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DOES CRANIAL TRAUMA PROVIDE EVIDENCE FOR PROJECTILE WEAPONRY IN LATE IRON AGE DORSET?

Summary. *Human remains form an independent dataset with which to examine martial activity in past societies, particularly how to understand the types of weaponry used and who was subject to lethal violence. In the Late Iron Age of Dorset (first century BC to first century AD), these data are useful in understanding such activity in light of the small range of extant evidence.This bioarchaeological study examined the crania of 80 inhumed and articulated sexed adults, using forensic, bioarchaeological and clinical criteria to determine whether osteological evidence for sharp and blunt projectiles could be observed. The sample showed evidence for peri- and ante-mortem traumas, with the majority of injuries sustained at the time of death; most affected males and were caused by blunt projectiles. Healed injuries were observed in both sexes but only females had evidence for remodelled blunt projectile injuries. The age-groups affected were predominantly young and middle-aged adults, suggesting that weapon training began early in life.*

INTRODUCTION

The nature of violence and martial activity in the British Iron Age receives limited attention, with research often focusing on warrior burials or the deposition of weaponry rather than the practicalities of combat (e.g. Collis 1972; Dent 1983). Recent work has addressed the interpretation of hillforts, examining how these may have been used in warfare and, crucially, how evidence for martial activities and violence is discussed within the literature (Armit 2007; Hill 1996; 2007; James 2007; Sharples 1991a). The majority of publications stress a cautious approach to the interpretation of martial activities because we lack a representative sample of weaponry throughout the period, and many of the arms recovered appear to have had a ceremonial or ritual purpose (James 2007; Ritchie and Ritchie 1997; Stead 1991).

In broad terms, Late Iron Age material culture indicates that communities during the first century BC to first century AD contained a warrior class, which engaged in episodes of warfare, manufactured weapons, and whose ideological frameworks contained aspects of violence, such as human sacrifice (Aldhouse Green 2001; Cunliffe 2004; Haselgrove 1994; James 2007; Kristiansen 1999; Steuer 2006). The presence of large multipurpose hillforts in southern Britain is also perceived as being suggestive of warfare throughout the period (Armit 2007; Cunliffe 2004; Hamilton and Manley 2001; James 2007; see also Bowden 2006; Hill 1995; 1996).

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The potential of human remains as a source of information for weaponry and the realities of martial activity has yet to be fully realized in Iron Age research. A small number of published studies have employed bioarchaeological data on weapon injuries and fractures to discuss the presence of warfare in the Iron Age (e.g. Dent 1983; James 2007). However, such data have yet to be included as fully within an interpretation as is seen in later periods of history, for example the medieval sample from Towton (Yorkshire) (Fiorato *et al.* 2000). Human remains provide an independent dataset that may be studied to investigate the types of weaponry used in the Late Iron Age, to evaluate age and gender differences in risk, and to contribute to the interpretation of other sources of evidence such as hillforts. Their analysis provides us with the opportunity to study warfare and acts of violence without relying on extant weaponry, as we are able macroscopically to identify injuries caused by blunt projectiles and sharp-bladed weapons of various sizes (Milner 1995; Novak 2000, 91). However, the interpretation of this evidence must also be undertaken with caution, with the bioarchaeological data always interpreted and understood within its archaeological context. Analysis of Iron Age human remains has shown that many frequently cited examples of violence, for example at Danebury hillfort, may derive from ritual acts rather than warfare; consequentially, the distribution and type of injuries can be different from those committed during warfare and interpersonal aggression (Craig *et al.* 2005). This distinction is important, as the identification of warfare in the archaeological record is highly contentious, particularly the extent to which it can be recognized using material culture and distinguished from other violent practices (Carman and Harding 1999, 247; Ferguson 1997, 326; Otterbein 2004).

In order to understand the nature of Late Iron Age warfare and age/sex differences in participation, this study examined the crania of 80 sexed adults to investigate projectile injuries in the Late Iron Age population of Dorset, England. Post-cranial injuries and other trauma are described in Redfern (2006; accepted). Projectile injuries were selected for study because these weapon types are designed to kill, they require skill in firing and because of their lethal nature; such injuries are unlikely to be accidental (Lambert 1997, 90).

ARCHAEOLOGICAL EVIDENCE FOR PROJECTILES

Finney (2006) proposes that hillfort development during the Middle and Late Iron Age (fifth century BC to first century AD) was in response to the use of projectile weapons – sling-stones, pebbles/stones and spears (see also James 2007, 164), although others consider that such investment was also related to elite power (e.g. Cunliffe 2004; Hill 1995). Furthermore, as Armit (2007, 36) suggests, there is no reason why both factors could not have influenced their development. Avery's (1986, 220–4) examination of hillforts suggests that stone- and timber-lined entrances, high dump ramparts, and inner portals formed a complex entrance that was designed to combat gate-burning tactics and allowed hillfort defenders to use stones to barrage a firing party. However, the firing party would also throw stones to prevent the defenders from removing the fire laid at the gate. Avery (1986, 225) suggests that after this point in the battle, multiple groups of slingers would be used to reduce the number of attackers. Cunliffe (2004, 247) notes that the eastern entrance of Maiden Castle would have provided protection for artillery platforms perhaps armed by sling-throwers, a scene echoing Wheeler's imaginative reconstruction of the battle between the Veneti tribe and the Roman army that he suggested had taken place at the hillfort (*Science News Letter* 1939).

In a bioarchaeological perspective, Late Iron Age projectile weapons may be divided into sharp (arrowheads and spears) and blunt (sling-stones and pebbles/stones) types (Byers 2006). The shape and size of these projectiles varied considerably, and were also subject to intense regional and temporal variation (Ritchie and Ritchie 1997). It should be noted that we do not have a representative sample of weaponry from this period, as many examples appear to have been produced for display rather than combat (e.g. the Battersea shield) (James 2007, 163; Jope 2000). Spear- and arrowheads were made in a range of sizes, typically oval in shape, and had smooth or serrated edges; however, arrowheads have only been identified at a small number of sites, suggesting that they were not in common use (Ritchie and Ritchie 1997; James 2002; Jope 2000). The use of slings by British tribes is attested by the recovery of slingshot from many hillforts and settlement sites (e.g. Danebury and Glastonbury); these were usually made of clay and ovoid or round in shape, or were small pebbles collected for the purpose (Poole 1984; Cunliffe 2004). Ritchie and Ritchie's (1997) discussion of Iron Age warfare notes that although the use of slings in southern Britain was recorded by Roman authors, it is a weapon hard to identify in the archaeological record since they were made from organic materials. Volleys of sling-stones, spears and pebbles/stones were used at the beginning of battles to reduce enemy numbers, but archery appears to have been less frequently used in comparison to other projectiles (Avery 1986; Ritchie and Ritchie 1997, 37; James 2002, 75). The adaptation of hillforts to the use of these weapons has been outlined above, but the rare examples of armour from this period suggest that efforts were made to safeguard combatants from projectiles and other sharp weapons, for example the use of shields and helmets, and, later in the period, mail shirts (Ritchie and Ritchie 1997; James 2002).

Harrison's (2006) review of projectiles summarizes the efficiency of these weapons, and shows that their effectiveness is influenced by skill and, to a certain extent, physical strength. To use a spear, a person needs little training but many hours of practice, as a cast's final velocity comes from the forearm and wrist rotation (Cotterell and Kamminga 1992, 160–3). Although heavy spears are more likely to injure prey or a combatant, their casts are shorter than lighter spears, despite being more mechanically efficient. For example, to cast a spear more than 50 m requires a velocity of more than 22 m per second – Tasmanian Aborigines who do not use atlatls are able to cast a 0.6 kg spear between 35 and 60 m (Cotterell and Kamminga 1992, 160–6).

The bow is a more sophisticated weapon and the development of the composite bow in the second millennium BC enabled it to be effective at 100–275 m. However, the fletching on an arrow adds air resistance that could result in its efficiency being reduced by 75 per cent at ranges over 50 m (Harrison 2006). Experiments of arrows shot using a compound bow into adult pig corpses found that these will penetrate the soft tissue by 17 to 60 cm and cause substantial injury to internal organs, if no thick bones have been perforated in the wound track (Karger *et al*. 1998). For example, an arrow weighing between 31 g to 45 g with a kinetic energy of 6.9–8.3 m kg will penetrate a large game animal but its effectiveness is also dependent on the length and weight of the bow, the strength of the draw, fletching, and the strength and stance of the archer (Cotterell and Kamminga 1992, 180–8; Klopsteg 1992, 11–24).

Although much simpler in design and manufacture, to use a sling effectively still requires considerable training (Harrison 2006; Savage 1999). Shaped sling-stones have less air resistance than arrows and, compared to stones/pebbles, are more able to penetrate soft tissue, whereas the latter produce internal bleeding and crushing injuries (Harrison 2006). Harrison (2006) also suggests that in antiquity, if a person had been trained from childhood, they could

Figure 1
Location map of Dorset, England (drawn by Kate Waddington).

have made accurate hits at a distance of more than 700 m.[1] Brown Vega and Craig's (in press) review of modern, historical and archaeological sling throws found that the maximum reported range was 500 m. Their ethnographic study of Quecha-speaking herders in Peru, who continue to employ slinging, found that the average throw was 65 m, with males averaging 78 m and females 53 m (Brown Vega and Craig in press).

Focusing upon the Durotriges, the tribe who occupied Dorset during this period (Fig. 1), research suggests that by the Late Iron Age the development and construction of hillforts had decreased, but the Durotriges had a fighting elite that was controlled by a small number of powerful individuals who centralized and devolved power using a framework of clients (Champion 1997, 92–3; Haselgrove 1994, 3; Gwilt and Haselgrove 1997, 7; Sharples 1991a, 84–7). Sharples (1991b) proposes that in the Late Iron Age, intra-tribe conflict decreased but external warfare increased, on the grounds that construction work at Maiden Castle ceased at the end of the second century BC.

An insight into the range of martial activity undertaken by the Durotriges may be inferred from Haas' (1990) analysis of the evolution of tribal polities, which suggests that tribal warfare was dominated by small intermittent raids into other territories to acquire goods, destroy resources and abduct individuals. With the development of Roman client kingdoms in south-east Britain after AD 43 (Mattingly 2006; Creighton 2000), an increase in tensions between these communities and more peripheral tribes (Cunliffe 2004) may have engaged the Durotriges in sporadic internal and external warfare (Sharples 1991a).

The majority of Late Iron Age projectiles discovered in Dorset were found at Maiden Castle. At this hillfort, two individuals were buried with sling-stones as grave-goods, one adolescent was buried with an arrowhead, and one adult male had an embedded Roman ballista

1 The Guinness World Record for a stone cast with a sling in 1981 was 437 m by Larry Bray, in a communication to Harrison; he believed that he could have exceeded 600 m if he had used a better sling and lead projectiles (Harrison 2006).

Figure 2
Example of a pebble cache at Maiden Castle hillfort (© Dorset County Museum, Dorset Natural History and Archaeological Society).

bolt in his vertebral column (Hamlin 2007; Redfern 2006; Wheeler 1943). The massive pebble caches (>500–20,000) near the eastern entrance of Maiden Castle have been interpreted as sling-stones owing to their uniform weight (50 g) and shape (Fig. 2) (Ritchie and Ritchie 1997, 52; Sharples 1991b, 83; Wheeler 1943, 47); however, Avery (1986, 225) suggests that these were thrown, rather than slung, at fire parties to prevent them from burning the gate. Sharples' (1991b, 85) excavations also identified a sling-stone hoard in the lowest floor level of a house built behind a rampart in the south-west corner of the hillfort.

Elsewhere in Dorset, sling-stones have been identified at other hillforts: excavations at Poundbury Camp revealed clay sling bullets, beach sling-stones and a spearhead (Ellison 1987, 138; Davis 1987, 142; Sparey-Green 1987, 98–9). At Shipton Hill more than 1000 sling-stones were found in a series of pits, and at Flower's Barrow, a pit containing pottery and sling-stones was uncovered (Gale 2003). Sling-stones have also been found in pits at the settlement sites of Gussage All Saints and Pins Knoll, where in pit 4 they were found in association with pottery, animal bone, bone implements, a chert scraper and loom weights, and a sling-stone formed part of the grave-goods deposited with an adolescent (Bailey 1967; Gale 2003; Hamlin 2007).

As the human remains used in this study date from the Late Iron Age, it is possible that many of these people were killed fighting against the Roman army. In Dorset, Roman sources record that in south-west Britain the Roman general Vespasian and troops from *Legio II* fought 30 battles with tribes, including the Durotriges (Mattingly 2006, 98). The Roman army frequently used projectiles, and the densely settled hillfort of Hod Hill contained large numbers of ballista bolts (Mattingly 2006, 99). Many authors consider that the 'Belgic war cemetery' at Maiden Castle reflects this encounter (Mattingly 2006, 99), with the identification of a Roman ballista bolt in the 12th thoracic vertebra of an adult male supporting this hypothesis (Morant and Goodman 1943, 352; Webster 1998, 245; see also Redfern 2006; accepted). However, analysis of the demography and burial phasing now suggests that the cemeteries reflect attritional and catastrophic deaths and are therefore unlikely to result from a single episode of warfare (Bishop and Knüsel 2005; Hamlin 2007; Redfern 2006; accepted; Sharples 1991a; 1991c).

OSTEOLOGICAL EVIDENCE FOR PROJECTILE INJURIES

The skull is one of the most complicated hard-tissue structures of the body owing to the number of bones involved in its creation and because it contains many of the most fragile bones of the skeleton (White 2000, 45, 53). The skull bones develop during infancy and childhood; these gradually grow and fuse to form the adult skull, which shows variations in normal shape and size (Scheuer and Black 2000, 36–47). The cranium is formed of two layers (tables) with a middle layer of spongy cancellous bone (diplöe). The tables are usually 2–6 mm thick with the outer table normally twice as thick as the inner table (Gurdjian and Webster 1958, 37). It should be noted that the term cranium is not interchangeable with skull, as the skull refers to the cranium and mandible (Bass 1995, 37–65). The local morphology (e.g. shape of the maxilla compared to the temporal bone) and stage of development all influence how the cranium responds to a blow (Berryman and Haun 1996, 3–4; Lovell 1997, 150). This is because the cranium contains four buttresses (mid-frontal, mid-occipital, posterior temporal and anterior temporal) made from thicker bone, which influence fracture patterns (Gurdjian and Webster 1958, 38, 65, 76; Byers 2006, 323–7). For example, a blow to the centre of a parietal bone will produce radiating fractures in the area between the mid-frontal and anterior temporal buttresses (Byers 2006, 324). The type and severity of injury produced is dictated by the velocity of the impacting object, its kinetic energy, and the location of the blow (Gurdjian *et al*. 1950a; 1950b). A blow's kinetic energy and object velocity will influence whether one or both tables are fractured, as bone is more likely to fracture under tension than compression (Berryman and Haun 1996, 3–4; Berryman and Symes 1998, 333–6).

Projectile injuries in prehistoric contexts can be classified as 'wounds caused by stone, bone, wood, cane or metal tipped projectiles' (Lambert 1997, 90). Projectile weapons will cause damage to the skeleton at a velocity of 60 m per second: they crush the tissues and the shape of the struck bone influences the resulting wound (Kimmerle and Baraybar 2008, 322–5, 402–5). Forensic and archaeological research has shown that projectiles, owing to their highly lethal nature, can cause extensive damage to the cranium and, if launched with sufficient power, will shatter the entire structure. These weapons will penetrate the bone surface and result in complete discontinuity, bone displacement, bevelling, and radiating and concentric fractures (Berryman and Symes 1998; Byers 2006; Kimmerle and Baraybar 2008, 272; M. Smith *et al*. 2007) (Table 1).

A limited number of clinical studies have addressed injuries caused by stones, and these data are crucial to the identification of trauma in past populations, as they provide information about the context and mechanism of the injury and the weapon used to inflict it (Scherer *et al*. 1989). Judd's (1970, 14) study of stoning injuries in western Samoa identified 20 patients with compound depressed skull fractures caused by stoning in 12 cases, with the remainder resulting from a falling coconut and domestic violence. Amir *et al*. (2005) also observed skull fractures and severe anatomical brain injuries in children killed by stoning, and Nahlieli *et al*. (1993) observed mandibular fractures caused by stone-throwing. The clinical literature shows that

TABLE 1
Sample analysed for projectile injuries

Cemetery	Sex	N with >50% observable cranial bones
Alington Avenue (Davies *et al*. 2002)	Male	4
	Female	4
Broadmayne (Woodward 1981)	Male	1
Flagstones (R.J.C. Smith *et al*. 1997)	Male	1
	Female	3
Gussage All Saints (Wainwright 1979)	Male	4
	Female	4
Hod Hill (Richmond 1968)	Female	1
Kimmeridge (O'Connell 2000)	Female	1
Maiden Castle (Wheeler 1943)	Male	14
	Female	19
Newfoundland Wood (Toms 1970)	Male	1
Poundbury Camp (Farwell and Molleson 1993)	Male	4
	Female	4
Tolpuddle bypass (Hearne and Birkbeck 1999)	Male	2
	Female	2
Western link (R.J.C. Smith *et al*. 1997)	Male	3
	Female	3
Whitcombe (Aitken and Aitken 1991)	Male	3
	Female	1
Regional total	Male	37
	Female	43
	Both sexes	80

stoning injuries will result in depressed fractures; these are formed when an object hits the cranium with force making the bone bend inwards, creating a fracture on the inner table. With the increasing force, the fracture extends to the outer table and a concentric fracture will develop, causing internal bevelling (Berryman and Haun 1996, 5).

In the archaeological record, numerous skeletal samples throughout the world have evidence for projectile injuries and depressed cranial fractures (e.g. Frayer 1997; Tung 2008). In prehistoric British samples, these traumas have been identified from the Neolithic period onwards (Roberts and Cox 2003; Schulting 2006). Depressed cranial fractures have been identified at a number of Iron Age sites. At Worlebury hillfort (Somerset), two disarticulated cranial bones have fractures present: a male frontal bone has a healed oval depression fracture present and a female frontal bone was broken by two peri-mortem blows from a puncturing instrument (Dymond and Tomkins 1886, 103). Jones' (2008) reanalysis of the disarticulated human remains from Cadbury Castle hillfort (Somerset) identified peri-mortem penetrating cranial traumas and the presence of blunt-force fractures. In cemeteries from east Yorkshire, King (2009) observed two healed cases of penetrating cranial trauma (see also Dent 1982), and at Garton Slack, a healed puncture wound was noted in one adult skull (Brewster 1981). Peri-mortem projectile injuries to the cranium have also been reported from Danebury (Hampshire) (Hooper 1984; 1991), and McKinley (pers. comm.) identified a peri-mortem depressed fracture to the temporal and parietal bones, considered to be a slingshot injury, in an adult male from Andover (Kent). Depressed cranial fractures or projectile injuries to the head were not observed in the east Yorkshire cemeteries of Burton Fleming, Rudston, Garton-on-the-Wolds and Kirkburn or in the sample from Mill Hill (Kent) (Anderson 1997, 121; Stead 1991, 135–6).

TABLE 2
Macroscopic criteria used to identify blunt and sharp projectile injuries (Amir *et al*. 2005; Berryman and Haus 1996; Berryman and Symes 1998; Byers 2006; Judd 1970; Kimmerle and Baraybar 2008; Lovell 1997; M. Smith *et al*. 2007)

Blunt projectiles	Sharp projectiles
• Depressed fracture	• Penetration or perforation
• Penetration or perforation	• V/semi-V/U-shaped cross section
• Bone displacement	• Bevelling at injury site
• Internal bevelling	• Point insertion or notched defect
• Radiating and concentric fractures	• Radiating fractures
• Lozenge-shaped apertures (pointed objects)	• Lozenge-shaped apertures
• Delamination at the entrance wound	• Delamination at the entrance wound

Osteological evidence for embedded projectiles has also been reported in British Iron Age burials. In addition to the individual from Maiden Castle with a projectile embedded in his thoracic spine (Morant and Goodman 1943, 352; Webster 1998, 245), at Spetisbury hillfort, during construction of the railway in 1857, a skull with an embedded spearhead was found (now believed to be lost) and native spearheads were also recovered (Gresham 1939). In cemeteries from east Yorkshire, three male burials from Rudston have evidence for peri-mortem spear injuries to the torso; however, these may represent the ritual spearing of the body after death. One female burial from Wetwang Slack also had a spearhead in the stomach region whose point touched the spine, and at Burton Fleming three burials had embedded spearheads in the pelvis and vertebrae (Dent 1982; Stead 1979; Stead 1991, 136–7).

MATERIALS AND METHODS

This study focused upon 80 articulated and inhumed sexed adults aged between 20 and more than 50 years old, who had at least 50 per cent of the cranium present (Table 2).[2] This was achieved by using the recording system described by Buikstra and Ubelaker (1994, 6) which scores each bone as being between 25 per cent and >75 per cent complete. The human remains were derived from inhumation burials in Dorset dating from the first century BC to the first century AD. The crania were examined macroscopically for evidence of ante-mortem and peri-mortem depressed fractures, and for the presence of peri-mortem apertures that were divided into blunt and sharp projectile injuries based upon the criteria described in Table 2 (Amir *et al*. 2005; Berryman and Haun 1996; Berryman and Symes 1998; Byers 2006; Judd 1970; Kimmerle and Baraybar 2008; Lovell 1997; M. Smith *et al*. 2007). Individuals with cranial fractures associated with sharp-force weapon injuries and those with blunt-force radiating fractures (Byers 2006; Knüsel 2005) which did not conform to the criteria outlined in Table 2 were excluded from the analysis. It is acknowledged that this conservative approach may exclude some cases but all trauma data are described in Redfern (2006).

The identification of blunt and sharp projectiles in the absence of embedded weapons is not definitive, as small lozenge-shaped apertures in the skull could have been caused by daggers rather than arrow- or spearheads; and apertures or depressed fractures may also be caused by

2 Subadults were not included in this study, as none had evidence for a projectile injury. Please note that because this study only used individuals with at least 50 per cent of the cranium present, the results will differ from those given in Redfern (2006).

blunt objects, such as clubs/hammers or sustained by a fall from a height (Byers 2006; Kimmerle and Baraybar 2008; Knüsel 2005. See also M. Smith *et al*. 2007). However, it is proposed that by rigorously comparing the observed human remains to clinical, forensic and archaeological criteria for the diagnosis of projectile trauma, these injuries could be identified in Late Iron Age crania. Nevertheless, in each case, blunt-force (e.g. a club) or sharp-force (e.g. a sword) traumas remain the differential diagnosis.

The articulated sample available for analysis was recorded following the widely accepted osteological standards proposed in the collection edited by Buikstra and Ubelaker (1994). For adult individuals (>20 years old) assessment of biological sex was achieved by scoring the morphology of the skull and pelvis. The pelvic girdle is 95 per cent and the skull 90 per cent accurate in the determination of biological sex (Krogman and İsçan 1986). Age-at-death was determined using the pelvis by assessing the stage of pubic symphysis and auricular surface degeneration, and age-related changes in sternal rib end morphology (Buikstra and Ubelaker 1994; İsçan and Loth 1986a; 1986b). For the purposes of this study, based upon the age-group divisions devised by Buikstra and Ubelaker (1994), an individual was considered an adult if over 20 years old.

The results were tested for statistical significance using a two-tailed T-test with the *P* value set at 0.05 (Madrigal 1998).

RESULTS

The macroscopic analysis of cranial injuries in Late Iron Age sexed adults from Dorset identified ante- and peri-mortem blunt and sharp projectile injuries in individuals buried in hillforts, which was a statistically significant result ($P = 0.0001$) (Table 3). No ante-mortem injury showed evidence for infection, which is common in open injuries, or surgical intervention (e.g. trepanation). In the majority of cases both cranial tables had been penetrated, indicating that these injuries were most probably the cause of, or significantly contributed to, the individual's death (Vinas and Pilitsis 2008).

The majority of sustained injuries were produced by blunt projectiles shortly before or at the time of death (16.2 per cent). In ante-mortem injuries, a higher crude prevalence rate of blunt projectiles was observed in females (9.3 per cent) compared to males (2.7 per cent), whereas the reverse was true for sharp projectiles, where only males had evidence of healed injuries (2.7 per cent). Three individuals (3.7 per cent), two females (4.6 per cent) and one male (2.7 per cent), had both ante- and peri-mortem blunt projectile injuries present. A similar number of males (N = 7) and females (N = 6) had peri-mortem blunt-force projectile injuries but males had a higher crude prevalence rate of sharp projectile injuries (16.2 per cent). The difference in the number of males and females with a blunt or sharp projectile injury (peri- and ante-mortem) was not found to be statistically significant ($P = 0.3335$).

The ante-mortem evidence for blunt projectile injuries consisted of healed depressed fractures; one young adult female from Maiden Castle had a healed oval depression on the left orbital margin (3 × 4 mm) (Fig. 3), and another young adult female had a large oval depression (35 × 24 mm) to the right lateral aspect of the frontal bone that showed evidence for comminution of the cranial tables (Fig. 4). In the male sample, an older adult from Poundbury Camp had a small depressed fracture (7 × 6 mm) to the posterior aspect of the left parietal bone. The fracture appears to have affected only the outer table and diplöe bone, and is the only trauma observed in this individual.

TABLE 3

Number of individuals with evidence for ante-mortem (AM) or peri-mortem (PM) projectile traumas. Numbers of individuals affected are given in parentheses. Prevalence rates are calculated by sex and age-group by site and at the regional level

Cemetery	Sex	Age-group	N of individuals with >50% cranial bones present	Blunt projectile		Sharp projectile	
				AM	PM	AM	PM
Maiden Castle	Male	Young adult (20–35 years old)	14	–	28.6% (4)	14.3% (2)	14.3% (2)
		Middle adult (36–50 years old)	8	–	37.5% (3)	–	12.5% (1)
		Adult(>20 years old)	1	–	–	–	100% (1)
	Female	Young adult (20–35 years old)	12	25% (3)	25% (3)	–	8.3% (1)
		Middle adult (36–50 years old)	10	10% (1)	30% (3)	–	–
Poundbury Camp	Male	Older adult (>50 years old)	1	100% (1)	–	–	–
Region	Male	All age-groups	37	2.7% (1)	16.2% (7)	2.7% (2)	10.8% (4)
	Female		43	9.3% (4)	13.9% (6)	–	2.3% (1)
	Both sexes		80	6.2% (5)	16.2% (13)	2.5% (2)	6.2% (5)

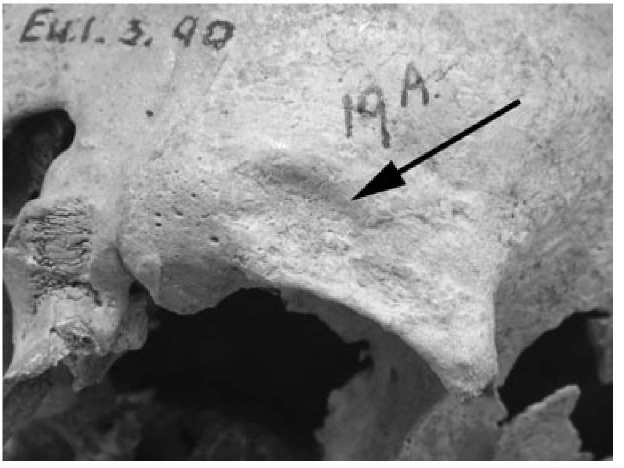

Figure 3
Anterior view of an adult female from Maiden Castle, with evidence of a healed depressed fracture on the left orbital margin (arrowed). Please note that the nasal bones and right maxilla bone are no longer in anatomical position (author).

Figure 4
Right lateral view of an adult female from Maiden Castle, with evidence of a healed comminuted depressed fracture (author).

The majority of peri-mortem blunt projectile injuries were circular perforations. These were a minimum of 10 mm in size and the majority had penetrated both tables. For example, in one middle-aged male from Maiden Castle, a large circular perforation was present in the left frontal bone (Fig. 5). Two females also had large circular perforations to the side of the head (parietal bone), which had evidence for bevelling and delamination (Fig. 6). In each case, despite the penetrating nature of the injury, no projectile was reported in the field notes as being found within the cranial vault or associated with the skeleton, suggesting that these had not become embedded or were removed when the body was prepared for burial.

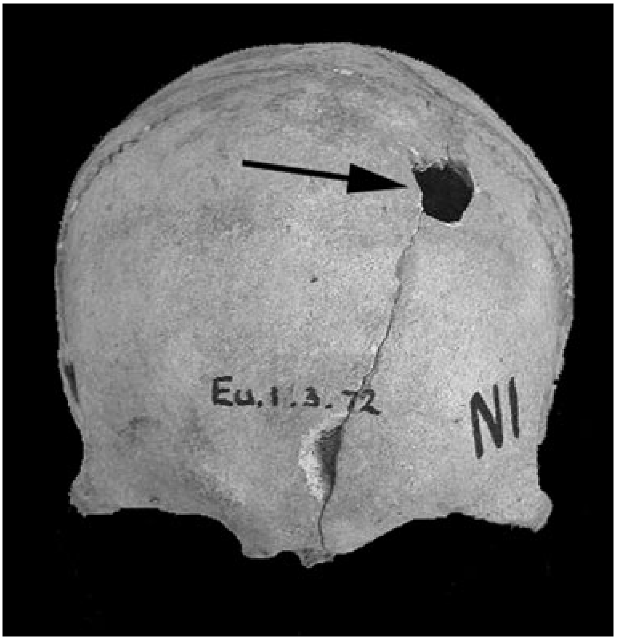

Figure 5
Anterior view of a male frontal bone from Maiden Castle, showing evidence of a peri-mortem projectile injury (arrowed) (author).

Figure 6
Superior view of an adult female from Maiden Castle, showing evidence of a peri-mortem projectile injury (author).

Sharp projectile injuries predominantly affected males, and all but one consisted of small lozenge-shaped perforations, with bevelling on each side, focused on the posterior aspect of the head (Fig. 7). Two such lesions were observed in a young adult male from Maiden Castle, and were located in the right lambdoid suture and in the right temporal bone. Only one sharp

Figure 7
Right lateral view of a male cranium from Maiden Castle, with evidence for a peri-mortem sharp projectile injury to the right lambdoid suture (author).

Figure 8
Left lateral view of a male cranium from Maiden Castle, with evidence for a peri-mortem square perforation to the left temporal bone (author).

projectile injury was square-shaped; this was observed in a young adult male from Maiden Castle and may have been caused by a sharp-force bladed weapon (Fig. 8). This individual also had a lozenge-shaped defect in the right lambdoid suture. The majority of projectile injuries in males had penetrated only the outer table and diplöe. In parallel with the blunt projectile injuries, no crania were found to have embedded projectiles, again suggesting that they were removed after death.

Multiple projectile injuries were also observed; for example, a young adult male from Maiden Castle had two peri-mortem blunt and one peri-mortem sharp projectile injuries present to the frontal and right parietal bones, in addition to a large healed oval defect located on the mid-portion of the right parietal bone (Fig. 9). The distribution of injuries suggests that all areas

Figure 9
Superior view of a healed sharp projectile injury to the superior aspect of a right parietal bone in an adult male from Maiden Castle (author).

of the head were struck by projectiles (Fig. 10). The majority of blunt projectiles were directed to the front and sides of the head, and the pattern does not appear to show any differences between the sexes (Fig. 11).

The data also show age-related patterns, with the majority of injuries sustained by young and middle-aged adults (20–50 years old) (Table 3). In females, only young adults (20–35 years old) have blunt and sharp projectile injuries, and more young adults (25 per cent) than middle-aged adults (10 per cent) have ante-mortem blunt projectile injuries. In males, only young adults have ante- and peri-mortem sharp projectile injuries, and this age-group has the highest crude prevalence rates for all projectile injuries (Table 3). Only middle-aged males have peri-mortem blunt (37.5 per cent) and sharp (12.5 per cent) projectile injuries, with most injuries caused by blunt projectiles. One older adult male had a healed blunt projectile injury (100 per cent), and was the only male to have a healed injury of this type.

DISCUSSION

The presence of ante-mortem and peri-mortem traumas indicates that both sexes had experienced multiple episodes of martial activity or interpersonal violence in which projectiles had been used. The small number of ante-mortem injuries may not indicate that the risk of death was low from these weapons but rather that earlier wounds had not penetrated the cranium. It may also suggest that on earlier occasions, protective headgear was worn or was stronger than that used at the time of death. The few Iron Age helmets that have survived, and more recent finds (e.g. at North Bersted), show that their design was highly variable – most appear to have covered the head but not the face – although we cannot be sure whether these were made for burial or ritual purposes rather than for practical use (Ritchie and Ritchie 1997; James 2002; Jope 2000). We may postulate that projectiles could have been used following Avery's (1986) reconstruction of hillfort warfare, with skilled teams on opposing sides using volleys of sling-stones, spears/arrows, stones and pebbles to reduce enemy numbers, and attackers using projectiles to ensure that their 'stoning and fire' technique stood a chance of success, whilst being barraged by

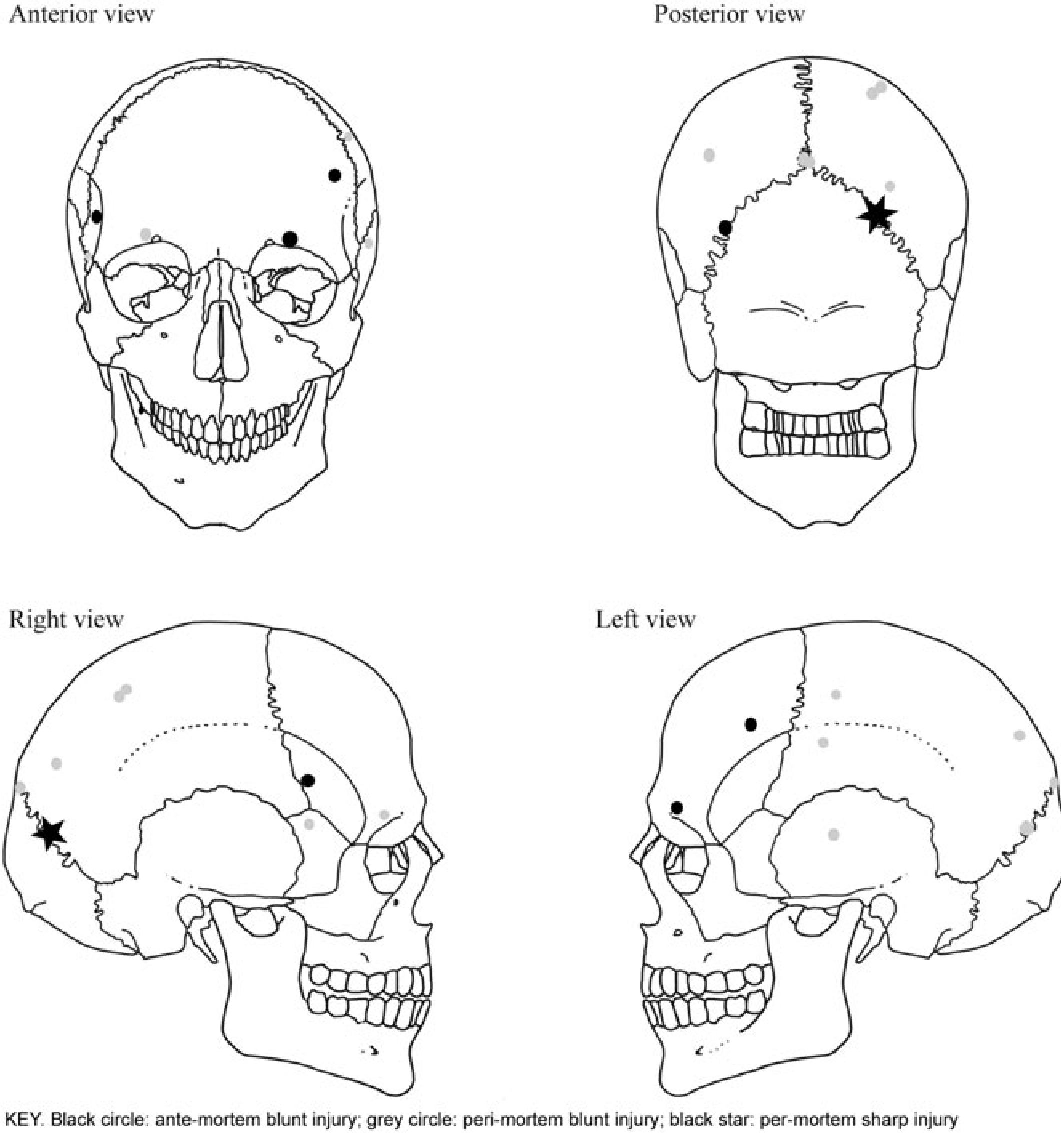

Figure 10
Location of ante- and peri-mortem projectile injuries in females (author).

defenders (see also Armit 2007). The bioarchaeological study provides new, independent data for these martial acts, and lends support to Avery's (1986) assertion that Iron Age warfare did involve large numbers of skilled people organized by warrior elites.

The study observed that individuals with evidence of projectile injuries had only been buried in hillforts – a statistically significant result – which may be a local trend, as elsewhere in Britain injured people have been found in attritional and catastrophic cemeteries (e.g. east

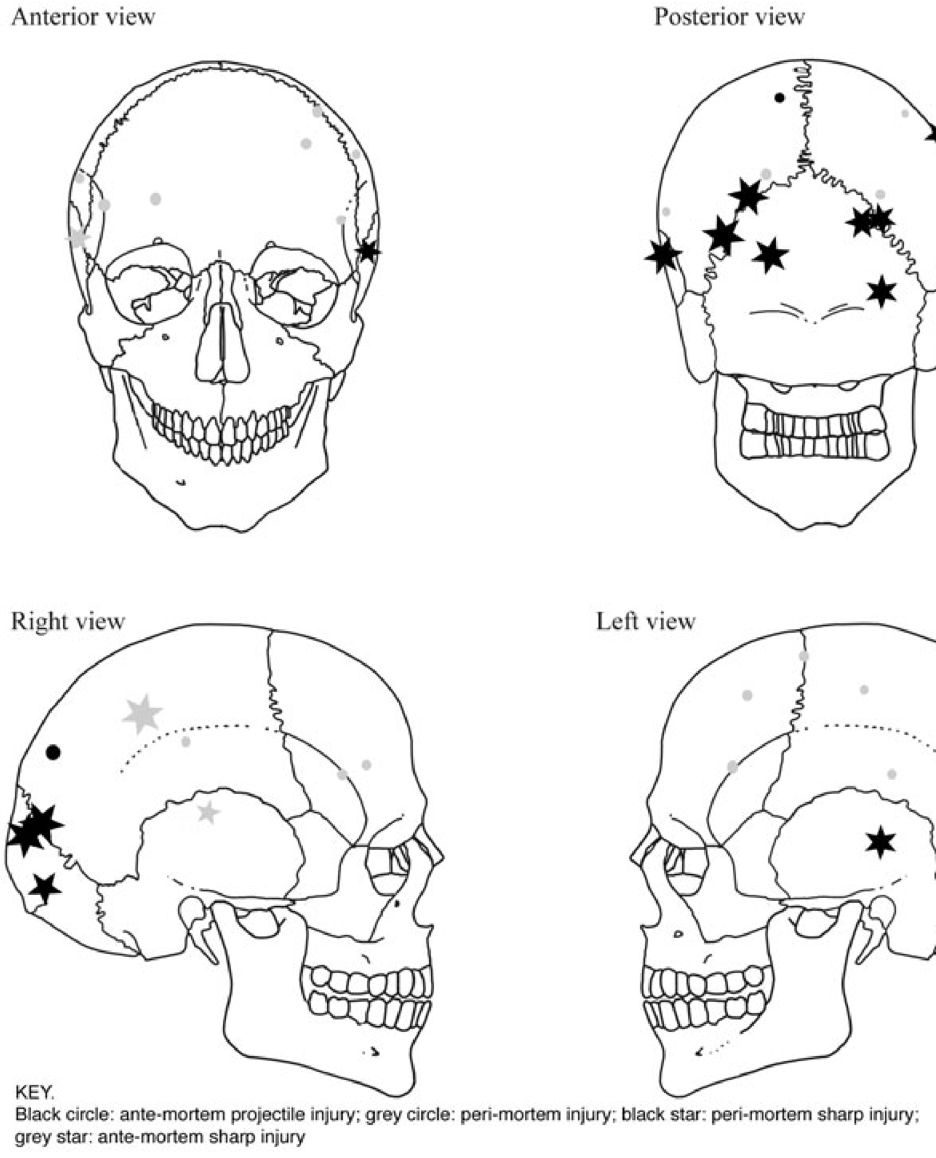

Figure 11
Location of ante- and peri-mortem projectile injuries in males (author).

Yorkshire). It is interesting to note that in Dorset most of these people were buried at Maiden Castle hillfort, where a large number of projectiles have been recovered, and the site architecture of which is considered to counter the use of such weapons (Avery 1986; Finney 2006). Nevertheless, this finding may be a false positive, since only a few Dorset hillforts have been excavated (e.g. Hod Hill), we have lost many catastrophic burials, and other individuals may not have sustained skeletal injuries from projectile weapons. Hamlin's (2007) study of Late Iron Age

Figure 12
Burial of an adult male at Maiden Castle, with sling-stones as grave-goods (© Dorset County Museum, Dorset Natural History and Archaeological Society).

funerary practices identified three people buried with sling-stones, two males from Maiden Castle – one of which was a middle-aged male who had a peri-mortem blunt projectile injury (Fig. 12) – and an adolescent buried in the small farmstead of Pins Knoll.[3] Another adolescent from Maiden Castle was buried with an arrow in their hands, and most probably died from a peri-mortem blunt-force cranial injury (Redfern 2007; Hamlin 2007; Wheeler 1943).

The exclusive involvement of Late Iron Age adult males in martial acts, based on the inclusion of weapons in burials, is rejected, since the relationships between age, sex and grave-goods are now understood to have more nuanced social meanings rather than to represent simplistic associations between sex and occupation/activities (Gibbs 2002). The inclusion of weapons in Durotrigian inhumations is a minority male burial rite, suggesting that their inclusion hints at more complex socio-cultural motivations (Hamlin 2007), whilst bioarchaeological evidence has independently proven the active participation of some Durotrigian females in interpersonal violence (Redfern 2006; 2008). The identification of peri-mortem and healed injuries in both sexes suggests that gender did not restrict an individual from participating in violent acts, particularly those employing projectiles. These weapons can be mastered (after considerable practice) by either sex from an early age (Dawe 1997), and are often used by women who regularly hunt to feed their families (e.g. Munson 2000; see also Noss and Hewlett 2008).[4] Brown Vega and Craig's (in press) experimental research found that the most effective

3 It is not possible to determine reliably the biological sex of adolescent skeletons (Lewis 2007). This individual was reburied after excavation.

4 The degree to which we are able to recognize musculoskeletal markers (MSM) and ligament injuries caused by throwing projectiles is not clear-cut. One study on a Neolithic Swedish sample (Molnar in press) cautiously suggested that, based upon male MSM development, part of their activities may have included archery and fishing with a harpoon. Clinical data obtained from studies of modern adult archers have shown that individuals will only suffer ligament injuries (e.g. rotator cuff) if they are not drawing the bow and firing correctly (Rayan 1992; Mann and Littke 1989), and one study observed an epiphyseal injury to the coracoid process in a child archer due to over-use of the shoulder (Naraen *et al.* 1999). Rotator cuff injuries and os acromiale were recorded in the Maiden

slingers were middle-aged males, which they consider to reflect sex differences in body dimensions but caution that this result belies a lack of cultural continuity in slinging practices. Thus, on current evidence, there is no reason to believe that children and females were not familiar with these weapons (see Brown Vega and Craig in press), or excluded from their manufacture and use (e.g. Gero 1991).

The presence of an adolescent with blunt-force cranial trauma (Redfern 2007) and the inclusion of projectiles in adolescent grave-goods (Hamlin 2007) suggest that active participation in martial activity began at this age, if not earlier, as the majority of people affected by injuries were young adults (20–35 years old) – a common mortality profile in martial contexts (Bishop and Knüsel 2005). This supports the hypothesis that weapon training began in adolescence, or before – perhaps marking the transition to adulthood in Late Iron Age society. Molloy and Grossman's (2008) analysis of the psychology and physiology of interpersonal violence shows that in order for people to fight effectively and efficiently, weapon handling must become instinctive – what they term 'muscle memory' – thereby increasing a person's chance of survival because they do not have to question their weapon handling and it allows them to make effective strikes against their opponent. Conditioning people to become unequivocal fighters, with the ability to fire at women and children, also suggests that training began early in life (Dyer 1985; Grossman 1996, 264–5, 257–8).

The focus of sharp projectile injuries to the back of the head indicates that these were sustained when the individual was prone or facing away from their attackers (Byers 2006; Novak 2000). But it is not clear how these data reflect the realities of violence: were people fleeing a battle, killed in a rout or already lying injured when they were hit? One insight may perhaps be gained from Livy's *History of Rome* (38.21), which notes that Gauls fighting on a slope sustained missile shots, including those from Cretan archers and slingers, to all sides of their bodies.[5] Forensic research has shown that it is very common for the back of the head to be targeted in executions (Kimmerle and Baraybar 2008), but because these samples are derived from attritional rather than catastrophic cemeteries, the context in which these injuries were sustained cannot be reliably proven. Additionally, it should be noted that it is possible that these sharp-force injuries were produced by daggers rather than projectiles (i.e. spear-tips or arrowheads), as their tip morphology is comparable (Byers 2006; see also Karger and Vennemann 2001). In contrast, the presence of blunt projectile injuries to all areas of the head (Fig. 11) does suggest

Castle population (author pers. ob.) but as these osseous lesions cannot be exclusively linked to the use of projectiles, the data are not presented here.

5 Livy's *History of Rome* (38.21): 'The Gauls feeling confident that on two sides they were unassailable directed their attention to the southern slope. To close all access on this side they sent 4000 men to seize a height which commanded the road . . . When they saw this, the Romans made ready for battle. Somewhat in front of the legions went the velites, the Cretan archers and slingers and the Tralli and Thracians under Attalus. The heavy infantry advanced slowly as the ground was steep and they held their shields in front of them, not because they expected a hand-to-hand contest, but simply to avoid the missiles. With the discharge of missiles the battle began, and at first it was fought on even terms as the Gauls had the advantage of their position, the Romans that of the variety and abundance of their missile weapons. As the struggle went on, however, it became anything but equal; the shields of the Gauls though long were not broad enough to cover their bodies, and being flat also afforded poor protection. On all sides they were being hit by the arrows and leaden bullets and javelins . . . But when the head of an arrow has gone in or a leaden bullet buried itself and it tortures them with what looks like a slight wound and defies all their efforts to get rid of it, they fling themselves on the ground in shame and fury at so small an injury threatening to prove fatal. So they were lying about everywhere, and some who rushed down on their enemy were being pierced with missiles from all sides.'

that sling-stones and pebbles were also used in barrages as Avery (1986) proposes. The presence of injuries to the face suggests that these may have been targeted hits; experienced slingers are able to fire projectiles accurately at a considerable range (Brown Vega and Craig in press; Harrison 2006). Harrison (2006) notes that the Roman historian Livy (38.29) recorded that slingers recruited from Aegium, Patrae and Dyme (Greece) had been trained from childhood to fire (from a distance) sling-stones through hoops, which would have enabled them to hit enemies' heads or any part of the face they wished.

The identification of multiple injuries suggests that these were sustained in a violent and concentrated battle, perhaps during the defence of or attack on a hillfort. The presence of healed injuries demonstrates that such events took place several times within a person's lifetime, with the bioarchaeological evidence providing only examples of injuries that damaged bone rather than soft tissue. We must assume, therefore, that the number of injuries in the past was far higher, particularly as it is possible to survive a penetrating projectile injury. Harrison's (2006) review refers to statements by Roman military historians that if blunt projectiles hit armour or an unprotected torso, superficial or shallow wounds were produced, which would not limit a soldier's capacity to fight (see also Baker 2009). This is also supported by clinical data derived from native Papua New Guinea, which found that people with non-fatal arrow injuries did not attend hospital for several days after sustaining the injury, and data from western India found that in a sample of 67 males, most did not go to hospital for 11 hours after the arrow injury (Madhok *et al*. 2005; van Gurp *et al*. 1990).

The use of missiles – arrows, bolts and stones – by the Roman army is well established (Southern 2007), as is their deployment of special units such as Balearic slingers, particularly in the Mediterranean during civil wars, but soldiers often carried slings for use in the field because the army considered them to be more deadly than arrows, with shot easily manufactured in the field or collected from the local area (Erdkamp 2007, 89). As the author has only been able to identify the injuries caused rather than the exact weapon used, it is possible that these injuries were sustained whilst fighting Vespasian and *Legio II Augusta*. Considering the date of these burials, the evidence for a Roman projectile point embedded in the 12th thoracic vertebra of a male from Maiden Castle, and the presence of Roman ballista bolts at Hod Hill, it is possible that many of these cranial injuries were produced by Roman rather than native weaponry (Cunliffe 2004, 222; Webster 1998, 245).

CONCLUSIONS

The bioarchaeological analysis of Late Iron Age human remains from Dorset has identified a range of sharp and blunt projectile injuries in people buried at hillforts – Maiden Castle and Poundbury Camp. The range of injuries sustained indicates that a variety of weapons were employed, such as spears, pointed and round sling-stones, larger pebbles, and perhaps arrows. One unique square perforation was observed in an adult male from Maiden Castle, and may reflect either a sharp projectile or sharp-bladed weapon injury. Blunt and sharp injuries were identified in both sexes, with males having more peri-mortem injuries present. Females were the only group to have healed blunt injuries present, and two males had evidence for healed sharp projectile injuries. The presence of healed injuries shows that assaults using projectile weapons occurred several times in a person's lifetime, and are most likely to reflect the minimum number of acquired injuries.

Many injuries appear to have targeted vulnerable areas of the head, particularly the face, which suggests that they were inflicted by highly skilled combatants who were able to sustain multiple focused attacks to reduce enemy numbers. It is suggested that these combatants included adolescents, females and males, whose weapon training had begun early in life. The presence of multiple injuries indicates that these were sustained in a concentrated attack, possibly by the Roman army or other Late Iron Age communities.

The independent bioarchaeological data for female exposure to and probable engagement in martial acts support the author's analysis of fracture patterns and trauma rates in Durotrigian females (Redfern 2008). These data contrast with the funerary evidence, where a minority of males and adolescents were buried with projectiles or other weaponry. This suggests that their inclusion relates to other socio-cultural factors (Hamlin 2007), rather than reflecting the relationship between gender and participation in violence.

This bioarchaeological study has demonstrated that in the absence of weaponry, human remains can be used to understand the range and type of weapons used in past societies, and it highlights the need for osteological data to play more of a role in the interpretation of British Late Iron Age societies. These Durotrigian skeletons also show us that first century BC to first century AD communities were trained to participate in vicious, bloody acts of martial violence, with no quarter given to younger members of a tribe.

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