looked only at modern Bantu-or Khoesan samples and the majority of this work has used cast material. Although many of these studies are systematic, the use of only modern Bantu-speakers ignores the historic and pre-historic interface within this region, which, as was discussed in section 6.2, has made an impact on genetic relationships in southern Africa via gene flow. Also, the use of cast materials limits the number of traits that can be observed.

Researchers have characterized living populations into large dental complexes (Scott and Turner, 1997). Based on his work with modern Bantu-and San samples, Irish (1997, 1999; Irish and Guatelli-Steinberg, 2003) has been a forerunner in developing the concept of a "sub-Saharan dental complex". In this work, Irish has indicated that sub-Saharan Africans have high frequencies of the canine mesial ridge, Carabelli's trait (UM1), three-rooted M2s (UM2), Y-groove patterns (LM2), cusp7 (LM1), Tome's root, two-rooted LM2s and the presence of UM3 (Irish, 1997b: 464) when compared with other large geographic regions (i.e.

North African, European, Sundadont and Sinodont). Low frequencies of double shovelling (UI1) and enamel extension (UM1) were also observed. Figure 5.4.1 shows how Irish's (1993) frequencies compare with those of the Iron Age samples used in this study. While the general trends were similar (high frequencies of canine mesial ridge, UM1 Carabelli's trait, LM2 Y-groove pattern, LM2 two roots, UM2 three roots, LM1 cusp 7 and UM3 presence and low frequencies of UI1 double shovelling and UM1 enamel extension), the trait frequencies often differed substantially. Traits which differed significantly in their frequency include interruption groove (UI2), canine mesial ridge, UM1 cusp 5, LP1 Tome's root, LM2 groove pattern, LM2 cusp number, LM1 disto-trigonid crest, LM1 cusp 6, LM1 cusp 7, UM1 enamel extension, UP1 root number and LC root number. Therefore, 65% of the trait frequencies are significantly different between the reported sub-Saharan Dental Complex and the Iron Age groups studied here, while 50% of the trait frequencies differ significantly between Irish's work and the modern cadaver sample.

Despite these differences, the overall pattern (e.g. relatively high versus low frequencies) is largely consistent, suggesting that the "sub-Saharan Dental Complex" is a useful model for large-scale geographic comparisons so long as it is not applied too strictly, given the likelihood that trait frequencies vary between populations within sub-Saharan Africa over time and space, as shown here. It is not surprising that dental complexity would exist within sub-Saharan Africa today, as well as in the past, considering the historical changes that have occurred. It is also important to remember that because Irish (1997b) has mostly used modern or historical human samples, which have undergone considerable recent historical change (and gene flow both within and potentially outside of Africa), and has used specimens from all over sub-Saharan Africa, his results are not strictly comparable to what is presented here. Indeed, it could be argued that non-modern populations are more appropriate models for developing a sub-Saharan Dental Complex, though whether that would substantially change the pattern of the dental complex is a question that remains unanswered.

One trait that warrents further comment is the midline diastema. Little research has been made on the midline diastema in African populations. A midline diastema is a space between adjacent teeth that is greater than 0,5mm (Richardson *et al.,* 1973). These have been shown to occur in high frequencies in African populations (Richardson *et al.,* 1973 and Horowitz, 1970, Shaw, 1931b; Jacobson, 1982; Irish, 1998b), but are unusual and not often recorded outside of Africa. Sub-Saharan African populations have been shown to have between 2.8 and 44% occurrence (Irish, 1998b; with Nguni having 44% occurrence). Within this study, 48.6% of specimens had a midline diastema (based on 35 total specimens). Although the Iron Age samples ranged from 25% to 100%, this was only based on very small sample sizes (between 1 and 15 specimens).

Proportions of midline diastema have also been shown to reduce with age (Richardson *et al.,* 1973). A maxillary midline diastema, or gap between the maxillary incisors, is often seen in African and Asian populations (Arigbede and Adesuwa, 2012). Attitudes towards midline diastema have differed depending on cultural views and norms, but studies have focussed mostly on modern populations. Some cultures desire midline diastema. The Mende people, from Sierra Leone, have been shown to see gaps between the frontal incisors (or *sape)* as indications of feminine beauty, to be admired (Boone, 1986: 100). Boone (1986) suggests this can be seen as interplay between sexuality and looks: the gap between the teeth and the gap between the legs. This implies more passion and seduction. Modern Nigerians admit to not mind having artificial dental modification, sometimes leading to obsession (Omotosho and Kadir, 2010 and Arigbede and Adesuwa, 2012).

6.5. Health and culture

Although this section will not answer questions about gene flow and physical identity, sometimes cultural identity can be observed in the dentition through analysis of diet and cultural changes to teeth. Dental health is often compared between hunter-gatherers and farmers. Caries rates correlate with proportion of carbohydrates in diet, which differs between hunter-gatherers and farmers (Walker and Hewlett, 1990; Mosothwane, 2010). The higher the proportion of carbohydrate in a diet of a population, the higher the average of caries will be observed. Mosothwane and Steyn (2009) looked at the population health within Toutswe sites, noticing lower proportions of hypoplasias than in K2/Mapungubwe, possibly due to better health during childhood in eastern Botswana.

Dlamini (2006) has noted differences between the health of sub-Saharan populations in different regions, dividing populations into Wet Savannah (coastal areas such as KwaZulu Natal and Zambia), Dry Savannah (the low and high veld) and Forest. The proportion of individuals with caries and total carious teeth observed was much higher in this study than Dlamini’s. Her thesis reports between 21% and 64% of the individuals showed caries, and between 1.3% and 10.8% of teeth showed caries, differing between her Iron Age samples. This may indicate diet or be due to smaller sample size when sub-divided. This study has shown that between 57% and 80% of individuals showed caries, and between 12% and 21% of teeth, also indicating differences between the populations. Dlamini’s data suggested that “Wet Savannah” populations had lower levels of caries than “Dry savannah”, and this conclusion is reflected in the data collected in this thesis. The Zambian sample (wet Savannah) shows a high proportion of individuals with caries (79%), although the LIA western sample (mostly dry Savannah) has the highest proportion of individuals with caries (80%). The lowest proportions of caries are seen in the EIA and LIA (eastern) samples. This could likely be due to resources with EIA populations exploiting coastal and riverine regions and LIA eastern populations mostly occurring in the wetter KwaZulu Natal region.

The larger proportions of noted individuals with dental caries may be due to differences in how the data were collected, or sample size differences, but regardless, it is also possible that caries rates were influenced by many more factors other than biomes or even environment. Mosothwane and Steyn (2009) have shown that although Toutswe populations existed in more harsh environments, they were healthier, on average, than K2/Mapungubwe populations (Steyn and Henneberg, 1996). Mosothwane and Steyn (2009) also suggest that political stability may be the difference between the two areas, which would possibly affect overall health. As with my study, they showed that certain teeth (canines and incisors) were more prone to enamel hypoplasia than others (molars and premolars). A total of 46.2% of teeth within their Iron Age sample showed hyploplasia. This implies a generally poor health of Iron Age farmers, which is expected (Walker and Hewlett, 1990; also see above). This is also seen in the high proportions of periodontal disease and abscesses seen in the Iron Age samples.

Also significant in sub-Saharan Africa is dental mutilation and modification. The first evidence of dental mutilation in southern-most Africa occurs right at the beginning of the Early Iron Age (Morris, 1998 and 1993b). Dental mutilation has been seen in sub-Saharan in many forms, from chipping to the removal of the incisors or variations thereof (Morris, 1993b). Removal of teeth leads to alveolar loss and could lead to loss of lateral incisors and canines (Morris, 1993b). This practice has been suggested as either decoration, an expression of group identity or as some kind of rite of passage (Van Reenen, 1986 and Morris, 1993b and 1998). The Tonga, of southern Zambia, removed teeth for ritual purposes even in the early twentieth century (Colson, 1958 and 2006). Women were expected to remove their teeth after the first menstruation and were not expected to give birth until they had removed the teeth (Colson, 1958 and 2006). EIA remains in southern Africa often exhibit dental mutilation from specimens from Nanda in KwaZulu Natal, to Happy Rest and Broederstroom and even in Zambia (Morris, 1993 and 1998; Steyn *et al*., 1994). The importance of dental mutilation in the EIA can even be seen on the Lydenberg Heads, which exhibit gaps between the teeth. This practice is not seen on all EIA specimens and occurs rarely after 1300AD (Morris, 1998).

Dental modification of Iron Age peoples in southern Africa has been noted many times before (Steyn, 1994; Morris, 1989 and 1993b; Murphy, 1996; Mosothwane, 2003). Often this can be seen as antemortem loss of the incisors (and eventually the canines by alveolar loss; Morris, 1993b). Within this thesis, specimens with antemortem incisor loss ranged from 10% to 25% in Iron Age populations, with greater proportions of incisor loss in EIA and Zambian samples. Dlamini (2006) noted tooth extraction ranging from 3% to 26.7%, which is consistent with the samples used in this thesis. However, whether this is an indication of lifestyle or purposeful incisor pulling is unknown.

In this thesis, I noted three kinds of cultural modification in the Iron Age sample. Chipping or filing of the medial and lateral edges of the upper incisors to produce a point was the most common, especially in the EIA. Wear along the medial edge of the upper frontal incisors, producing a V-shaped gap was also noted. Lingual wear was also noted in the Zambian sample. This last attribute was the least visible and therefore possibly unintentional. However, an unintended cultural habit may have created this kind of wear.

Chipping of the frontal incisors to produce a point and medial wear has been reported previously (Dlamini, 2006). Dental modification has also previously been noted for Early Iron Age, Zambian (Iron Age) and Toutswe specimens (Morris, 1989; Mosothwane, 2003; Dlamini, 2006). Dental modification in the southern African Iron Age is cultural, and seen in both males and females (Morris, 1989). The five specimens showing cultural modification in the Late Iron Age and Middle Iron Age were surprising, because dental modification is often considered an EIA habit. However, only one specimen, from Pilanesberg (described by L'Abbe *et al.*, 2008), showed dental chipping. The other four (from Skutwater, Pilanesberg and Phalaborwa) showed medial wear. These results could be the result of a number of circumstances. It is possible that some individuals were mis-identified as LIA in the catalogues; "Late Iron Age" versus "Early Iron Age" can be difficult to define using skeletal evidence alone. Assuming the LIA specimens are indeed LIA, these results imply cultural continuity into certain LIA sites (Evers and van der Merwe, 1987, discuss this possibility with the Phalaborwa site). In this case, dental modification may have continued in some populations into the early parts of the second millennium. It is also possible that the V-shape (medial wear) is unintentional and results from some habit or occupation rather than being culturally transmitted. Regardless, it is clear that dental modification is much more complex within the Iron Age and needs further evaluation as to how and why certain features occur.

6.6. Strengths, limitations and future directions

Dental anthropology (metric and non-metric) and three-dimensional cranio-mandibular metrics are useful for analysing biological relationships in order to contribute to our understanding of genetic connections and gene flow. This kind of analysis has never been undertaken on southern African Iron Age populations using such a large sample size. Ribot *et al.* (2010) has used craniometrics on 17 KwaZulu Natal specimens that date from before and after the arrival of Iron Age populations. Specimens in this study were from a number of areas, covering a wide time span (from EIA to LIA). Analysing these Iron Age specimens, Historic Cave specimens and modern cadavers has allowed for useful comparisons over time. Similarly comparisons between Iron Age and Khoesan samples allow for further understanding of relationships between the different food-acquiring groups within southern Africa.

There are, of course, some limitations to this work. This study would benefit from larger sample sizes from specific sites within the archaeological record, such as the Mapungubwe specimens which have been reburied. This would have allowed for more directional comparisons between populations that are more defined. The situation where only one or two specimens are excavated per site is always a problem within Iron Age archaeology (Steyn, 2003), and creates difficulties when trying to define a population sample (especially EIA versus LIA). Also, while the total Iron Age sample size is greater than 100, the sample size is comparatively small when considering the total number of people who have lived during the Iron Age in southern Africa, with populations rising constantly (Vogel and Fuls, 1999). The use of dental anthropological techniques means that all specimens with adult human teeth may be included in this study. The cranio-mandibular metrics, however, can be done only on adults, which further limits sample size. All juveniles without adult teeth are not included in this study at all. A final, more theoretical problem, is trying to compare physical or genetic identity with cultural identity. A simple one to one relationship is never expected; it is difficult to determine how culture is affected by gene flow and vice versa with a simple model (Mulder, 2001).

This thesis is an important step in analysing biological relationships within the Iron Age, but the need for more specimens from single sites and more specimens in general means that future morphological analyses (or rather, continuous analyses as skeletons are excavated) will be useful. Also, a more detailed comparison between this sample and the Khoesan sample studied by Wendy Black (PhD thesis, in progress) is necessary for understanding the full complexity of gene flow within southern-most Africa. A more thorough look at the Dart collection is also necessary, specifically how cadaver material has been classified and what these specimens signify in terms of physical, cultural and linguistic identity. Finally, this study paves the way for a more intense, widespread study of dental modification within the Iron Age.

6.7. Conclusion

The low proportion of statistically significant differences between Iron Age groups before colonialism supports continuity, and by extension gene flow, between Iron Age communities in general. This is seen over space (between groups North and South of the Zambezi, and between second millennium groups) and time (between EIA and LIA groups). This supports the idea that cultural or typological differences within the Iron Age are mostly attributable to factors other than biological differences. Also, this result may be used as support for continued pre-historic connections between farmer populations further north and these southern-most African populations. This thesis has also shown that historic events, unsurprisingly, have had an effect on biological relationships among southern African populations. This result is strongly supported by other genetic studies. Also, Iron Age samples show greater similarity with each other than between them and Khoesan. Similarly, modern Bantu-speakers show greater similarity to Iron Age samples than to Khoesan samples.

The findings of this study support the idea that sub-Saharan African populations differ from other world-wide samples in their dental complex, and the general trends seen in previous studies are consistent with the groups analysed here. However, the use of modern and historic individuals for previous studies may explain the differences between trait frequencies observed in those studies and the results seen here. Once again, the use of modern and historic specimens needs to be properly evaluated before pre-historic or evolutionary claims should be made. It is clear that historic circumstances do affect relationships, contact, and therefore interaction, thereby altering the pattern of morphological diversity.

Finally, this study shows that the dentition of Iron Age populations is also influenced by the cultural habits and diet of these individuals. Poor dental health and dental modification (both intentional and the result of habit or occupation) are easily visible throughout the Iron Age, although much more predominant in the Zambian and EIA populations. More comprehensive work needs to be done on dental modification in the Iron Age.

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APPENDIX

Appendix 6.1 Table showing the sample sizes and proportions of non-metric traits for each of the populations looked at in this study. It includes the combined EIA and Toutswe sample (EIA-T), Late Iron Age (LIA), Zambian (ZAM), modern cadavers (MOD), Historic Cave (HC), Toutswe (TOU), Early Iron Age without Toutswe (EIA), LIA-east, LIA-west and the entire Iron Age sample (IA).

	EIA-T		LIA		ZAM		TOU		EIA		LIA-EAST		LIA-WEST		MOD		ALL IA		HC	
	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Winging- UI1	0.0	18	5.3	19	0.0	10	0.0	15	0.0	3	0.0	5	7.1	14	16.0	25	2.1	47	0.0	2
Labial Curve-UI1	15.8	19	25.8	31	13.3	15	13.3	15	25.0	4	0.0	7	33.3	24	33.3	21	20.0	65	8.3	12
Shovel- UI1	5.6	18	3.7	27	22.2	9	6.7	15	0.0	3	0.0	7	5.0	20	8.7	23	7.4	54	0.0	12
Double Shovel UI1	0.0	19	0.0	29	0.0	15	0.0	15	0.0	4	0.0	7	0.0	22	0.0	22	0.0	63	0.0	12
Int. Groove UI1	0.0	19	0.0	29	0.0	14	0.0	15	0.0	4	0.0	7	0.0	22	0.0	23	0.0	62	0.0	12
I and C td UI1	5.6	18	3.6	28	18.2	11	7.1	14	0.0	4	0.0	7	4.8	21	12.5	24	7.0	57	0.0	12
Shovel UI2	39.1	23	21.2	33	26.7	15	40.0	20	33.3	3	25.0	8	20.0	25	24.2	33	28.2	71	62.5	8
Double Shovel UI2	0.0	25	5.9	34	0.0	17	0.0	20	0.0	5	0.0	8	7.7	26	24.2	33	2.6	76	0.0	8
Int Groove UI2	0.0	24	11.1	36	0.0	18	0.0	18	0.0	6	12.5	8	10.7	28	6.1	33	5.1	78	0.0	10
I and C td UI2	24.0	25	2.9	35	13.3	15	26.3	19	16.7	6	12.5	8	0.0	27	19.4	31	12.0	75	22.2	9

Peg UI2	0.0	33	0.0	42	0.0	21	0.0	24	0.0	9	0.0	10	0.0	32			0.0	96	0.0	11
Shovel UC	19.2	26	24.2	33	5.9	17	17.6	17	22.2	9	37.5	8	20.0	25	25.7	35	18.4	76	50.0	10
Double Shovel UC	13.3	30	12.8	39	5.3	19	5.3	19	27.3	11	0.0	10	17.2	29	37.1	35	11.4	88	10.0	10
I and C td UC	17.2	29	17.6	34	23.5	17	10.5	19	30.0	10	12.5	8	19.2	26	27.8	36	18.8	80	50.0	10
C mesial ridge UC	75.0	24	70.0	30	57.1	14	81.3	16	62.5	8	50.0	8	77.3	22	70.6	34	69.1	68	100.0	9
CDAR UC	76.2	21	63.0	27	80.0	10	64.3	14	100.0	7	57.1	7	65.0	20	73.5	34	70.7	58	85.7	7
P m and d cusps UP2	15.4	26	13.5	37	4.8	21	20.0	15	9.1	11	10.0	10	14.8	27	35.1	37	11.9	84	0.0	1
Double shovel UP1	18.8	32	27.0	37	4.5	22	22.2	18	14.3	14	20.0	10	29.6	27	43.2	37	18.7	91	14.3	7
P m and d cusps UP	18.2	33	13.2	38	4.5	22	22.2	18	13.3	15	0.0	11	18.5	27	21.6	37	12.9	93	18.8	16
Root no. UP1	30.6	36	31.3	48	21.7	23	47.6	21	6.7	15	10.0	10	36.8	38	35.7	14	29.0	107	40.0	10
Metacone UM1	100.0	34	100.0	42	100.0	20	100.0	20	100.0	14	100.0	11	100.0	31	100.0	39	100.0	96	100.0	6
Metacone UM2	100.0	37	100.0	46	100.0	23	100.0	21	100.0	16	100.0	12	100.0	34	100.0	38	100.0	106	100.0	9
Metacone UM3	100.0	29	97.4	38	100.0	20	100.0	17	100.0	12	100.0	8	96.7	30	64.9	37	98.9	87	100.0	5
Hypocone UM1	100.0	35	100.0	43	100.0	19	100.0	20	100.0	15	100.0	11	100.0	32	100.0	39	100.0	97	100.0	7
Hypocone UM2	76.7	30	92.7	41	77.3	22	89.5	19	54.5	11	100.0	12	89.7	29	84.2	38	83.9	93	87.5	8
Hypocone UM3	50.0	24	63.9	36	60.0	20	61.5	13	36.4	11	60.0	10	65.4	26	62.9	35	58.8	80	50.0	4
Cusp 5 UM1	76.0	25	93.5	31	64.3	14	83.3	18	57.1	7	81.8	11	100.0	20	97.4	39	81.4	70	83.3	6
Cusp 5 UM2	84.0	25	82.4	34	56.3	16	86.7	15	80.0	10	81.8	11	82.6	23	92.1	38	77.3	75	50.0	6

Cusp 5 UM3	77.3	22	78.6	28	60.0	20	92.9	14	50.0	8	70.0	10	83.3	18	86.1	36	72.9	70	50.0	2
Carabelli UM1	14.3	35	16.7	42	4.5	22	19.0	21	7.1	14	20.0	10	15.6	32	41.0	39	13.1	99	28.6	7
Carabelli UM2	6.5	31	9.1	44	4.2	24	10.5	19	0.0	12	25.0	12	3.1	32	13.2	38	7.1	99	22.2	9
Carabelli UM3	0.0	25	2.5	40	9.5	21	0.0	14	0.0	11	10.0	10	0.0	30	22.6	31	3.5	86	0.0	5
Parastyle UM1	0.0	39	2.2	45	8.3	24	0.0	23	0.0	16	0.0	10	2.9	35	0.0	37	2.8	108	0.0	7
Parastyle UM2	5.6	36	9.5	42	4.0	25	5.0	20	6.3	16	0.0	11	12.9	31	0.0	38	6.8	103	0.0	9
Parastyle UM3	16.1	31	2.6	39	4.8	21	22.2	18	7.7	13	0.0	9	3.3	30	9.4	32	7.7	91	0.0	5
Root no. UM1	95.1	41	97.4	38	4.8	21	96.3	27	92.9	14	100.0	9	96.6	29	87.5	24	96.0	100	100.0	8
Root no. UM2	33.3	30	95.1	41	80.8	26	100.0	17	76.9	13	100.0	10	93.5	31	75.0	12	89.7	97	100.0	6
Root no. UM3	30.8	26	64.5	31	65.0	20	85.7	14	50.0	12	50.0	8	69.6	23	90.0	10	66.2	77	25.0	4
Enamel extension UM1	2.3	44	4.3	46	4.3	23	3.6	28	0.0	16	0.0	9	5.4	37			3.5	113	10.0	10
Peg, reduced absent UM3	0.0	31	0.0	46	4.3	23	0.0	18	0.0	13	0.0	11	0.0	35	0.0	38	1.0	100	0.0	7
Shovel LI	3.2	31	0.0	41	0.0	16	0.0	19	8.3	12	0.0	9	0.0	32	0.0	34	1.1	88	0.0	25
CDAR LC	63.0	27	75.7	37	53.3	15	58.8	17	70.0	10	37.5	8	86.2	29	72.7	33	67.1	79	36.4	11
P ling cusp LP1	68.6	35	81.8	44	60.0	15	60.0	20	80.0	15	80.0	10	82.4	34	79.5	39	73.4	94	62.5	8
P ling cusp LP2	67.9	28	73.7	38	78.6	14	62.5	16	75.0	12	62.5	8	76.7	30	73.0	37	72.5	80	75.0	4
Tome root LP1	14.8	27	4.0	25	0.0	3	16.7	18	11.1	9	0.0	8	5.9	17	14.3	7	9.1	55	50.0	4
Root no. LC	0.0	12	0.0	45	0.0	19	0.0	19	0.0	12	0.0	8	0.0	37	0.0	38	0.0	76	0.0	9
Ant Fovea LM1	90.9	22	85.7	28	85.7	7	93.3	15	85.7	7	88.9	9	84.2	19	94.7	19	87.7	57	90.0	10

Ant Fovea LM2	100.0	28	87.9	33	84.6	13	100.0	15	100.0	13	100.0	8	84.0	25	97.4	39	91.9	74	90.9	11
Groove pattern LM1	100.0	34	93.8	32	94.4	18	100.0	20	100.0	14	88.9	9	95.7	23	97.1	34	96.4	84	70.0	10
Groove pattern LM2	85.3	34	80.0	40	100.0	19	78.9	19	93.3	15	90.0	10	76.7	30	76.3	38	86.0	93	90.9	11
Groove pattern LM3	56.0	25	56.4	39	53.3	15	64.3	14	45.5	11	40.0	10	62.1	29	40.0	35	55.7	79	66.7	3
Cusp no. LM1	100.0	33	100.0	36	100.0	16	100.0	20	100.0	13	100.0	9	100.0	27	100.0	35	100.0	85	100.0	11
Cusp no. LM2	100.0	34	100.0	41	100.0	18	100.0	19	100.0	15	100.0	10	100.0	31	100.0	35	100.0	93	90.9	11
Cusp no. LM3	100.0	25	100.0	35	100.0	17	100.0	13	100.0	12	100.0	9	100.0	26	100.0	33	100.0	77	100.0	2
Def Wrinkle LM1	26.3	19	12.5	24	0.0	6	38.5	13	0.0	6	33.3	6	5.6	18	32.4	34	16.3	49	0.0	9
Def Wrinkle LM2	20.8	24	8.6	35	23.1	13	33.3	12	8.3	12	14.3	7	7.1	28	10.8	37	15.3	72	0.0	9
Def Wrinkle LM3	11.8	17	11.1	27	16.7	12	12.5	8	11.1	9	0.0	8	15.8	19	17.6	34	12.5	56	0.0	1
DT crest LM1	30.0	20	13.6	22	37.5	8	33.3	15	20.0	5	0.0	5	17.6	17	31.4	35	24.0	50	20.0	10
DT crest LM2	17.9	28	11.8	34	7.1	14	20.0	15	15.4	13	0.0	9	16.0	25	13.5	37	13.2	76	20.0	10
DT crest LM3	5.6	18	0.0	31	7.1	14	0.0	9	11.1	9	0.0	9	0.0	22	0.0	34	3.2	63	0.0	1
Protostylid LM1	2.7	37	0.0	39	0.0	18	4.3	23	0.0	14	0.0	8	0.0	31	16.2	37	1.1	94	0.0	10
Protostylid LM2	8.8	34	4.7	43	0.0	18	10.5	19	6.7	15	9.1	11	3.1	32	21.6	37	5.3	95	11.1	9
Protostylid LM3	19.2	26	23.7	38	5.9	17	21.4	14	16.7	12	30.0	10	21.4	28	29.0	31	18.5	81	0.0	1
Cusp 5 LM1	97.0	33	97.2	36	94.1	17	100.0	20	92.3	13	100.0	9	96.3	27	100.0	36	96.5	86	100.0	11
Cusp 5 LM2	73.5	34	65.9	41	61.1	18	68.4	19	80.0	15	80.0	10	61.3	31	74.3	35	67.7	93	72.7	11

Cusp 5 LM3	76.0	25	88.2	34	88.2	17	92.3	13	58.3	12	88.9	9	88.0	25	91.2	34	84.2	76	50.0	2
Cusp 6 LM1	26.5	34	25.0	36	31.3	16	20.0	20	35.7	14	44.4	9	18.5	27	40.0	35	26.7	86	9.1	11
Cusp 6 LM2	14.7	34	22.0	41	5.6	18	26.3	19	0.0	15	30.0	10	19.4	31	45.7	35	16.1	93	54.5	11
Cusp 6 LM3	32.0	25	44.1	34	29.4	17	23.1	13	41.7	12	44.4	9	44.0	25	63.6	33	36.8	76	0.0	2
Cusp 7 LM1	56.3	32	68.6	35	47.1	17	60.0	20	50.0	12	88.9	9	61.5	26	75.0	36	59.5	84	54.5	11
Cusp 7 LM2	58.1	31	47.5	40	42.1	19	62.5	16	53.3	15	62.5	8	43.8	32	63.2	38	50.0	90	72.7	11
Cusp 7 LM3	69.6	23	47.2	36	29.4	17	81.8	11	58.3	12	55.6	9	44.4	27	78.1	32	50.0	76	0.0	2
Torso. Angle	0.0	22	7.5	40	6.3	16	0.0	12	0.0	10	0.0	10	10.0	30	47.2	36	5.1	78		0
Root no. LM1	2.4	41	4.2	48	0.0	18	3.8	26	0.0	15	25.0	8	0.0	40	25.0	20	2.8	107	0.0	11
Root no. LM2	100.0	36	97.7	44	94.4	18	100.0	23	100.0	13	88.9	9	100.0	35	100.0	12	98.0	98	100.0	7
Root no. LM3	91.3	23	88.2	34	91.7	12	84.6	13	100.0	10	87.5	8	88.5	26	100.0	6	89.9	69	0.0	1

Appendix 6.2 Table showing the t-test p-values for dental metric comparisons between the samples looked at in this study. It includes the combined EIA and Toutswe sample (EIA-T), Late Iron Age (LIA), Zambian (ZAM), modern cadavers (MOD), Historic Cave (HC), Khoesan (KHO), Toutswe (TOU), Early Iron Age without Toutswe (EIA), LIA east (LIA-E), LIA west (LIA-W).

		EIA-T/ LIA	**EIA-T/ ZAM**	**EIA-T/ HC**	**EIA+T/ MOD**	**EIA-T/ KHO**	**LIA/ ZAM**	**LIA-/ HC**	**LIA/ MOD**	**LIA/ KHO**	**ZAM / HC**	**ZAM/ MOD**	**ZAM/ KHO**	**HC/ MOD**	**HC/ KHO**	**MOD/ KHO**	**LIA-E/ LIA-W**	**LIA-E/ TOU**	**LIA-E/ EIA**	**LIA-W/ TOU**	**LIA-W / EIA**	**TOU/ EIA**
BL-Lower	LI1L	0.973	0.589	0.650	0.238	0.138	0.550	0.605	0.188	0.145	0.557	0.653	0.410	0.323	0.461	0.569	0.821	0.938	0.681	0.811	0.769	0.626
	LI2L	0.997	0.589	0.736	0.194	**0.005**	0.520	0.686	0.123	**0.001**	0.926	0.700	**0.070**	0.640	0.142	**0.023**	0.247	0.618	0.301	0.325	0.572	0.273
	LCL	0.639	0.606	0.806	0.975	**0.021**	0.361	0.963	0.676	**0.042**	0.595	0.729	**0.032**	0.856	0.154	0.120	0.697	0.751	0.776	0.411	0.941	0.511
	LP1L	0.760	**0.036**	0.056	**0.081**	**0.000**	**0.070**	0.136	0.156	**0.001**	0.664	0.391	0.103	0.273	0.413	**0.005**	0.082	0.112	**0.075**	0.748	0.920	0.828
	LP2L	0.613	0.133	0.485	0.322	**0.005**	0.219	0.599	0.595	**0.007**	0.964	0.375	0.156	0.698	0.361	**0.011**	0.641	0.511	0.492	0.831	0.746	0.911
	LM1L	0.462	0.859	**0.020**	**0.000**	**0.008**	0.455	0.141	**0.003**	**0.070**	**0.037**	**0.001**	**0.022**	0.536	0.990	0.488	0.975	0.194	0.758	0.121	0.657	**0.047**
	LM2L	0.692	0.487	**0.008**	**0.011**	0.199	0.318	**0.010**	**0.004**	0.114	0.109	0.202	0.701	0.237	0.105	0.348	0.777	0.942	0.993	0.687	0.749	0.946
	LM3L	0.424	0.796	—	0.664	0.176	0.335	—	0.715	**0.044**	—	0.524	0.302	—	—	**0.089**	0.613	0.667	0.139	0.954	0.325	0.340
MD-Lower	LI1L	0.823	0.801	0.975	0.690	0.960	0.944	0.876	0.719	0.876	0.835	0.826	0.838	0.770	0.936	0.858	0.210	0.296	0.449	0.770	0.840	0.732
	LI2L	0.717	0.640	0.560	0.736	0.451	0.798	0.306	0.962	0.258	0.317	0.863	0.276	0.400	0.651	0.371	0.183	0.338	0.259	0.770	0.764	0.662
	LCL	0.166	0.107	0.455	**0.002**	**0.051**	0.549	**0.089**	**0.034**	0.166	**0.055**	0.278	0.308	**0.003**	**0.029**	0.669	0.618	0.225	0.792	**0.034**	0.843	0.123
	LP1L	0.526	0.115	0.774	**0.021**	**0.064**	0.214	0.474	**0.047**	**0.082**	0.125	0.698	0.366	**0.060**	**0.097**	0.502	0.324	0.391	0.281	0.817	0.785	0.993
	LP2L	0.518	0.121	0.541	**0.001**	0.133	0.349	0.457	**0.017**	0.422	0.230	0.355	0.867	**0.031**	**0.055**	0.634	0.948	0.717	0.719	0.626	0.649	0.995
	LM1L	**0.012**	**0.043**	**0.094**	**0.001**	**0.038**	0.948	0.924	0.255	0.702	0.887	0.305	0.689	0.508	0.829	0.655	0.999	**0.048**	0.343	**0.010**	0.178	0.576
	LM2L	0.144	**0.044**	0.266	**0.012**	0.927	0.279	0.816	0.206	0.281	0.597	0.894	0.146	0.572	0.375	**0.070**	0.709	0.373	0.714	0.129	0.404	0.633
	LM3L	0.542	0.915	—	0.217	**0.033**	0.472	—	0.369	**0.025**	—	0.213	**0.033**	—	—	0.183	0.433	0.198	0.102	**0.021**	0.253	**0.008**
BL-	UI1L	0.689	0.796	0.996	0.697	0.547	0.542	0.742	0.410	0.369	0.822	0.941	0.725	0.739	0.613	0.714	0.763	0.793	0.337	0.847	0.353	0.218
	UI2L	0.239	0.781	0.729	0.528	0.802	0.124	0.173	0.610	0.228	0.883	0.360	0.960	0.402	0.938	0.475	0.820	0.420	0.492	0.351	0.484	0.951

BL-Lower	UCL	0.864	0.882	0.993	0.248	**0.006**	0.736	0.886	0.239	**0.002**	0.905	0.218	**0.006**	0.380	**0.024**	**0.026**	0.544	0.676	0.970	0.923	0.562	0.695
	UP1L	0.974	0.266	0.148	0.165	**0.014**	0.133	**0.043**	**0.075**	**0.001**	0.276	0.941	**0.036**	0.308	0.426	**0.022**	0.513	0.990	0.481	0.502	0.654	0.457
	UP2L	0.629	0.152	0.825	0.199	**0.009**	0.178	0.954	0.308	**0.002**	0.397	0.577	**0.061**	0.519	**0.074**	**0.009**	0.448	0.566	0.456	0.945	0.757	0.868
	UM1L	0.763	0.369	0.251	**0.032**	**0.000**	0.522	0.333	**0.056**	**0.001**	0.549	0.313	**0.011**	0.980	0.277	**0.039**	0.705	0.767	0.471	0.855	0.637	0.521
	UM2L	0.693	0.103	0.100	**0.029**	**0.003**	**0.055**	**0.080**	**0.010**	**0.002**	0.467	0.754	**0.051**	0.538	0.511	**0.050**	0.715	0.714	0.445	0.992	0.691	0.673
	UM3L	0.298	0.928	0.564	0.976	**0.066**	0.230	0.126	0.238	**0.001**	0.559	0.945	**0.058**	0.545	0.354	**0.048**	0.535	0.584	0.093	0.792	0.181	0.536
	UI1L	0.688	0.283	0.894	0.151	0.945	0.535	0.655	**0.058**	0.765	0.141	**0.050**	0.351	0.305	0.977	0.445	0.359	0.385	0.097	0.673	0.344	0.147
	UI2L	0.255	0.807	0.357	0.572	0.657	0.104	0.739	**0.027**	0.964	0.106	0.771	0.392	**0.082**	0.751	0.344	0.795	0.587	0.253	0.524	0.156	0.601
	UCL	0.924	0.680	0.284	0.136	**0.085**	0.679	0.156	**0.088**	**0.038**	0.081	0.278	**0.087**	**0.023**	**0.029**	0.317	0.414	0.864	0.474	0.468	0.764	0.490
	UP1L	0.702	0.722	0.323	**0.016**	0.932	0.495	0.386	**0.024**	0.910	0.341	**0.027**	0.807	0.556	0.310	0.207	0.312	0.620	0.267	0.655	0.594	0.454
	UP2L	0.619	0.483	**0.012**	**0.058**	0.225	0.685	**0.006**	**0.004**	0.209	**0.058**	**0.010**	0.427	**0.000**	0.578	0.016	0.680	0.852	0.350	0.885	0.399	0.492
	UM1L	0.165	0.219	0.504	**0.035**	0.489	0.956	0.994	0.475	0.727	0.971	0.482	0.741	0.746	0.846	0.371	0.557	0.380	0.888	0.087	0.607	0.283
	UM2L	0.265	0.577	0.474	0.946	0.970	0.146	0.218	0.222	0.502	0.787	0.611	0.770	0.510	0.686	0.999	0.147	0.244	**0.031**	0.820	0.237	0.182
	UM3L	0.813	0.353	0.383	0.806	0.196	0.156	0.344	0.962	0.148	0.111	0.204	**0.032**	0.440	0.792	0.233	0.138	0.579	0.359	0.486	0.717	0.805