Chapter 5

Dental modification in the Circle: shaping bodies, shaping culture in Neolithic Malta

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5.1. Introduction

The modification of human teeth is a subject of great curiosity and enquiry across bioarchaeology, anthropology and ethnography for many reasons, not the least of which includes its expression in apparently disparate cultures across time and geographical space. Substantial efforts have been devoted to categorizing the myriad variations of shape and style; demographic incidence; technology and intention of intervention ('passive' or 'active'; Alt & Pichler 1998, 388; Bocquentin *et al.* 2013, 386; Larsen & Kelley 1991, 4; Mayes *et al.* 2017, 285; Milner & Larsen 1991); and, where undertaken as an act of deliberate physical manipulation, the aetiology and impetus for such dramatic, irreversible and potentially dangerous change. While individual-level variation in dental modification may provide powerful indicators of individual identity, at a broader societal level, there is ample cross-cultural evidence that, in many societies, intentional dental modifications play an important role in the expression and mediation of social identities (De Groote & Humphrey 2016; Knudson & Stojanowski 2008).

Comprehensive reviews of the practice, incidence and cross-cultural attestations of dental modification have been carried out by Scott & Turner (1988), Milner & Larsen (1991), Alt & Pichler (1998), and Mower (1999). More recent work by van der Reijden (2014) has focused on attempts to standardize the terminology and categorization of dental modification phenomena, as called for by many practitioners in the field (González *et al.* 2010). The variation in previous works has unwittingly obfuscated understanding of the true incidence and prevalence rates of specific modification types, thus limiting our ability to harness observations as signifiers of possible connection and communication amongst and between cultures.

The current study presents the first dedicated enquiry into the nature and scope of dental modification in any skeletal population from the Maltese archipelago, and thus hopes to contribute to broader research into the phenomenon across the Mediterranean, particularly for the prehistoric period. It must be noted, however, that modified teeth were first observed in the Circle assemblage by Stoddart *et al.* (2009a), with reports of 'parafunctional wear' (pp. 318, 325) as well as the use of the teeth as a 'third hand' (p. 329). These comments delineate the extent of reporting into this matter to-date, and were followed by a recommendation that 'the teeth need to be investigated further in order to take this idea forward' (Stoddart *et al.* 2009a, 329). It is from this platform that the present work emerges, and seeks to offer the first detailed, quantitative investigation into this fascinating aspect of human behaviour for Neolithic Malta.

The broad aim of this chapter is to introduce the Neolithic population of the Xagħra plateau to the wider discourse of dental modification. It seeks to report the nature and scope of this phenomenon amongst contemporary prehistoric central Mediterranean populations, and to look towards a wider network of activity and identity markers across broader Mediterranean, African and European cultural contexts. Despite the significant challenges presented by the highly fragmented, commingled and predominantly disarticulated nature of the Circle assemblage, the present study seeks to demonstrate the importance and value of including Neolithic populations from such contexts into scholarly accounts of these intriguing phenomena. The very nature of assemblages like Xagħra precludes traditional approaches to whole-body analyses; however, aspects of funerary behaviour should not exclude these populations from their rightful inclusion in considerations of broader cultural dynamics. Despite long-standing disciplinary traditions of recording and reporting intact arcades, we argue that our shift in focus to teeth as a single category of element provides: i) the greatest consistency, ii) most numerous scientific analytical capabilities, iii) maximum systemic insights, and iv) best possibility for comparative studies across contemporaneous regional populations. This chapter will consider the background to dental modification in human behaviour and the history of its study in biological anthropology. For context, we will offer a brief review of the incidence of these phenomena across Africa and Europe. We will then present the findings of our analyses of dental modification within the Circle burial population and discuss their significance for Maltese prehistory.

It must be remembered that this group of people most likely contained the individuals responsible for constructing amongst the oldest free-standing stone structures in the world, the megalithic temples of Ġgantija, located 400 m away from the Circle. The members of this population were therefore globally significant innovators in design, architecture, technology, materials extraction and craftwork, all requiring a combination of substantial intellectual and physical activity. As reported in Chapters 4, 7 and 8, the body offers a powerful means to access the activities and lived experiences reflected within its hard tissues. By considering the ways the people of Xagħra applied intellectual and/or physical activities to shape their teeth, we are situating this important Neolithic Maltese community within the wider local and regional cultural dynamics that were also shaping the rapidly changing world around them.

5.2. Background

'Active' dental modification is a highly visible and geographically widespread form of body modification, while 'passive' dental modification is an almost ubiquitous phenomenon. As a result of the exceptional preservation of teeth, it is also the most likely form of body modification to preserve in the archaeological record and is increasingly noted to have been practised amongst diverse prehistoric populations (Burnett & Irish 2017b, 2; Geller 2006; López Olivares 1997; van der Reijden 2014, 7). As humans communicate predominantly through movements of the mouth during speech and other non-verbal interpersonal forms of expression, these gestures involve regularly displaying and observing the dentition (van der Reijden 2014, 7). Recognizing this, cultural groups spanning much of the globe have exploited the orofacial complex as a key site for conveying messages about identity, ethnicity, status and even emotion (Anderson *et al.* 2005; Burnett 2017. 252; De Groot & Humphrey 2017, 26; Langsjoen 1998, 410; Larsen 2017, xvi; Linne 1940; Mower 1999, 47; van Reenen 1978a; van der Reijden 2014, 7; Watson & García 2017, 298). For this reason, the majority of dental modification observations recorded for archaeological populations pertains to the anterior dentition of the maxillary incisors and canines, referred to by Larsen as 'the social six' (Larsen 2017, xvi), considering their capacity to provide important social cues and signals. Cases of active dental modification have been recorded in the ethnographic and ethnohistoric literature from a staggering number of regions, including cultures in Australia, Africa, Asia, North, central and South America and, in several places, these practices appear to have significant time depth (Burnett & Irish 2017a; Campbell 1925; De Groote & Humphrey 2016; Ikehara-Quebral *et al.* 2017; Jones 1992, 2001; Langsjoen 1998, 41; Lee 2017; Milner & Larsen 1991; Ortner 2003, 603; Pardoe & Durband 2017; Pietrusewsky *et al.* 2017; Tayles 1996). Despite its widespread distribution, the styles and patterns of dental modification often follow highly localized forms, resulting in marked regional characteristics (Alt & Pichler 1998, 405). The archaeological evidence similarly reflects this historic and contemporary diversity, in terms of the form or style of dental modification, the means by which tooth shape is altered, and the motivations for such practices.

The importance of distinguishing between dentition altered through usual mastication, and through non-alimentary practices such as intentional shaping and using the teeth as tools (parafunctional wear), has been recognized within biological anthropology for several decades. An early dental modification recording system categorized modifications arising from the following processes: i) dietary wear; ii) implemental wear (commonly referred to as 'use of teeth as tools'); iii) incidental cultural practices; and iv) intentional cultural practices (Scott 1997). Alt & Pichler (1998) later refined these to distinguish between 'active' (intentional) and 'passive' modifications (encompassing those caused by diet, habitual practices and parafunctional wear). Importantly, they noted that passive changes to the dentition develop through repetitive action, accruing over a greater timeframe than active modifications (Alt & Pichler 1998, 388). Active modifications are carried out purposefully to fulfil specific aesthetic, cultural or ritual aims. Therapeutic or palliative interventions are excluded from these categories; although these were defined as active modifications by Alt & Pichler (1998, 388), we classify these as preventative procedures unrelated to symbolic socio-cultural practices.

Teeth can be intentionally altered through chiselling, drilling, extraction (ablation or avulsion), filing, inlaying, polishing, repositioning, scoring and staining

(Burnett & Irish 2017b, 1; Langsjoen 1998, 410; Milner 2017, 318; Ortner 2003, 603; Roberts & Manchester 2005, 81). These interventions involve a range of tools across cultures, but typically a hammer and chisel, stone or metal file, knife, stone axe and/or hardwood stick are required (Aseffa *et al.* 2016; Fastlicht 1976; Headland 1977; Kanner 1928; van Reenen 1978a, 1978b; van Rippen 1917). Ethnographic observations of sub-Saharan African groups describe the subject laying with their head in the operator's lap, biting on a stick between their molars while the operator chipped their anterior teeth using a knife or a chisel, pounded by a hammer stone (Irish 2017, 40; van der Reijden 2014, 22). Depending on the desired effect, a file could then be used to smooth the margins (Irish 2017, 41).

Other modifications include attaching prostheses such as dentures and decorative caps or grills (Milner & Larsen 1991; Alt & Pichler 1998; Peter *et al.* 2013). In her recent review of active (cultural) dental modification, van der Reijden (2014, 16) argues that chipping should be considered an outcome of passive modification, while germectomy (Barzangi *et al.* 2013; Bataringaya *et al.* 2005; Garve *et al.* 2016; van der Reijden 2014) is often sought as a treatment for infant illness (cf Pindborg 1969). Distinguishing between modification processes, means, and other dental pathologies can be challenging (Burnett 2017, 251; Burnett & Irish 2017b, 4; Milner 2017, 318; Milner & Larsen 1991; Molnar 1972). In general, active modifications are primarily found on the anterior dentition and are symmetrical in pattern, while habitual changes are more likely to appear on the anterior dentition but may also be observed for the distal arcade (Alt & Pichler 1998, 399; Langsjoen 1998, 410; cf. Chapter 4). Furthermore, intentional reduction of crown height may be confused with extensive attrition because of parafunctional wear (van der Reijden 2014, 18). Additionally, dental avulsion and *antemortem* tooth loss may be indistinguishable if alveolar bone resorption is advanced, although several scholars (Milner & Larsen 1991, 363) recommend the following criteria for identifying avulsion: lack of surrounding dental pathology; symmetry in the pattern of tooth loss; and repetition of this pattern amongst multiple individuals in the skeletal assemblage (Buikstra 1987; Lee 2017, 97; Milner & Larsen 1991, 363; Newton & Domett 2017, 161–162; Pietrusewsky *et al.* 2017, 107; however see Spencer & Gillen 1927; van der Reijden 2014, 21; van Rippen 1918a, 1918b). The same methodology is also useful in evaluating various other forms of dental modification.

5.2.1. 'Active' versus 'passive' modifications

There are myriad different reasons as to why past populations practised or experienced dental modification (Burnett & Irish 2017b, 2). Cross-cultural reviews of active dental modification (Benedix 1998; Burnett & Irish 2017b, 2; Mower 1999; Pinchi *et al.* 2015) reveal a plethora of intentions behind this practice, including: cosmetic enhancements; ensuring feeding if lockjaw arises as a result of tetanus; tradition; initiations or rites of passage, especially into adulthood or parenthood; mourning; improving linguistic pronunciation; intimidating enemies; signalling tribal or ethnic identity or affiliation; punishment; pain endurance; to practise folk medicine; and/or to mimic or differentiate appearance from totemic animals (Artaria 2017; Bolhofner 2017; De Groote & Humphrey 2017; Erlandsson & Bäckman 1999; Geller 2004, 2006; Irish 2017; Mower 1999; Noman *et al.* 2015; Pardoe & Durband 2017; Pietrusewsky *et al.* 2017; Watson & García 2017; van der Reiden 2014; Scott & Turner 1997; Milner & Larsen 1991; Van Rippen 1918a; Shaw 1931; Singer 1953; Campbell 1925). Alt & Pichler (1998) have summarized these intentions as being of either therapeutic or non-therapeutic motivations; and Stojanowksi *et al.* (2016) have characterized the latter as 'culturally mediated dental modification'. Intentionally altering the shape of teeth induces significant pain and carries the risk of future complications from infection and tooth loss. Amongst practising cultures, dental modification is frequently endured and persists with some longevity, illustrating the cultural significance of this form of body modification (Alt & Pichler 1998, 407). Dental modification is noted as early as the Upper Palaeolithic in Maghreb (20,160–12,000 cal. BP), with the majority of preserved maxillae from the Iberomaurusian period presenting avulsion of at least one incisor (De Groote & Humphrey 2016, 2017; Humphrey & Bocaege 2008). While there is variation in the avulsion pattern throughout this period, it appears to have been carried out almost universally regardless of sex and, in cases of multiple extraction, at different times in most individuals' lives (De Groote & Humphrey 2016). Yet, considering the staggering range of potential motivations noted across numerous studies, the specific reasons for dental modification observed in the archaeological record are difficult to identify with certainty.

Passive dental modification is a universal occurrence but highly variable according to environment and subsistence base, as well as individually specific occupations, habits and idiosyncrasies. Unintentional shape changes can be caused by dietary and non-dietary chewing. Non-dietary tooth wear is often a result of the use of teeth as tools, for example to split materials such as bone, shell, plants and fibres (Buikstra & Ubelaker 1994; Cybulski 1974; Lukacs & Pastor 1988; Schulz 1977); to process fibres or scrape hides (Langsjoen 1998, 410; Roberts & Manchester 2005, 81); to edge flaked stone tools (Buikstra & Ubelaker 1994; Turner & Cadien 1969); or as a 'third hand' to hold material static in the teeth to allow manipulation (Alt & Pichler 1998, 394; Merbs 1983; Roberts & Manchester 2005, 81). Further means of passive modification include holding or carrying objects with the teeth; wearing jewellery such as lower lip labrets and discs; bruxism; trauma and/or violence (Alt & Pichler 1998; Milner & Larsen 1991; Molnar 1972). The repetitive use of toothpicks to remove food trapped in the interproximal spaces is typically the most common form of passive dental modification and also appears to be the oldest, noted in numerous Pleistocene populations (Boaz & Howell 1977; Bermudez de Castro *et al.* 1997; Frayer & Russell 1987; Ungar *et al.* 2001; Sun *et al.* 2014; cf Ubelaker *et al.* 1969; Buikstra & Ubelaker 1994).

5.2.2. History of study in biological anthropology

Records of dental modification provided from late 19th and early 20th century travellers have been of interest to social and biological anthropologists since they were produced (Livingstone 1861, 185, 348; Milner 2017, 318; cf Galton 1853; Hamy 1882; Schweinfurth 1874; Serpa Pinto 1881; Werner 1906; Starr 1909; van Rippen 1918a, 1918b, 1918c; Guthe 1934; Tozzer 1941). From the 1960s, there is an evident increase in bioarchaeological research on the topic, some describing the phenomenon as 'dental transfigurement' (Turner 2000), or more negatively as a form of 'dental mutilation', a pejorative term which has regularly been criticized (Burnett & Irish 2017b, 2; Geller 2006; Jones 2001; Mower 1999; Turner 2000). Within biological anthropology, much work until recently has been restricted to the description and analysis of regional trends, according to the availability of skeletal remains from archaeological excavations and ethnological collections. This has led to particularly rich literature on dental modifications amongst Indigenous and prehistoric North American, Mesoamerican and South American populations (Blakely & Beck 1984; Fastlicht 1976; Kirk 2006; Scherer 2018; Schulz 1977; Tiesler *et al.* 2017; Turner II 2000, 2004; Turner II & Cadien 1969; Turner II & Machado 1983; Ubelaker 1984; Williams & White 2006).

The primary focus of much research has been to develop classification systems encompassing ever-greater numbers of modification styles. These have often been regional in focus, with catalogues compiled for African (Almeida 1953, 1957; Starr 1909; von Jhering 1882; Wasterlain *et al.* 2016) and South American and Mesoamerican styles (Fastlicht 1948; Romero 1986; Rubín de la Borbolla 1940; Saville 1913). The relevance of these classificatory efforts beyond the intended region is unfortunately limited, because of their localized nature. Despite this, Romero's (1986) catalogue, recognized until recently as the largest and most sophisticated coding system, is often referred to as the general standard for active dental modifications. However, it has been noted that errors have been introduced into the classification systems over time through transcription errors and misinterpretations of drawings and/or descriptions (van der Reijden 2014, 38).

Perhaps as a result of the extensive (but often difficult to access) literature on this topic, there is little standardization in terms of recording dental modifications. Buikstra and Ubelaker (1994, 58) recommend thoroughly describing all altered dentition, noting the affected surface(s), the nature of modification and any introduced foreign materials, and providing codes for filing; drilling (with or without inlays); dental restorations or applications; wear associated with artefact use or production; and tooth evulsion or ablation. Recently, the most comprehensive recording system for intentional modifications has been collated, uniting all forms in the current literature and introducing several recently identified types (van der Reijden 2014). This global classification system comprises almost 300 styles, making a series of recommendations for recording and coding. In particular, van der Reijden (2014, 15, 36) emphasizes that shaped teeth often exhibit multiple forms of modification, each of which should be coded separately. Passive modifications have been researched by Bonfiglioli (2002) and, although not fully published, her criteria for scoring chipping, interproximal grooves and notches are presented in a recent work (Bonfiglioli *et al.* 2004). A recent brief review of AIDMs (activity induced dental modifications; including notching, grooving, labial and occlusal striations); LSAMAT (lingual surface attrition of the maxillary anterior teeth; Turner & Machado 1983); wear facets and polishing; interproximal striations; and chipping, highlights the need for both standardized terminology and recording methods (Molnar 2011).

Beyond the limitations of many existing corpora of dental modification styles, and the variation in recording standards, there are opportunities for the development of this field in alignment with the aims of social bioarchaeology. Milner and Larsen (1991, 373) were early to note the interpretative difficulties concerning the cultural significance of intentional modifications and the causes of unintentional modifications. These difficulties largely remain; while there are many available ethnographic studies, establishing the means by which modifications were achieved amongst a given population (whether active or passive) often relies upon a combination of contextual data and inference. Greater attention is needed to consider the dynamic use of the mouth in non-alimentary activities, combining archaeological and biochemical evidence for subsistence and craft practices. Furthermore, the age at which individuals underwent intentional dental modification, and the length of time it may have taken to shape teeth, are pertinent for advancing our understanding of both the social and individual experience of this phenomenon (van der Reijden 2014, 91). Although this is difficult to assess in many cases, recent work by De Groote and Humphrey (2016, 2017) accounts for stages of alveolar remodelling to identify typical ages at which dental avulsion was implemented during the Late Stone Age in Northwest Africa.

Increasingly, scholarship is considering the socio-cultural implications of such visible and visceral practices, establishing the relationship between age, sex, diet, mobility, and group identity amongst individuals displaying modified dentition (Artaria 2017; Bolhofner 2017; De Groote & Humphrey 2017; Erlandsson & Bäckman 1999; Geller 2004, 2006; Irish 2017; Milner & Larsen 1991; Mower 1999; Noman *et al.* 2015; Scott & Burgett Jolie 2008; Scott & Turner 1997; Pardoe & Durband 2017; Pietrusewsky *et al.* 2017; van der Reiden 2014; Watson & García 2017). Interestingly, where it is possible to scrutinize the demographic profile of individuals with intentionally and/or incidentally modified dentition, there is often little engagement with the relationship of this phenomenon to gender identity (for example, Blakely & Beck 1984; Bonfiglioli *et al.* 2004; Sperduti *et al.* 2018; Williams & White 2006), even and especially where incidences do not fit the culturally expected pattern (for example, Sperduti *et al.* 2018, 237), there are clear regional differences (Waters-Rist *et al.* 2010), or significant diachronic changes (Humphrey & Boceage 2008; Stojanowski *et al.* 2014). Future studies of dental modification must seek to move beyond biological markers of sex and age to examine the significance of such practices within their cultural framework of meaning.

5.2.3. Dental modification in prehistoric Africa and Europe

Intentional dental modification by way of ablation is noted as early as the Late Stone Age in the Maghreb (Northwest Africa) and endured through to the Neolithic (Bonfiglioli *et al.* 2004; De Groote & Humphrey 2016, 2017; Humphrey & Bocaege 2008). Skeletal remains from the Iberomaurusian period (21,160–*c.* 12,000 cal. BP), indicate that nearly all adults underwent ablation of at least one maxillary incisor (Briggs 1955; De Groote & Humphrey 2016; Humphrey & Bocaege 2008). The earliest evidence derives from Taza (Eastern Algeria), between 16,100 and 13,800 cal. BP (Meier *et al.* 2003), although it is possible that earlier material remains to be dated. The extraction of both maxillary central incisors has been deemed 'characteristic' of this period although, interestingly, individuals presenting only one ablated incisor were not always younger in age (De Groote & Humphrey 2016, 56; Humphrey & Bocaege 2008, 115). Analysing only dental arcades presenting alveolar remodelling in individuals with >1 ablated tooth, De Groote & Humphrey (2016) found that most individuals presented at least one phase difference between remodelling alveoli; this suggests that ablation was practised sequentially and was not strongly correlated with chronological age. At Taforalt necropolis (Morocco), 44 adults with complete maxillae and/or mandibles displayed incisor ablation, while enamel chipping and notches were noted predominantly on male adults, suggesting sex-specific dietary aspects or task distribution (Bonfiglioli *et al.* 2004). Across the region, avulsion declined during the subsequent Capsian period, present on just over half of the sampled individuals (62%), although it was markedly more common in females who had often undergone the removal of all eight incisors (Humphrey & Bocaege 2008, 116). Avulsion was increasingly uncommon during the Neolithic (27% of the sample), with significant regional variation, in contrast to the initial cultural homogeneity of this practice (Humphrey & Bocaege 2008).

Incisor avulsion amongst groups around the Sahara from 9500 cal. BP suggests the region was at least partially settled by populations moving from Northwest Africa, further supported by phenotypic and cultural evidence (Sereno *et al.* 2008; Stojanowski *et al.* 2014, 86). At Gobero, in the central Niger, amongst Early Holocene remains (9500–8200 cal. BP), 21% of the sample (four adults) presented avulsion of at least one central incisor with no apparent jaw or side preference (Stojanowski *et al.* 2014, 84). Of burials dating to the Middle Holocene (6500–4500 cal. BP), 16% of the sample (five adults) displayed avulsion of between two to six incisors (Stojanowski *et al.* 2014, 84–6). The practice extended to include lateral incisors and appears to have been restricted to male individuals, two of which also displayed intentional filing (Stojanowski *et al.* 2014). Nearby, in Libya, a male adult deposited in levels pre-dating 7800–7500 cal. BP presented occlusal grooves on all seven preserved teeth alongside wear facets on the mandibular dentition, likely a result of clenching fibres between the teeth while weaving mats, ropes and baskets (Minozzi *et al.* 2003). Further prehistoric evidence suggests that dental modification was not practised in West Africa until the 3rd millennium BC (Finucane *et al.* 2008). At Karkarichinkat Nord (Mali), four individuals of unknown sex displayed shaping of the maxillary incisors and canines, probably through filing, to create pointed teeth (Finucane *et al.* 2008). Dental modification persisted throughout Sub-Saharan

Africa into the historical period (Finucane *et al.* 2008) and is still practised by some cultures, albeit to a diminished degree (Alt & Pichler 1998; Friedling 2017; Friedling & Morris 2005, 2007; Irish 2017; Jones 1992; Milner 2017; Willis *et al.* 2008).

Outside Africa, early evidence for dental avulsion is recorded at several Natufian sites in the Levant (Crognier & Dupouy-Madre 1974; Eshed *et al.* 2006; McCown 1939). There is far greater evidence for AIDMs, frequently in the form of occlusal grooves as well as severe attrition, interproximal grooves and LSAMAT across individuals dating from the Natufian to the late Chalcolithic (Bocquentin *et al.* 2013; Eshed *et al.* 2006; Irvine *et al.* 2014; Molleson 1994, 2005). Chipping and severe attrition of the anterior dentition are likely attributed to a combination of both masticatory and habitual activities (Irvine *et al.* 2014, 27), especially when individuals present advanced AMTL (*antemortem* tooth loss) of the posterior dentition (Eshed *et al.* 2006, 153). Inferred habitual activities include abrasion of the incisors as a result of use of a bow drill or application of a gritty substance to stain the teeth (Bocquentin *et al.* 2013), processing animal skins (Eshed *et al.* 2006), holding objects such as staves in the mouth while making baskets or nets (Eshed *et al.* 2006), and processing materials including lithics and fibres (Irvine *et al.* 2014).

Heading westwards into Europe and the Mediterranean, there is relatively minimal evidence for intentional dental modification during prehistory (Burnett & Irish 2017b, 6; for later examples, see Alexandersen & Lunnerup 2017; Arcini 2005, 2011; Kjellström 2014). The clearest indication for a cultural practice of dental modification comes from Neolithic Central and Southern Italy (*c.* 6500–3200 BC), where only women displayed avulsion primarily of the maxillary incisors and/or canines (Robb 1997). Allowing for the limitations of the analysed skeletal sample, Robb (1997) estimates that between 25–50% of Neolithic women would have undergone selective and intentional tooth removal, perhaps optionally as a cosmetic treatment or according to specific life experiences or rituals, such as mourning. There is even rarer evidence for incisor avulsion in Neolithic Britain, with several cases reported from cave sites in Lancashire and Wales (Jackson 1915) and Ty Isaf chambered tomb in Wales (Wysocki & Whittle 2000, 592). At the latter site, *antemortem* tooth loss of the anterior dentition is an unusual pattern and is suggested to be a result of either avulsion, trauma or parafunctional wear (Wysocki & Whittle 2000).

In contrast, skeletal remains from Neolithic and Copper Age sites across Europe display an impressive range of passive modifications associated with habitual practices or parafunctional wear. At numerous Eastern, Central and Northern European sites, AIDMs including incisal notches, labial grooves and chipping are regularly observed and often present local or site-specific patterns in terms of their distribution in the dental arcade and relationship to sex. A study of 76 individuals from a range of early to late Neolithic sites in the western Lake Baikal region (Siberia), found that occlusal grooves were commonly encountered in 17-36% of individuals at each site and their prevalence increased with age (Waters-Rist *et al.* 2010, 272–3). Grooves were often orientated in linguo-labial direction, likely representing the processing of plant fibres and animal sinews for a variety of purposes, including sewing string, baskets, nets, snares, and sinew or cordage for fastening composite tools (Waters-Rist *et al.* 2010). The importance of fishing amongst indigenous populations in the region particularly suggests these activities involved the manufacture of fishing nets and baskets. Dental modifications did not show a strong preference according to arcade or side, but variation was found between riverine and lakeshore sites, as well as diachronically (with greater variation in late Neolithic-Bronze Age sites and increased thickness in grooves over time), and in terms of the prevalence according to sex at each site (Waters-Rist *et al.* 2010, 275). This reveals the extent to which dental modifications are intertwined with diet, ecology, material culture production, and the distribution of tasks and activities according to sex and/or gender.

Incisal notches amongst a Neolithic Polish assemblage present sex-specific differences in terms of orientation and morphology, with males apparently clenching a thicker material or holding objects in their teeth while females processed thinner fibres or sinews (Lorkiewicz 2011). In Slovakia and the Czech Republic, incisal notches were again mostly observed on female individuals, and craft processing appears to have first involved the lateral incisors and progressed to the central incisors throughout life (Frayer 2004). Alt & Pichler (1998, 394–7) present a mandible of a single Neolithic individual from Wandersleben (Germany) displaying occlusal grooves on their heavily worn central incisors; these grooves track a hemispherical 'path' and are suggested to indicate fibre or sinew processing. A middle Neolithic hunter-gatherer-fisher population in Sweden displayed occlusal wear facets, labial striations, interproximal grooves, chipping and excessive attrition, with slight differences observed in their distribution between male and female individuals (Molnar 2008). Overall, Molnar (2008, 428) found that males used their teeth more intensely for habitual purposes, displaying a high proportion of occlusal facets, attrition and interproximal grooves, while females mostly presented labial striae, possibly by holding meat in the mouth in order to cut it. Finally, in Britain, at Ty

Table 5.1. *Materials included in dental studies, including provenance and representation.*

Context	Location	Date	N teeth isolated	Σ teeth studied	% Context
595	East Cave	Early	123	123	100
833	West Cave: north niche	Early	18	2	11
951	West Cave: north niche	Early	2306	751	33
698	East Cave: southern pit	Early	13	3	23
1209	West Cave: shrine	Middle	4	4	100
1241	East Cave	Middle	170	170	100
433	East Cave: central	Late	35	6	17
436	East Cave: central	Late	32	32	100
715	East Cave	Late	56	54	96
738	East Cave	Late	17	15	88
790	Intermediate zone	Late	11	11	100
1206	West Cave: shrine	Late	642	508	79
960	West Cave: shrine	Latest	870	405	47
783	West Cave: display	Latest	2900	976	34
		Total	7197	3060	43

Isaf, one maxillary central incisor displayed an incisal notch as a result of parafunctional wear (Wysocki & Whittle 2000, 592).

In Southern Europe, the most comprehensive study of passive dental modifications derives from a large Eneolithic–Bronze Age cemetery in Southwest Italy (Sperduti *et al.* 2018). At Gricignano d'Aversa, 117 individuals with >1 incisor preserved were analysed for the presence of AIDMs. Incisal notches and striations on the maxillary incisors were commonly observed on 36 individuals, all >15 years old and predominantly female adults (Sperduti *et al.* 2018). As with contemporary archaeological and further ethnographic evidence, this is attributed largely to fibre processing. The presence of preserved textiles in the calculus of two adult females with AIDMs strengthens this interpretation (Sperduti *et al.* 2018). Although later prehistoric skeletal remains from the central Mediterranean often present analytical challenges because of frequent commingling, fragmentation and poor preservation (Robb 2007, 222), teeth are often the best-preserved skeletal elements and offer a wealth of insights into diet, health, habitual and cultural practices. There is evidently scope for a more widespread and comprehensive investigation of both active and passive dental modifications in this region. It is clear that the Circle population has a great deal to contribute to this discourse.

5.3. Materials

As discussed by Mercieca-Spiteri *et al.* (Chapter 2), a total of 11,706 teeth were isolated from their associated highly fragmented, commingled and predominantly disarticulated skeletal remains and inventoried according to context by the *FRAGSUS* Population History Workgroup across five laboratory seasons at the National Museum of Archaeology (NMA), Valletta, between November 2014 and May 2017. Of these, a total of 3,060 teeth (26.1% of isolated sample) of all types were studied for the purposes of interrogating the experience of dental pathology, anthropology and modification among the population/s represented within the Circle. Any observations for dental modification were recorded as part of these analyses. As noted previously and detailed in Table 5.1, the studied teeth are only a subsample of the overall assemblage, representing a proportion (or, complete in the cases of contexts (436), (595), (790), (1209) and (1241)) of 14 selected contexts as excavated thus far. Further to this, it is critical to note that the site was not completely excavated, and it is known that further remains are preserved at the site to allow for work to continue at the hands of future generations of archaeologists. As previously mentioned, in accordance with the temporal and pecuniary parameters of the project, the contexts examined here were determined by the excavators to be of greatest cultural and temporal significance to the overarching research questions, and thus included in whole or part here.

5.4. Methods

For the Circle dental modification study, anterior teeth (maxillary and mandibular central and lateral incisors and canines) of all articulation states (exfoliated and loose *postmortem* or in occlusion) were examined individually within their context batches. The individual tooth type, as well as the modification location, type and severity was recorded for each batch in a Microsoft Excel spreadsheet to form a searchable digital database/inventory. Each batch was marked once analysis was completed and curated within the NMA as part of the *FRAGSUS* Research Archive.

In terms of naming conventions, we follow the notation system developed by the *Fédération Dentaire Internationale* (FDI; FDI 1971; International Organization for Standardization [ISO] 3950, ISO 1984, 1995; Alt & Türp 1998b). Anterior tooth surfaces are referred to as: incisal or occlusal (the biting or chewing surfaces; incisal is more specifically for the anterior teeth); and labial (the lip surface of the anterior teeth) or lingual (the tongue surface of all teeth). Directions are referred to as mesial (towards the midline) and distal (away from the midline). Our formal and technical classifications follow the taxonomy of van der Reijden (2014), which builds on the foundational works of Romero (1958, 1960, 1965, 1970, 1986). Our general macroscopic osteological analytical techniques are based on standard criteria described in Buikstra and Ubelaker (1994: specific references indicated alongside analyses, below). All surfaces were examined macroscopically and under magnification using a 10x hand lens.

In alignment with the methodologies recommended by Buikstra and Ubelaker (1994), Bonfiglioli (2002), Molnar (2011) and van der Rijden (2014), every tooth was examined for the presence/absence of modifications including chipping, chiselling, drilling, extraction (ablation or avulsion), inlaying, polishing, repositioning, scoring and staining, notching, and/or a change of occlusal profile (discreet wear/filing in various directions/orientations). Where present, modifications were further scrutinized for location across the crown and root, and severity (dentine exposure). Observations of relative age (permanent or deciduous) were recorded for every affected tooth, and special notes were made for the occurrence of modification of juvenile teeth; where observed, modifications were recorded in the same manner as adults. Unfortunately, because of the highly fragmented and commingled nature of the assemblage, it was not possible to undertake comprehensive sex assessment as part of this study. In all cases, only *in vivo* modifications were recorded, these were distinguished from *postmortem* phenomena via the identification of *antemortem* wear (appearing as sheen) on extant surfaces, confirming their use in the mouth subsequent to modification (Hillson 2000, 258; Langsjoen 1998, 410; Ortner 2003, 603). Each instance of modification was recorded, resulting in some observations of more than one modification type on a single tooth. In alignment with the recommendations made by Milner and Larsen (1991, 369), we ensured that the frequency and distribution of damaged teeth were recorded in detail, forming the basis of the results presented and discussed below. We also recorded the size of chips and fractures, as well as their location and distribution for every affected tooth. Analysis of these particular data is ongoing and will be the subject of further publications. Coincidentally, certain types of extreme wear reported in Chapter 4 should also be considered alongside the dental modification data for anterior teeth within the study sample. The categories of extreme wear relevant to the current analysis include labial and lingual extreme wear and gross crown loss of the anterior teeth. Within the study sample, selected items were identified as worthy of further examination via radiographic analyses.[1]

5.5. Results: overview

Amongst the 3060 teeth in the study sample, 172 were observed to feature some form of dental modification (Table 5.2; note that the number of modifications is greater than the number of teeth as some teeth featured more than one modification). At 5.62%, this indicates that a relatively low proportion of the examined population were engaged in activities that actively or passively modified their teeth. When organized according to chronological distribution, the Late contexts are observed to feature the highest incidences of dental modification by some measure (Fig. 5.1). With 138 observations (80.23% total modification; 6.86% of 'Late' total study sample), the Late use phase of the Circle featured six times the number of observations of dental modification for the Early use phase (Σ=28; 16.28% total modification; 3.19% of 'Early' total study sample) and 23 times the number of observations for the Middle use phase (Σ=6; 3.49% total modification; 3.45% of 'Middle' total study sample). The individual contexts with the highest raw incidences of dental modification amongst the dataset were (783) (Σ=75); (960) (Σ=31); (1206) (Σ=8); (951) (Σ=15); and (595) (Σ=13). When expressed as prevalence rates within the full study sample of each context, the distribution is (783) (7.68%); (960) (7.65%); (1206) (5.51%); (951) (1.99%); and (595) (10.56%). According to the latter distribution, while the Late contexts had the highest overall incidence of dental modification, the prevalence rate was highest amongst Context (595), the earliest of the study sample.

Also noteworthy are the observations of certain types of 'extreme wear', described in Chapter 4 of this volume. The nature and location of such extreme attrition on the anterior teeth of both adult and non-adult members of the Xagħra population are suggestive of

Table 5.2. *Dental modification of anterior teeth summary by context and chronology (Σ teeth mod. = Σ teeth modified; >1 mod. = Σ teeth presenting >1 modification).*

Context	Location	Date	Σ teeth studied	Σ teeth mod.	% teeth mod.	Incisal notch	Chipping	Undulating	Diagonal	>1 mod.	Σ deciduous
595	East Cave	Early	123	13	10.57	5	6	2	2	2	2
833	West Cave: north niche	Early	2	0	0	0	0	0	0	0	0
951	West Cave: north niche	Early	751	15	2.00	5	3	6	1	0	0
698	East Cave: southern pit	Early	3	0	0	0	0	0	0	0	0
1209	West Cave: shrine	Middle	4	0	0	0	0	0	0	0	0
1241	East Cave	Middle	170	6	3.53	1	4	1	3	1	1
433	East Cave central	Late	6	0	0	0	0	0	0	0	0
436	East Cave central	Late	32	1	3.13	0	1	0	0	0	0
715	East Cave	Late	54	1	1.85	0	0	0	1	0	0
738	East Cave	Late	15	1	6.67	1	0	0	0	0	0
790	Intermediate zone	Late	11	1	9.09	1	0	0	0	0	0
1206	West Cave: shrine	Late	508	28	5.51	15	11	1	2	1	3
960	West Cave: shrine	Latest	405	31	7.65	16	16	3	1	4	6
783	West Cave: display	Latest	976	75	7.68	27	49	1	5	11	6
		Total	3060	172	5.62	71	90	14	15	20	18

an aetiology beyond 'ordinary' mastication, perhaps associated with food processing (for example, cracking, breaking and/or chewing hard foods); and/or processing materials other than food in association with cultural practices. As such, they must be included in considerations of both 'active' and 'passive' dental modification and are thus also presented here. Table 5.3 presents the data for extreme wear of anterior teeth by context, chronology and tooth surfaces, and also features the incidences of extreme wear to anterior

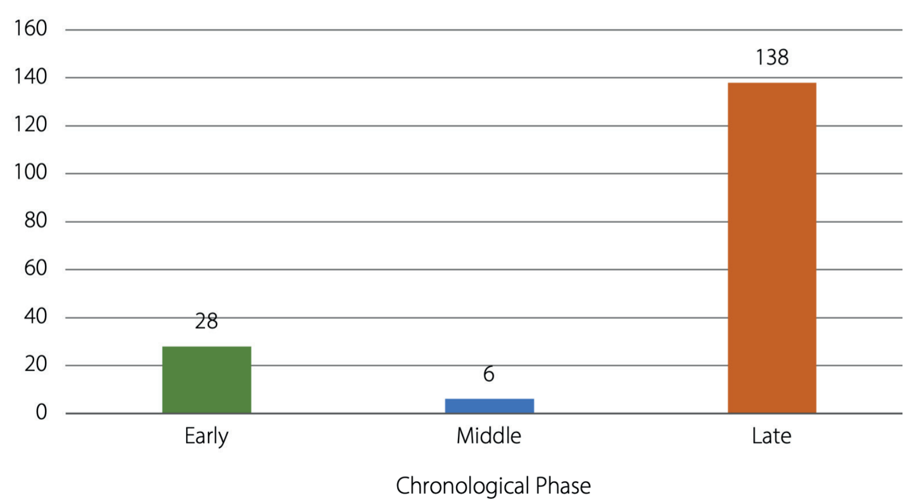

Figure 5.1. *Frequency distribution of dental modification observations by chronological phases in the Circle sample (Σ=172).*

Table 5.3. *Extreme wear of anterior teeth summary by context, chronology and tooth surface observations.*

Context	Location	Date	Σ teeth studied	Labial xWear	Lingual xWear
595	East Cave	Early	123	7	2
833	West Cave: north niche	Early	2	0	0
951	West Cave: north niche	Early	751	4	7
698	East Cave: southern pit	Early	3	0	0
1209	West Cave: shrine	Middle	4	0	0
1241	East Cave	Middle	170	0	0
433	East Cave central	Late	6	0	0
436	East Cave central	Late	32	0	0
715	East Cave	Late	54	0	0
738	East Cave	Late	15	0	0
790	Intermediate zone	Late	11	0	0
1206	West Cave: shrine	Late	508	2	0
960	West Cave: shrine	Latest	405	4	3
783	West Cave: display	Latest	976	8	3
		Total	3060	25	15

deciduous teeth amongst the study sample. Observations include extreme labial and lingual wear, and alongside individual descriptions of deciduous dental modification and extreme wear to the anterior teeth, these phenomena are presented in more detail in §5.5.1, below.

As enumerated in Figure 5.2, adult teeth were most often observed to be modified, with 154 teeth identified with these phenomena amongst the study sample (89.53% total modified teeth). Modified deciduous teeth were far fewer in number, but are present in the dataset nonetheless. A total of 18 modified deciduous teeth were observed amongst the current study sample (10.47% total modified teeth). The distribution of adult modified teeth is schematically presented in Figure 5.3. Here, we see that the maxillary dentition features substantially more examples of modification, with 110 teeth accounting for 71.43% of total adult observations, compared to 44 modified mandibular teeth (28.57% total adult modified teeth). There also appears to be a slight bias towards modifications by side, with 87 examples observed on the left side (56.50% total adult

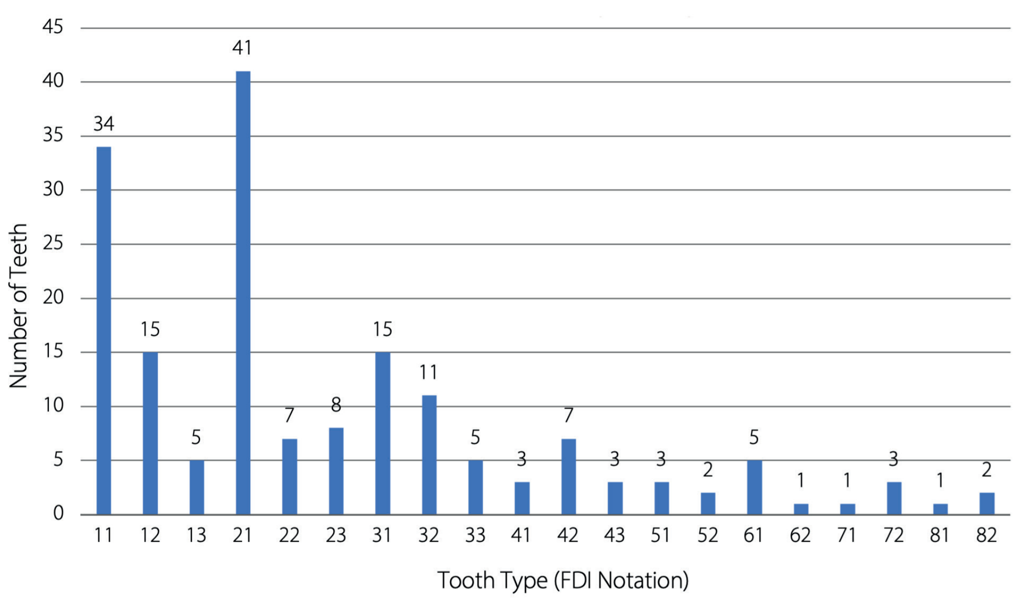

Figure 5.2. *Frequency distribution of tooth types featuring dental modification in the Circle sample (Σ=172).*

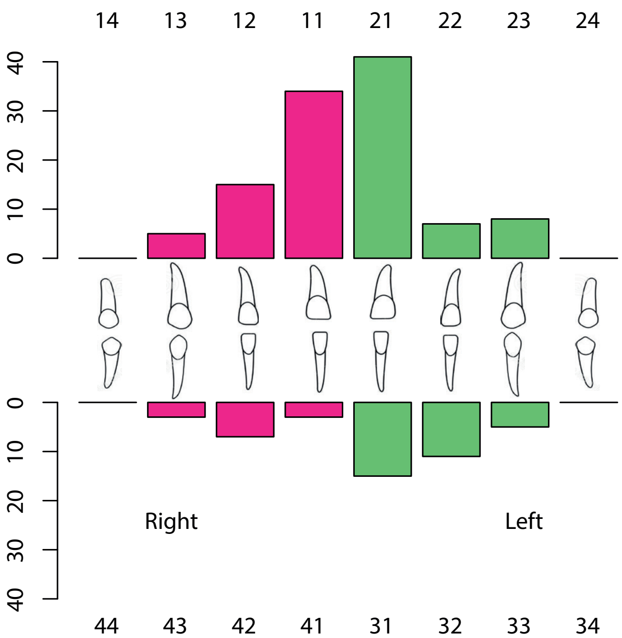

Figure 5.3. *Dynamic schema of dental modification observations by permanent anterior tooth type and arcade side in the Circle sample (follows FDI notations). (Rowan McLaughlin).*

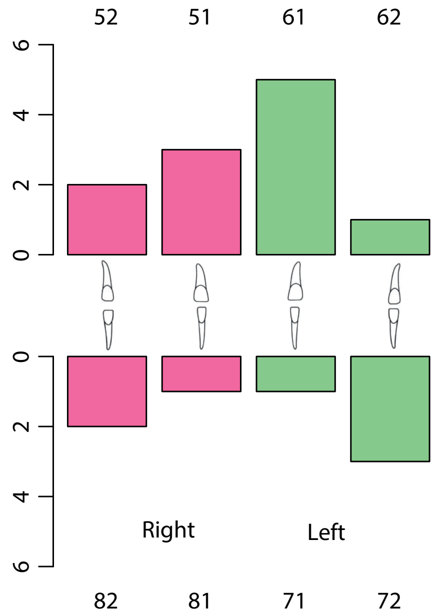

Figure 5.4. *Dynamic schema of dental modification observations by deciduous anterior tooth type and arcade side in the Circle sample (follows FDI notations). (Rowan McLaughlin).*

modified teeth) and 67 examples identified on the right (43.50% total adult modified teeth). The distribution of deciduous modified teeth is schematically presented in Figure 5.4. Although the overall numbers are far fewer than for the adult dentition, we see a similar pattern emerge in terms of distribution across the mouth. Here again, there are more observations of modified teeth on the maxilla (Σ=11; 61.11% total deciduous modified teeth) than on the mandible (Σ=7; 38.89% total deciduous modified teeth; and more observations of modification on the left side of the mouth (Σ=10; 55.56% total deciduous modified teeth) than on the right (Σ=8; 44.44% total deciduous modified teeth).

The data may be further examined to determine the individual tooth types most frequently affected by modification practices. The left permanent maxillary central incisor (FDI 21) was the most commonly involved tooth, with 41 observations amongst the study sample accounting for almost a quarter of all modified teeth (23.83%). This was followed by 34 examples of right permanent maxillary central incisor engagement (19.77% total modified teeth); while 15 observations were recorded for both the right permanent maxillary lateral incisor (FDI 12) and left permanent mandibular central incisor (FDI 31; each 8.72% total modified teeth). There were 11 examples of modified left permanent mandibular lateral incisors (FDI 32; 6.39% total modified teeth), while all other affected anterior tooth types presented fewer than 10 modifications each.

Although the numbers of modified teeth for any single deciduous tooth type do not exceed single figures, the relative rarity of this phenomenon for non-adults in archaeological data demands that all examples are highlighted (Frayer 2004, 94; Irvine *et al.* 2014, 25). Extending the patterns already described above, the most frequently modified tooth type is the same for the affected children and adults of the Circle sample population. Left deciduous maxillary central incisors were the most commonly modified teeth, with five observations amongst the sample (FDI 61; 27.78% total deciduous modified teeth; 2.90% total modified teeth). Further to this, there were three examples each of right deciduous maxillary central incisors (FDI 51) and left deciduous mandibular lateral incisors (FDI 72; each 16.67% total deciduous modified teeth; 1.74% total modified teeth); two examples each of right deciduous maxillary lateral incisors (FDI 52) and left deciduous mandibular lateral incisors (FDI 82; each 11.11% total deciduous modified teeth; 1.16% total modified teeth); and one example each of left deciduous maxillary lateral incisor (FDI 62), left deciduous mandibular central incisor (FDI 71) and right deciduous mandibular central incisor (FDI 81; each 5.56% total deciduous modified teeth; 0.60% total modified teeth).

5.5.1. Modification types

Dental modification observations were classified according to particular types, including chipping, incisal notches, labial extreme wear, diagonal profiling, lingual extreme wear and undulations. When combined, there were 230 individual observations of these phenomena on anterior adult and deciduous teeth amongst the study sample. These are expressed proportionately in Figure 5.5, and presented in more detail, below. Incidences of gross crown loss of the anterior teeth are also reported.

5.5.1.1. Chipping

'Chipping' refers to any form of enamel removal in discrete portions or 'chunks' by either deliberate ('active') or incidental ('passive') means. Chipping often has a 'disorganized' appearance, and can present as a sequence of micro-insults, resulting in stepped, rough or jagged margins. This form of modification can occur across the incisal margin of the anterior teeth, although it is frequently observed on either mesial or distal corners. van der Reijden (2014, 16) recommends a distinction between 'chipping' and 'chiselling' as respectively incidental and intentional phenomena. Chipping of the anterior teeth is one of the most commonly reported forms of dental modification across archaeological populations (Alt & Pichler 1998, 398), and it can now be reported that the phenomenon extends to Neolithic Malta. A selection of examples from amongst the dataset are presented in Figure 5.6a to k. In this figure, it is apparent that there are a variety of forms of chipping amongst the Circle population, with some clearly identifiable as incidental or parafunctional wear. Others, however, closely resemble forms described by van den Reijden as intentional (2014, Table 4.5; B1.1; B1.3; B1.4; B4.3; B4.4; C2.3). As seen in Figure 5.5, chipping was the most commonly observed dental modification amongst the study sample, with 90 recorded incidences accounting for 39.13% of all modifications. When plotted by chronological distribution (Fig. 5.7), the highest frequencies of chipping modification were observed among the Late contexts of the dataset. A total of 77 chipped teeth were identified in this phase (85.56% total chipping), representing 8.5 times more observations than for the Early use-phase contexts (Σ=9; 10.00% total chipping) and slightly less than 20 times more observations than for the Middle use-phase (Σ=4; 4.44% total chipping). As seen in Table 5.2, incidences of chipping within individual contexts in descending order are: (783) (Σ=49); (960) (Σ=16); (1206) (Σ=11); (595) (Σ=5); (1241) (Σ=4); (951) (Σ=3); and (436) (Σ=1). Expressed as a proportion of the chipped teeth sample, the distribution is (783) (54.44%); (960) (17.78%); (1206) (12.22%); (595) (6.67%); (1241) (4.44%); (951) (3.33%); and (436) (1.11%). Across both distributions, Context (783) has the highest raw and proportional incidences of chipping modifications within the Xagħra study sample.

Figure 5.8 reveals that the majority of chipping modifications amongst the Xagħra study sample were observed on adult dentition, with 81 observations (90.00% total chipping) as opposed to nine on deciduous teeth (10.00% total chipping). Within the adult category, maxillary teeth were more likely to be chipped, with 57 observations pertaining to upper permanent anterior teeth (70.37% total adult chipping;

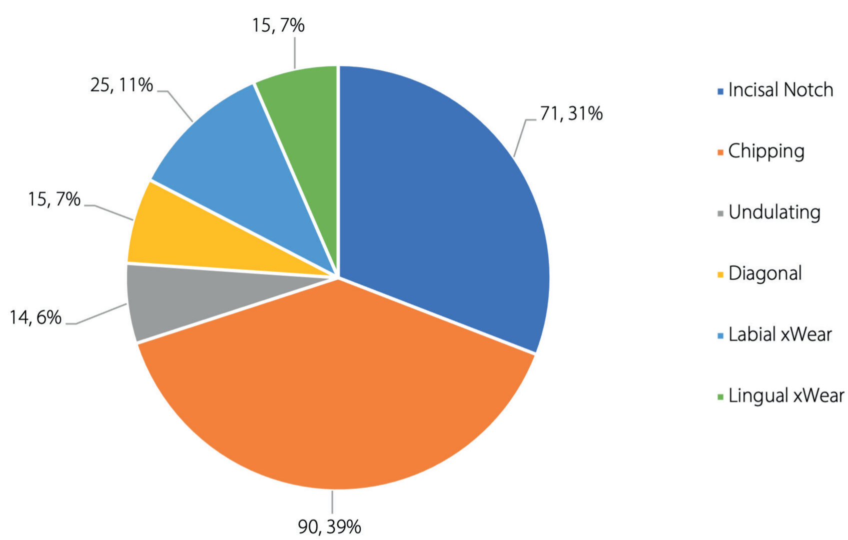

Figure 5.5. *Frequency distribution of dental modification types in the Circle sample (Labial xWear = Labial Extreme Wear; Lingual xWear = Lingual Extreme Wear) (Σ=230).*

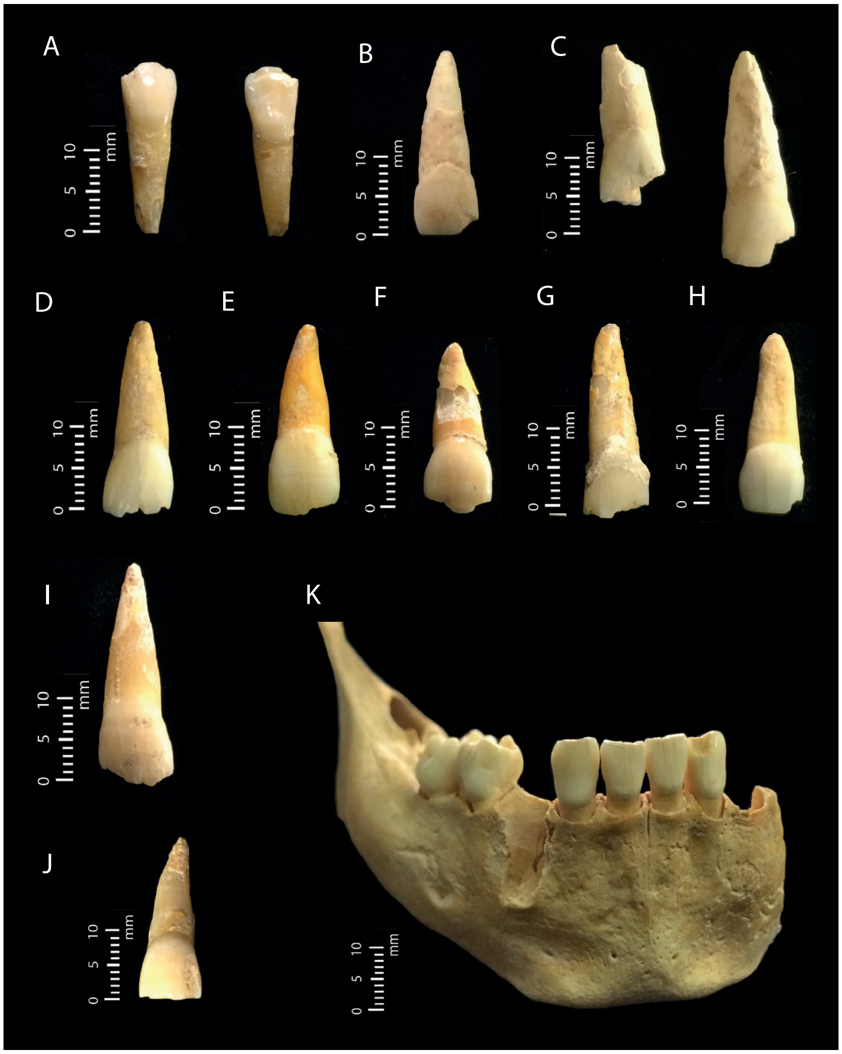

Figure 5.6. *Examples of chipping modifications in the Circle sample. a) labial and lingual aspects, Context (951) 96E/115N; b) Context (951) E3 No. 34; c) Context (951) 96E/ 114N; d) Context (960) 99E/111N Spit 3, Unit 1; e) Context (783) 95E/110N; f) Context (783) 95E/113N (deciduous); g) (783) 94E/111N; h) (783) 95E/112N; i) Context (783) 96E/113N; j) Context (783) 96E/112N Spit 1, No. 13; k) Context (783) 97E/112N Sk. 9 (deciduous). Scale bar: 1 cm. (Photos Ronika K. Power).*

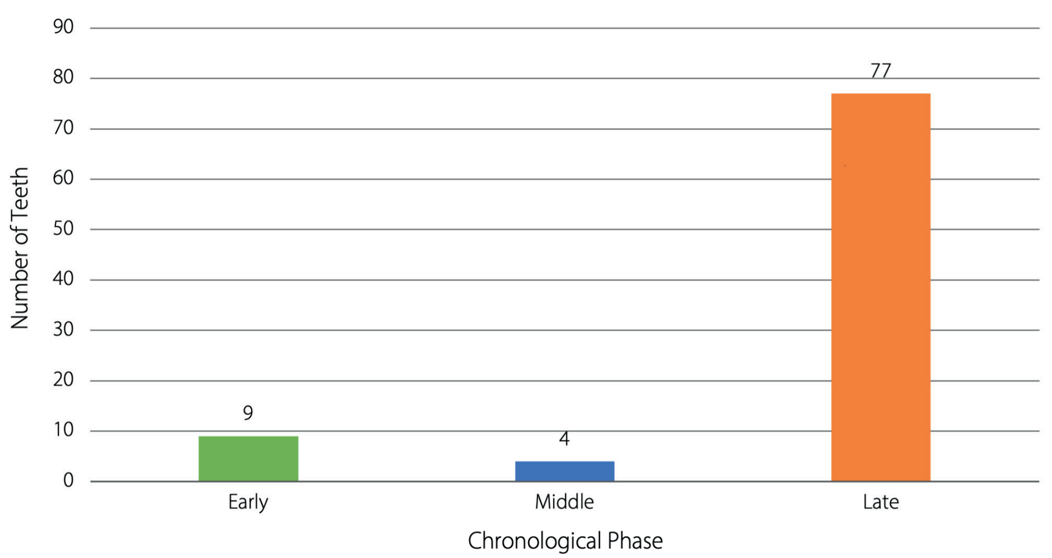

Figure 5.7. *Frequency distribution of chipping modifications by chronology in the Circle sample (Σ=90).*

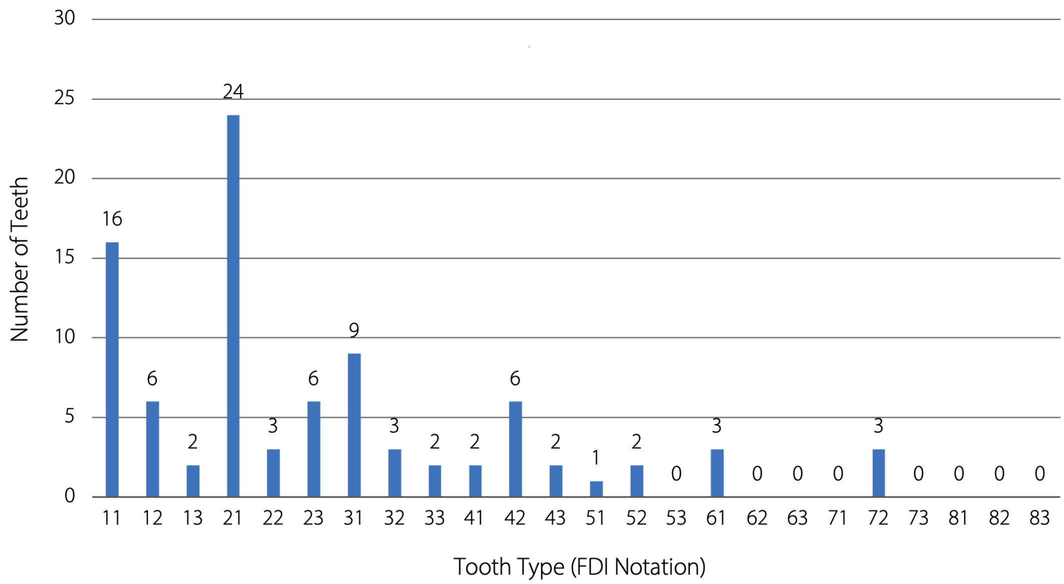

Figure 5.8. *Frequency distribution of chipping by tooth types in the Circle sample (tooth type follows FDI notation) (Σ=90).*

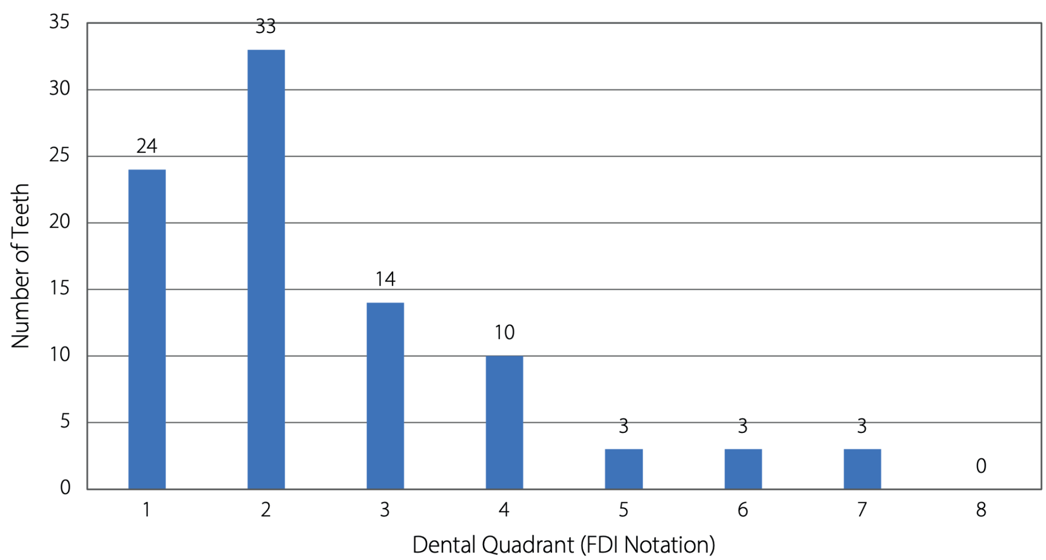

Figure 5.9. *Frequency distribution of chipping by quadrants in the Circle sample (quadrants follow FDI notation) (Σ=90).*

63.33% total chipping) as opposed to 24 on the lower anterior arcade (42.11% total adult chipping; 26.67% total chipping). Among the affected deciduous dentition, maxillary teeth were observed to be chipped twice as frequently, with six examples (66.67% of deciduous chipping; 6.67% total chipping) *versus* only three on mandibular teeth (33.33% of deciduous chipping; 3.33% total chipping).

When considered in terms of distribution by quadrants (Fig. 5.9), the left permanent maxillary anterior dentition account for the highest number of chipping observations with 33 teeth presenting this phenomenon (36.67% total chipping; 40.74% total adult chipping). The right permanent maxillary anterior teeth featured the second highest number of affected teeth with 24 observations (26.67% total chipping; 29.63% total adult chipping), followed by the left permanent mandibular (Σ=14; 15.56% total chipping; 17.28% total adult chipping) and right permanent mandibular arcades (Σ=10; 11.11% total chipping; 12.35% total adult chipping). The nine deciduous teeth presenting chipping were evenly distributed across three quadrants, with the upper right and left and lower left each featuring 3 affected teeth (each 3.33% total chipping; each 33.33% total deciduous chipping). There were no observations for the deciduous mandibular right quadrant.

The most commonly chipped individual type of anterior tooth amongst the sample was the left permanent maxillary central incisor, with 24 teeth presenting this form of modification (FDI 21; 26.67% total chipping; 29.63% total adult chipping). This was followed by the right permanent maxillary central incisor, which was observed to be chipped on 16 occasions (FDI 11; 17.78% total chipping; 19.75% total adult chipping). All remaining affected adult dentition presented less than ten observations per tooth type. In terms of deciduous dentition, the affected teeth are clustered tightly in numbers, with chipping observed on three left deciduous maxillary central incisors (FDI 61) and three left deciduous mandibular lateral incisors (FDI 72; each 33.33% total deciduous chipping; 3.33% total chipping), followed by two right deciduous maxillary lateral incisors (FDI 52; each 22.22% total deciduous chipping; 2.22% total chipping) and one right deciduous maxillary central incisor (FDI 51; 11.11% total deciduous chipping; 1.11% total chipping).

5.5.1.2. Incisal notches

'Incisal notches' may be variably referred to as 'incising' or 'grooving' (Burnett & Irish 2017b, 3; Langsjoen 1998, 410; van der Reijden 2014, 16). Incisal notches involve the removal of enamel from the incisive margins of the anterior teeth, however in this case the affected area is quite discrete or contained, with smooth and well-demarcated margins. They may present as either tightly shaped notches or grooves, or be more expansive in their gauge. The latter form of incisal notches can take on a 'swallow-tail' appearance (Irish 2017, Fig. 3.2e). Incisal notches may also be caused by either deliberate ('active') or incidental ('passive') means and are a common mode of dental modification across cultures. In the selection presented from the Circle sample (Fig. 5.10a–j), incisal notches

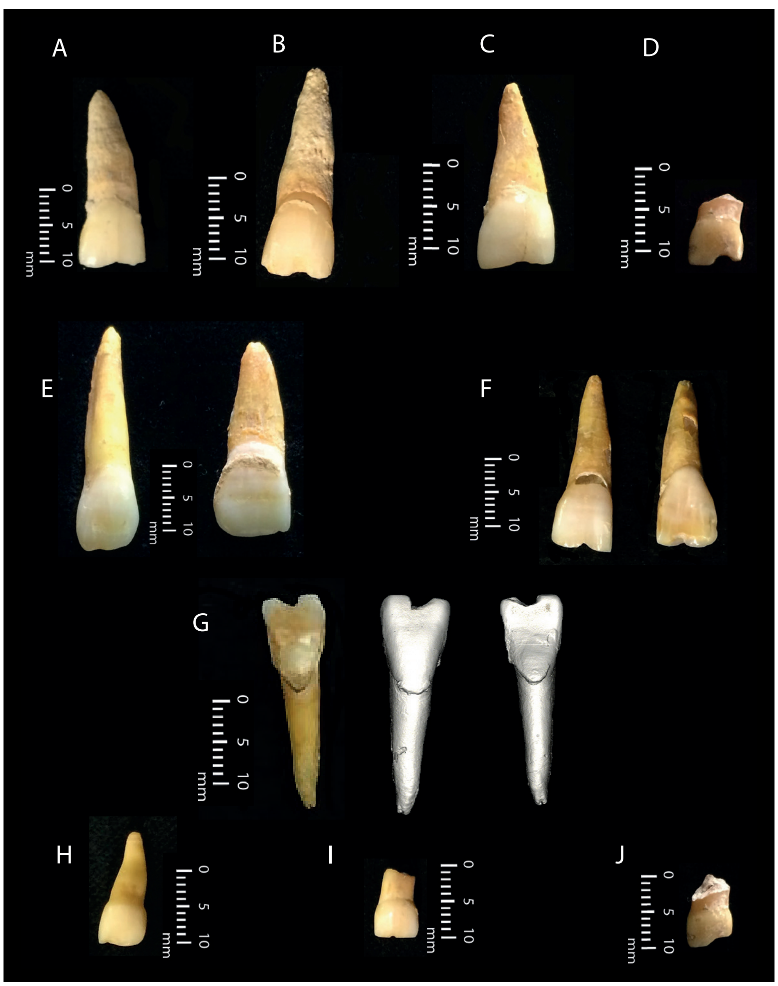

Figure 5.10. *Examples of incisal notch modifications in the Circle sample. a) Context (960) 99E/111N Spit 3, Unit 12; b) Context (783) 96E/110N Quad X; c) Context (783) 95E/112N; d) Context (783) 94E/113N Quad X (deciduous); e) Context (783) 94E/113N Quad X; f) labial and lingual aspects, Context (595) 100E/104N Quad H; g) lingual aspect (photo), labial and lingual aspects (3D render), Context (783) 95E/111N (?) Spit 1; h) Context (783) 95E/113N (deciduous); i) Context (783) 95E/111N Spit 1 (deciduous); j) Context (783) 94E/112N Quad X (deciduous). Scale bar: 1 cm. (Photos Ronika K. Power; radiological images captured by L. Buck, Cambridge Biotomography Centre; processed by J. Magnussen & M. Pardey, Macquarie Medical Imaging).*

feature across the incisal edge in a linguo-labial direction but are more commonly observed within the central portion rather than on the mesial or distal corners, with the direction of the groove indicating the direction of the pulling force (Langsjoen 1998, 410). As for chipping, Figure 5.10a–j reveals a variety of forms of notching amongst the Circle burial population. Although some are readily identified as incidental or parafunctional wear; others align with forms described by van der Reijden as intentional (2014, Table 4.5; Types A6.4; A8.1). They were the second most common dental modification amongst the Circle study sample (Fig. 5.5), observed on 71 teeth and representing slightly less than one-third of all modifications (30.87%).

Considered from a chronological perspective (Figure 5.11), the majority of incisal notch modifications precipitated from Late contexts of the Circle. In total, 60 teeth were attributed to the final phase of interments (85.7% total notches). This is substantially more than was observed for the Early contexts (Σ=10; 14.08% total notches); and the Middle use-phase had only one example of an incisal notch modification (1.14% total notches). Table 5.2 reveals the intensity of the Late

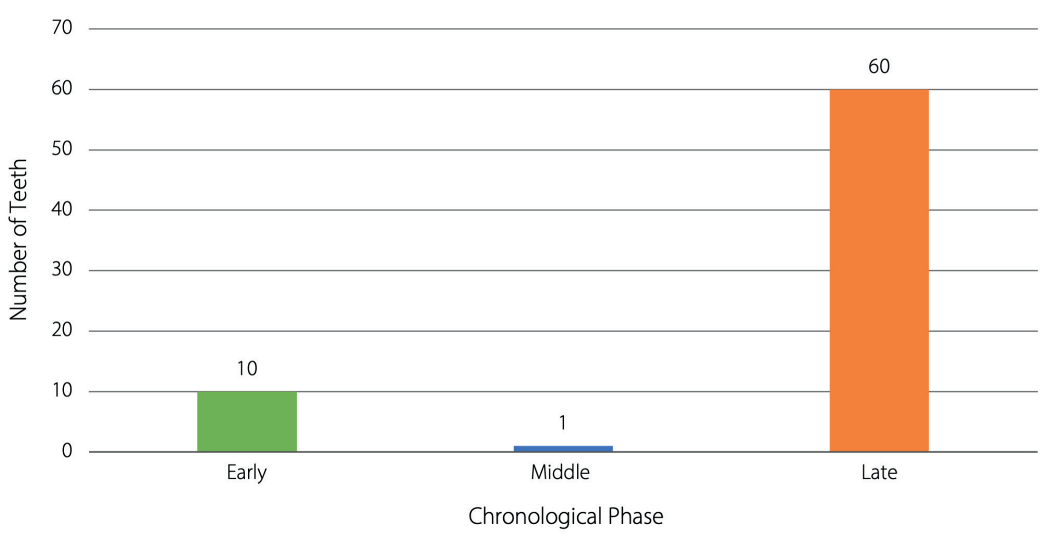

Figure 5.11. *Frequency distribution of incisal notch modifications by chronology in the Circle sample (Σ=71).*

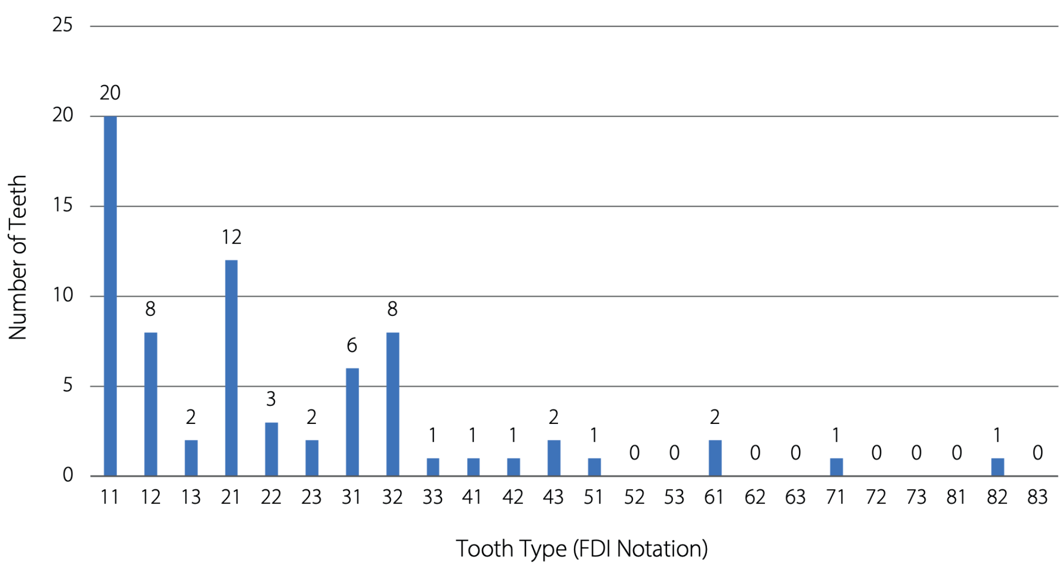

Figure 5.12. *Frequency distribution of incisal notches by tooth types in the Circle sample (tooth type follows FDI notation) (Σ=71).*

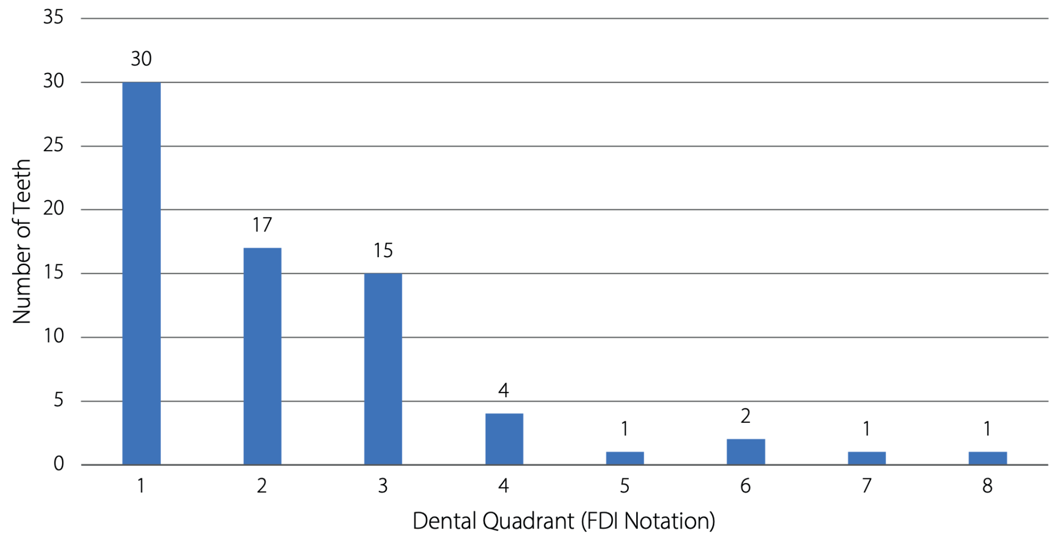

Figure 5.13. *Frequency distribution of incisal notches by quadrants in the Circle sample (quadrants follow FDI notation) (Σ=71).*

use-phase incidence of incisal notches, with the data listed in descending order as: (783) (Σ=27); (960) (Σ=16); (1206) (Σ=15); (595) and (951) (each Σ=5); and (1241), (738) and (790) (each Σ=1). Viewed proportionately for all notched teeth, the results are: (783) (38.02%); (960) (22.54%); (1206) (21.13%); (595) and (951) (7.04%); and (1241), (738) and (790) (1.41%). In both incidence and proportion, Context (783) features the highest representation of incisal notches across this sample of the burial population.

When analysed according to tooth types (Fig. 5.12), we see that 66 adult teeth presented incisal notch modifications (92.96% total notches), alongside five examples of deciduous teeth (7.04% total notches). Within the affected adult teeth, 47 maxillary teeth presented incisal notches (71.21% total adult notches; 66.20% total notches) compared with 19 instances on mandibular teeth (28.79% total adult notches; 26.76% total notches). The data are more balanced among the deciduous group, with three examples observed on maxillary teeth (60.00% total deciduous notches; 4.23% total notches) and two on mandibular dentition (40.00% total deciduous notches; 2.82% total notches).

To interrogate further the representation of incisal notches, we may consider their appearance across the oral quadrants (Fig. 5.13). In this case, the distribution follows FDI notation order: the right permanent maxillary anterior dentition features 30 examples of incisal notches (45.45% total adult notches; 42.25% total notches), which is just under twice the amount of notched left permanent maxillary teeth (Σ=17; 25.76% total adult notches; 23.94% total notches). The left permanent mandibular teeth featured 15 examples of incisal notches (22.73% total adult notches; 21.13% total notches), which is substantially greater than the four observations attributed to right permanent mandibular dentition (6.06% total adult notches; 5.63% total notches). The five deciduous teeth presenting incisal notches were almost evenly distributed across the oral quadrants, with the right deciduous maxillary arcade featuring 2 examples (40% total deciduous notches; 2.82% total notches), and one example on each of the right maxillary and left and right mandibular quadrants (each 20.00% total deciduous notches; 1.41% total notches).

The permanent right and left maxillary central incisors (FDI 11, 21) most frequently displayed incisal notches amongst the study sample, accounting for 20 (30.30% total adult notches; 28.17% total notches; Fig. 5.12) and 12 (18.18% total adult notches; 16.90% total notches) examples respectively, or 32 collectively (48.49% total adult notches; 45.07% total notches). The remaining teeth presented less than 10 examples for each type, although it is noteworthy that the right permanent maxillary lateral incisors and left permanent mandibular lateral incisors each featured 8 notched teeth (12.12% total adult notches; 11.26% total notches). The affected deciduous teeth are tightly grouped, with two examples of notches attributed to left deciduous maxillary central incisors (FDI 61), and single examples observed for a right deciduous maxillary central incisor (FDI 51), left deciduous mandibular central incisor (FDI 71), and right deciduous mandibular lateral incisor (FDI 82).

5.5.1.3. Labial extreme wear

In addition to discussions presented in Chapter 4 of this volume, labial extreme wear is included here because of its likely aetiologies in activities beyond 'ordinary' mastication, potentially including food processing and/or processing materials other than food in association with cultural practices. For the purposes of this study, labial 'extreme wear' is defined as wear resulting in the substantial blunting and accompanying dentine exposure of the anterior teeth on the labial surface. This mode of dental modification is known in populations across the globe (Burnett & Irish 2017b, 3), and is particularly associated with the use of the mouth as a tool during the processing of animal skins (Alt & Pichler 1998, 394; Eshed *et al.* 2006; Langsjoen 1998, 410; Lous 1970; Roberts & Manchester 2005, 81). In these circumstances, the fibrous nature of the hide erodes the enamel from the labial surface of the anterior teeth, and in some cases can also compromise the gingiva. In some cultural contexts, this mode of modification is also associated with wearing labial body ornaments such as labrets (Alt & Pichler 1998, 402). Examples of this 'passive' modification phenomenon were observed amongst the Circle study sample, as seen in Figure 5.14a–j. Here, an extreme case is noted in Figure 5.14i, where the entire labial surface of an unsided permanent mandibular incisor has been eroded in coronal section, obliterating the architecture of the tooth from the incisal margin to the apex of the root, including the destruction of the pulp chamber and root canal. The level of destruction prevents identifying the tooth as either a central or lateral mandibular incisor. It is difficult to appreciate how this tooth remained viable in the mouth, considering not only the compromise and destruction of the dental nerve, but also that the level of labial attrition indicates that the anterior aspect of the alveolar margin must have also been completely abraded. This abrasive process may have happened in isolation, but it may also have occurred in concert with alveolar recession if the individual in question was suffering a co-morbidity of severe periodontal disease (Hillson 2005, 292, 305–6). In addition to these

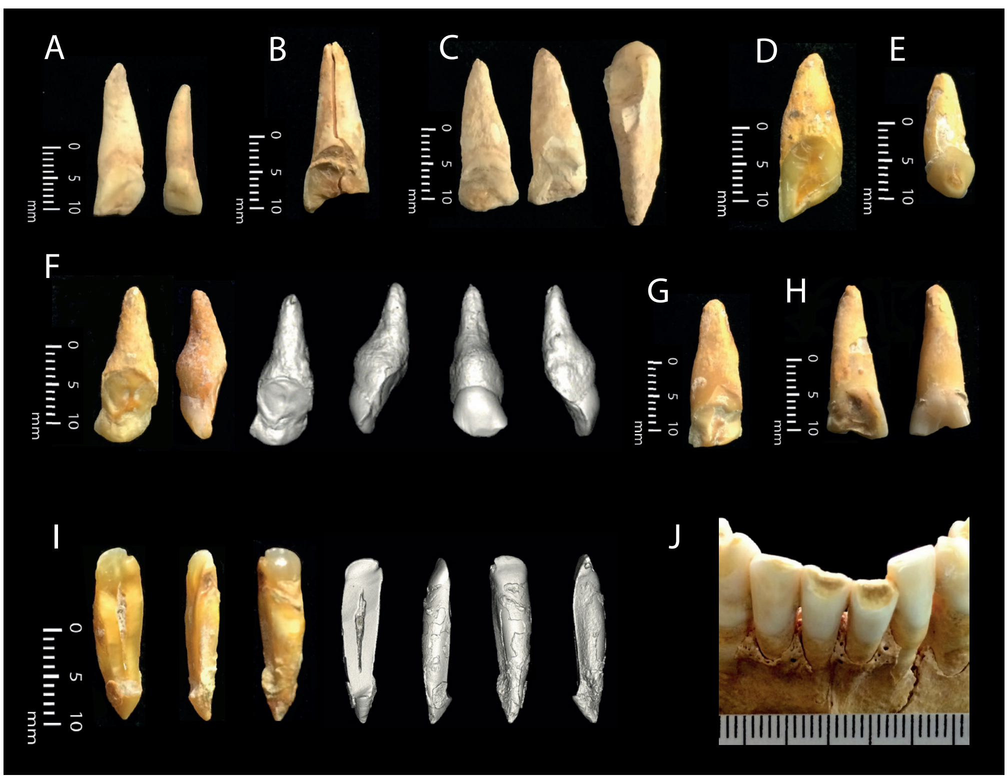

Figure 5.14. *Examples of labial extreme wear modifications in the Circle study sample. a) Context (951) 98E/116N; b) Context (951); c) Context (951) 98E/116N Area X; d) Context (783) 96E/111N; e) Context (783) 95E/110N Quad X; f) photographs and micro-CT 3D renders, Context (783) 95E/11N Quad X; g) Context (783) 96E/110N Quad X; h) labial and lingual aspects, Context (783) 96E/110N; i) photographs and micro-CT 3D renders, Context (783) 95E/112N Quad X; j) Context (783) 95E/115N Skull 1. Scale bar: 1 cm. (Photos Ronika K. Power; radiological images captured by L.T. Buck, Cambridge Biotomography Centre; processed by J. Magnussen & M. Pardey, Macquarie Medical Imaging).*

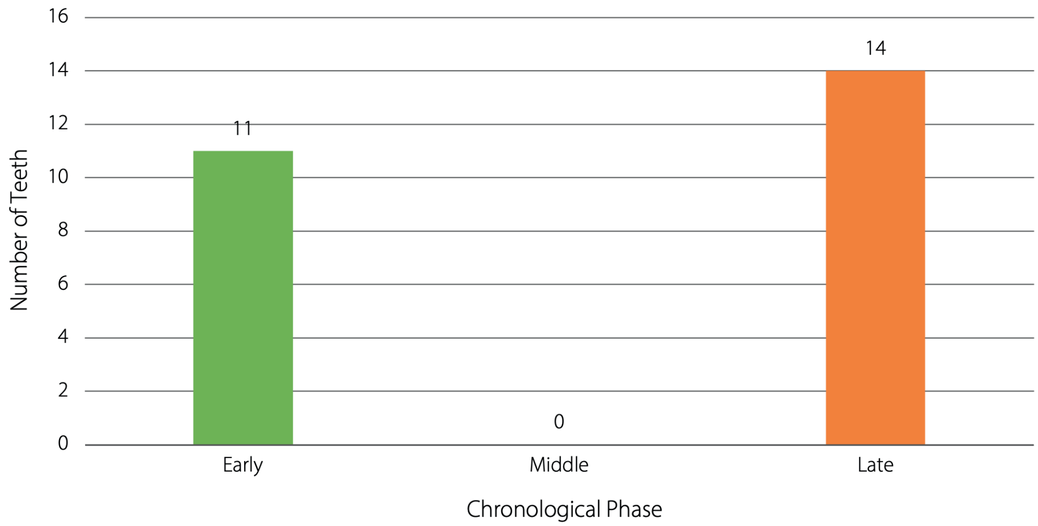

Figure 5.15. *Frequency distribution of labial extreme wear by chronology in the Circle sample (Σ=25).*

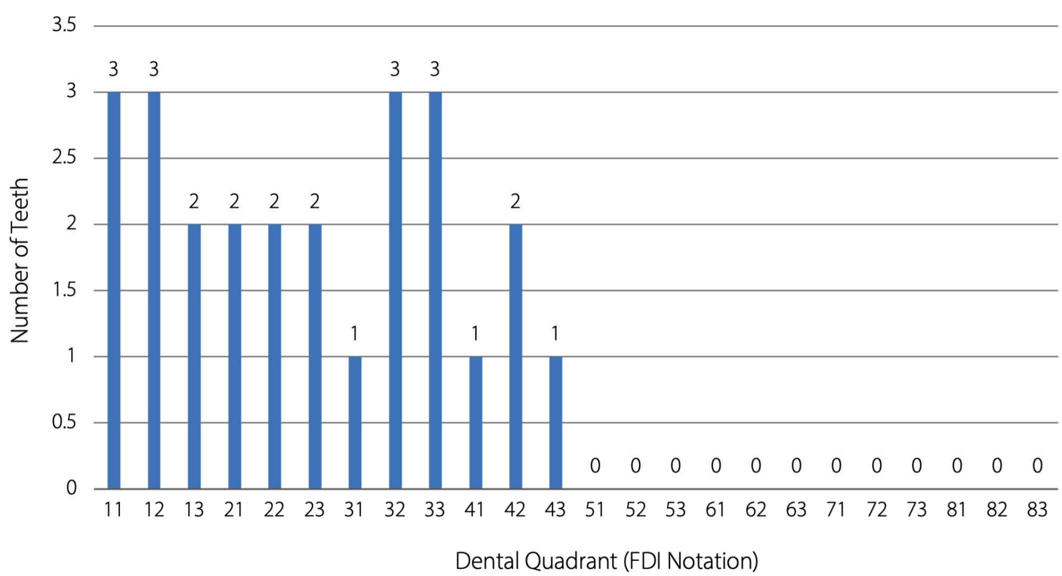

Figure 5.16. *Frequency distribution of labial extreme wear by tooth types in the Circle sample (tooth type follows FDI notation) (Σ=25).*

phenomena, we can see that this particular individual was using the mouth as a multi-purpose tool. A pronounced incisal notch is also observed on the occlusal margin (Fig. 5.14i). Whatever activities produced and maintained the incisal notch were occurring until close to the time of death, as the notch channel is embedded into both the incisal margin and abraded labial surface. This individual was not alone in their employment of their mouth as a multi-purpose tool or signifier. Several of the teeth included in these images feature more than one kind of modification, including manipulation of the incisal edges resembling van der Reijden's 'B' Types, where the modification distinctly affects one edge (2014: Table 4.5). This type of modification will be discussed regarding 'Diagonal' types in §5.5.1.5, below.

Labial extreme wear is the third most common dental modification amongst the Xagħra study sample (Fig. 5.5), observed on 25 teeth and representing 10.87% of the modified dataset. Considered from a chronological perspective, labial extreme wear has an intriguing distribution (Table 5.3 & Fig. 5.15). All recorded cases of this mode of dental modification are derived from either the Early (Σ=11; 44.00% total labial extreme wear) or Late (Σ=14; 56.00% total labial

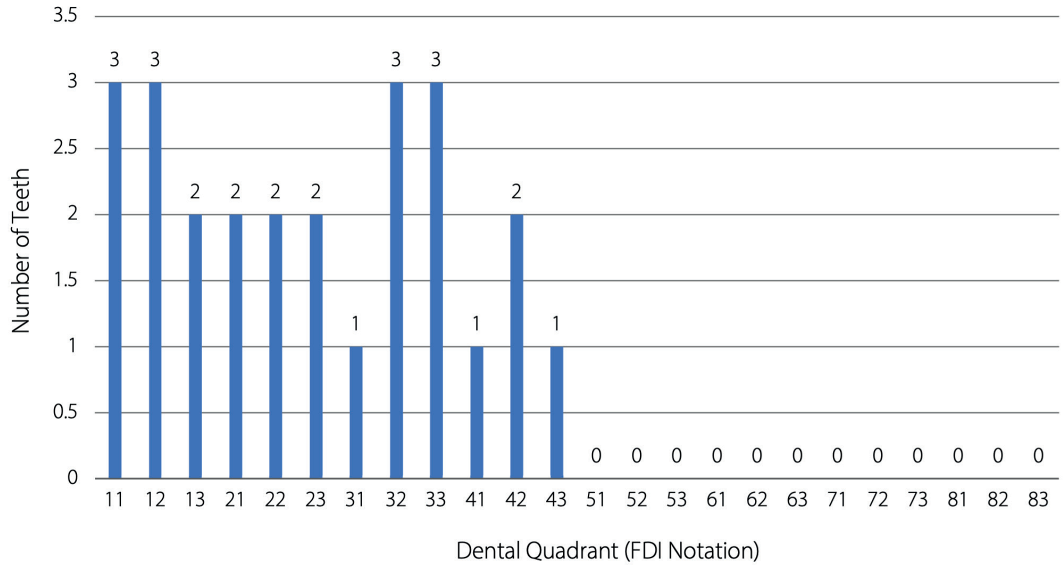

Figure 5.17. *Frequency distribution of labial extreme wear by quadrants in the Circle sample (quadrants follow FDI notation) (Σ=25).*

extreme wear) use-phases of the Circle. Of these, the Late use-phase had slightly more examples. There were no observations of labial extreme wear amongst the Middle use-phase dataset whatsoever. In terms of individual contexts, Table 5.3 also reveals that the experience of this modification was quite similar between the Early and Late use-phases, with the data tightly clustered in descending order as follows: (783) (Σ=8); (595) (Σ=7); (951) and (960) (each Σ=4); and (1206) (Σ=2). When calculated proportionately for all teeth affected with extreme labial wear, the results table as: (783) (32.00%); (595) (28.00%); (951) and (960) (each 16.00%); and (1206) (8.00%). Context (783) features the highest representation of labial extreme wear in both incidence and proportion across this sample of the burial population.

To explore the broader experience of extreme labial wear, the teeth were analysed according to individual types (Fig. 5.16). In this case, this particular form of modification is restricted to adult teeth; no deciduous dentition was observed with extreme labial wear. Amongst the 25 affected adult teeth, the maxillary dentition was slightly more frequently observed, with 14 examples recorded (56.00% total labial extreme wear) as opposed to 11 mandibular observations (44.00% total labial extreme wear). The experience of this modification was relatively even across the oral quadrants (Fig. 5.17). Although the right permanent maxillary anterior dentition presented the highest incidence of extreme labial wear (Σ=8; 32.00% total labial extreme wear), this was closely followed by the left permanent mandibular anterior dentition (Σ=7; 28.00% total labial extreme wear), the left permanent maxillary anterior teeth (Σ=6; 24.00% total labial extreme wear) and the right permanent mandibular anterior teeth (Σ=4; 16.00% total labial extreme wear). This suggests that these abrasive activities were relatively evenly experienced across both upper and lower arcades.

This observation extends to analyses of the experience of labial extreme wear across individual tooth types (Fig. 5.16). Results were very tightly clustered amongst the individual affected teeth, supporting the notion of broad impact of abrasive parafunctional activities across the upper and lower anterior arcades. The right permanent maxillary central and lateral incisors (FDI 11, 12) and left permanent mandibular lateral incisors and canines (FDI 32, 33) each presented three examples within the dataset (each 12.00% total labial extreme wear). Further to this, the right permanent maxillary canine (FDI 13), left permanent maxillary central and lateral incisors and canine (FDI 21, 22, 23), and right permanent mandibular lateral incisor (FDI 42) each featured two examples (each 8.00% total labial extreme wear). Finally, single observations were recorded for the left permanent mandibular central incisor (FDI 31), and right permanent mandibular central incisor and canine (FDI 41, 42; each 4.00% total labial extreme wear).

5.5.1.4. Lingual extreme wear

As with labial wear, lingual wear is included in discussions of both dental pathology (Chapter 4) and modification. This is because its aetiology was attributed to parafunctional activities including food and/

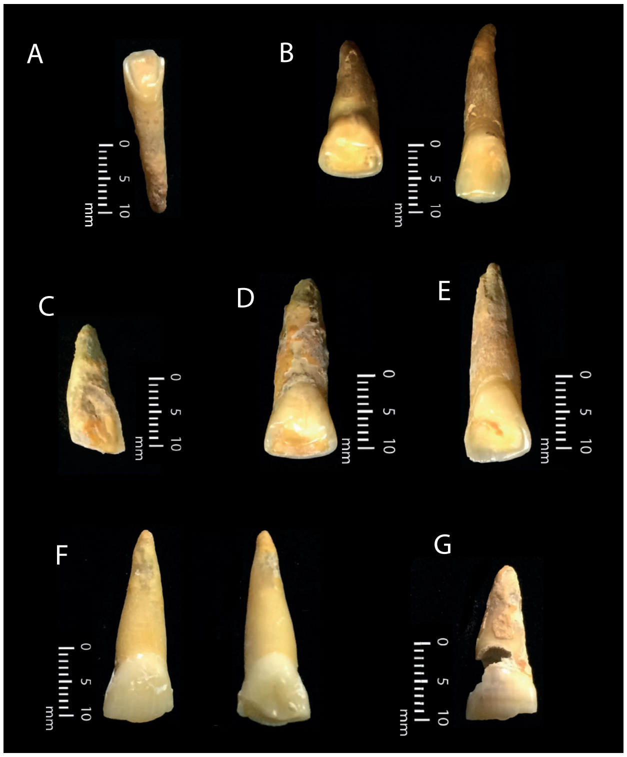

Figure 5.18. *Examples of lingual extreme wear modifications in the Circle sample: a) (951) 95E/110N; b) (783) 95E/112N Quad X; c) (783) 94E/112N; d) (783) 95E/111N Quad X; e) (783) 94E/113N. Examples of undulating profile modifications in the Circle sample: f) (783) 95E/113N labial and lingual aspects (also loss of vertical height, possibly multiple small notches); g) (783) 94E/111N Quad X (also cervical carious lesion). Scale bar: 1 cm. (Photos Ronika K. Power).*

or material processing in association with cultural practices. In this study, lingual 'extreme wear' is defined as wear that results in the substantial blunting and accompanying dentine exposure of the anterior teeth, on this occasion on the lingual surface. For consistency with the current analyses, this chapter will restrict investigations to observations of lingual wear on the anterior teeth. Considering that this mode of modification takes place inside the mouth outside of public view, it may be that it is a 'passive' modification which results from the kinds of processing activities suggested above. Examples of lingual extreme wear were observed amongst the Circle study sample, as seen in Figure 5.18a–e. Alongside diagonal profiling, lingual extreme wear was the equal-fourth most common form of dental modification amongst the dataset, each with 15 observations (6.52% total modifications).

Echoing the reported distribution for labial extreme wear, similar modifications of the lingual surface were also observed amongst only the Early and Late use-phases of the Circle study sample, with no identification of extreme lingual wear for the Middle use-phase data at all (Fig. 5.19). A total of nine examples were observed amongst the Early use phase population (60.00% total lingual extreme wear), and six within the sample for the Late interment contexts (40.00% total lingual extreme wear). As seen in Table 5.3, only four contexts presented evidence for this mode of dental modification amongst the sample. In this case, the data were also quite tightly clustered, following the highest frequency of observations in an Early use-phase context, (951) (Σ=7), equal observations in (960) and (783) (each Σ=3), and finally (595) (Σ=2). Expressed proportionately for all teeth affected with extreme lingual wear, these

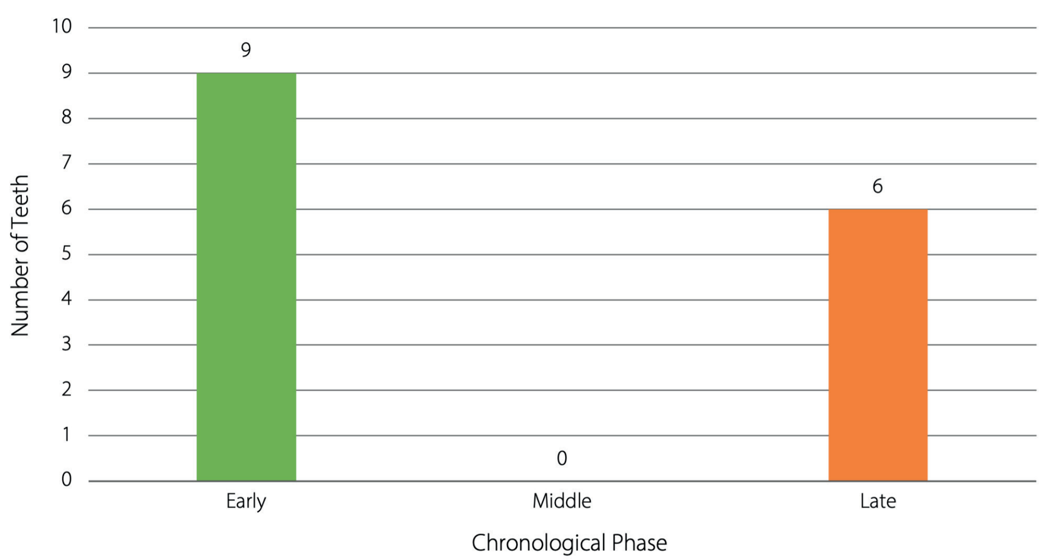

Figure 5.19. *Frequency distribution of lingual extreme wear by chronology in the Circle sample (Σ=15).*

results table as: (951) (46.67%), (960) and (783) (each 20.00%), and (595) (13.33%). On this occasion, Context (951) features the highest representation of lingual extreme wear in both incidence and proportion across this sample of the Circle population.

The data may also be evaluated according to tooth types (Fig. 5.20). As for labial extreme wear, incidences of lingual modifications were restricted to adult dentition; there were no observations of deciduous teeth with extreme lingual wear. Even amongst this small sample size, there appears to be a bias towards maxillary teeth being exposed to lingual extreme wear; there were 14 maxillary teeth to present this type of modification (93.33% total lingual extreme wear), as opposed to only one mandibular tooth (6.67% total lingual extreme wear). Naturally, this bias extends to the distribution by oral quadrants (Fig. 5.21). Here we see that the right permanent maxillary anterior arcade predominates with eight examples (53.33% total lingual extreme wear), followed closely by six observations for the left permanent maxillary anterior teeth (40.00% total lingual extreme wear). There were no observations whatsoever for the left permanent mandibular anterior dentition, and only one for the right permanent mandibular anterior arcade (6.67% total lingual extreme wear).

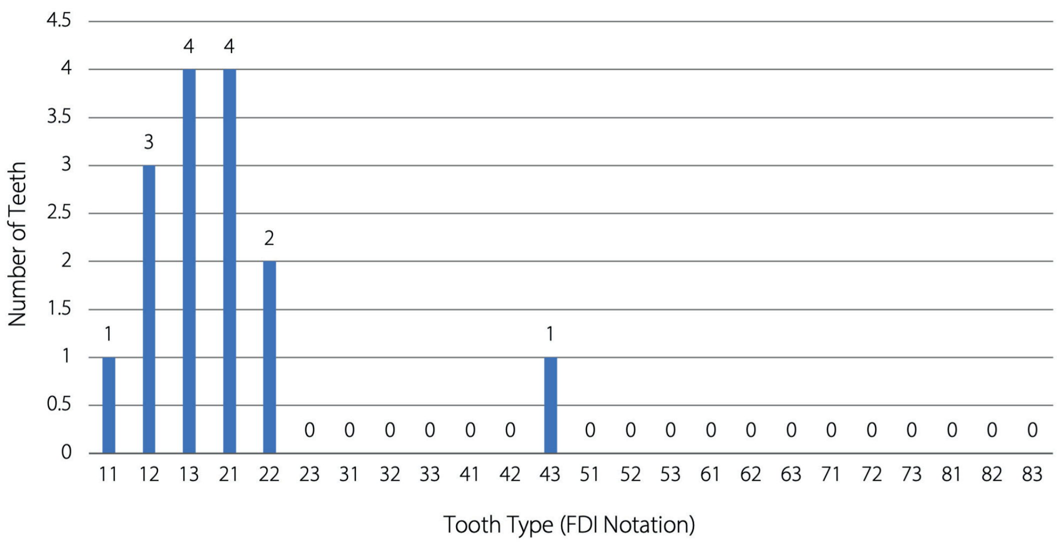

Figure 5.20. *Frequency distribution of lingual extreme wear by tooth types in the Circle sample (tooth type follows FDI notation) (Σ=15).*

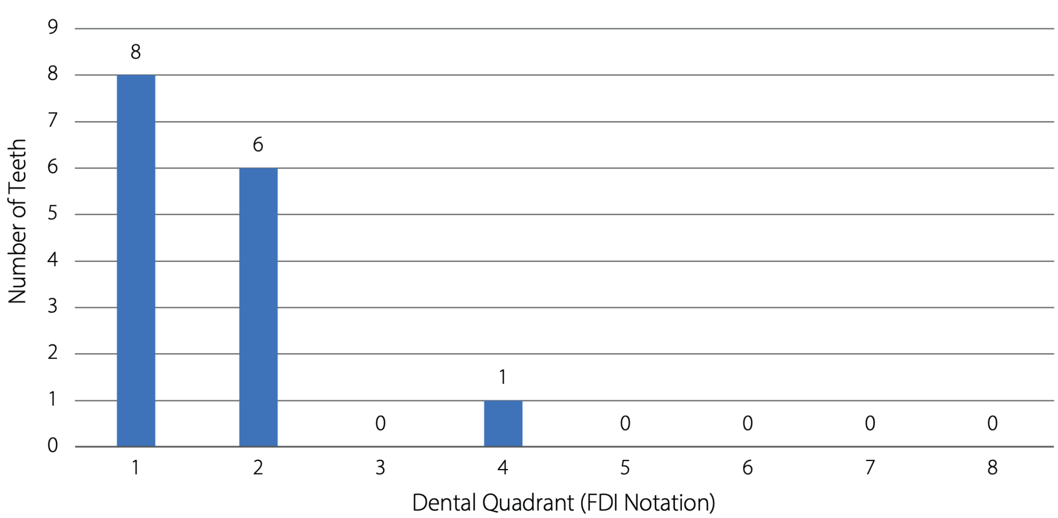

Figure 5.21. *Frequency distribution of labial extreme wear by quadrants in the Circle sample (quadrants follow FDI notation) (Σ=15).*

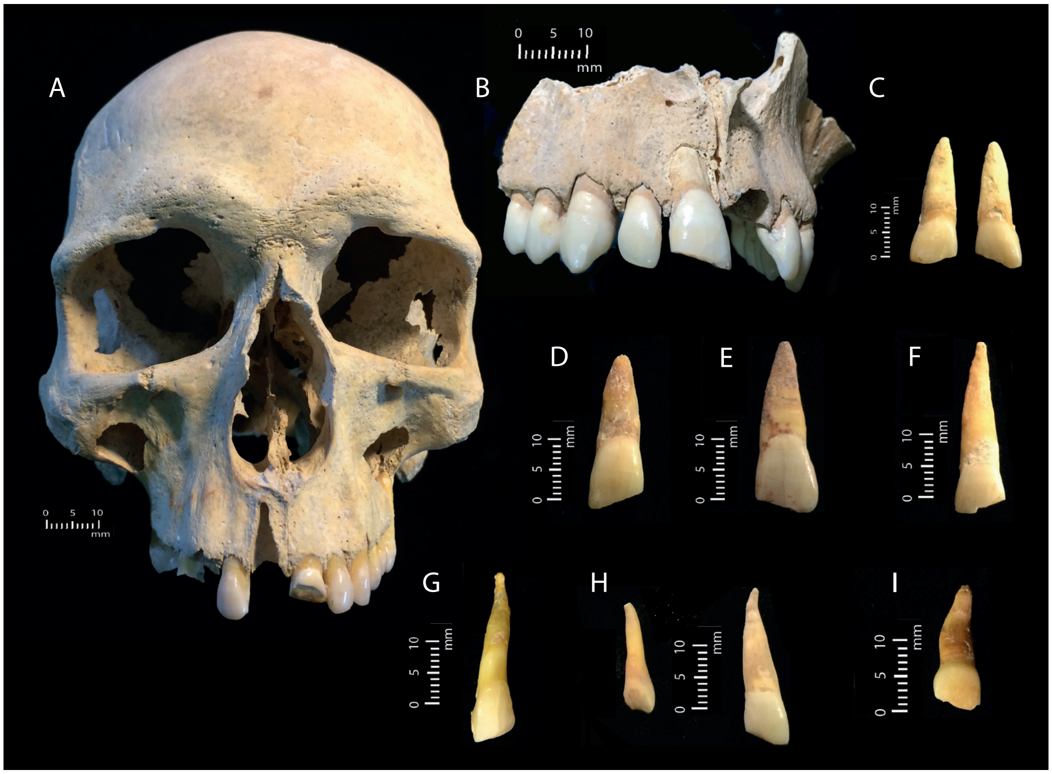

Figure 5.22. *Examples of diagonal profile modifications in the Circle sample. a) Context (1241) 105E/104N Spit 4, Unit 5; b) Context (783) 95E/113N; c) Context (783) 96E/110N; d) Context (783) 95E/111N; e) Context (960) 101E/109N Spit 5; f) Context (783); g) Context (783) 96E/110N Spit 1; h) Context (960) 100E/111N Spit 4; i) Context (783) 95E/111N Spit 1 (deciduous, also chipping and notching). Scale bar: 1 cm. (Photo Ronika K. Power).*

Only six types of permanent anterior teeth presented this phenomenon (Fig. 5.20), with the most numerous observations reported for the right permanent maxillary canine (FDI 13) and left permanent maxillary central incisor (FDI 21; each Σ=4; each 26.67% total lingual extreme wear). There were three observations of this modification for right permanent maxillary lateral incisors (FDI 12; 20.00% total lingual extreme wear); two for left permanent maxillary lateral incisors (FDI 22; 13.33% total lingual extreme wear); and one observation each for a right permanent maxillary central incisor (FDI 11) and a right permanent mandibular canine (6.67% total lingual extreme wear).

5.5.1.5. Diagonal profile

A diagonal profile modification involves the deliberate or incidental attrition of the incisal margin of the anterior teeth. The modification may be either mesially or distally inclined (maxilla) or declined (mandible), and may range between irregular to extremely sharp and smooth in character. The steepness of the modification is also variable. Despite the dramatic appearance of this form of modification, singular teeth within the arcade may be subject to alteration while the adjacent dentition show no evidence of manipulation whatsoever, as seen in examples from the Circle (Fig. 5.22a–i). One of the most striking images to emerge from this dataset soundly demonstrates this phenomenon. In Figure 5.22a we observe the cranium of an individual excavated from Context (1241) during the Middle use-phase of the Circle. The individual was determined to be an adult, based on the complete eruption and occlusion of the right and left maxillary permanent second molars (FDI 17, 27); bilaterally, the third molars appear to be either impacted or congenitally absent. The commencement of sutural obliteration also supports an adult age determination (Buikstra & Ubelaker 1994, 33ff.). The individual was subject to sex assessment based on evaluation of the cranial sexually dimorphic traits presented in Buikstra and Ubelaker (1994, 20), including nuchal crest (4/5), mastoid process (5/5), supraorbital margin (5/5) and supraorbital ridge/glabella (5/5). According to these criteria, the individual was assessed as a probable male. This individual presents a complex diagonal modification observed in occlusion on the left permanent maxillary central incisor (FDI 21). In this case, diagonal wear of the incisal edge is noted, mesially inclined from distal margin and terminating inferior to the cementum enamel junction. This individual illustrates the co-existence of modification modes, as we also observe approximately vertical labial wear extending from extant incisal margin. The labial wear comprises approximately two-thirds of the extant tooth crown, and also terminates inferior to the cementum enamel junction. Perhaps in association with both the diagonal and labial modes of attrition, the dentine has been exposed and presents a concave wear platform. Additionally, we observe that the crown height has been reduced by half, aligning with van der Reijden's N1.2 type (2014, 68). Although the neighbouring right permanent maxillary central incisor has been lost *postmortem* (FDI 11), we are able to observe that the adjacent left permanent maxillary lateral incisor (FDI 22) bears no changes to the mesial, labial or incisal surfaces or margins corresponding to the pronounced modifications described for the central incisor. Moreover, as seen in Figure 5.22a, no further modifications or extreme wear observations were recorded for any other of the extant retained dentition.

This is also the case for the arcade of an individual excavated from Context (783), for whom we were able to refit fragmentary left and right adult maxillae (Fig. 5.22.b). In this case, we observe a sharp, steeply inclined diagonal modification of the incisal edge of a right permanent maxillary central incisor (FDI 11). The modification is distally inclined from the mesial margin, comprising the inferior distal approximate third of the tooth. The tooth also displays mild chipping on the mesial margin; and this individual was also reported to feature multiple diastemata across the anterior maxillary arcade (Chapter 4). Again, note that the neighbouring right permanent maxillary lateral incisor (FDI 12) bears no evidence of the substantial abrasive processes that would have been required to produce this sharp, steeply inclined modification to the central incisor. Unfortunately, the adjacent left permanent maxillary central incisor has been lost *postmortem*; however, we observe that the extant retained maxillary dentition is in almost pristine condition, showing no further evidence of modification or extreme (or even moderate) wear.

Diagonal profiling is another commonly observed mode of dental modification across cultures, with the means of alteration being some form of abrasion or filing, of either 'active' or 'passive' impetus (Burnett & Irish 2017b, 3). The diagonal modifications observed in the Circle assemblage most closely align with van der Reijden's 'B' Types, where the modification distinctly affects one edge (2014, Table 4.5; B1.1, B1.3, B1.4); however, it is possible that some of the examples extend her criteria, as the filed edge is observed to extend across the entire incisal margin; and in some case the crown height is reduced by more than half. As mentioned above, diagonal profile modifications were the equal-fourth most frequently observed amongst the study sample, featuring 15 observations together with lingual extreme wear (Fig. 5.5; 6.52% total modifications). The chronological distribution of diagonal profiling was quite balanced amongst the population, with an equal number of observations attributed to both the Early and Middle use-phases (each Σ=3; each 20.00% total diagonal; Fig. 5.23). The highest frequencies of diagonal profiling were amongst the Late use-phase, with 9 observed within this component of the sample (60.00% total diagonal). Table 5.2 indicates that the

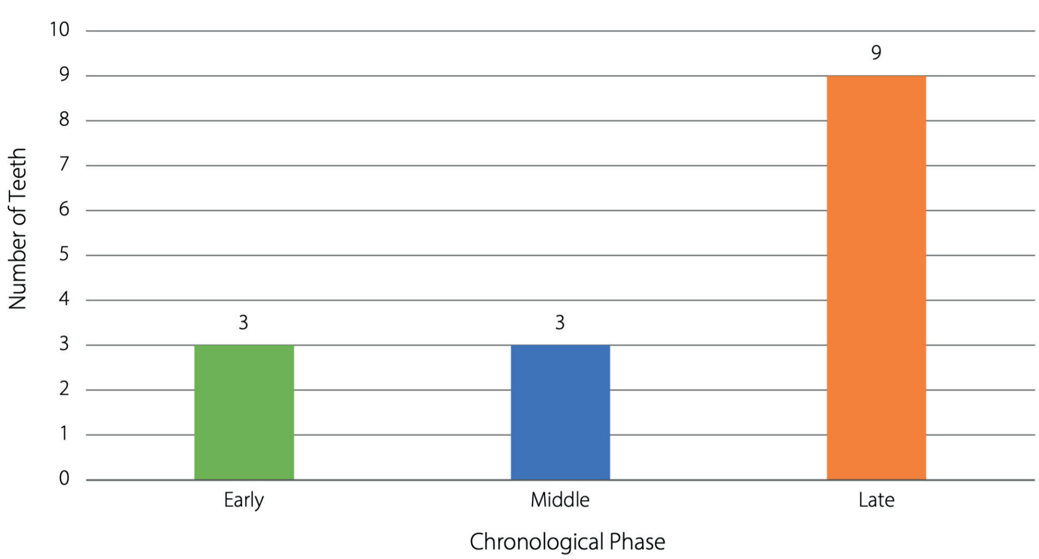

Figure 5.23. *Frequency distribution of diagonal profile modification by chronology in the Circle sample (Σ=15).*

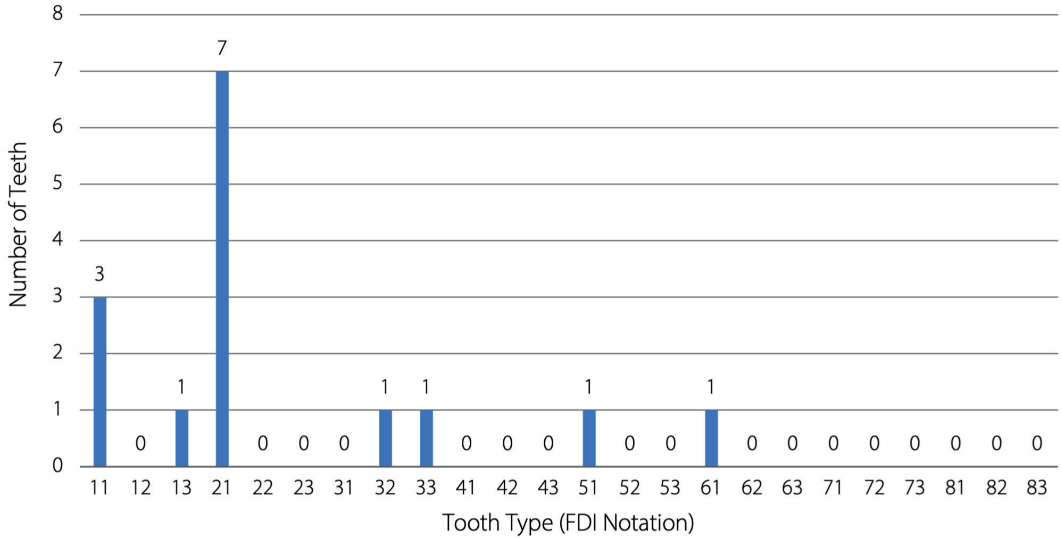

Figure 5.24. *Frequency distribution of diagonal profile modification by tooth types in the Circle sample (tooth type follows FDI notation) (Σ=15).*

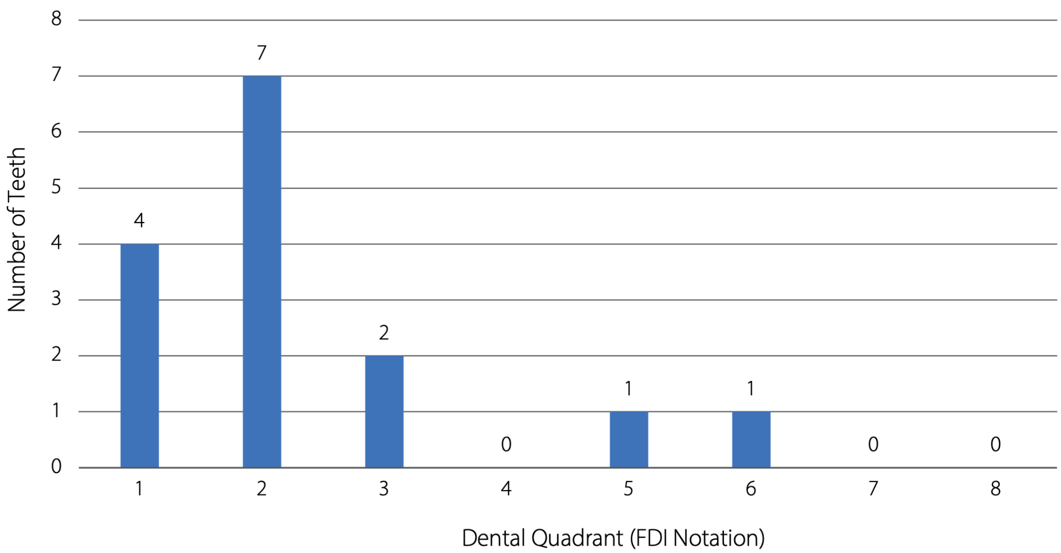

Figure 5.25. *Frequency distribution of diagonal profile modification by quadrants in the Circle sample (quadrants follow FDI notation) (Σ=15).*

majority of these precipitated from the latest of the Late use-phase contexts, (783), which featured five observations. The remaining contexts with diagonal profile modifications fall in descending order as: (1241) (Σ=3); (595) and (1206) (each Σ=2); and (951), (715) and (960) (each Σ=1). The proportions of teeth with diagonal profiling attributed to each context are: (783) (33.33%); (1241) (20.00%); (595) and (1206) (each 13.33%); and (951), (715) and (960) (each 6.67%). Here, we see that both in number of observations and proportionally (783) features the highest rates of diagonal profile modifications amongst the Circle study sample.

To understand better the expression of this mode of modification amongst the Neolithic Circle population, the data can be analysed according to tooth types (Fig. 5.24). Although both adults and non-adults appear to have been included in this form of dental manipulation, incidence was far higher amongst the adult members, with 13 observations recorded for permanent teeth (86.67% total diagonal), and two for deciduous dentition (13.33% total diagonal). There also appears to be a predilection for the maxillary teeth for this form of manipulation, with 11 observations attributed to the adult upper dentition (73.33% total diagonal; 84.62% total adult diagonal), *versus* only two for the mandibular permanent teeth. A similar pattern extends to the affected non-adult dentition, with both observations pertaining to maxillary teeth (13.33% total diagonal; 100.00% total deciduous diagonal). When considered according to distribution by oral quadrants (Fig. 5.25), the left permanent maxillary anterior teeth featured the highest number of diagonal profile modifications (Σ=7; 46.67% total diagonal; 63.64% total adult diagonal). This was followed by four observations for right permanent maxillary anterior teeth (26.67% total diagonal; 30.77% total adult diagonal); and two examples for the left permanent mandibular anterior arcade (13.33% total diagonal; 15.38% total adult diagonal). For the deciduous teeth, we observed one example of diagonal profile modification for each of the right and left maxillary anterior dentition (each 6.67% total diagonal; each 50.00% total deciduous diagonal).

A singular individual tooth type emerged as most frequently subjected to diagonal profile modification amongst the Circle study sample (Fig. 5.24). Almost half of all observations of this mode of modification were attributed to left permanent maxillary central incisors (FDI 21; Σ=7; 46.67% total diagonal; 53.85% total adult diagonal). This was more than double the next highest-frequency tooth, and greater than the sum of all other adult affected teeth. Three observations were recorded for right permanent maxillary central incisors (FDI 11; 20.00% total diagonal; 23.08% total adult diagonal); and one example each observed for a right permanent maxillary canine (FDI 13); left permanent mandibular lateral incisor (FDI 32); and a left permanent mandibular canine (FDI 33; each 6.67% total diagonal; each 7.69% total adult diagonal). As previously mentioned, both deciduous teeth displaying diagonal profile modification were attributed to the upper arcade, and both were central incisors, however one precipitated from the right (FDI 51) and one from the left (FDI 61; each 6.67% total diagonal; each 50.00% total deciduous diagonal).

5.5.1.6. Undulating profile

Undulating profile modifications are those observed to present a distinctly uneven, amorphous incisal margin across the anterior teeth. As seen on the examples displayed from the Circle study sample (Fig. 5.18f & g), the expression of this type of modification is extremely variable and its aetiology is somewhat enigmatic. Although this emerged as a distinct form of anterior tooth modification for this assemblage, it is not a widely reported phenomenon amongst other archaeological populations. As such, it is difficult to attribute it as either an 'active' or 'passive' modification, however it seems more likely to be the latter. Although undulating profile modifications were the least common of all the dental manipulations (Σ=14; 6.09% total modifications; Fig. 5.5), this is only by a margin of one, so it should be considered with equal gravity to both diagonal modifications and extreme lingual wear (each Σ=15; 6.52% total modifications).

Despite the small number of affected teeth, the chronological distribution appears to be relatively consistent across the dataset (Fig. 5.26). For undulating profile modifications, the greatest number of examples were observed amongst the Early use-phase interments (Σ=8; 57.14% total undulating teeth). There was only one example attributed to the Middle use-phase (7.14% total undulating); and a small resurgence was observed amongst the Late use-phase population sample (Σ=5;

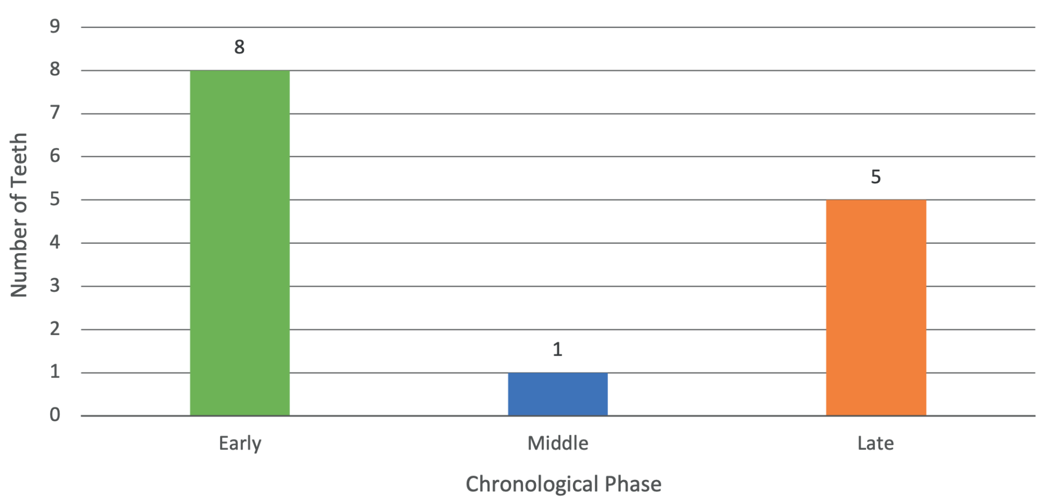

Figure 5.26. *Frequency distribution of undulating profile modification by chronology in the Circle sample (Σ=14).*

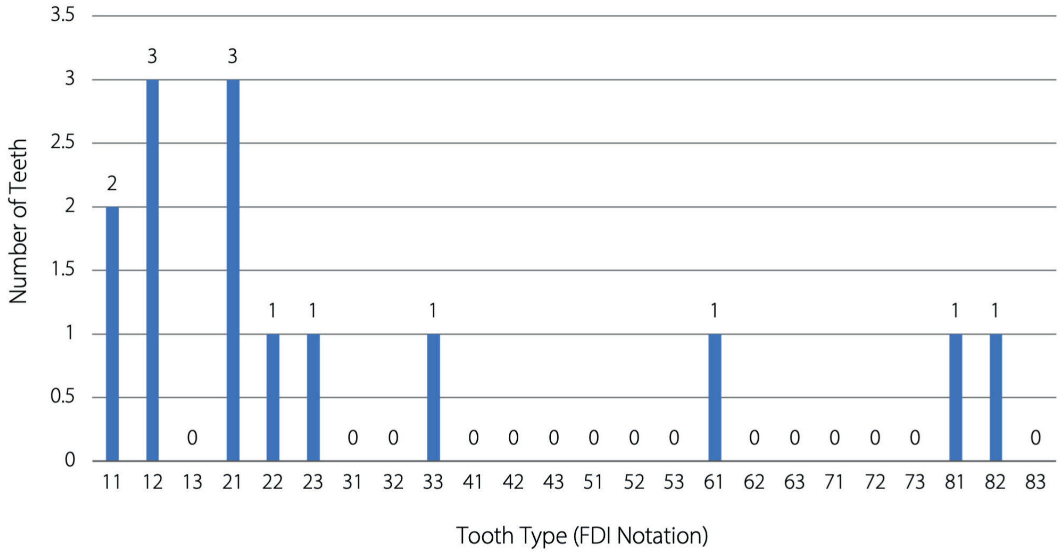

Figure 5.27. *Frequency distribution of undulating profile modification by tooth type in the Circle sample (Σ=14).*

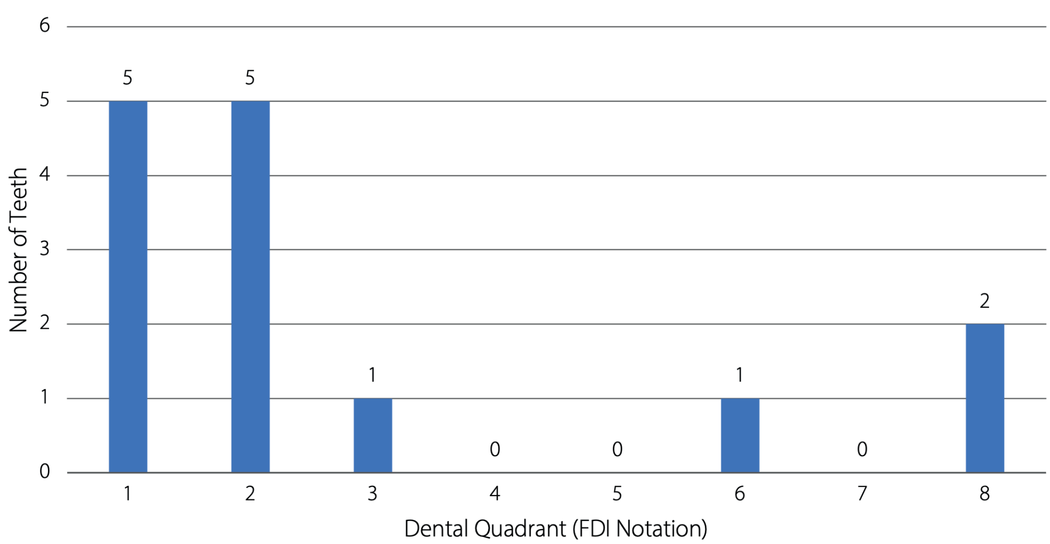

Figure 5.28. *Frequency distribution of undulating profile modification by quadrants in the Circle sample (quadrants follow FDI notation) (Σ=14).*

35.71% total undulating teeth). Table 5.3 demonstrates that although six contexts featured teeth with undulating modifications, the greatest proportion of affected teeth precipitate from Context (951), with six of the 14 teeth recorded from these Early stratigraphic units. The remaining contexts only feature scattered representations, listed in descending order as: (960) (Σ=3); (595) (Σ=2); and (1241), (1206) and (783) each feature one example (7.14% total undulating teeth). When presented as a proportion of all undulating modifications, the results emerge as: (951) (42.86%); (960) (21.43%); (595) (14.29%); (1241), (1206) and (783) (each 7.14%). Here again, both in raw incidence and proportion, Context (951) has the highest occurrence of undulating profile modifications across the study sample.

Figure 5.27 reveals the distribution of data when analysed according to tooth types. In this case, we see that there is a spread of incidences of undulating profile modifications across both adult and non-adult members of the Circle population, with 11 examples recorded for permanent teeth (78.57% total undulating teeth), and three examples for deciduous dentition (21.43% total undulating teeth). Across the sample, there is a pronounced pattern in terms of distribution across the arcade. Amongst the affected adult teeth, 10 of the 11 examples were identified on maxillary dentition (90.91% total adult undulating teeth; 71.43% total undulating teeth), and only one on a mandibular tooth (9.10% total adult undulating profile teeth; 7.14% total undulating teeth). For the deciduous dentition, this was reversed, with two of the three affected non-adult teeth recorded as mandibular (66.66% total deciduous undulating teeth; 14.29% total undulating teeth), and only one as maxillary (33.33% total deciduous undulating teeth; 7.14% total undulating teeth). These trends are reinforced when viewing the data according to oral quadrant distribution (Fig. 5.28). The adult maxillary left and right anterior quadrants are the strongest – and equal – representatives amongst the dataset, each featuring five examples of this mode of modification (each 45.45% total adult undulating teeth; each 35.71% total undulating teeth). The left permanent mandibular anterior teeth had only one example (9.10% total adult undulating profile teeth; 7.14% total undulating teeth); while the right permanent mandibular anterior quadrant had none. Amongst the deciduous sample, only two quadrants featured affected teeth, including two for the right deciduous mandibular anterior arcade (66.66% total deciduous undulating teeth; 14.29% total undulating teeth) and one for the left deciduous maxillary anterior dentition (33.33% total deciduous undulating teeth; 7.14% total undulating teeth).

Although the expression of undulating profile modifications appears to cluster when analysed according to chronological, demographic and quadrant distributions, it disperses when organized according to individual tooth types (Fig. 5.27). There is a slight grouping across the adult maxillary anterior teeth, with the right lateral incisor (FDI 12) and left central incisor (FDI 21) each presenting three examples (each 27.27% total adult undulating teeth; each 21.43% total undulating teeth); and two examples recorded for right central incisors (FDI 11; 18.18% total adult undulating teeth; 14.29% total undulating teeth). All remaining affected teeth presented only single examples across both adult and non-adult dentition, including a left permanent maxillary lateral incisor and canine (FDI 22, 23); a left permanent mandibular canine (FDI 33); a right deciduous maxillary central incisor (FDI 61), and a right deciduous mandibular central and lateral incisor (FDI 81, 82; each 7.14% total undulating teeth).

5.5.1.7. Gross crown loss

As discussed above for labial and lingual extreme wear (§5.5.1.3–4, above), there is the possibility of cross-over between the aetiologies and quantifications of extreme wear cases and dental modification. As mentioned above, especially when considering the anterior dentition, alterations to the labial and incisal profiles may be attributed to either active and/or passive processes which result in identical physical and aesthetic affect(s). It is also possible that modifications to the teeth caused by habitual behaviour may have produced specific identity-markers held as significant within a cultural group (Alt & Pichler 1998, 388; Milner & Larson 1991, 357; Scott 1991, 798; cf Chapter 4). For these reasons, the phenomenon of gross crown loss to the anterior teeth is also presented here.

On 10 occasions amongst the sample, teeth were worn to the extent that only fractions of the crown remained; three of these examples left only functional root stumps. Four teeth were observed to have approximately half of their crowns eroded by the processes of extreme wear. Amongst the earlier use-phases of the Circle, in Context (951) a left permanent maxillary central incisor (FDI 21) was observed to present almost vertical concave erosion on the lingual surface from incisal margin to cingulum, leaving approximately half of the crown extant. In the Later use-phase of Context (960), another left permanent maxillary central incisor (FDI 21) presented approximately diagonal wear on the lingual surface from the incisal edge to a point just inferior to the cementum enamel junction, leaving approximately half the crown extant. In this case, we see another example of complex dental attrition processes, as labial wear was also observed on this tooth in the area immediately superior to the cementum enamel junction, forming a slight concavity in the dentine. Two teeth recovered from Context (783), the latest use-phase of the Circle, were observed to retain only half-crowns; the first was a right permanent maxillary central incisor (FDI 12) presenting an approximately horizontal wear platform across the incisal surface; the second was a left permanent maxillary central incisor (FDI 21), on which an approximately diagonal, mesially inclined, wear platform was observed across the incisal margin, leaving approximately half of the crown extant. Pronounced labial wear was also observed on this tooth, having smoothed and removed almost all extant enamel; additional lingual wear also appears to have eroded all enamel to a point beyond the cingulum, just inferior to the cementum enamel junction.

Three of the teeth within the sample were observed to be worn to the extent that only one-third of the crown remained. Two of these teeth were identified within the Early use-phase of Context (951): the first being a right permanent central maxillary incisor (FDI 11), the second was a right permanent maxillary lateral incisor (FDI 12). For both teeth, not only did the tooth crowns display the loss of approximately two-thirds of their height, they also presented labial wear that extended vertically across the extant surface beyond the cementum enamel junction onto the root. The other tooth within this wear category was observed in the Late use-phase Context (783): another right permanent maxillary lateral incisor (FDI 12). This tooth exhibited approximately diagonal wear which was inclined towards the lingual aspect and eroded approximately two-thirds of the crown.

Functional root stumps were also observed, as reported in Chapter 4. In these cases, the tooth crowns are thought to have been obliterated *in vivo* through processes associated with extreme wear, carious lesions, *antemortem* crown fractures and/or combinations of these phenomena. The continued functional use of these root stumps in the mouth prior to death is evident through wear (smoothing, glossing, rounding) of the extant occlusal surfaces. The earliest incidence was identified on a right permanent maxillary lateral incisor (FDI 12) associated with Context (951), one of the early use-phases of the Circle. The crown of this tooth was obliterated beyond the cementum enamel junction. The remaining two incidences within this wear category are attributed to the distal dentition, and therefore not within the focus of the current analyses. For further information on these teeth, see Chapter 4.

5.6. Case studies

Although population-based reporting is the foundation of bioarchaeological analyses, it is important to present case studies to bring sharp focus to the lived experiences of 'real people' amongst archaeological assemblages. It is particularly important to do so in assemblages such as the Circle, where many might assume that the levels of fragmentation and commingling would render such testimonies inaccessible. With this in mind, two case studies are presented to shed light on the complexities of identifying intentional dental modification in past populations, and to introduce two compelling individuals to the discourse.

5.6.1. Congenital variation, cultural intervention, or both?

An intriguing example of apparent variation in eruption and alignment can be seen in the articulated cranium and mandible of an individual from Context (960) (2500–2400 cal. BC); Figures 5.29a–e; 5.30a–i. The individual was determined to be an adult, based on the complete eruption and occlusion of the right and left maxillary permanent third molars (FDI 18, 28). The left and right mandibular permanent third molars are also completely erupted and in occlusion (FDI 38, 48) and all apices are observed to be closed under radiological examination. The individual was subject to sex assessment based on evaluation of the cranial sexually dimorphic traits presented in Buikstra and Ubelaker (1994, 20), including nuchal crest (2/5), mastoid process (2/5), supraorbital margin (2/5), supraorbital ridge/glabella (3/5) and mental trigone (2/5). According to these criteria, the individual was assessed as a possible female.

Close observation of the maxillary dentition reveals that both right and left permanent lateral incisors are absent (FDI 12, 22), and the permanent canines (FDI 13, 23) appear in their place. Distal to the canines, bilateral patent spaces are observed in the maxillary alveolar process. These spaces present as pitted, slightly roughened patches of bone. When viewed from both right and left lateral aspects of the maxillae, the margins of these spaces present as roughened and irregular, appearing to retain residual evidence of vascular impressions, pitting and porosity (Fig. 5.29b–e). The bilateral aspects of the labial-buccal alveolar process also present slight focal resorption in these areas. The lingual margins appear to be slightly smoother, however they also present slight pitting and porosity. The canine pillar is absent on both left and right labial aspects of the maxilla. The remainder of the bilateral maxillary dentition is in correct anatomical sequence. Slight calculus is observed on the labial/buccal aspects of all extant dentition at the level of the cementum enamel junction, accompanied by indications of mild periodontal disease including minimal resorption of the alveolar process (approximately 3–5 mm) and slight pitting and porosity. There is no indication of mesial drift in the teeth distally adjacent to the spaces in the anterior arcade, despite the bilateral impaction of the permanent third molars; the right is mesially tilted by approximately 30°, the left by approximately 20°. There is slight distal rotation of the right maxillary permanent first premolar (~10°), however the lack of tilting or encroachment into the adjacent space suggests that this may be an ontogenetic variation. It is also important to highlight that this individual presents moderate prognathism of the maxillary arcade, which is noticeable against the overall gracility of the skull. The associated mandible articulates well with the cranium, and all posterior teeth occlude evenly with their antagonists (Fig. 5.29d & e).

The mandible presents all adult teeth in correct anatomical sequence – the right permanent lateral incisor has been lost *postmortem*. Perturbations in alignment are minimal; the left permanent second premolar presents slight mesial rotation (~15°), while the right permanent third molar is slightly impacted, being mesially tilted by approximately 45°. It is important to note here that the teeth opposing the previously mentioned bilateral spaces in the maxilla, the left and

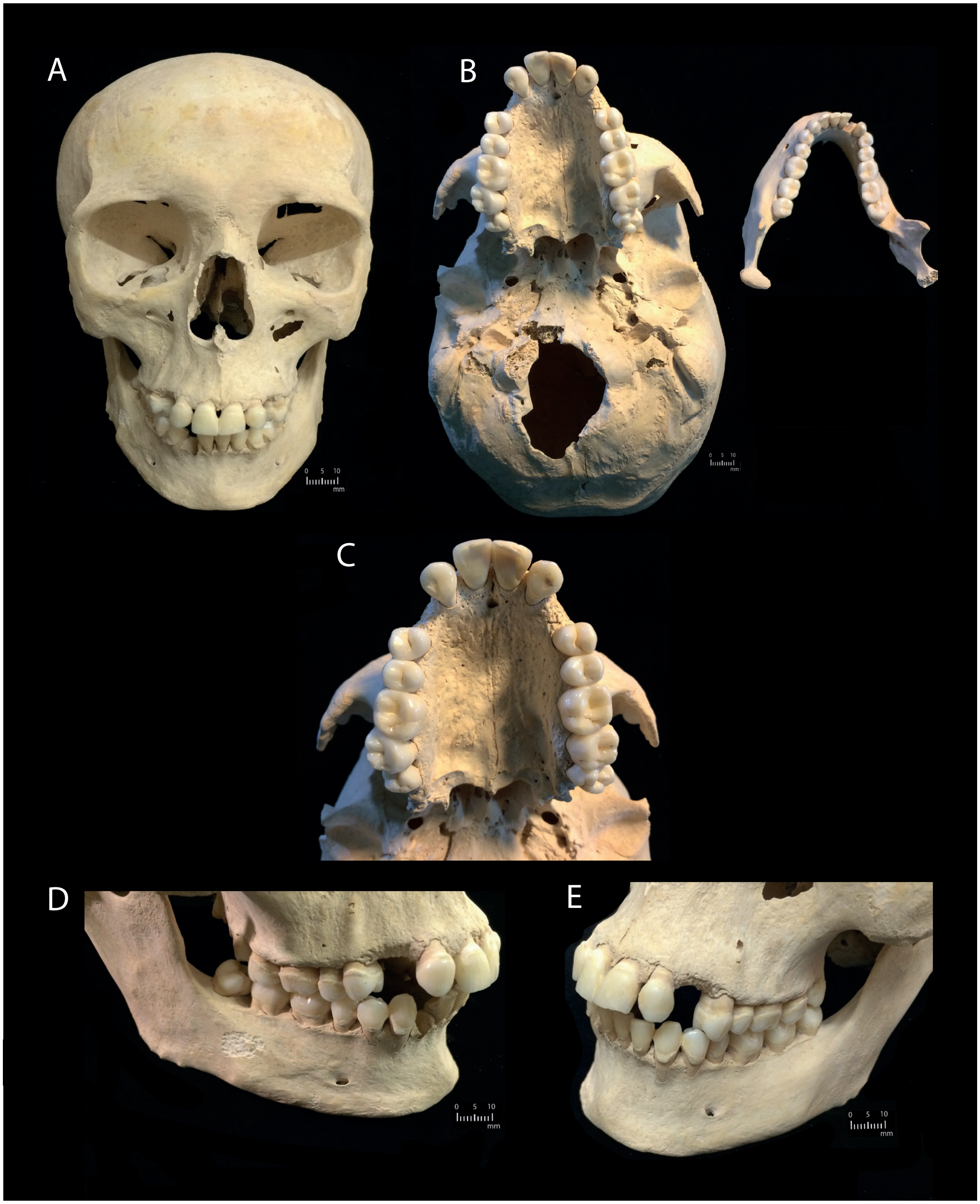

Figure 5.29. *Almost complete skull of probable female adult individual with variation of eruption and alignment from Context (960) of the Circle sample: a) articulated cranium and mandible in anterior view; b) disarticulated, inferior view of cranium and superior view of mandible; c) detailed inferior (palatal) view of maxillary dental arcade, featuring atypical positioning of the bilateral permanent canines (FDI 13, 23) and immediately distal patent alveolar spacing; d–e) detailed right and left anterolateral views of the articulated maxillae and mandible, detailing the opposing relationships of the dentition relative to the atypical positioning of the maxillary permanent canines and the distal patent alveolar spacing. Scale bar: 1 cm. (Photos Ronika K. Power).*

right permanent canines, both present evidence of wear consistent with all other extant dentition, and do not demonstrate any evidence for compensating (or 'continuous') eruption in the absence of vertical opposition (Fig. 5.30d–e; Hillson 2000, 254). Slight calculus is observed on the labial/buccal aspects of the mandibular arcade at the level of the cementum enamel junction on the left (FDI 31–36) and right (FDI 41, 43–46) sides; and also at the cementum enamel junction on the lingual aspects of the left (FDI 31–33) and right (FDI 41–43) sides.

To determine the aetiology of the phenomena described above for the anterior maxillary teeth of this individual, CT-scans were taken of both the cranium and mandible by L.T. Buck in the Cambridge Biotomography Centre, according to the procedure outlined in §5.4, above (Fig. 5.30a–c). For the cranium, these scans reveal that the maxillary central incisors appear morphologically normal, with symmetrical wear on incisal surface and no periodontal ligament space changes within the alveolus (Fig. 5.30e & f). The maxillary canines also appear normal and well-spaced as lateral teeth in relation to the central incisors, and present slight bilateral wear on the tips of the cusps. The horizontal and vertical dimensions of the alveolar process appear very well preserved, and the bilateral remnant portions of the alveolar process where the dentition are absent appears slightly rounded. The profile of the maxilla is continuous and indicative of consistent load-bearing through normal mastication and use of the mouth. As seen in Figure 5.30d–f, no residual socket is observed within the right or left alveolar processes superior to these spaces. There is no evidence of either impacted maxillary lateral incisors, or any ectopic dentition. For the mandible (Fig. 5.30g–i), the CT-scans confirm that occlusal wear is present on all crowns, suggesting good apposition across the arcade (cf De Groote & Humphrey 2016, 2017; Milner *et al.* 1991; Newton & Domett 2017). The bilateral mandibular canine cusps are both worn to the

Figure 5.30. *a–c) 3D render of cranium in anterior, right lateral and posterior views; d–f) cross-sections of maxillary alveolar process in transverse and right and left lateral views; g–i) 3D render of mandible in anterior, left lateral and posterior views. Radiological images captured by L.T. Buck, Cambridge Biotomography Centre; processed by J. Magnussen & M. Pardey, Macquarie Medical Imaging.*

extent that they present slight dentine exposure, and neither display any evidence of compensating eruption.

In combination, this evidence presents a curious case for which there may be several differential diagnoses. Firstly, there are a number of possible explanations to account for the presence of the bilateral maxillary permanent canines in the positions normally occupied by the lateral incisors. Agenesis (or congenital absence) of the maxillary permanent lateral incisors is one of the more common variations of the development and eruption of the adult dentition (Hillson 2005, 281; Lee 2017, 92; Kavadia *et al.* 2011). It is possible that the lateral incisors simply did not develop, potentially creating an opportunity for another congenital variation to manifest: canine transposition. Canine transposition is a well-described dental phenomenon involving the development and eruption of the permanent canine in either of the adjacent positions within the same quadrant; maxillary canines are the category of teeth second-most frequently presenting eruption disturbances, after the third molars. (Tripathi *et al.* 2014; cf Garib *et al.* 2010; Shapira & Kuftinec 1989). In clinical studies, tooth transposition is more frequent and variable in the maxilla, the canine presents the most common involvement, and females are most commonly affected (Tripathi *et al.* 2014; cf Budai *et al.* 2003; Mayes *et al.* 2017, 288, 289; Peck & Peck 1995; Plunket *et al.* 1998; Shapira & Kuftinec 1989). The aetiology of this phenomenon is associated with several factors, including genetics, position exchange of developing tooth buds, trauma, cyst and tumour formation, mechanical interference and early loss of incisors (Tripathi *et al.* 2014; cf Feichtinger *et al.* 1977; Peck *et al.* 1993; Peck *et al.* 1998; Shapira 1980; Shapira & Kuftinec 2001). Canine transposition can occur with or without accompanying agenesis of other dental elements, however studies have revealed co-occurrence in 40% of cases with agenesis; in 25% of cases with peg-shaped lateral incisors; and in 50% of cases with retention of deciduous teeth (Budai *et al.* 2003; Lee 2017; Tripathi *et al.* 2014).

In one clinical case, a nineteen-year-old female presented with a retained left deciduous maxillary canine (FDI 63), agenesis of the left permanent maxillary lateral incisor (FDI 22) and transposition of the left permanent maxillary canine (FDI 23) in its place (Tripathi *et al.* 2014). In this case, although the crown of the deciduous canine was still *in situ* and being used for functional occlusion and mastication in the mouth, radiographic examination revealed that the roots and the corresponding alveolus were almost entirely resorbed (Tripathi *et al.* 2014, Fig. 1). This case bears striking resemblance to that of the individual excavated from Context (960). All phenomena parallel those observed on our Neolithic Maltese individual, including the resorbed alveolus, absence of canine pillar, and pitted and porous alveolar margin in the traditional canine space. Were a living, functional deciduous tooth with resorbed root retained here within the gingiva, it is likely that it would have promoted the pitted, roughened and porous character of the alveolar margin via vascular and masticatory activity. It also accounts for the lack of mesial drift and interproximal contact facets in the neighbouring dentition, as well as the absence of compensating eruption on the opposing elements.

The above presents a convincing scenario and compelling comparative case study. However, differential diagnoses may extend further, and for this reason the possibility of autogenous transplantation must also be addressed. Autogenous transplantation (or autotransplantation) involves the transplantation of one tooth within an individual's mouth to another location elsewhere in the arcade (Clokie *et al.* 2001; Northway & Konigsberg 1980). This is opposed to allotransplantation, which involves the transplantation of a tooth from one individual's mouth to that of another individual (Nimčenko *et al.* 2013). Both of these practices are argued to have ancient origins, with medical historians arguing for attestations of the practice in ancient Egypt (Heithersay 1975; Morel *et al.* 2018; Nimčenko *et al.* 2013; Schwartz *et al.* 1985). When considering these possibilities, the former is perhaps more likely than the latter, as allotransplantation is known to have a high likelihood of rejection caused by histoincompatibility (Nimčenko *et al.* 2013). We are obliged to consider a scenario in which the maxillary lateral incisors (permanent or deciduous in the case of retention) may have been extracted or avulsed for various reasons (including but not limited to pathology, culture or ritual), and the canines extracted and transplanted into the neighbouring alveoli. After all, as discussed in §5.2.3, above, the intentional removal (variably referred to as extraction, avulsion or ablation) of the anterior teeth is known for Neolithic populations within the Mediterranean (Robb 1997), Levant (Eshed *et al.* 2006), Europe (Jackson 1915), extending into the Middle East and Africa (Humphrey & Bocaege 2008) and all the way to Taiwan (Pietrusewsky *et al.* 2017).

On one hand, there is nothing within the bilateral internal architecture of the maxillary alveolar process to indicate that there were ever alveoli (and thus, teeth) within the patent spaces normally occupied by the permanent canines. However, it is clinically noted that alveoli can be completely remodelled within less than one-year post tooth loss (Covani *et al.* 2011; Johnson 1969; Morgan 2011; Pietrokovski & Massler

1967; Schropp *et al.* 2003). Considering the evidence mentioned above including the absence of mesial drift on the neighbouring bilateral first maxillary premolars; the absence of compensating eruption on the opposing bilateral mandibular permanent canines; and the presence of occlusal wear across the arcade, including the opposing bilateral mandibular permanent canines, it is possible that there were once teeth within the maxillary alveolar spaces, or perhaps proto-prosthetic devices or spacers of some description. Early accounts of dental prostheses have been attributed to ancient Egypt in approximately 2500 BC (Harris *et al.* 1975; Junker 1929), although physical re-examination of the prostheses and recent research casts some doubt on these claims (Forshaw 2009; Leek 1972 cf. Becker 1999a, 1999b; Crubézy *et al.* 1998; Seguin *et al.* 2014). While the bilateral absence of interproximal contact facets for both the distal interproximal aspects of the maxillary permanent canines and the mesial interproximal aspects of the maxillary permanent first premolars suggests that there was no enduring *in situ* adult dentition in these spaces, one cannot absolutely rule out that there were never teeth (deciduous – exfoliated or retained, as argued above – and/or adult) or prostheses present. In parallel cases in Neolithic China, where selective avulsion or ablation of anterior teeth was practised, including lateral incisors, scholars classify any absent teeth with persistent spaces as evidence for ablation (Lee 2017, 96). The same diagnosis applies for observations of symmetrically absent teeth, as previous research across cultures revealed very little symmetry in dental agenesis and/or pathology resulting in *antemortem* tooth loss (Buikstra 1987; Lee 2017, 97; Newton & Domett 2017, 161–2; Pietrusewsky *et al.* 2017, 107; Spencer & Gillen 1927; van der Reijden 2014, 21; van Rippen 1918a, 1918b).

5.6.2. Active modification, passive alteration, or both?

Although they were not recovered from any of the contexts included in the study sample, an individual identified amongst the remains excavated from Context (845) is important to feature here (Fig. 5.31a–e). This context was a substantial burial deposit found in the northern niche of the 'West Cave' dating to between 2625–2500 cal. BC (Chapter 3), at the height of the Tarxien phase. To determine the aetiology of the phenomena described below for the anterior maxillary teeth of this individual, their remains were initially examined macroscopically in the National Museum of Archaeology, Valletta, and CT-scans were later taken by L.T. Buck in the Cambridge Biotomography Centre, and subsequently analysed at the Macquarie Medical Imaging Unit, Macquarie University Hospital, according to the procedure outlined in §5.4, above.

These are the fragmentary remains of an adult cranium, approximately 20% complete. The remains are restricted only to the splanchnocranium (facial skeleton), consisting of the inferior aspect of the frontal bone, incorporating the inferior third of the frontal squama, the glabella, the left and right supraorbital margins, zygomatic processes and partial orbital roofs; the left and right nasal bones; the left and right zygomae, bilaterally fragmented at the roots of the temporal processes; and the left and right maxillae. The left maxilla is fragmented at the posterior aspect, so that the alveolar process is absent distal to the left permanent second premolar (FDI 25); the corresponding dentition are also absent, including the permanent first, second and third molars (FDI 26, 27, 28). All remaining left permanent maxillary dentition are present and *in situ* within the alveolar process (FDI 21–25). The right maxilla is fragmented immediately distal to the permanent third molar (FDI 28), so that the maxillary tubercle is absent. All right permanent maxillary dentition is present and *in situ* within the alveolar process (FDI 11–18). The posterior walls of the left and right maxillae are fragmented and absent, so that the bilateral maxillary antra are exposed. The left and right palatines are absent. The vomer and all nasal conchae are absent. All reported damage is assessed to be *postmortem*.

Age estimation is based on overall size, robusticity, density of cortices and the eruption of the left permanent maxillary third molar (FDI 28). Furthermore, the apices of all permanent teeth are observed to be closed under radiological examination. Although this individual is highly fragmented, the extant splanchnocranium was subject to sex assessment, based on evaluation of the cranial sexually dimorphic traits presented in Buikstra and Ubelaker (1994, 20), including supraorbital margin (4/5), and supraorbital ridge/glabella (4/5). We also note the rugosity and breadth of the zygomae, and the length, breadth and robusticity of the palate (Schwartz 1995, 280). According to these criteria, the individual was assessed as a possible male. Despite the strength of expression of the extant traits, we remain conservative in our evaluation considering the absence of the majority of the cranium and further diagnostic traits.

Linear hypoplastic defects are observed on the enamel of the anterior teeth (central incisor: between 2.0 mm to 9.5 mm from cementum enamel junction [equates to 5.4–8.8 years of age; Goodman & Rose 1990, 98, Table 3]; canine: 7.2 mm from cementum enamel junction [equates to 10.5 years of age, Goodman & Rose 1990, 98, Table 3]). The observation of hypoplastic defects across these permanent teeth indicates that this individual was subject to chronic biological,

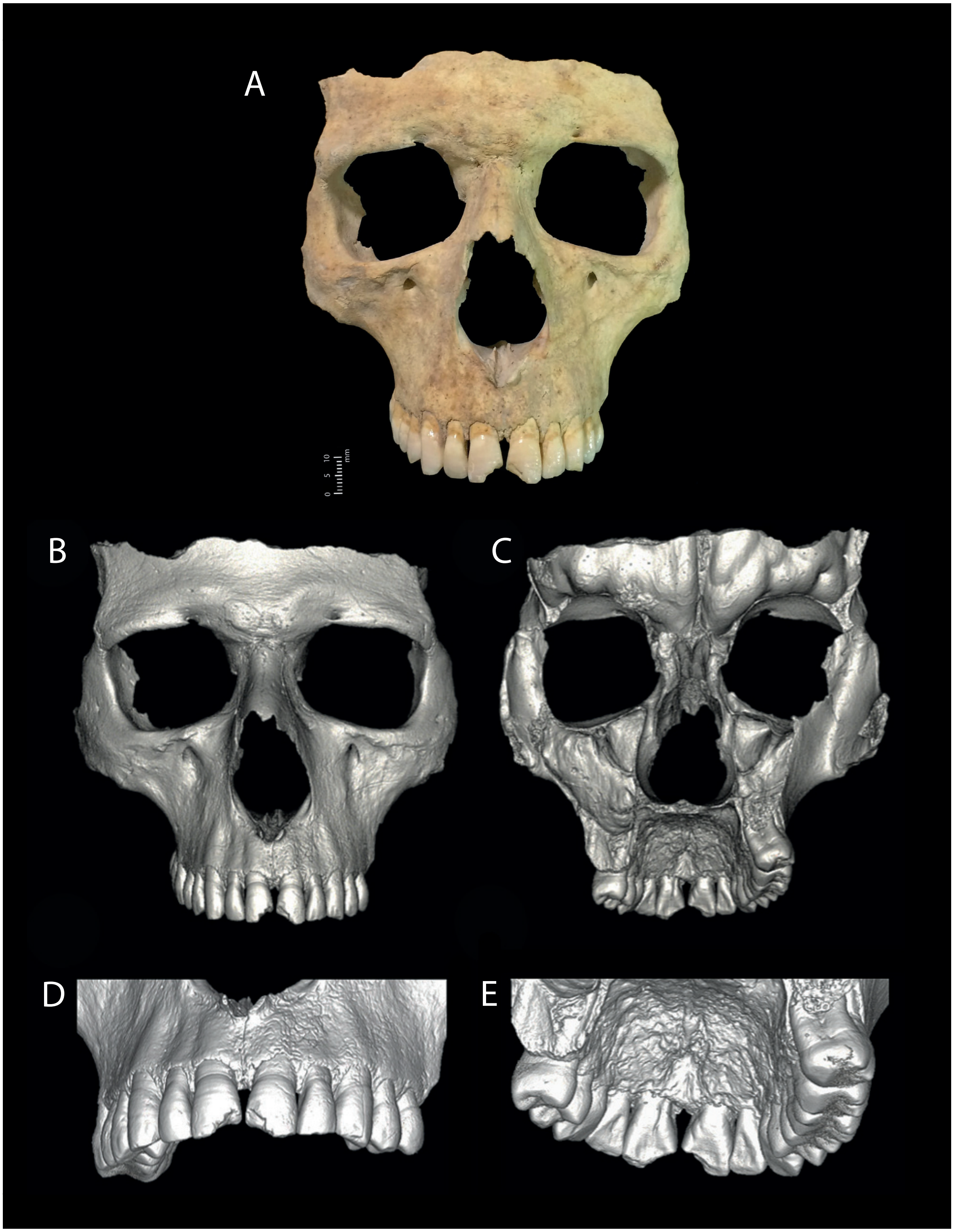

Figure 5.31. *Adult splanchnocranium featuring modification of the left and right permanent maxillary central incisors (FDI 11, 21): a) anterior view; b) 3D render anterior view; c) 3D render posterior view; d) 3D render maxillary arcade anterior close-up view; e) 3D render maxillary arcade posterior close-up view. Scale bar: 1 cm. (Photos Ronika K. Power; radiological images captured by L.T. Buck, Cambridge Biotomography Centre; processed by J. Magnussen & M. Pardey, Macquarie Medical Imaging).*

nutritional, environmental and/or psychological stress throughout childhood (Goodman 1991; Goodman & Capasso 1992; Goodman & Rose 1990, 1991; Ortner 2003; Pindborg 1970; Roberts & Manchester 2005). As a result of fragmentation, we are unable to determine if further indicators of systemic stress including *cribra orbitalia* or porotic hyperostosis were also present on the orbital roofs or cranial vaults, respectively.

The right and left permanent maxillary central incisors (FDI 11, 21) are both observed to be modified in a similar, symmetrical manner. Both teeth have approximately two-thirds of the incisal margin removed at the mesial aspect, to a height of approximately one-third of the inferior aspect of the crown. The distal aspects and corners of the extant incisal margins do not appear to have been subject to modification beyond normal masticatory processes. The extant labial and lingual surfaces of the crown also do not appear to have been modified. The alterations are determined to have taken place *in vivo*, as interpreted from pronounced smoothing, rounding, polishing and colour consistency across the extant margins, all indicating the continued use of the teeth in the mouth following modification (Hillson 2000, 258; Langsjoen 1998, 410; Ortner 2003, 603). Both teeth appear to have had the enamel removed in small chunks, as the extant surfaces are relatively uneven and do not appear to have been subject to subsequent intentional smoothing. Under magnification, the modification margin differs slightly in appearance between the right and left teeth – the right margin is slightly more stepped, while the left is slightly rounder. Furthermore, the margin on the left incisor appears to have had slightly more enamel removed on the labial aspect, resulting in a more concave appearance because of the additional exposure and attrition of dentine. We must keep in mind that these alterations were most likely carried out using lithic tools, so a degree of variation should be expected. Notwithstanding these slight differences, when viewed naturally as one would *in vivo*, the modification appears as an approximately symmetrical hemispherical negative space between the two most prominent teeth of the entire human dentition. The modifications most closely resemble van der Reijden's type B2.3 (2014, 49), having modified crown height reduced by one-quarter to one-third; crown width reduced by two-thirds; and concave edges returning to reach the incisive margin.

It is important to note that none of the remaining maxillary dentition for this individual bear any indication of modification whatsoever. A few of the incisal and/or occlusal margins feature miniature cracks and chips consistent with normal *in vivo* oral activity (but none to the extent that they would be recorded as *antemortem* fractures or chips), and/or *postmortem* damage as is consistent for this assemblage. Considering these factors, and the description presented above, it is argued that this individual was subject to intentional dental modification a substantial amount of time prior to his death and interment within the Circle.

To place this individual within an even wider context, we can consider if there is any evidence reported for similar modifications in populations elsewhere. As will be discussed in §5.7.5, below, although it is not a definitive or comprehensive methodology, the manner in which groups modified their bodies, particularly their teeth, may infer some degree of cultural contact or connection. The many caveats that must be applied to such hypotheses are addressed in detail below. Notwithstanding these precautions, we can report that a similar modification type (B2.3) has been identified by van der Reijden (2014, 49), who traces the form to Starr's (1909, 18) ethnographic work in the Congo. We acknowledge that millennia separate these observations, and we do not propose any direct connection. It is nonetheless an important addition to the discourse that this particular mode of corporeal expression observed on the African continent in the early 20th century was once performed on an individual who, by all accounts, lived and died in Neolithic Gozo.

5.7. Discussion

5.7.1. Limitations of study

Even under the most straightforward burial and depositional circumstances, it can be difficult to ascertain reliable rates of dental modification within a population because of *ante-* and *postmortem* tooth loss and dental attrition and pathology (Milner & Larsen 1991; Stojanowski *et al.* 2016). These challenges are compounded for the Circle assemblage as a result of its highly fragmented, commingled and predominantly disarticulated nature. This calls us to address a number of issues. Firstly, while the majority of published modification studies have been carried out on intact dental arcades, the nature of our assemblage necessitates that we study loose *postmortem* exfoliated teeth and/or fragmented bony jaws with *in situ* dentition. Secondly, concerning *in vivo* processes, as has been noted previously (Stoddart *et al.* 2009a, 318) and expanded upon in Chapter 4, dental attrition across the population is relatively minimal. This is perhaps because of their fluoride fortified enamel in concert with a soft local limestone substrate which, when incidentally included in the diet as a by-product of food production, does not bring about the catastrophic wear observed on contemporaneous neighbouring regional populations embattled by silica (sand) as the prevailing inorganic particulate (Forshaw 2009, 421, 422; Hillson 2008, 124; Miller 2008, 55–6). As such, the observations tabled here are thought to be genuine reflections of the lived experiences of both intentional and incidental modification processes across the life course. With these factors in mind, the systematic and detailed recording practices applied to this population offer valuable contributions towards local and global understanding of this phenomenon.

In archaeological populations, complications of dental modification have included tooth fracture or caries (Ikehara-Quebral *et al.* 2017, 201–2; Irish 2017, 39, 41; Milner 2017, 320; Tiesler *et al.* 2017). We have reported on both crown fractures and caries in Chapter 4, however on no occasion did we note a primary modification as the fracture or caries aetiology of an anterior tooth. This is demonstrated in Figures 5.10f and 5.18g, where cervical carious lesions are observed on central maxillary incisors presenting incisal notch and undulating profile modifications from contexts (595) and (783), respectively. In these cases, there were no observations of pulp chamber compromise, nor of secondary dentine deposition, suggesting that factors other than the modifications were responsible for the carious lesions. Notwithstanding this, we did not include observations of infectious or inflammatory processes in the maxillary or mandibular alveolar processes, as it was not within current project parameters, particularly because of the high incidence of *postmortem* exfoliated teeth amongst the study sample. This component of the research design is discussed further in §4.4. Future considerations of the wider lived experience of dental modification for this population would benefit from such investigations, and it is hoped that they can be included in further studies wherever they are observed *in situ* in alveoli.

For similar reasons, we are unable to offer extended commentary on the incidence of avulsion or ablation amongst the Circle assemblage, beyond the single potential example described in §5.6.1, above. As mentioned before, the primary focus of this project was on the dentition itself, rather than the hard tissues of the jaws, which would be essential for identifying *antemortem* tooth loss of any aetiology. Considering the difficulties associated with identifying avulsion or ablation in intact skulls within discrete burials (Buikstra 1987; Lee 2017, 97; Milner & Larsen 1991, 363; Newton & Domett 2017, 161–2; Pietrusewsky *et al.* 2017, 107), we anticipate that these obstacles would be amplified for this, and other, highly fragmented, commingled and predominantly disarticulated samples. Nevertheless, considering the widespread nature of ablation and/ or avulsion in the deeper prehistoric periods and the general North African regional diminishment of the practice in the Neolithic (Humphrey & Bocaege 2008), we would like to incorporate these considerations into future research to understand the extent to which it did or did not manifest across the Maltese archipelago.

We also acknowledge that the majority of the sample were not examined using light microscopy, scanning electron microscopy or micro-CT data as it was beyond the temporal, logistical and pecuniary parameters of the current project. As stated in §5.4, above, every tooth was examined macroscopically, observations were enhanced using a 10x magnification hand lens, and selected specimens were chosen for micro-CT scanning.

Finally, we underscore the awareness that any results and interpretations presented here should only be perceived as a minimum number of incidences, and not as overall statistical prevalence of a complete burial population. The Circle assemblage has not been fully excavated, nor has the excavated population been exhaustively analysed. Ongoing studies by the current authors will seek to further elucidate all aspects of the pathology, anthropology, demographics, affinity and cultural engagement of the Neolithic Maltese community interred in this space, including their practices of dental modification.

5.7.2. The Circle in context

The observations reported here are of profound significance for Maltese archaeology, and indeed prehistoric archaeology across the central Mediterranean, as it presents the first detailed analyses of dental modification for the archipelago. We have reported a relatively low incidence rate of dental modification (Σ=172; 5.62% total sample) across all use-phases of the Circle, which accords with the generally low-to-moderate rates described for archaeological populations across the globe (Burnett & Irish 2017b, 5). We have described both active and passive modification types that are commonly reported across prehistoric cultures, including chipping (or chiselling), incisal notches, labial and lingual wear, diagonal and undulating profile modifications and gross crown loss, while also presenting some potentially novel augmentation types, including diagonal incisal profile modification. Acting upon these observations, we seek to address the calls for illuminating the biocultural significance of these practices – it is not enough to merely describe what we see; we must strive to incorporate all available data to understand *why* people altered or removed their teeth. Through these acts, be they intentional or unintentional, these individuals forever changed themselves and each other, making powerful statements through their bodies about who they were, what they did and where they came from (Burnett & Irish 2017, 6; Milner 2017, 321). The following sections explore these issues.

5.7.3. Demographic insights

As with all subdisciplines of human bioarcheology, the demographic distribution of dental modification is one of the primary touchpoints for biocultural research. To understand best the cultural and behavioural impetuses behind the selection of individuals for this intentional cultural practice –or their participation in the behavioural practices that incidentally caused them– and the subsequent lived experiences of affected individuals, we seek to determine if there are any observable patterns in the distribution of the modifications by age, biological sex, health or any other observable skeletal markers. In this case, our observations are somewhat limited because of the fragmented and commingled nature of the assemblage, and the fact that for the overwhelming majority of the study sample we are analysing *postmortem* exfoliated loose teeth. One of the great advantages of working with dentition is that they are amongst the most reliable indicators of age-at-death; however, in isolation and from commingled assemblages, we are reliant upon this assessment for a single tooth rather than an entire arcade. Moreover, although there are some populations for which metric dental analyses may be somewhat reliable for sex assessment (Black 1978a, 1978b; Garn *et al.* 1964, 1966, 1967, 1979; Mayhall 1992; Molleson 1993; Moss & Moss-Salentijn 1977; Owsley & Webb 1983; De Vito & Saunders 1990), such seriations have not yet been performed for the Circle assemblage. In the absence of widespread biomolecular analyses, the determination of biological sex is currently beyond our reach for this dental dataset. As such, we are as yet unable to provide any detailed insights into the sex distribution of labour or aesthetic markers based on dental modification data. Chapter 7 provides further information on other corporeal pathways to understanding demographic patterns of activity-related changes in Neolithic Malta.

Based on this research, however, we have a preliminary understanding of the relative experience of dental modification across the life course for the people interred in the Circle. Adults were by far the dominant group to feature this mode of cultural engagement, representing 89.53% (Σ=154) of affected teeth within the sample. Although the number of affected deciduous teeth is far fewer (Σ=18; 10.47% total modified teeth) their appearance within the sample is highly significant, as is the similarity to adults for the distribution of these modifications across the anterior arcade (Figs 5.3 & 5.4). Observations of either intentional or incidental modification or extreme wear on deciduous teeth are very rare in archaeological populations (Van der Reijden 2014, 7), so this represents an important finding. The presence of children in this space confirms their inclusion in the range of cultural practices that produced these corporeal interventions: either the sudden and most likely ritual and/or aesthetic interventions of intentional dental modification, or the enduring and repetitive behavioural interventions of incidental augmentation (Alt & Pichler 1998), discussed further below.

Although the nature of the assemblage precludes broader and more precise understanding of the age at which modifications took place, the observation of four types of modification (chipping, incisal notches, diagonal and undulating profiles) on deciduous anterior dentition suggests that if/when practised locally, the augmentation of anterior teeth was not exclusively reserved for pubescent or post-pubescent community members, as in other cultures (Irish 2017, 39). In terms of incidental modification, parallels may be found with the Namibian Herero and Sambyu groups, who are known to have practised modification before puberty (van Reenen 1978b; van Reenen & Briedenhann 1985). For the Sambyu people, agency for the timing of the modification lay with the children themselves, who decided when the timing of the chipping, or *mbereko*, would take place (Irish 2017, 39). This observation serves to acknowledge the role of human agency in the analyses of dental modification. Individual choices and decisions as well as purposeful or accidental variations from traditional practices also contribute to expressions of the phenomena that we witness in the Circle assemblage (Milner 2017, 326). All these factors should be considered as we build pictures of Malta's ancient past through this growing research.

The absence of deciduous dentition from two modes of dental modification (labial and lingual extreme wear) does not rule out the participation of children in the particular activities that are closely associated with these phenomena (such as the processing of hides). There are numerous possibilities which may explain this apparent absence of evidence. Firstly, the length of time engaged in the specific activities required to impact on the labial and lingual surfaces to the extent represented in Figures 5.14a–j and 5.18a–e may exceed the lifespan of the deciduous anterior teeth: from the point at which the individual is developmentally able to participate in the activity to tooth exfoliation. It is also possible that such examples might exist within the population but were not included in the current study sample. Further analyses are required to understand better the demographic distribution of these particular phenomena for the communities of Neolithic Gozo.

When we consider what archaeological and ethnographical research has put forward as possible aetiologies for the incidental or 'passive' modifications observed within the Circle population sample, our picture of life in prehistoric Gozo acquires a finer resolution. Activities including clenching fibres between the teeth while weaving mats, ropes and baskets (Minozzi *et al.* 2003); processing animal skins (Eshed *et al.* 2006; Langsjoen 1998, 410; Roberts & Manchester 2005, 81); holding objects such as staves in the mouth while making baskets or nets (Eshed *et al.* 2006); processing materials including lithics, plant fibres, bone, shell and animal sinews (Buikstra & Ubelaker 1994; Cybulski 1974; Irvine *et al.* 2014; Lukacs & Pastor 1988; Schulz 1977; Turner & Cadien 1969; Waters-Rist *et al.* 2010); and using the mouth as a 'third hand' to hold material static in the teeth to allow manipulation (Alt & Pichler 1998, 394; Merbs 1983; Roberts & Manchester 2005, 81) are all raised as prospective impetuses for the incidental dental augmentation observed on some of the children and adults in these communities. It is also possible that other activities beyond those listed here were augmenting the dentition of some of those interred in the Circle. While populations elsewhere also include activities associated with fishing as prospective activities, such as the manufacture of fishing nets and baskets, research carried out by McLaughlin *et al.* indicates that marine proteins were a marginal feature of the Neolithic Maltese subsistence strategy (Chapter 10).

Over and above considerations of the specific activities involved in incidental dental modification, we can view the identification of these markers not only as embodied teaching and learning experiences, but also as economic events within prehistoric communities. Studies undertaken by Finlay (1997) on the identification of children in lithic production are of relevance here, as they cause us to consider children as imbricated in ancient knowledge transfer and socio-economic frameworks. They learned their skills from more experienced people within a community of practice (Lave & Wenger 1991), and then served as producers themselves, creating items or services to comply with societal norms and circulate within local or regional networks – or perhaps even more broadly (Finlay 1997, 205; cf Power 2012). These considerations expand our conceptions of the producers of material culture and highly skilled craft practitioners in prehistoric Malta also to include children. Frequently, in archaeological narratives across cultures, these activities and agencies are reconstructed as andro- and adult-centric (Finlay 1997, 204; Gero 1991; Wajcman 1991).

Following this, an important point to return to is the relatively low incidence rate of dental modification (Σ=172; 5.62% total sample) across all use-phases of the Circle within the study sample. Furthermore, it is noteworthy that on at least 20 occasions within the sample (Table 5.2), more than one type of modification was observed on a singular tooth. When translated into lived experiences, these observations suggest that at any given time, only a relatively small number of adults and children were participating in some of the proposed activities (and possibly others) described above. For some, these may have been a specific task or a range of tasks and/or rituals that modified their anterior teeth in more than one way. In sum, this evidence provides insights into the proportion of individuals engaged in specialized crafts or services, or selected for ceremonial or aesthetic augmentation, at various times across the use-life of this burial space and therefore also within prehistoric Maltese communities. Assuming the equitable funerary treatment afforded to members of the population across demographic categories within the Circle (Chapter 12), there is little reason to believe that dental modification in this population was restricted to any particular status group, or resulted in any form of social differentiation within the mortuary sphere. We do, however, require further study of this and other contemporary populations to understand better if any discernible patterns exist.

5.7.4. Aetiologies

As discussed in §5.2.1, above, it can be extremely difficult and, on occasion, impossible to distinguish between intentional and incidental dental modifications (Blakely & Beck 1984; Dembo *et al.* 1949; van der Reijden 2014, 9). Abrasion from processing fibres for textile production and/or basketry can result in incisal grooves that are difficult to differentiate from intentional notching (Burnett 2017, 251; Larsen 1995; Schulz 1977). Similarly, dental chipping can result from both masticatory, parafunctional and intentional modification activities (Burnett 2017, 251; Milner & Larsen 1991). It can also be extremely challenging to identify the difference between *antemortem* tooth loss caused by carious lesions, trauma and intentional avulsion and/or ablation (Burnett 2017, 251; Cook 1981; Hrdlička 1940; Merbs 1968; Milner 2017, 319). The findings of the current study for Neolithic Malta are not immune from these ambiguities. If we align with Reichart *et al.*'s (2008) analyses of Cameroonian populations to see chipping of the mesial corners of maxillary central incisors as a common form of intentional or 'active' modification, we will likely fall foul of those who agree with studies such as Haour and Pearson (2005), who argue that similarly modified teeth in Niger are attributed to parafunctional or 'passive' modification (Burnett 2017, 252). Others may contest that deep incisal notches are the clear signature of intentional alteration (Afsin *et al.* 2013), yet be met by opposition from those who view it as *postmortem* damage (Burnett 2017, 252; Dembo *et al.* 1949; van der Reijden 2014, 40). Further consideration must be devoted to these diverging opinions in order to determine the aetiologies of the modifications reported for the Circle dentition by this research.

We accept the likelihood that many of the modifications within the Circle population sample are 'passive', unintentional or parafunctional alterations to the teeth, associated with habitual cultural activities. Certainly, as emphasized by Burnett (2017, 255), intentional or active modifications are rarely observed to encompass the entire crown and are therefore unlikely to extend to the cementum enamel junction or traverse onto the tooth root, as described and illustrated for the categories of labial and lingual wear to both maxillary and mandibular anterior teeth in §5.5.1.3 and §5.5.1.4, above, and Figures 5.14a–j and 5.18a–e. Furthermore, most deliberate modifications manipulate the enamel and/or dentine only and will infrequently compromise the pulp chamber (Burnett 2017, 255; Tiesler 2001). We propose that some of the observations of chipping and incisal notches presented in §5.5.1.1 and §5.5.1.2, above, and Figures 5.6a–k and 5.10a–j are clearly activity-related change, as indeed are some of the modifications described as diagonal and undulating profile modifications in §5.5.1.5–6, above, and Figures 5.22a–i and 5.18f and g.

Although the nature of the modification itself is of critical importance, classification of passive dental augmentation may also be addressed via analyses of distribution. While agreeing that the anterior teeth are most commonly affected, Burnett (2017, 255) asserts that the distribution of parafunctional modifications are quite random, unilateral and irregular across the 'social six', and may present a lateralization bias towards handedness. It is in these considerations of lateralization that the biocultural narrative of modification within the Circle population begins to crystallize. The results here demonstrate wear patterns that are most frequent in the left first maxillary incisors, with decreasing frequencies from the right first maxillary incisor as one moves distally in the right maxillary arcade. As reported in Chapter 4, distributions of the major forms of activity-related dental pathology across the Circle sample align with this distribution, insofar as crown fractures and extreme wear all predominate on the right side. It is proposed that this pattern is associated with parafunctional wear. Chapter 7 reports findings of sample-wide trends towards right handedness. Their research echoes global patterns of right-handed predominance in anthropological studies of fossil hominins and anatomically modern humans, usually ranging between 70–80% of populations (Steele 2000, 307, 316–7; cf Constandse-Westermann & Newell 1989; Steele & Mays 1995; Stock *et al.* 2013; Macintosh *et al.* 2014a; Trinkaus *et al.* 1994; Walker & Leakey 1993). The remainder are characterized as left-handed and ambidextrous. The predominance of right-sided dental wear and the contralateral wear on the left maxillary first incisor is consistent with the use of the dentition as tools among right-handed individuals.

However, distributions of both adult and non-adult dental modification across the Circle population sample oppose the handedness trend, as the majority of modified teeth are observed on the left side of the mouth (§5.5, above, & Figs 5.2, 5.3 & 5.4); that said, this observation is not statistically significant (χ^2 = 2.2, p=0.14). Moreover, Burnett argues that maxillary dentition is more visible than the mandibular arcade and are therefore observed to be more frequently modified across cultures (Burnett 2017, 252; Romero Molina 1952; Tiesler 2001). The Circle data emphatically agree with this, with both adult and non-adult distributions significantly favouring the maxilla as the locale for this mode of cultural display (χ^2 = 29, p<0.0001 for the adult dentition).

Additionally, active modifications are most often observed as bilateral and will be present in both antimeres (Burnett 2017, 252). It is also argued that deliberate modifications are symmetrical in both type (for example: notching, chipping) and appearance (for example: single, double; Burnett 2017, 255; cf Alt & Pichler 1998, 399; Langsjoen 1998). The depositional context of our sample prevents us from studying –and therefore presenting– many complete and intact dental arcades. We have nonetheless put forward some compelling case studies in §5.6, above, and also argue throughout this chapter for the alignment of some of the distinctive shape changes observed amongst the Circle population sample with several of van der Reijden's (2014) intentional modification classifications.

Rather than determining that *either* intentional *or* incidental dental modification took place amongst the Neolithic communities represented within the Circle, we propose that both are noted within the population.

5.7.5. Cross-cultural insights

The identification of dental modification types in archaeological assemblages are often used as proxies for connections between groups and/or cultures (De Groote & Humphrey 2017, 22; van der Reijden 2014; van Rippen 1918a), and to infer migration patterns (De Groote & Humphrey 2017, 19, 23; Hedman *et al.* 2017, 241–2; Irish 2017, 35, 44; Kusaka 2017, 150; Kusaka *et al.* 2008, 2009, 2011; Lee 2017, 99; Milner 2017, 325; Morita *et al.* 2012; van Reenen 1977, 1978a, 1978b, 1986). In §5.6, above, we presented scenarios in which the potential intentional modifications observed on an adult female and male indicate either that these individuals experienced dental interventions in Malta itself, or that they travelled to Malta having had the alterations carried out elsewhere. Such modifications are relatively rare in European and more common in African populations; however, the modification is not diagnostic alone and its presence could represent either migration or cultural influence from Central or Southern Italy, or Africa. Often the appearance of similar types of modification can be enigmatic and inexplicable, and this can be because of purposeful or accidental variations from traditional practices, individual choices and decisions, serendipity, and the innumerable possibilities for pattern combinations (Gould *et al.* 1984; Larsen 2017, xvi; van Reenen 1986). Appearances of specific modification types in various geographical settings may also be unrelated (Larsen 2017, xvi). Further to this, one must account for errors of interpretation, translation and identification between and amongst classification systems and researchers (van der Reijden 2014, 10); a consideration from which the present study is certainly not immune, despite our most stringent efforts. However, perhaps the most significant issue to contend with is that of the geographical bias inherent within the classification systems themselves. Most diagnostic hypotheses/taxonomies have been developed on modified teeth from the Americas, so they are therefore not exhaustive in terms of type, mode or expression and are generally far younger in appearance than our prehistoric context. They are nonetheless helpful in informing our evaluation of dental modification in Malta, and likewise our observations for the predominantly under-studied prehistoric Central Mediterranean region will inform global understanding of this enigmatic aspect of human behaviour.

As presented above, this study has identified dental modifications within the Circle population that resemble van der Reijden's (2014) A6.4, A8.1, B1.1, B1.3, B1.4, B2.3, B4.3, B4.4, C2.3 and N1.2 types, and may even present new forms. In terms of cultural attestations, several of these types have only previously been reported for individuals and groups from the Americas, including A8.1 ('notch' type – van der Reijden 2014, 47; after Autry 1991; Boman 1908; Gill 1985; Perino 1967; Romero 1986; Spence & Pereira 2007 Weinburger 1948; Whittlesey 1935); B4.3 ('right-angled cut-out' – van der Reijden 2014, 49; after Coe 1959; Weinburger 1948); C2.3 ('concave side edges with flattened occlusal end' type – van der Reijden 2014, 51; after Rojas *et al.* 2011); and N1.2 ('reduction in crown height' type – van der Reijden 2014, 68; after Montandon 1934; Rojas *et al.* 2011; Romero 1986; Rubín de la Borbolla 1940; Smith 1972). Other forms observed within the Circle population have further attestations across the Americas, but have also been observed on the African continent, including B1.1 ('single corner, straight edge' type – van der Reijden 2014, 48; after Romero 1986; Starr 1909; von Jhering 1882); and B4.4 ('right-angled cut-out' – van der Reijden 2014, 49; after Campbell 1944; Lignitz 1919; Novotny 2008; Starr 1909; van Reenen 1978a; van Rippen 1917). Finally, the remaining intentional modification forms observed within the Circle assemblage have direct parallels restricted to the African continent, including B1.3 ('single corner, straight edge' type – van der Reijden 2014, 48; after van Reenen 1978a); B1.4; ('single corner, straight edge' type – van der Reijden 2014, 48; after Starr 1909); and B2.3 ('concave edge, reduced crown height' type – van der Reijden 2014, 49; after Starr 1909). The only modification form within the Circle sample without cultural attribution in van der Reijden's classification was A6.4 ('one notch reaching to corners' type – van der Reijden 2014, 47), however this form is well-known throughout the literature as the 'swallow-tail' type, and has also been attributed to the African continent (Irish 2017, 36).

Considering both the temporal and geographical context of the Circle use life, the similarities with African dental modification forms is certainly worthy of further consideration because of its relative proximity and contemporaneity for the beginnings of intentional modification (Finucane *et al.* 2008). More research is required to determine Malta's position within this biocultural dynamic. Genetic data (Chapter 11) suggest the immediate ancestors of the majority of the individuals studied had similar origins, descended from a broadly 'Neolithic' group of people. These analyses attest to potential genetic influences on the relationships between the people of the Circle and mid-Holocene agricultural and hunter-gatherer populations from the Northern Mediterranean and Europe. At this stage the aDNA analyses are principally derived from three individuals and as such, provide information on only a subset of the people interred in the Circle. Despite the relatively small sample size, the genetic analyses reveal relative homogeneity. In contrast, the non-metric traits of the dentition (Chapter 6) were analysed for a larger subset of the assemblage, with comparative samples derived from the entire circum-Mediterranean region, including North Africa. Analyses of non-metric traits of the posterior dentition revealed similarities throughout the region, and to populations in Southern Europe and North Africa. Whilst it is premature to interpret these as definitive indicators of genetic distance, without further analyses of the anterior dentition, they are suggestive of broader genetic links between the populations of Neolithic Malta and others to both the North and South. When the results of dental modification are interpreted in this context, cultural or biological influences from Africa are certainly plausible and may explain the presence of patterns of dental wear in the Circle assemblage that would be considered rare or unknown in Europe.

Strontium isotope data (Chapter 9) tentatively speak to the limited degree of mobility over the life of the individuals we have studied, all of whom ranged within the limestone areas of Malta and/or southern Sicily. Thus, the dental modification evidence potentially opens a new bioarchaeological perspective on biological and/or cultural connectivity beyond Malta's shores that is not possible from as-yet limited isotopic or genomic perspectives. Such biocultural hints of outside influence in prehistoric Malta are also suggested by the material culture of the Temple Period, which saw raw materials such as obsidian circulated throughout the Central Mediterranean and several traits in pottery style and decoration shared across the region (Volume 2, Chapter 10).

A possible single case for dental avulsion amongst the sample is presented in §5.6.1, above, and it is intended that future analyses of the hard tissues of the jaws will explore the extent to which this may or may not have been an isolated case. Although the differential diagnosis for this young adult female is complex, extraction and/or avulsion must be considered as potential interventions. It is appropriate to propose that she may have been involved in the activities described by Robb (1997) for Neolithic Central and Southern Italy. As discussed in §5.2.3, above, he estimated that between 25–50% of Neolithic women from this region would have undergone selective and intentional removal of the maxillary incisors and/or canines for symbolic or ceremonial reasons. This young woman prompts us to consider the possibility that she may have lived in Italy and been subject to these cultural practices before coming to live –and ultimately die– at a young age in Malta. Alternatively, she may have been subject to these practices in Malta, presenting evidence for the movement of cultural ideas and practices as well as material culture into the archipelago (Evans 1971, 223; Malone *et al.* 2009a, 238, 242; Robb & Farr 2005; Malone & Stoddart 2004; Trump 2002; Vella 2009; cf Volume 2, Chapters 10 & 12). Of particular relevance to this discussion is the appearance of 'Thermi' pottery in Malta in the 25th century BC, which occurred around the time or not long after the burial of the young woman discussed above (Volume 2, Chapters 2 & 10). Was she a personal agent of this cultural change? To answer these questions, we may follow the methodologies established in research involving more recent populations of enslaved peoples in the New World. Here, dental modification analyses have been aided by targeted isotopic studies to determine whether the modifications were performed in individuals' country of origin or in the diaspora (Corrucini *et al.* 1987; Goodman *et al.* 2009; Price *et al.* 2006, 2012; Schroeder *et al.* 2009; 2014; cf Hedman *et al.* 2017; Kusaka 2017; Pietrusewsky *et al.* 2017, 128). Considering the role that modification plays in understanding migration patterns (Irish 2017, 44; cf Handler 1994; Handler *et al.* 1982; Ortner 1966; van Reenen 1977, 1978a, 1978b, 1985, 1986), alongside the work presented in Chapters 6, 9 and 10, further archaeometric analyses incorporating the biochemical, biomolecular and morphological characteristics of the dentition may refine insights regarding the origins and connections of dental modification practices amongst the Circle population.

In addition to further scientific analyses, extended research into the attestations of the intentional shape modifications may also shed light on the scope of cross-cultural connections at play in Neolithic Malta. Following the painstaking work of van der Reijden (2014) and many of her predecessors across continents (Almeida 1953, 1957; Fastlicht 1948; Romero 1986; Rubín de la Borbolla 1940; Saville 1913; Starr 1909; von Jhering 1882; Wasterlain *et al.* 2016), we have illustrated above that Malta needs to be considered within a dynamic web of biocultural innovation and expression – and perhaps even be located towards its centre.

5.7.6. Chronological insights

Humans have been modifying their teeth for millennia. To determine where the Circle populations sit in terms of regional and global chronological representations of modification, the most relevant issues for consideration are: i) whether the modifications were undertaken for therapeutic or non-therapeutic purposes; ii) whether avulsion or ablation was practised; and iii) whether the reported modifications were intentional or incidental. These issues are discussed in more detail, below.

Early evidence for therapeutic intervention appears to date back to at least the Neolithic (Coppa *et al.* 2006), with some claims extending as far as the Late Upper Palaeolithic (Oxilia *et al.* 2015; cf. Bennike & Fredebo 1986; Ortiz *et al.* 2016; Seidel *et al.* 2005; Turner 2004; White *et al.* 1997). In terms of the representation of therapeutic dental intervention amongst the Circle study sample, a prospective case is presented in Chapter 4. Here, a fragment of adult left mandible from Context (897), radiocarbon dated to 2575–2500 cal. BC, features a sharp-force trauma lesion to the buccal aspect of the mesial root of the first left mandibular permanent molar (FDI 36). It is argued that this observation indicates that this individual was subject to a proto-surgical procedure to relieve probable symptoms of pain and pressure resulting from the infectious and inflammatory response observed in the alveolus surrounding both mesial and distal roots, associated with a massive carious lesion on the crown. Although this case does not directly augment the crown *per se*, it is nonetheless an example of therapeutic intervention on a pathological tooth, and should thus be included amongst the small global corpus of prehistoric dental proto-surgery (Langsjoen 1998, 411; Leigh 1937, 294).

As discussed in §5.2.3, above, avulsion and ablation extend even deeper into human prehistory, with the earliest known examples attributed to the middle Iberomaurusian (~13,800–16,100 cal. BP) on an isolated skull from Taza, Morrocco (Meier *et al.* 2003). The practice is widespread at Maghrebian sites thereafter and continues through to the Neolithic (De Groote & Humphrey 2016, 2017; Humphrey & Bocaege 2008), including the Mediterranean region according to Robb's (1997) reporting of the practice as carried out on women in Central and Southern Italy (*c.* 6500–3200 BC). A possible single case for avulsion amongst the Circle sample analysed thus far is presented in §5.6.1, above, and further research is required to determine the nature and scope of the practice within this population. This is the first potential case of avulsion presented for prehistoric Malta; however, an enigmatic link in early literature proposes a connection between the 'Neolithic Maltese' (Keith 1932, 284) and the peoples of North Africa and the Fertile Crescent, who are also reported to have engaged in this practice. Considering that this individual was excavated from Context (960) (2530–2475 cal. BC, Malone *et al.* 2019), during one of the later use-phases of the Circle, it seems that avulsion was being carried out in Malta towards the end of the Temple Period in the 26th and 25th centuries BC (Chapter 3), or that individuals already bearing this type of modification were travelling to Gozo at this time. Either way, this case extends our knowledge of this practice into the 3rd millennium.

When considering the chronology of both incidental and intentional modification amongst the study sample, we argue that both were part of the cultural and lived experiences of the prehistoric communities of the Xagħra plateau. Evidence presented throughout this chapter, and Chapter 4 of this volume, indicates that parafunctional wear was observed amongst the earliest use-phases of the Circle. This research has qualified and quantified the initial observations made by Stoddart *et al.* (2009a) that 'parafunctional', 'distinctive' or 'habitual' wear was present for individuals interred from the Żebbuġ period onwards (Stoddart *et al.* 2009a, 318, 319, 323, 324, 325, 329). As presented in detail over the preceding pages, these forms of non-alimentary wear included some forms of chipping, incisal notches, lingual and labial extreme wear, and diagonal and undulating profile changes associated with a range of habitual practices most likely associated with food processing (for example, cracking, breaking or stripping hard foods); and/or processing materials other than food in association with cultural practices commencing from the earliest contexts included within this study.

The earliest known intentional non-therapeutic shape changes appear to be more recent than the practices of avulsion and ablation. As described in §5.2.3, above, examples come from across the globe, including observations from an adult male burial dating between 2570 BC and 2332 BC in Michoacán, Mexico (Kirk 2006). It is reported that the man's maxillary teeth were intentionally filed down to insert a ceremonial prosthesis, most likely of animal origin, such as the palate of a wolf or jaguar. In Africa, early examples are attributed to Karkarichinkat Nord in Mali in the 3rd millennium BC, where four individuals of unknown sex had their maxillary incisors and canines intentionally shaped to points, probably through filing (Finucane *et al.* 2008). Situated within both regional and global contexts, some of the findings reported here for the Circle population are of great significance, as they may represent amongst the earliest incidences of intentional non-therapeutic dental modification in the world. As reported above, and presented in Figures 5.6a–k, 5.10a–j and 5.22a–i, the Neolithic people of Gozo deposited within the earliest use-phases of the Circle had deliberately modified anterior dentition, featuring shapes that resemble van der Reijden's (2014) A6.4, A8.1, B1.1, B1.3, B1.4, B2.3, B4.3, B4.4, C2.3 and N1.2 types, and may even present new forms. As described in §5.5.1.5, the diagonal modifications observed in the study sample align with van der Reijden's 'B' Types, where the modification distinctly affects one edge (2014, Table 4.5; B1.1, B1.3, B1.4); however, for some of the Circle examples, the filed edge extends across the entire incisal margin; and in some case the crown height is reduced by more than half.

As discussed in greater detail in Chapter 4 of this volume, the prevalence of dental modification presents an interesting comparison with dental pathologies. Rates of dental modification steadily increased throughout the use-life of the Circle, commencing at 2% around 2700 BC, and maintaining a plateau at approximately 8% after 2450 BC (Fig. 5.32). It is apparent that dental modification increased over time, and, of all other pathologies (including enamel hypoplasia, caries, crown fractures, extreme wear and hypercementosis) bears closest (albeit loose) relationship to the prevalence of enamel hypoplasia within the sample. This is an important point of consideration because of the tendency of enamel hypoplasia to serve as a proxy for more endogenous biological stress indicators

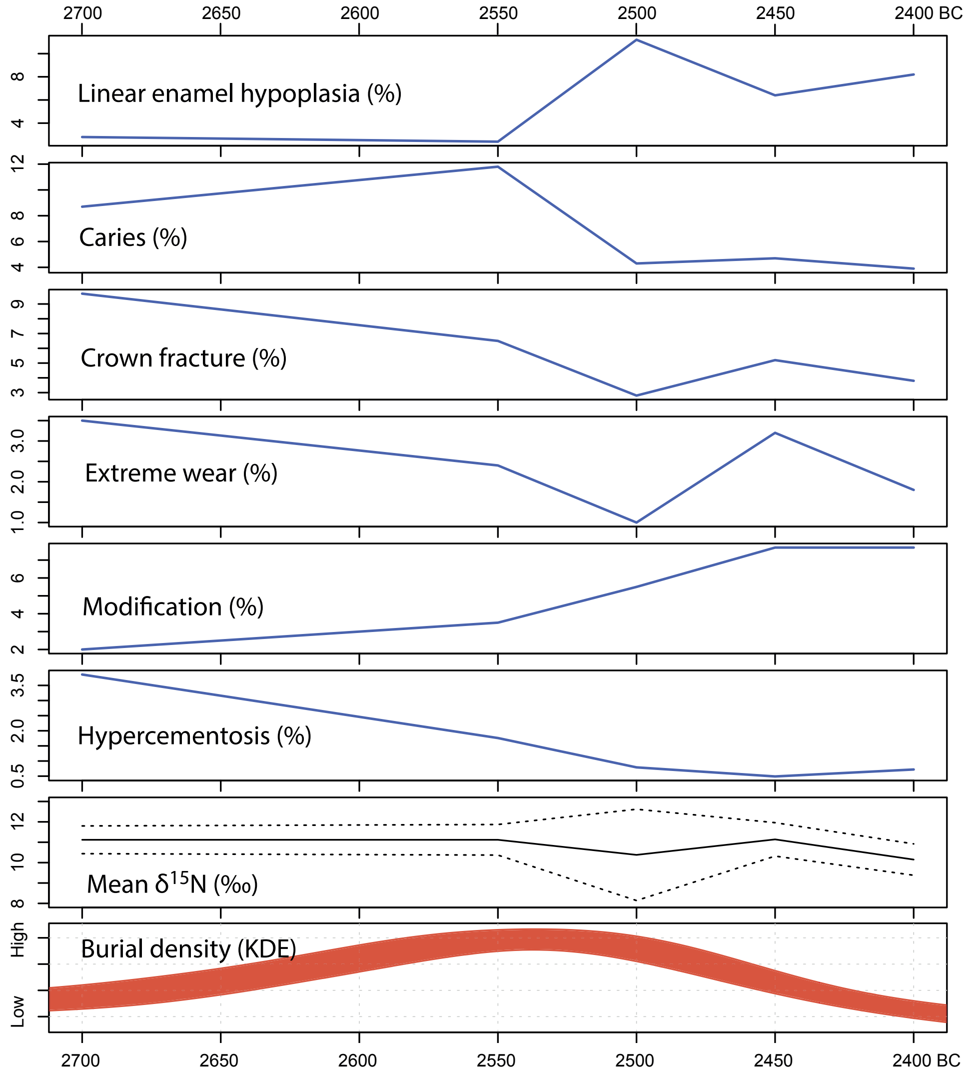

Figure 5.32. *Schematic chronological representation of dental modification incidence within the Circle sample, plotted alongside various dental pathologies, average nitrogen isotope values and burial density from ~2700-2400* BC. *(Rowan McLaughlin).*

(Goodman 1991; Goodman & Capasso 1992; Goodman & Rose 1990, 1991; Ortner 2003; Pindborg 1970; Roberts & Manchester 2005). As discussed in Chapter 4, enamel hypoplasia has a very low sample prevalence rate during the Earliest-to-Middle use-phases of the Circle (approximately 2% until 2550 BC). From this point, a steep increase in enamel hypoplasia is observed, eventually occurring in one in ten of the teeth found within each stratigraphic context. In effect, the prevailing biological stressors during this period resulted in a very significant increase in the number of observations for this pathology. Crucially, this is the moment of maximum activity at the site, when other dental pathologies were reduced in frequency. Subsequently, there was a slight oscillation in the number of cases of enamel hypoplasia, but the average rates were nonetheless still much higher than earlier in the Circle's history.

Of all the recorded dental phenomena, dental modification was unique in remaining at peak incidence rates from around 2500 BC until the end of the Circle's use-life at approximately 2350 BC. All modification types recorded by this study, with the exception of lingual wear and undulating profiles, were observed to increase in incidence across the use-life of the Circle. The peak of incidence in the Late use-phase is particularly noticeable after very low rates recorded for the Middle use-phase for all modification types. Thus, a correlation exists between increased dental modification and indicators of the prevailing biological and cultural stressors present, especially enamel hypoplasia. Biological stress was therefore present during the circumstances that led to the end of the Temple Period in Neolithic Gozo. Whatever the causes of this stress, it is clear that at this time some of the adults and children within these communities were increasingly engaging in food or material culture production requiring parafunctional use of the mouth; in cultural activities designed to create intentional permanent corporeal identity markers; or in travel that brought them to Malta from elsewhere, already bearing these modifications.

5.8. Conclusion

The present study represents the first dedicated enquiry into the nature and scope of dental modification in any skeletal population from the Maltese archipelago. Observations of modified teeth were first reported in the Circle population by Stoddart *et al.* (2009a). The current research has met recommendations for further investigations into this intriguing aspect of human corporeal intervention for prehistoric Malta, and it introduces the experiences of those living in Neolithic Gozo into the wider discourse of dental modification across the Mediterranean and the world. Notwithstanding the numerous and important insights summarized below, as a first foray into the field we anticipate that this work will serve as a genuine introduction, and that subsequent analyses can build on our foundation to clarify and extend these primary engagements.

Overall, our reporting of the relatively low incidence and proportion of modification amongst the Circle study sample accords with studies elsewhere. These findings suggest that at any given time, only a relatively small number of people were participating in specific tasks or a range of tasks and/or rituals that modified their anterior teeth. These observations provide insights into the proportion of individuals engaged in particular specialized crafts or services, or those selected for ceremonial or aesthetic augmentation within prehistoric Maltese communities.

This research has also made important discoveries concerning *who* was undertaking these activities, or perhaps even selected for participation. In Neolithic Gozo, both adults *and* children were engaged in the range of cultural practices that produced these corporeal interventions: either the immediate and most likely ritual and/or aesthetic interventions of intentional dental modification, or the gradual and repetitive behavioural interventions of incidental practices. Adult teeth were most often observed to be modified, but deciduous teeth are present in the dataset, with examples reported for every modification type except labial and lingual extreme wear. Observations of either intentional or incidental modification or extreme wear on deciduous teeth are very rare in archaeological populations, so this represents an important finding. This research calls us to reconsider existing archaeological narratives of prehistoric Mediterranean communities and view children as key participants and contributors in ancient knowledge transfer and socio-economic frameworks.

Biocultural approaches to intentional corporeal modifications engage the body as a translator of lived experiences and actions. Our research provides tangible evidence for tactile activities, the material components of many of which are as-yet elusive in the prehistoric Maltese archaeological record as a result of the tyranny of preservation. We have described features which may be associated with food processing (for example, cracking, breaking and/or chewing hard foods); and/or processing materials other than food in association with cultural practices such as clenching fibres between the teeth while weaving mats, ropes, nets and baskets; processing animal skins; holding objects in the mouth while making baskets or nets; processing materials including lithics, plant fibres, bone, shell and animal sinews; and using the mouth as a 'third hand' to hold material between the teeth.

This research extends the findings offered in Chapter 4, by shedding light on corporeal engagement and the effects of aspects of Maltese Neolithic behaviours on the body. Amongst other results, we report consistent evidence for fibre processing in the form of incisal notches on deciduous and permanent dentition. No organic materials have yet been found preserved in late Neolithic contexts on the Maltese archipelago, yet scrutiny of the figurative and burial records provides some tantalizing glimpses into textile production techniques and uses. The most well-known figurines from the islands, the 'Sleeping Lady' from the Ħal Saflieni Hypogeum, and the seated paired figurine from the Circle, both appear to be resting upon a 'bed' comprising a frame of wooden struts overlain with straw and/or reed bundles (Malone *et al.* 2009a, 289–98). Other similar styles of figurines are known from Tarxien and Ħaġar Qim, although they depict these 'beds' less clearly (Malone *et al.* 2009a, 296–8). It is inferred that the straw and/or reed bundles, as well as the struts and bearers forming the base of the frame, were tied with cordage (Malone *et al.* 2009a, 293). These exceptional figurines might provide a rare depiction of a relatively routine furnishing, one core component of which was created through repeatedly passing fibres through and between the teeth and hands, resulting in permanent and visible wear to the anterior dentition. Further insights might be gleaned through careful analysis of depositional practices within the Circle itself. The unique cache of nine figurines referred to as the 'Shaman's Cache' was carefully placed together in a tightly grouped package, alongside a small Tarxien ochre offering pot (Malone *et al.* 2009a, 298). Such a close spatial relationship strongly suggested that they were placed within a box, bag or other organic wrapping material. If the latter, it might have been woven from small fibres, although no trace remains. Finally, it remains possible that some of the dead were interred in the Circle covered or shrouded in textiles of some kind, which, upon disintegration, allowed the remains to be accessed later and redistributed throughout the cave system. Indeed, Stoddart and Malone (2010, 24) and more recently Thompson *et al.* (2018) have suggested that some individuals were deposited in the Circle and the Xemxija tombs covered in animal hides that may still have retained head and hoof elements, providing a precedent for a packaged and wrapped form of engagement with the dead.

We have described both active and passive dental modification types that are commonly reported across prehistoric cultures, including chipping (or chiselling), incisal notches, labial and lingual wear, diagonal and undulating profile modifications and gross crown loss, while also presenting some potentially novel augmentation types, too, including diagonal incisal profile modification. We have also presented an intriguing case study of a young woman with complex presentation of her anterior teeth, for which extraction and/or avulsion must be considered amongst other potential interventions. Based on our analyses of the nature, forms and distributions of the modification types observed within the study sample, we have argued that *both* intentional and incidental dental modification took place amongst the Neolithic communities of the Xagħra plateau. Some of the findings reported here for this population are of great significance, as they may represent amongst the earliest incidences of intentional non-therapeutic dental modification in the world. Moreover, in terms of cultural connections, our findings may contribute to consolidating Neolithic Malta's important position within wide mobility networks of people and ideas across broader Mediterranean, African and European cultural contexts.

In terms of chronological distribution, we have reported that the Late contexts feature the highest incidences of dental modification by a substantial proportion. The Late use phase of the Circle featured >80% of all dental modifications observed within the study sample; more than six times the number of observations for the Early use phase and 23 times the number of observations for the Middle use phase. With the exception of lingual wear and undulating profiles, all modification types were observed to increase in incidence across the use-life of the Circle. The peak of incidence in the Late use-phase is particularly noticeable after very low rates recorded for all modification types in the Middle use-phase. When paired with observations of the loose relationship between prevalence rates of dental modification and enamel hypoplasia, this suggests that a correlation may exist between increased dental modification and the prevailing biological and cultural stressors present during the circumstances leading to the end of the Temple Period in Neolithic Gozo.

Our research has only 'scratched the surface' of the possibilities for dental modification analyses in Neolithic Malta. There is a great deal more work to be done, particularly in the pursuit of additional archaeometric multiproxy analyses. Opportunities for further study include (but are not limited to): deeper discussion of the precise location, surface and size of modification locations on individual teeth to understand modification phenomena of the Circle at an even greater resolution; associations of infectious or inflammatory processes on the maxillary and/or mandibular alveolar processes wherever affected teeth are retained *in situ* to determine if relationships exist between dental modification and pathology for this population; studies of extant dental calculus to determine if microscopic fragments of processed fibres or other materials (stone chips, *etc.*) retained in the mouth can shed further light on inferences about tasks involving the teeth (Sperduti *et al.* 2018); scanning electron microscopy of affected tooth surfaces to complement and extend our efforts to distinguish between intentional and incidental modifications (van der Reijden 2014, 19; Farrell 2013; Havill *et al.* 1997); and aDNA analyses to assist in attempts to determine if there are any associations between dental modification, biological sex distribution and geographical affinities.

This work contributes important Neolithic Maltese evidence to the global quest to examine how the body can help us understand fundamental questions about human cultures, including the structure and composition of communities, connections between groups, the production of goods and services, the nature and persistence of traditions and the movement of people and ideas across space and time (Milner 2017, 317, 327). Despite the significant challenges presented by the nature of the Circle assemblage, our contextualized study of dental modification has allowed us to approach ancient people from both biological and cultural perspectives (Larsen 2017, xvii). In this way, our research presents a truly rare opportunity to view corporeal expressions of action, agency and meaning in the prehistoric Maltese archaeological record.

Note

1. These analyses were carried out in two tranches with the approval of Heritage Malta and the Superintendence of Cultural Heritage, Malta, the first in July 2015 and the second in July 2017. Transport was carried out by Bernardette Mercieca-Spiteri, Officer of the Superintendence of Cultural Heritage, Malta, with the agreement of Heritage Malta. On both occasions, radiographic analyses (micro-CT scans) were carried out by Jay Stock, Laura T. Buck and Jaap Saers at the Cambridge Biotomography Centre, University of Cambridge, UK, with a Nikon Metrology XT H 225 ST. Scans were created with voxel sizes ranging from 0.06 to 0.12μm3 (to two decimal places) as appropriate for the region of interest and specimen size. Further processing of individual files was carried out by Jaap Saers in the Department of Biological Anthropology, University of Cambridge, UK. Radiological examination and description of the micro-CT scans was carried out by John Magnussen, Ronika K. Power and Jess E. Thompson, using 3D Slicer (BWH, slicer.org), RaDiant DICOM Viewer (Medixant, radiantviewer.com) and AW Server (GE Medical Systems, Milwaukee, USA) software at Macquarie Medical Imaging, Macquarie University Hospital, Sydney, Australia. Radiological images were processed for publication by John Magnussen and Margery Pardey at Macquarie Medical Imaging.