Title: Characterizing Evulsion in the Later Stone Age Maghreb: Chronology and Significance

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Introduction

The expression of dental modification varies throughout the world and includes filing of teeth into predetermined shapes, colouring of teeth and applying precious stone inlays, as well as the intentional removal of whole teeth, referred to as ablation, avulsion or evulsion (Cook 1981, Hrdlička 1944). Intentional dental modification represents a strong and enduring visible representation of group affiliation and can contribute substantially to an individual's sense of identity (Willis, Harris, and Hergenrader 2008, Agbor, Naidoo, and Mbia 2011, Bocquentin 2011, Bonfiglioli et al. 2004b, Durband, Littleton, and Walshe 2014). Ethnographers have reported examples of dental modification in communities from around the world, and this practice continues into recent times (Bolhofner 2014, Cook 1981, Kangxin and Nakahashi 1996, Kusaka et al. 2011, Tayles 1996). Numerous studies have looked into associations between the type, extent and frequency of dental modifications seen in both the ethnographic and archaeological record (Bocquentin 2011, Briggs 1955, Humphrey and Bocaege 2008, Stojanowski, Carver, and Miller 2014). Tooth evulsion is the earliest form of dental modification known in the archaeological record (Humphrey and Bocaege 2008). Tooth evulsion is the deliberate removal of teeth from the mouth and does not include extraction of teeth associated with the treatment of oral health problems, such as caries or abscesses. A number of factors (including dental disease, age-related or traumatic loss [accidental or violent]) can lead to absence of a tooth and need to be excluded before tooth evulsion is inferred (Cook 1981, Hrdlička 1944, Lukacs and Hemphill 1990, Lukacs 2007, Merbs 1968, Tayles 1996, Russell et al. 2013). Under most circumstances dental disease is unlikely to result in the loss of anterior teeth since anterior teeth, and incisors in particular, are not commonly involved (Hillson 1996). Isolated examples of ante-mortem tooth loss may represent accidental tooth loss, for example a tooth knocked out during a fall or a fight, rather than tooth evulsion. However, when numerous individuals in a site or region show similar patterns of ante-mortem tooth loss, the cause is more likely to be evulsion (Merbs 1968, Tayles 1996).

Here we will focus on the practice of tooth evulsion in the Maghreb (Northwest Africa). Archaeological investigations in this region, encompassing modern day Morocco, Algeria and Tunisia, commenced in the late 19th century, and almost immediately archaeologists started to report on the absence of anterior teeth in many human remains excavated from Neolithic and earlier contexts (Bertholon 1912, Debruge 1914). Issues of interest include the geographical and chronological distribution of the tooth evulsion, differences in the patterning and extent of the practice within communities, the age at which the intervention occurred and how it was conducted, and most intriguingly, but also least accessible, the motives underlying this custom.

Geographical and chronological distribution

The geographical and chronological distribution of tooth evulsion has implications for understanding the cultural transmission of this practice, and has been studied in a number of regions (Bonfiglioli et al. 2004a, Finucane, Manning, and Touré 2008, Hadjouis 2002, Humphrey and Bocaege 2008, Kangxin and Nakahashi 1996, Mower 1999, Pietrusewsky and Douglas 1993, Stojanowski, Carver, and Miller 2014, Tayles 1996). Humphrey and Bocaege (2008) reported changing patterns from the Later Stone Age (Iberomaurusian) through to the Neolithic in the Maghreb. A recent paper by Stojanowski (2014) looked more broadly at the chronological and geographical distribution of evulsion across North Africa. His analyses suggested that Gobero, southern Sahara, was likely settled by migrants from the Maghreb who introduced tooth evulsion into the Southern Sahara region. Influx of other populations over time resulted in an increase in complexity of the behaviour and resulted in different patterns being observed in different groups (Stojanowski, Carver, and Miller 2014).

Here, we present an updated summary of the chronological and geographical distribution of tooth evulsion in the Maghreb from the Later Stone Age (Iberomaurusian) through the Capsian and into the Neolithic (Figure 1). We include only those individuals where burials were clearly linked to a specific cultural horizon or where the human skeleton or associated objects have been directly dated, and where it the original publications mention specifically whether or not evulsion was present.

The Iberomaurusian starts around 22,000 years ago (Bouzouggar et al. 2008) and spans the whole of the Maghreb region, with many of the documented sites located near the Mediterranean and Atlantic coasts. The Iberomaurusian tool industry is characterised by *pieces esquillées* and a bladelet production using the microburin technique (Barton, Bouzouggar, Bronk-Ramsey, et al. 2005, Bouzouggar et al. 2008). At the site of Grotte des Pigeons, Taforalt, Morocco, the Aterian is the industry underlying the Iberomaurusian deposits, but, until now, no clear evidence for continuity from the Aterian to the Iberomaurusian has been found (Debénath 1992, Barton, Bouzouggar, and Stringer 2001, Barton, Bouzouggar, Collcutt, et al. 2005, Bouzouggar et al. 2008, Barton et al. 2013). Instead, the Iberomaurusian may have arisen through population movement into the area by about 22,000 years ago (Ferembach 1985, Barton et al. 2013, Irish 2000). The oldest evidence for tooth evulsion comes from an isolated skull from Taza, Morocco, and dates to the middle Iberomaurusian (between 13.800 +/-130B.P. and 16.100 +/- 1400 B.P. (Meier et al. 2003). Although this evidence is restricted to a single individual, the almost universal presence of evulsion at Iberomaurusian sites (Figure 1: top), suggests this was a deliberate intervention rather than an accidental occurrence. Some sites, such as Taforalt and Afalou are large Iberomaurusian cemeteries and more than 94% of

individuals in these sites underwent evulsion of the upper central incisors (see below for more detail).

The Capsian industry is found primarily in what is now Algeria and Tunisia and dates back to between 9,500 calBC and 5,000 calBC (Camps 1975, Jackes, Meiklejohn, and Bocquet-Appel 2008, Linstädter 2008, Lubell 1984). It has not been found as far west in what is at the present time Morocco. Although it was an industry that was considered to be introduced into the region (Balout 1955, Camps 1974), the idea that it developed out of the Iberomaurusian is now increasingly supported (Lubell, Sheppard, and Jackes 1984, Nehren 1992, Linstädter 2008). Backed bladelets still are an important component of the industry along with endscrapers on blades or flakes, and microliths produced from light bladelets (Camps 1974, Rahmani 2004). Two regional variants are recognised: the Typical Capsian and the Upper Capsian. The Typical Capsian is restricted to Tunisia and Eastern Algeria and the Upper Capsian is found throughout the region, including Central Algeria (Rahmani 2004). Many of the sites are open-air sites with a frequent presence of land molluscs, giving the sites the name "escargotieres". During the Capsian the practice of tooth evulsion became less prevalent but more extreme frequently included the mandibular as well as the maxillary incisors (Figure 1: middle). The practice became remained more prevalent among women than among men (Humphrey and Bocaege 2008, De Groote and Humphrey in press).

The Mediterranean Neolithic developed in coastal regions of the western Maghreb from around 5.8 cal BP (Linstädter 2008, 2011) and may be linked to the emergence of the Neolithic in Southern Iberia (Cortés Sánchez et al. 2012). The earliest well-dated evidence for the presence of a full Neolithic economy, including Cardium impressed pottery as well as domesticated animals and plants in the Maghreb occurs at around 5,300 years BC at Ifri Oudadane in Morocco (Linstädter 2008, 2011). In Capsian regions the transition to the Neolithic was delayed by several millennia and may initially have involved a reduction in the distances travelled during seasonal movements during a period known as the Neolithic of the Capsian Tradition (Lubell, Sheppard, and Jackes 1984). The transformation of the Capsian into the Neolithic of Capsian Tradition was influenced by the Mediterranean Neolithic to the North West and the Saharan Sudanese Neolithic to the south (Linstädter 2008, Cortés Sánchez et al. 2012). Although cranial gracilisation suggests the introduction of more gracile morphotype with the onset of the Neolithic (Briggs 1955, Ferembach 1985), evidence for regional population continuity in dental morphology (Irish 2000) suggests the introduction of the Neolithic may have involved the adoption of Neolithic innovations by existing populations rather than a massive influx of new people. The gradual adoption of innovations as required or desired by local groups is consistent with the early appearance of pottery at sites such as Hassi Ouengua in Morocco with a hunter-gatherer economy (Linstädter 2011).

Tooth evulsion occurred less commonly at Neolithic sites than in sites from earlier periods (Figure 1 bottom), and at sites where the practice was recorded, the frequency of affected individuals was lower. Previous reports suggest that the practice was equally common among Neolithic males and females, but there are too few well contextualised examples to demonstrate this conclusively (Humphrey and Bocaege 2008). The decline in prevalence of tooth evulsion after the Iberomaurusian suggests that the cause underying the emergence of the custom became less important with time and disappeared almost completely by the Neolithic. The cluster of Neolithic sites with cases of evulsion in the Oran region of Algeria (Figure 1: bottom) suggests that in some regions evulsion remained common whereas in others it was no longer present. This would suggest a more regional approach to evulsion by the Neolithic: an identification one came from the area, belonged to a specific tribe or had a similar role within the society.

With the re-dating of the two large Iberomaurusian assemblages from Afalou (dating back to 13,120 CalBP) (Hachi 2006, Humphrey et al. 2012) and Taforalt (ca. 15,000 to 12700 CalBP) (Barton et al. 2013, Humphrey et al. 2014) it has become apparent that evulsion was widespread amongst these hunter-gatherers of Northwest Africa by at least 15,000 years ago. The practice spread to the Sahara region by the early Holocene (9500 cal BP) (Sereno et al. 2008, Stojanowski, Carver, and Miller 2014). In other areas of the world the oldest evidence for common evulsion comes from the Late Natufian (13-11600 CalBP) (Belfer-Cohen, Ashkenazy, and Grosman 2005) in the Levant where evulsion was recorded in a number of individuals from Nahal Oren, Ain Mallaha, El Wad, Kebara and Shukbah (Bocquentin 2008, 2011, De Groote et al. 2014, Eshed, Gopher, and Hershkovitz 2006).

Variation within communitities

The relationship between the presence, type and extent of dental evulsion seen in the archaeological record, and social differentiation has been the subject of a number of papers ((Alt and Pichler 1998, Domett et al. 2013, Tayles, Domett, and Nelsen 2000, Durband, Littleton, and Walshe 2014, Mower 1999, Pietrusewsky and Douglas 1993, Williams and White 2006). Among the Jomon of Yoshigo, Japan (3500-2300BP) different frequencies of evulsion were recorded among males and females. Some males had all canines removed, whereas some males and females had only the two maxillary canines removed as well as all four incisors. Stable isotopic signatures were found to vary with evulsion type. Those males with all canines removed had higher strontium isotope ratio, indicative of greater marine component in the diet, whereas males and females with two maxillary

canines and four mandibular incisors had less marine resources in their diet. This suggested a pattern of social differentiation that among the Jomon people that was reflected in both dental modification and diet. Group membership would have been immediately evident from the appearance of the front teeth (Kusaka et al. 2011).

In the Maghreb, during the Iberomaurusian De Groote and Humphrey (in press) found few patterns. In the two largest Iberomaurusian assemblages from Taforalt and Afalou similar results were found for males and females. In Taforalt, 76.9% of males and 90% of females had evulsion and all unsexed individuals had evulsion. At Afalou all but one female had evulsion. By looking at trends in the tooth type and the number of teeth being removed, it was possible to assess the pattern of evulsion from those individuals where both the left and right maxilla was preserved. The removal of both upper central incisors was the most common Iberomaurusian practice (65.2%). The removal of fewer, none and more teeth was also recorded. Ten out of 46 individuals exhibited the removal of only one incisor on either the right or the left side, and one individual had two left incisors removed but no right. Two individuals had all upper incisors removed and two individuals had three out of their four incisors removed. There were no differences in this pattern between the sexes nor was there a difference between the two main sites. Only one individual was missing a lower incisor, indicating that mandibular evulsion was not commonly practiced and an accidental cause cannot be ruled out in this isolated case.

Age of occurrence and method

Briggs (1955) attempted to ascertain the age at which tooth evulsion occurred using tooth wear and the mesial drift of the remaining teeth. He suggested, based on low levels of tooth wear and mesial drift of the neighbouring teeth, that individuals underwent the procedure between the ages of 8 and 11. De Groote and Humphrey (in press) employed a novel technique based on alveolar remodelling. Alveolar resorption and remodelling occurs after a tooth has been extracted. A number of studies have noted an amount of variation in socket healing. Morgan (2012) recently found that it takes at least 29 weeks in humans for alveoli to heal. Healing was defined as the presence of bone throughout the cavity (Morgan 2011). Another study (Hansson and Halldin 2012) found that there was no complete remodelling of the bone 12 months after extraction. The definition of “complete” remodelling was not described, but it is clear that the rate of remodelling during its early phases varies between individuals (Trombelli et al. 2008). Initial observations show active remodelling in a large number of individuals indicative that evulsion occurred shortly before death. We would expect

remodelling to have been more extensive if all individuals underwent tooth evulsion prior to puberty, as suggested by Briggs (1955). Whether there are differences in alveolar remodelling between teeth extracted at the same time is unknown. Nonetheless, it is predicted that differences will become less visible with time and that differences will eventually become eliminated once the process of remodelling is completed. De Groote and Humphrey recorded the extent of remodelling for each alveoli for a sample of Iberomaurusian individuals to determine whether tooth removal occurred during a single event or whether teeth were removed at different times.

When the remodelling phases of the alveoli were categorised by remodelling stage (from slight hints of remodelling inside the socket to full remodelling of the jaw to a level contour) the majority of cases presented a difference of either one or two phases between alveoli. In those individuals where there was no difference between left and right it was likely due to simultaneous extraction of both teeth. In some cases there was an alveolar rim that was fully remodelled or almost fully remodelled on one side while the other side showed an earlier phase of the remodelling process. The reason for removing one tooth at a time may have been because there were multiple events that needed marking by evulsion, or could have been simply to spread out the discomfort.

The ethnographic record offers information on the methods used for dental evulsion. These methods are either extractive (where the whole tooth is removed, including the root) or traumatic (the tooth is hit with an object and often only the crown removed which results in residual roots). Both methods carry with them the risk of post-evulsion infection but whole tooth removal is often preferred because broken teeth carry with them an increased risk of caries formation and root canal infection. A traumatic technique was used in Hawaii, where the teeth were knocked out with a stick that was struck by a stone. This procedure was repeated each time a tribal leaser died and resulted in the frequent presence of residual roots within the jaw (67% of cases) (Pukui 1989, Pietrusewsky and Douglas 1993). In Africa, extractive techniques were more common. In Egypt, for example, an iron spike was used to first loosen the tooth from its socket and then pulled. In Sudan, the teeth of infants were removed from the alveoli prior to eruption by using metal wires and fishhooks (Konnild 1987). In all of these cases, evulsion would have been a painful process that carried with it a risk of infection.

The absence of residual roots in tooth sockets is indicative of an extractive technique. Residual roots were only observed twice in the whole North African sample (De Groote and Humphrey in press) suggesting that an extractive technique was used most commonly. Occlusal wear on the lower incisors, albeit minor (De Groote and Humphrey in press), as well as the presence of active remodelling in the alveoli demonstrate that the teeth were extracted when erupted. Therefore the

technique was not that used by the Efe on infants who used fish hooks to remove unerupted teeth from the jaw. Instead it is more likely a form of spike was used to loosen the tooth and then remove it whole.

Underlying motives

Recent research on the distribution and characteristics of tooth evulsion the Maghreb has provided some new information on this cultural practice which may aid in understanding the origins of the custom. At present, there is no conclusive evidence for dental modification prior to the Late Pleistocene anywhere in the world. In the Maghreb, evulsion is first recorded among individuals dating from the later part of the Iberomaurusian (there are no well dated Iberomaurusian skeletons prior to 15,000 cal BP), suggesting that the practice of dental evulsion originated during or at the onset of the Iberomaurusian. Removal of one or both upper central incisors may have been rapidly established as the normal pattern for Iberomaurusian individuals, but the practice became more variable, both in presence and pattern, as time went on. The question therefore remains: Why did humans decide to start removing their upper central incisors during the late Pleistocene?

Ethnographic accounts can provide insights into the cultural reasons underlying different types of dental modification, including tooth evulsion. A variety of reasons were found in ethnographic accounts for the intentional removal of healthy teeth and these were summarized by Marcellino (Marcellino 1972) and others:

1) Initiation rituals and rites of passage
2) Vanity/aesthetics
3) Intimidation of enemies
4) Totemic initiation
5) Mourning of loved ones
6) Tribal identity
7) Avoidance of evil influences
8) Avoidance of dental disease
9) Prevention of lockjaw from tetanus

11) Practical reasons such as using extracted teeth as tools

12) Language pronunciation (MacDonald, 1999) in (Mower 1999)

13) Improved sexual performance (Konnild 1987)

The practical or social significance of tooth evulsion is difficult to ascertain in archaeological populations given the diversity of underlying reasons identified through ethnographic studies. Nevertheless, the patterning of this behaviour within a population in terms of age or ages of occurrence, within group variability and gender bias, as well as the manner in which the procedure was conducted can provide a basis for the exclusion of some possible reasons.

The age at which tooth evulsion is practiced may narrow down the range of possible social and practical reasons. Within the Iberomaurusian sample analysed by De Groote and Humphrey (in press) there was no clear pattern with age. Young individuals did not necessarily have fewer teeth removed than older adults. Therefore the event that led to evulsion was unlikely to be age-related. Most rites of passage are to mark an important event in the life of an individual: becoming adult or marriage, for example, and the lack of age pattern does not support a particular age-related rite of passage as the cause of evulsion. Instead, it was observed that there may have been a hiatus in the removal of the two upper incisors. In a number of cases, individuals only had one tooth removed. Can it be assumed these individuals had not yet presented the need, or experienced the reason for evulsion? This hiatus, in addition to a lack of age or sex pattern, would suggest that individuals underwent the event of evulsion multiple times. When the patterns are observed, the prevailing pattern is the removal of both upper central incisors. Thus, the event usually occurred twice in the course of someone's lifetime. Death of a parent, tribal leader or birth of a child may be some of these reasons.

A strong sex bias in the presence of patterning of tooth evulsion could indicate a reason linked to gender specific roles or attributes within that community, including for example attractiveness in males and females or evidence of endurance. There was no significant difference in the presence of evulsion between males and females within the Iberomaurusian sample analysed by De Groote and Humphrey (in press). During this period, the practice was almost universal with 90.6% and 88.9% of males and females (29/32 males, 16/18 females) missing anterior teeth. This indicates a community wide ritual that would have created a sense of cohesion and identity, or may have served a practical purpose in both sexes. . The decreased prevalence of tooth evulsion males but not females during the Capsian (Briggs 1955) may suggest a change in social meaning. Other social reasons suggested in

the literature such as avoidance of evil influence or improved sexual performance, are more difficult to assess using the evidence available.

The presence of evulsion in nearly all sites across the Maghreb during the Iberomaurusian implies that the removal of teeth was not undertaken to provide a visible means of distinguishing between individuals affiliated with different groups. This indicates that the existence of regional tribal politics, such as seen with the Jomon in Japan, is unlikely to explain the custom. The diversification of the practice during subsequent periods, seen in the both in distribution of sites where the practice was present and absent and the number and type of teeth removed is consistent with increased cultural heterogeneity during the Capsian and Neolithic.

Evulsion of the anterior teeth would have resulted in a change in the pronunciation of language and other sounds (MacDonald, 1999 in Mower, 2009). Therefore, the desire to achieve a particular style of language pronunciation is a possible explanation for the widespread practice of evulsion during the Iberomaurusian. The importance of this would have to have diminished during the Capsian to account for the reduced prevalence of tooth evulsion. It is possible that removal of mandibular teeth would have had an additional impact on pronunciation.

It is unlikely that the Iberomaurusians removed incisors to avoid or treat dental disease because there is no evidence for a similar treatment of teeth elsewhere in the mouth. The Iberomaurusians had very poor oral health with more than 50% of all observed teeth affected by carious lesions (Humphrey et al. 2014, De Groote, Morales, and Humphrey in prep) but there is no evidence for deliberate extraction of diseased teeth, even those showing an advanced state of decay.

The very high occurrence of land snails in Iberomaurusian and Capsian cultural deposits suggests that there were a key element of the Iberomaurusian and Capsian subsistence strategy (Lubell 2014, 2004, Taylor et al. 2011). Harvesting and consumption of land snails may have exposed the individuals more frequently to soil-borne pathogens such as tetanus. The risk of tetanus was given as a reason for evulsion during interviews by the Nilotic (Kenya) and other African populations (Fedders and Salvadori 1981, Handler 1994, Hinde and Hinde 1901, Humphreys 1954, Willis, Harris, and Hergenrader 2008). Cook (1981) also suggested the origin for the practice of widespread evulsion could be the exposure of the individuals to tetanus. The gap left by evulsion would have enabled individuals suffering tetanus induced lockjaw to drink water and other liquids. Tooth evulsion in many societies is practiced in during late childhood, at an age the anterior teeth and premolars

would have coming into full occlusion, closing any gaps in the dentition that were present at earlier stages of tooth emergence

Summary

The earliest form of dental modification known to us today comes from Northwest Africa. The Iberomaurusians who lived in the Maghreb region from around 22,000 years ago were the first population to follow the widespread practice of evulsion, Deliberate removal of the upper central incisors from the mouths of most males and females was firmly established as a cultural norm by at least 15,000 calBP. . Studying the geographical and temporal distribution and trends within the groups, has allowed us to understand the emergence of this custom better and view it in the light of explanation reported in the ethnographic record.

Based on the review presented above, we suggest that the practice is likely to have originated for practical reasons such as tetanus and became almost universal throughout the region. Large numbers of edible land snails are associated with Iberomaurusian deposits at several sites. Systematic harvesting and consumptionof snails may have been associated with an increase in the incidence of tetanus and greater awareness of lockjaw as a life-threatening symptom Tooth evulsion would have allowed an individual suffering from lockjaw to be given liquids through the gap left by the extraction. Differentiation in patterns and distribution during the Capsian and Neolithic suggests these initial motives wereacompanied by and perhaps eventually replaced by symbolic reasons such as mourning or initiatiatioritualsr, beautification or demonstration of tribal identity. The practice of tooth evulsion spread further throughout the world via the Middle East and the Southern Sahara and then gradually disappeared from its region of origin.

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