

**Title: Newly-discovered Neanderthal remains from Shanidar Cave, Iraqi Kurdistan, and their attribution to Shanidar 5**

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## **Abstract**

The Neanderthal remains from Shanidar Cave, excavated between 1951 and 1960, have played a central role in debates concerning diverse aspects of Neanderthal morphology and behaviour. In 2015 and 2016, renewed excavations at the site uncovered hominin remains from the immediate area where the partial skeleton of Shanidar 5 was found in 1960. Shanidar 5 was a robust adult male estimated to have been aged over 40 years at the time of death. Comparisons of photographs from the previous and recent excavations indicates that the old and new remains were directly adjacent to one another, while the disturbed arrangement and partial crushing of the new fossils is consistent with descriptions and photographs of the older discoveries. The newly-discovered bones include fragments of several vertebrae; a left hamate; part of the proximal left femur and a heavily crushed partial pelvis; and the distal half of the right tibia and fibula and associated talus and navicular. All these elements were previously missing from Shanidar 5, and morphological and metric data are consistent with the remains belonging to this individual. A newly-discovered partial left pubic symphysis indicates an age at death of 40–50 years. The combined evidence strongly indicates that the new finds can be attributed to Shanidar 5. Ongoing analyses of associated samples, including for sediment morphology, palynology, and dating, will therefore offer new evidence as to how this individual was deposited in the cave, and permit new analyses of the skeleton itself and broader discussion of Neanderthal morphology and variation.

**Keywords:** hominin skeletal remains; postcrania; hand; foot; morphology

**Funding**

This work was supported by the Leverhulme Trust (RPG-2013-105, held by GB). EP is supported by the Leverhulme (ECF-2015-520) and Isaac Newton Trusts. MML's and FC's research is supported by the European Research Council (ERC #295907). The funding bodies had no role in study design; in the collection, analysis and interpretation of data; in the writing of the report; or in the decision to submit the article for publication.

## 1. Introduction

Excavations led by Ralph Solecki from 1951 to 1960 at Shanidar Cave in the Zagros Mountains, Iraqi Kurdistan (Figure 1A, Supplementary Figure S1), yielded the remains of 10 Neanderthal individuals (Solecki, 1961, 1963; 1971; Trinkaus, 1983b; Cowgill et al., 2007). The skeletons vary in their degree of completeness, but range in age from infants to older adults at the time of death and represent both males and females (Trinkaus, 1983b; Cowgill et al., 2007). The Shanidar Neanderthals have played a key role in debates regarding Neanderthal biology and behaviour, ranging from social behaviours such as care for the ill and injured (Dettwyler, 1991; Trinkaus, 1983b), mortuary practices (Leroi-Gourhan, 1975; Solecki, 1975; Gargett, 1999; Sommer, 1999), interpersonal violence (Stewart, 1969; Trinkaus and Zimmerman, 1982; Trinkaus, 1983b; Churchill et al., 2009), artificial cranial modification (Trinkaus, 1982; Chech et al., 1999; Clark et al., 2007), aspects of growth (Martín-González et al., 2012), health (Trinkaus, 1983b; Crubézy and Trinkaus, 1992; Berger and Trinkaus, 1995; Anton, 1997), diet (Henry et al., 2011) and demography (Trinkaus and Thompson, 1987); as well as morphological variation and its causes (Trinkaus, 1981, 1983b; Pearson, 2000; Pablos et al. 2017).

[FIGURE 1 NEAR HERE]

Solecki (1961, 1963, 1971) ascribed the original burials to two main periods within his 'Layer D' (Figure 1B). Shanidar 1, 3 and 5 were assigned to around 46–50 thousand years ago (ka) based on a radiocarbon date from charcoal associated with Shanidar 1 (Solecki, 1971). Although this date needs to be regarded cautiously, more recent re-dating of the site has broadly supported this chronology (Cowgill et al., 2007). Shanidar 2, 4, 6, 7, 8, 9 and 10 were assigned to an earlier period estimated to be between 60 and 100 ka (Solecki, 1971; Cowgill et al., 2007), although these are inferred rather than direct dates and should therefore be taken as tentative (Cowgill et al., 2007).

### *1.1. The Shanidar 5 individual*

Shanidar 5 was originally discovered by Ralph Solecki, who excavated the skeleton with T. Dale Stewart in August 1960 (Solecki, 1961). The fragmented remains of this individual were found at a depth of 4.39 – 4.48 m below Solecki's datum, at the top of his 'Layer D' (Solecki, 1961; Trinkaus, 1977; Figures 1B and 2A). Therefore, along with Shanidar 1 and 3, Shanidar 5 was one of the stratigraphically most recent Neanderthal individuals discovered at the cave, and Solecki considered Shanidar 1 and 5 to have been contemporaneous. Analysis of charcoal recovered close to Shanidar 1 gave a radiocarbon date of ca. 46–50 ka (Solecki, 1961, 1971).

[FIGURE 2 NEAR HERE]

The remains of Shanidar 5 were “badly damaged and scattered” (Trinkaus, 1977: 34), with many of the bones found beneath or between rocks, and with evidence of additional disturbance by rodent activity. On the basis of its position, Shanidar 5 was interpreted as the victim of rock fall (Solecki, 1961; 1971; Stewart, 1977; Trinkaus, 1983b). The pelvis was found crushed below a large rock, on top of which was the cranium. This large rock was thought to have fallen onto the individual's back pushing the body face down and forcing the head back so that it came to lie above the rock (Trinkaus, 1983b: 27), and the lower limb bones lay partially under other smaller rocks (Stewart, 1977: Figure 2). The skeleton was generally very fragmented, and the lower limb bones were friable in places. The lower limbs were flexed and lying on their anterior surfaces in approximate articulation but demonstrating some disturbance (Solecki, 1971; Stewart, 1977; Trinkaus, 1977, 1983b). Some remains of the upper limbs and torso were also recovered “out of context” (Trinkaus, 1983b: 27). The cranium and pelvis were removed along with the large stone, while the limb bones were recovered separately. All the remains were first unpacked and studied by Erik Trinkaus in 1976

(Trinkaus, 1977, 1983b) at the Iraq Museum, Baghdad, where they have been curated since their excavation.

Trinkaus (1977, 1983b, 1987) identified Shanidar 5 as a male, aged 40 years or more at death (based on femoral histomorphology and supported by dental wear), and noted the individual's exceptionally large and robust cranium (Trinkaus, 1982, 1983b). Although a number of the major bones were at least partially recovered, the skeleton was incomplete, and missing in particular were the mandible and most of the dentition, much of the vertebral column, both humeri, the left radius, the right tibia and fibula, parts of both hands and the whole of both feet (Trinkaus, 1983b). The combination of the large overburden that lay above parts of Shanidar 5 and the timing of the discovery of the skeleton at the end of the last season of excavation at the site, and within days of Shanidar 4, 6, 8 and 9, meant that the material was not fully recovered. Indeed, Trinkaus (1977) stated that "portions of Shanidar 5 were left in situ" (p34) and that future excavations might well unearth more of the skeleton.

## 1.2 *New investigations at Shanidar Cave*

In 2014, at the invitation of the Kurdish regional government, new excavations began at Shanidar Cave with the aim of revisiting Solecki's original trenches (Figure 1C, Supplementary Figure S1) to obtain a more detailed environmental and cultural record, and to re-investigate the chronology and nature of the Neanderthal burials (Reynolds et al., 2015, 2016).

During the 2015 and 2016 seasons, section cleaning and new excavations at the edge of Solecki's trench, in the vicinity of the Shanidar 5 find-spot, yielded new hominin remains (Reynolds et al., 2015, 2016). This paper presents the first description of these remains, and attempts to answer two specific questions. The first is whether the material can be confidently identified as Neanderthal. The

precise location of the new finds make it very likely that these are Neanderthal remains, but the presence of modern humans in the broader southwest Asian region from around 100 ka onwards (McCown and Keith, 1939; McDermott et al., 1993) makes it important to confirm the taxonomic affinity of every set of remains found in this area, particularly given the close proximity of the remains we describe here to presumed Upper Palaeolithic (Baradostian) levels at the site. Second, we discuss whether the remains likely represent a single individual, and in particular Shanidar 5. The identification of the new material as belonging to this previously incomplete skeleton would offer a direct link between the two excavations and the novel information arising from the detailed modern studies which are currently underway, including dating, stratigraphic, sedimentological, palaeontological and artefactual analyses.

## **2. Materials and Methods**

New excavations at Shanidar Cave began in 2015 with the aim of establishing a high resolution chronological, cultural, sedimentological and palaeoenvironmental framework for the Palaeolithic occupations by revisiting Solecki's trench and conducting new targeted investigations within and adjacent to it. During the course of excavations in 2015, a partial, fragmented lower right leg and part of the right foot preserving a complete talus and navicular were discovered, all in approximate articulation with one another (Figure 3). This find was followed by that of the left hip region (partial pelvis and proximal left femur) in spring 2016 (Figure 4), which was directly adjacent to the 2015 finds and tight against the base of a medium-sized stone. The pelvic remains included a partial pubic symphysis which can offer evidence on age at death. Other bones from the left hand, right and left feet and trunk were also discovered with both these finds, which are described below. Preservation of the remains is very variable. In general they are crushed and highly fragmented. Some elements, such as the talus and navicular, are well preserved, whereas others, such as the hip remains, were

fragile and friable. There is evidence of disturbance by rodent burrowing, particularly in the case of the right foot (Figure 3).

[FIGURE 3 NEAR HERE]

[FIGURE 4 NEAR HERE]

Comparison of our excavations with published photographs from those carried out by Solecki provides a strong indication that the new remains are from Shanidar 5. A rock beside the left hip remains discovered in 2016 can be confidently identified in a published image of the Shanidar 5 limbs in situ (Figure 2), and so demonstrates fairly conclusively that the left hip remains lay directly below and adjacent to the lower limb bones recovered in 1960. In addition, although the photographs are not from precisely the same angle, the left femoral shaft visible in Solecki's photograph aligns almost perfectly with the more proximal section of left femoral shaft recovered in 2016. Nonetheless it remains important to examine additional evidence that might link the old and new finds, including comparisons of morphology and dimensions with published data on Shanidar 5, other Neanderthals and modern humans, and confirmation that no elements are duplicated, in order to further demonstrate that we are dealing with a single individual.

The new remains are on loan for study to the McDonald Institute of Archaeological Research at the University of Cambridge, UK, with the kind permission of the Kurdistan General Directorate of Antiquities, and will be returned to the Directorate following study for long term curation. The new remains were measured using digital sliding callipers (Mitutoyo Inc., Japan) to the nearest 0.1 mm, or coordinate callipers (GPM, Switzerland) to the nearest 1 mm where appropriate. Sources for measurement definitions vary by element, and are referenced in the relevant tables. In the comparison of the left hamate with published measurements from Shanidar 3 and 5 right hamates to assess whether the new bone may pertain to one of these individuals, bilateral asymmetry was



calculated as the absolute difference between measurements of right and left bones (see also Supplementary Information).

Age at death was estimated using pubic symphyseal morphology following both the Todd and Suchey-Brooks methods (Todd, 1920, 1921; Brooks and Suchey, 1990) in accordance with current recommendations (Buikstra and Ubelaker, 1994; White et al., 2011). Any age estimates must be treated with caution, as the standards commonly applied are based on recent modern human populations and their reliability even in recent populations can be problematic (e.g. Molleson and Cox, 1993; Schmitt et al., 2002), while their applicability to early *Homo sapiens*, let alone to other hominins such as Neanderthals (Trinkaus, 1983b), is unknown. Degeneration of the joint surfaces might be accelerated by elevated activity levels (Mays, 2015), which is often inferred for Neanderthals given skeletal evidence for high levels of biomechanical loading (Trinkaus, 1983a, 1983b; Ruff et al., 1993; Trinkaus and Rhoads, 1999; Pearson et al., 2006; Weaver, 2009).

To give new insight into body size, stature was estimated from the total talus length (Martin number 1a) using the equation derived from Euroamerican males by Pablos et al. (2013a), and using equations for various talar measurements provided by Will and Stock (2015). Body mass was also estimated using equations for talar measurements for estimating body mass directly (McHenry 1992) and by using talar dimensions to estimate femoral head diameter (Will and Stock 2015), and in turn estimate body mass from femoral head diameter, taking the average estimate generated by the equations of Ruff et al. (1991), McHenry (1992) and Grine et al. (1995) for femoral head diameters  $\leq 47$  mm, and just Ruff et al. (1991) and Grine et al. (1995) for femoral head diameters  $> 47$  mm, following Will and Stock (2015) and Ruff (2010). Pooled sex equations were used in all cases following Plavcan et al. (2014).

It should be noted that the approaches for stature and body mass estimation suffer from multiple problems. The equations are derived from recent *H. sapiens* samples, which may have differed from other hominin species in the relationships between body size and skeletal dimensions. It is widely acknowledged that variation in limb and trunk proportions in relation to climate and other factors reduce the reliability applying equations derived from one population to skeletons from another, even within species (e.g., Pearson 1899; Trotter and Gleser, 1952; Trotter, 1970; Holliday and Ruff, 1997; Auerbach and Ruff, 2008; Pomeroy and Stock, 2012; Ruff et al. 2012). In addition, the long bones of the limbs, especially the lower limbs, are the preferred individual elements for stature estimation and provide the most reliable results (e.g., Pablos et al., 2013a; Will and Stock, 2015), presumably because those bones make a substantial contribution to an individual's actual stature. Furthermore, the method of Will and Stock (2015) involves multiple estimates (femoral head diameter from talar dimensions, then body mass from femoral head diameter). Errors will be introduced at each step of estimation, potentially limiting the reliability of results (Feldesman and Lundy, 1988; Porter, 2002; Will and Stock, 2015). Sample sizes from which the equations were derived were small ( $n = 18-19$ ), which may also limit their reliability. Therefore the estimates generated here should be treated with extreme caution, although are presented since they potentially offer additional new data on body size among Neanderthals and the reliability of the methods themselves, which were developed from (largely recent) *H. sapiens* skeletons, when applied to hominin species such as Neanderthals.

### **3. Results**

The new skeletal remains recovered from the area around the original Shanidar 5 skeleton are listed in Table 1, followed by descriptions of the individual specimens by anatomical region and a discussion of estimated age at death, body size estimates and pathological changes to the skeleton.

Larger and more complete bones or fragments are illustrated in the text, while the remaining elements are illustrated in Supplementary Figure S2 (see Table 1 for details).

[TABLE 1 NEAR HERE]

### 3.1. Axial skeleton

3.1.1. Vertebrae Three vertebral fragments and a piece of the sacrum were found in the region around the tibia/fibula/tarsals.

A left superior facet of a probable upper cervical vertebra (SH15A 72.2) was found in two refitting pieces, including the base of the transverse process and lateral margin of the transverse foramen. Following Gómez-Olivencia et al. (2013a) the sagittal and transverse diameters of the facet are 15.0 mm and 12.2 mm respectively.

SH15A 72.1 is the complete spinous process of a probable mid-thoracic vertebra, identified on the basis of its size, narrow mediolateral dimensions, and lack of bifurcation. Following Gómez-Olivencia et al. (2013a), the transverse diameter of the spinous process tip is 3.1 mm, and the minimum transverse diameter of the spinous process is 5.5 mm.

An 18 mm by 14 mm section of the margin of a vertebral body (SH15A 64.1) is tentatively identified as thoracic on the basis of size. The annular epiphysis is fully fused and there is no sign of any degenerative changes.

An almost complete adult thoracic vertebral body (SH16 269: Figure 5) was recovered from the region of the left proximal femur and pelvis. The preserved portion includes part of the left pedicle,

but the right pedicle is missing and there is minor damage to the lateral aspect of the body on the right side. Based on size (Table 2) and shape, this vertebra is from the mid-upper thoracic region, as its dimensions fall between Neanderthal second and seventh thoracic vertebrae as given by Gómez-Olivencia et al. (2013b). The annular epiphyses are both well fused, indicating an adult individual. The left superior costal demifacet is almost imperceptible, but the corresponding inferior demifacet is more clearly visible, while on the right the demifacet is missing superiorly and very small inferiorly. There is a slight anterior extension to the inferior surface of the body projecting approximately 1.8 mm from the normal margin of the body representing mild degenerative changes (see section 3.5). While the vertebrae, and especially the thoracic vertebrae, are commonly thought to be of limited value in assessing taxonomic affinities, Gómez-Olivencia et al. (2013b) suggest that the Neanderthal thoracic spine does show some unique characters. However, without confidently identifying the anatomical location of the vertebra, these criteria cannot be applied here.

[FIGURE 5 NEAR HERE]

SH15A 64.4 is a small fragment of the posterosuperior aspect of the left sacro-iliac joint of the sacrum, which includes part of the posterior surface of the sacrum. The whole fragment measures 21 mm by 23 mm.

[TABLE 2 NEAR HERE]

3.1.2. Pelvis An area of highly fragile and extensively crushed pelvic remains was found in 2016 in association with the remains of the proximal left femur, tight against the west side of the rock identified in Figure 2. Nonetheless, a number of identifiable fragments were recovered including the left pubic symphysis (SH16 239.1) and left superior pubic ramus (SH16 239.2) which are informative on age at death and taxonomy respectively. The original remains of Shanidar 5 included only

fragments of the iliac blades which could not be assigned to a specific side of the body (Trinkaus, 1983b), limiting the possibility of matching the new remains to the existing ones. Portions of the ilia were also discovered during the 2016 excavations (SH16 278), but as with those found in 1960, these are too fragmented to be informative. However, it is notable that all of the identifiable new pelvic remains were from the left side of the body, where side could be determined.

The pubic symphysis (SH16 239.1) comprises 6 refitting fragments, and while incomplete, preserves a substantial part of the inferior half of the pubic symphysis, including the inferior extremity, around 65% of the dorsal margin, and a small section of the ventral margin (Figure 6). The small preserved section of inferior pubic ramus suggests a relatively wide subpubic angle characteristic of Neanderthals and modern human females (Trinkaus, 1983b; Rak, 1990), although it was insufficiently preserved to allow an estimated measurement of the angle.

[FIGURE 6 NEAR HERE]

SH16 239.2 is a partial left superior pubic ramus measuring 35 mm long and comprised of 3 fragments. In common with some other Neanderthal specimens, it has a clearly-developed, flat and blade-like (but damaged) crest along the superior edge (McCown and Keith, 1939; Stewart, 1960; Trinkaus, 1976, 1983b; Rak and Arensburg, 1987). Other identifiable fragments include a more lateral fragment of the pubis (SH16 245.3) and unsided fragments of the obturator foramen (SH16 239.3 and 245.4). All the pelvic remains described thus far were recovered from the region where the proximal femur was found, but at least one fragment was also recovered from the region around the tibia/fibula/tarsals: SH15A 65 is a fragment of the visceral surface of the left greater sciatic notch measuring approximately 30 x 30 mm. It is insufficiently preserved to permit sex estimation, but includes the very edge of the left auricular surface and part of the arcuate line.

### 3.2. Upper limb

Two carpals, the left hamate and a fragment of left trapezoid, are the only remains from the upper limbs uncovered by the new excavations.

3.2.1. Hamate The adult left hamate was retrieved in the spring 2015 field season from an unstratified context in the vicinity of the original Shanidar 5 finds, before the rest of the material reported here was discovered. The hamate is one of the more distinctive bones of the Neanderthal wrist, having an absolutely and relatively large and robust hamulus (Trinkaus, 1983b; Niewoehner et al., 1997). Together with the fact that the right (but not left) hamates of Shanidar 3 and Shanidar 5 were recovered in previous excavations, this offers the possibility of attributing the left hamate to one (or neither) of these individuals and further testing the Neanderthal affinity of the remains. Shanidar 3 was found close to, but deeper than, Shanidar 5 and so merits consideration here given the unstratified nature of the new hamate.

SH15 590 is broken into two refitting fragments which preserve most of the body and the entire hamulus (Figure 7). There is a portion of the dorsal surface of the body missing, including the dorsolateral aspect of the fifth metacarpal articular facet and the distal portion of the capitate facet. Visually, the hamate demonstrates the long, thick and projecting hamulus and relatively short body characteristic of Neanderthals, which is confirmed by metric data (Table 3, Figure 8). While there is overlap between Neanderthal and *H. sapiens* morphology, the most diagnostic measurements for distinguishing between published data on Neanderthals, Late Pleistocene *H. sapiens* and a broad geographic sample of recent *H. sapiens* (see Table 3 and Supplementary Information) include hamulus length and hamulus projection index (hamulus projection relative to maximum height). Bivariate plots of articular length and hamulus projection index against hamulus length show that SH15 590 plots with Neanderthals rather than *H. sapiens* (Figure 8).

[FIGURE 7 NEAR HERE]

[FIGURE 8 NEAR HERE]

[TABLE 3 NEAR HERE]

In order to assess whether the left hamate could plausibly belong to either of the previous individuals preserving the right hamate and found in the vicinity (Shanidar 3 or 5), the degree of bilateral asymmetry was calculated for paired right and left bones from a range of recent *H. sapiens*, and the results compared to the differences between each of the Shanidar 3 and 5 right hamates and the SH15 590 left hamate (Supplementary Information and Supplementary Tables S 1 and S2). The results indicate that SH15 590 could plausibly be attributed to Shanidar 5, but not to Shanidar 3. Excluding the maximum height measurement, which was estimated due to the fragment missing from SH15 590, the mean difference in measurements between SH15 590 and the Shanidar 3 right hamate was 2.0 mm, approximately 3 times greater than that observed in the modern human sample, and considerably larger than the mean difference between SH15 590 and the Shanidar 5 right hamate (0.3 mm). This mean difference falls within the range for the difference between right and left hamate bones in the *H. sapiens* comparative sample (0.2–0.7 mm), indicating that the size of SH15 590 is consistent with it belonging to Shanidar 5. The SH15 590 left hamate is shown compared to the Shanidar 5 right hamate in Supplementary Figure S3.

3.2.2 Other hand remains A small fragment of the left trapezoid (SH15A 64.3) preserves partial facets for the capitate, scaphoid, and the medial portion of the second metacarpal. It is extensively damaged and covered by a hard, whitish concretion (similar to the tibia and fibula remains) on approximately 50% of its surface.

### 3.3. Lower limb

3.3.1. Femur The proximal left femur was found in association with, and partly overlain by, parts of the left side of the pelvis (Figure 4). The elements were lying with their anterior surfaces down and posterior surfaces facing upward (as with the original Shanidar 5 finds: Trinkaus 1977, 1983b). Much of the femoral head, trochanter and pelvic remains were extensively crushed and highly fragile.

A ~50 mm length of the posterior half of the proximal left femoral shaft (i.e., the subtrochanteric region) was relatively well preserved and was retrieved in seven refitting fragments (SH16 238: Figure 9). The very base of the lesser trochanter, as well as sections of the spiral line, pectineal line, linea aspera and gluteal tuberosity are identifiable. The preserved area of gluteal tuberosity is rugged but insufficiently preserved to allow comparative measurements of the midtuberosity breadth or to assess the presence of a hypotrochanteric fossa (cf. Trinkaus 1983b). The cortex of the bone is 8.7 mm thick in the region just distal to the root of the spiral line.

[FIGURE 9 NEAR HERE]

A fragment of the posterolateral part of the lower edge of the left greater trochanter (SH16 271.1), measuring approximately 40 x 20 mm, was also identified. Other fragments of the greater trochanter and small fragments of the femoral neck (SH16 245.1) and head (SH16 245.2) could be identified, although none of the remains were sufficiently intact to permit extensive metric or morphological analysis, or to allow an independent attribution to the left or right side of the body.

3.3.2. Tibia and fibula Substantial portions of the distal half of an adult right tibia and fibula were found lying on their medial side and approximately in articulation with one another and with the talus and navicular, although some movement from original anatomical position was evident (Figure 3). The bones lay on a 45 degree slope, with the tarsals lying at the highest point (Reynolds et al.,



2015, 2016). A burrow had disturbed the rest of the foot (Figure 3: Reynolds et al., 2015). Both the tibia and fibula were variably preserved and very fragmented, and the proximal ends of both bones and the distal end of the fibula were entirely missing. This severely limits any metric and morphological analyses of the remains. In both cases, the tibial and fibular shafts have a relatively thick cortex and heavily striated external cortical surface. Both the tibial and fibular fragments are covered by a patchy thin layer of a hard, whitish deposit which particularly affects the distal tibia and invades the trabecular bone along the lines of long-standing breaks (Figure 9).

The distal epiphysis of the right tibia is largely complete, although missing the medial malleolus. The talar facet is broken diagonally into two refitting fragments, although some damage has occurred to the broken edges. Nonetheless the refit between fragments is sufficiently tight to permit a reliable measurement of the distal lateral articular breadth, which is 29.3 mm. While a substantial part of the Shanidar 5 left tibia was recovered previously (Trinkaus, 1977, 1983b), this did not include the antimere of the distal articular surface we describe here. Nevertheless, the distal lateral articular breadth of SH15A 64.12 is intermediate between those recorded for Shanidar 1 (33.0 mm) and Shanidar 2 (28.6 mm): Trinkaus, 1983b), thus within the size range of the larger of the Shanidar Neanderthal remains. The posterior border of the joint surface shows slight lipping along most of its length indicative of mild osteoarthritic changes (Rogers and Waldron, 1995).

The SH15A 64.12 distal right tibia displays a lateral ankle flexion (or 'squatting') facet (Figure 9) measuring 14.9 mm by 4.5 mm at its greatest extent. Ankle flexion facets are extensions of the distal tibial and/or talar articular surfaces due to habitual hyperdorsiflexion of the ankle joint (Trinkaus, 1975b; Capasso et al., 1999). These lateral facet extensions on the distal tibia are common among Neanderthals, affecting 83% of European and southwest Asian individuals studied by Trinkaus (1975b), and are observed on the tibiae of Shanidar 1 and 3 (although not Shanidar 2: Trinkaus, 1983b). These facets are often considered to indicate habitual squatting behaviour, although other

causes have also been postulated such as locomotor stresses associated with travelling over uneven or steep terrain (Trinkaus, 1975b; Capasso et al., 1999).

3.3.3 Talus A small portion of an adult left talus (SH15A 64.5 and 76.1) and a complete right talus (SH15A 69.1) were recovered. The left talus is represented only by two small refitting fragments of the medial posterior process and the posterior-most margin of the posterior subtalar facet. While these fragments are too small to be measured or extensively described, their morphology matches the right bone very closely (Supplementary Figure S4), suggesting that they belong to one individual.

The complete right talus (SH15A 69.1) was found in articulation with the right navicular. It demonstrates an old postmortem transverse break across the neck region, but the fragments refit closely (Figure 10). While there is some minor erosion to the margins of the joint surfaces, the talus is in extremely good condition.

[FIGURE 10 NEAR HERE]

Many characteristics of Neanderthal tali fall within the modern human range, albeit tending to have larger joint surfaces and to fall at the more robust end of the distribution (Rhoads and Trinkaus, 1977; Trinkaus, 1983b; Mersey et al., 2013; Pablos et al., 2013b, 2017). The morphology of SH15A 69.1 is consistent with this pattern. Characteristics previously identified as distinguishing Neanderthal tali from those of *H. sapiens* include a short head and neck relative to the trochlea, a mediolaterally wide head, a broad lateral malleolar facet, a short medial subtalar facet, and a square trochlea (Rhoads and Trinkaus, 1977; Trinkaus, 1983a, 1983b; Pablos et al., 2013b, 2017).

Comparisons of measurements from SH15A 69.1 with published data (Table 4) indicate that it shares a short neck and head relative to the trochlea with published Neanderthal specimens (Trinkaus, 1975a, 1983a, 1983b; Rhoads and Trinkaus, 1977; Pablos et al., 2013b), with a head-neck length/trochlear length ratio of 59.0. This falls closer to the Neanderthal than modern European and African means ( $56.1 \pm 6.4$  vs.  $62.6 \pm 5.2$  and  $65.0 \pm 6.3$  respectively: Rhoads and Trinkaus, 1977), but is still within the modern human range. The head is mediolaterally broad at 35.6 mm, consistent with the Neanderthal mean ( $\pm$  standard deviation) of  $34.7 \pm 3.4$  mm ( $n = 23$ ) but greater than the modern human mean of  $32.5 \pm 2.9$  mm ( $n = 162$ , Pablos et al., 2013b), although again there is overlap between the species. The lateral malleolar facet is not particularly broad (9.8 mm), although again there is considerable overlap between *H. sapiens* and Neanderthals in this characteristic (mean  $9.4 \pm 2.2$  mm,  $n = 112$  and  $10.7 \pm 2.5$  mm,  $n = 24$  respectively, data from Pablos et al., 2013b). SH15A 69.1 also shows a short medial subtalar facet (18.1 mm) compared with a modern human mean of  $22.0 \pm 3.7$  mm ( $n = 111$ ), but comparable with a Neanderthal mean of  $19.8 \pm 3.3$  mm ( $n = 11$ , data from Pablos et al., 2013b).

The talus also shows other morphological characteristics more common in Neanderthals than *H. sapiens*. The trochlea is square, rather than showing the posteriorly narrow and the anterior and middle calcaneal articular surfaces are completely fused. This fusion of the facets is seen in 96% of Neanderthals ( $n = 25$ , data from Trinkaus, 1975a; Mersey et al., 2013; Pablos et al., 2012) and all 17 specimens from Sima de los Huesos (Pablos et al., 2012, 2013b). This compares with 88.9% of Pleistocene *H. sapiens* ( $n=17$ ) and 55-75% of individuals in samples of recent *H. sapiens* (Trinkaus, 1975a: Table 64; Pablos et al., 2012). Finally, there is an anterior extension of both the medial malleolar and medial trochlear articular surfaces. The former is found in all Neanderthal individuals ( $n=19$ ) and 52-100% of individuals in recent modern human samples, while the latter characterises 47.2% of Neanderthals ( $n=18$ ) and 42-100% of individuals in recent modern human samples (Trinkaus, 1975a, b).

Similar to the distal tibia and navicular articular surfaces, there is slight lipping around the margin of the posterior calcaneal facet and the inferior edges of the medial and lateral facets, consistent with mild joint degeneration. However, there is no lateral ankle flexion facet on the superior talar surface to correspond with that of the distal tibia.

[TABLE 4 NEAR HERE]

3.3.4. Navicular SH15A 69.2 is a complete adult right navicular found in articulation with the right talus (SH15A 69.1). It is extremely well-preserved, with only minor damage to the margins of the articular surfaces (Figure 10). The navicular demonstrates clear Neanderthal affinities: it is broad, with a markedly expanded tuberosity for the attachment of the plantar calcaneo-navicular ligament and the insertion of the tibialis posterior muscle. This expanded tuberosity is commonly observed in other Neanderthal specimens (McCown and Keith, 1939; Heim, 1982; Trinkaus, 1983b; Harvati et al., 2013; Mersey et al., 2013) and to a lesser extent in the earlier Sima de los Huesos hominins (Pablos et al., 2007), but distinct from *H. sapiens*. Even the earliest relatively complete modern humans (*H. sapiens*), from Skhul and Qafzeh in the southwest Asia, lack a pronounced tuberosity (McCown and Keith, 1939; Vandermeersch, 1981). The expanded tuberosity is thought to indicate reinforcement of the medial longitudinal arch as a response to greater overall loading and consequent robustness of the Neanderthal lower limb skeleton (Rhoads and Trinkaus, 1977; Vandermeersch, 1981); Trinkaus, 1983a, 1983b. In common with other Neanderthal navicular bones (Heim, 1982; Mersey et al., 2013), there is no groove between the talar facet and the tuberosity, reflecting expansion of the latter. The lateral cuneiform facet is deep and concave, the medial cuneiform facet is well defined and relatively triangular in shape, and the talar facet is subrectangular. Slight lipping of the margin of the talar articular surface is present inferomedially and superolaterally.

Measurements of the SH15A 69.2 navicular (Table 5) confirm the expansion of the tuberosity and the Neanderthal affinities of this specimen. Neanderthals are characterised by similar levels of thickness at the medial and lateral cuneiform facets of the navicular compared with modern humans, as reflected by the wedging index, and high maximum thickness relative to the minimum thickness compared with modern humans, as illustrated in Figure 11. SH15A 69.2 falls clearly within the Neanderthal range, and is outside of the *H. sapiens* range of variation, for both the wedging index and the relationship between maximum and minimum thickness. Similarly, the thickness of the tuberosity relative to the minimum (i.e., lateral) thickness of the navicular (tuberosity thickness index) is 302.9, towards the upper end of the Neanderthal range (236.7–330.7) and more than 2 standard deviations about the mean of a recent Native American sample ( $212.3 \pm 26.7$ ,  $n = 39$ ; Trinkaus, 1983b) and much larger than the early *H. sapiens* remains of Skhul 4 (220). SH15A 69.2 has a low wedging index (minimum relative to maximum thickness) at 34.2, compared with a mean of 49.2 for a modern human sample given by Harvati et al. (2013) and the values for early *H. sapiens* individuals, including Skhul 4 (McCown and Keith, 1939) and Omo 1 (Pearson et al., 2008: 44.8 and 49.2 respectively), but within the range of published Neanderthal specimens (31.0–45.6).

[FIGURE 11 NEAR HERE]

[TABLE 5 NEAR HERE]

3.3.5. Other tarsals Other tarsal bones recovered are partial and highly fragmentary, precluding any detailed comparative analyses. Identifiable fragments included a small fragment of the right calcaneus (lateral edge of the calcaneal tuberosity: SH15A 64.16), the dorsal half of the left intermediate cuneiform (SH15A 64.2), and a small fragment of left lateral cuneiform (partial navicular/intermediate cuneiform facet: SH15A 64.10). A limited suite of measurements could be collected from the intermediate cuneiform (Table 6), and comparisons with published data on the

Sima de los Huesos hominins, other Neanderthals, Late Pleistocene and recent *H. sapiens* indicate that SH15A 64.10 falls within the range of all of these groups.

[TABLE 6 NEAR HERE]

3.3.6. Metatarsals The metatarsals are similarly represented only by fragments which were insufficiently preserved to allow detailed comparative analyses. A fragment of the base of the fifth left metatarsal (SH15A 64.8) and a metatarsal head (possibly second or third left, based on the size and orientation of the head: SH15A 64.9) were identified. Measurements were only possible on the metatarsal head (SH15A 64.9) and are given in Table 7. There is considerable overlap between recent *H. sapiens* and Neanderthals in these measurements (Pablos et al., 2012: Table 4).

[TABLE 7 NEAR HERE]

3.3.7. Pedal phalanx A single distal toe phalanx (SH16A 591) was recovered in September 2016 from the same area as the other remains described in this paper (Figure 12). It is included here on the grounds that it most likely pertains to the same individual, although this cannot be confirmed morphologically due to a lack of other similar bones. It is likely a distal phalanx of the second toe (DP-2) based on size and morphology, although it is large compared with recent *H. sapiens* material. It is relatively short and wide and lacks lateral deviation of the distal tuberosity relative to the orientation of the proximal facet, so it is unlikely a first phalanx. Comparison with measurements for other Shanidar distal phalanges suggests it is from the second or third toe, and most probably the second given its size (Table 8). Neanderthal manual and pedal phalanges are generally large relative to those of more recent *H. sapiens* (Trinkaus, 1975a, 1983b), and assuming SH16A 591 is a second or third distal phalanx, its distal breadth of 10.4mm falls outside the range of Trinkaus' (1983b) Holocene Native American sample for distal breadth (DP-2:  $7.5 \pm 0.8$  mm,  $n = 14$ ; DP-3:  $7.0 \pm 1.1$  mm,

n = 16; DP-4:  $6.4 \pm 0.7$  mm, n = 11; DP-5:  $5.2 \pm 1.1$  mm, n = 20). However, it is similar to the mean of other Neanderthal second and third distal pedal phalanges ( $10.0 \pm 1.3$  mm, n = 10: data from Trinkaus (1975a, 1983b)). This specimen is therefore most consistently identified as a Neanderthal phalanx. The proximal articular facet is shallow and the division of the facet into medial and lateral parts is barely discernible. There is osteophyte formation around the proximal joint surface, which is particularly marked medially and laterally (Figure 12).

[FIGURE 12 NEAR HERE]

[TABLE 8 NEAR HERE]

### *3.4. Estimated age at death*

All visible epiphyses of the new remains are fully fused, indicating adult status. The partial left pubic symphysis (SH16 239.1) permits a more precise estimate of age at death. SH16 239.1 shows strong dorsal lipping, with extension to the margin of the pubic symphysis of up to 5 mm dorsally by a large, continuous osteophytic outgrowth separated from the original surface by a deep porous cavity (Figure 6). The surface of the pubic symphysis has a faint hint of transverse ridges and furrows remaining, and there is no clear rim to the face in its inferior extremity, although a rim is forming across the dorsal border. This combination of characteristics means that the symphysis does not obviously match a single stage of the Todd or Suchey-Brooks methods. Using Todd (1920, 1921), the following characteristics suggest phase 9 (age 40–45 years): the defined inferior extremity; porosity of the symphyseal face but retention of faint ridges; incomplete symphyseal rim suggested by a hiatus at the limit of the preserved ventral section; and marked dorsal lipping along the preserved length of the dorsal margin but a lack of lipping on the (admittedly incomplete) ventral margin. By the Suchey-Brooks method (Brooks and Suchey, 1990), the pitted face, more than 'moderate' lipping of the dorsal border, marked porosity and developed osteophyte of the ventral surface (Figure 6, b

and c respectively) suggesting advanced degeneration (although only a limited portion of this ventral surface is preserved), are indicative of phase 6. This phase is associated with a mean age of 61.2 ( $\pm$  12.2) years in the modern sample on which the standards were developed and a range of 34–86 years (Brooks and Suchey, 1990). Combining the Todd and Suchey-Brooks estimates, the evidence suggests an older adult aged around 40–50 years.

This age estimate fits well with published estimates of Shanidar 5's age at death, and is consistent with the new remains belonging to this individual. The age at death of Shanidar 5 was directly estimated using femoral histomorphology at  $40 \pm 6.7$  years (Trinkaus and Thompson, 1987), refining a previous estimate of 35–50 years, based primarily on a comparative level of dental wear to Shanidar 3, whose age was in turn estimated using pubic symphysis and auricular surface morphology of the pelvis, extensive dental wear and degenerative joint disease (Trinkaus, 1983b).

### *3.5. Estimated stature and body mass*

Stature ( $\pm$  standard error) estimated from the total length of the talus following Pablos et al. (2013a) is 167 ( $\pm$  4) cm (approximately 5' 6"). This is consistent with stature estimates made from the long bones of Shanidar 5 by Trinkaus (1983b) using the regression equations of Trotter and Gleser (1952) for Euroamericans. These yielded estimates of 167.3 cm based on ulna length, 170.4 cm based on estimated femur length, and 168.8–171.3 cm based on estimated tibia length. Stature estimates from various talar measurements following Will and Stock (2015) were more variable, ranging from 156–170 cm. Apart from the estimate of 170 cm based on talar head length (M9), estimates were relatively low (156 - 165 cm: Supplementary Table S3). It should be noted that Will and Stock's equations were based on relatively small samples ( $n = 18-19$ ), which may affect their reliability.



Body mass estimates from talar measurements following McHenry (1992) and Will and Stock (2015) were overall less consistent with published estimates for Shanidar 5 and Neanderthals more generally. Only one of the Will and Stock (2015) equations, again using length of the talar head (M9), gave a femoral head diameter comparable with the actual measurement of the Shanidar 5 femoral head (47.5 mm vs. 47.5 mm: Trinkaus 1983b) which produced a body mass estimate of 70.6 kg (Plavcan et al., 2014). Estimated body mass based on our estimated femoral head measurement is identical to that of Plavcan et al. (2014) since the same method was used to estimate body mass from femoral head diameter in both.

The McHenry (1992) ordinary least squares regression equation gave a body mass of 52.6 kg, while the equations from Will and Stock (2015) gave femoral head diameter estimates of 41.5-45.1 mm, in turn giving body mass estimates between 56.3 and 64.1 kg (Supplementary Table S4). Such body mass estimates are low compared with those for other Neanderthals (males: 73.65-84.9 kg, n = 7; females: 59.9-71.5 kg, n = 5; data on individuals with pelvic sex determination only, from Plavcan et al. 2014, Table 2), particularly as Shanidar 5 is thought to be male.

### *3.6. Pathological changes to the skeleton*

Pathological lesions on the skeleton are limited to mild osteoarthritic changes to several joints joint (marginal lipping or osteophyte formation: Rogers and Waldron, 1995). The proximal joint surface of the pedal distal phalanx (SH16A 591) and the anterior margin of inferior surface of the thoracic vertebral body (SH16 269) demonstrate marginal osteophytes. The posterior calcaneal facet and the inferior edges of the medial and lateral facets of the right talus (SH15A 64.5 & 76.1), the talar articular surface of the right navicular (SH15A 69.2), and the posterior margin of the distal joint surface of the right tibia (SH15A 64.12) show marginal lipping. Such changes could be secondary to

trauma or simply due to high levels of biomechanical loading over a lifetime (Rogers and Waldron, 1995). Trinkaus (1983b) states that Shanidar 5 shows relatively little evidence of pathological lesions, although noted mild osteoarthritic changes to the proximal right ulna, and the proximal articular facets of two right ribs. Similar to the new finds, there was no involvement of the subchondral bone in any of the joints showing osteophytes or lipping (Trinkaus, 1983b). These mild degenerative changes are generally common throughout the adult Shanidar Cave skeletons, though more pronounced in Shanidar 1, 3 and 4 than in Shanidar 5, and interpreted as reflecting an active lifestyle (except in cases of clear trauma, e.g., Shanidar 1: Trinkaus, 1983b).

#### **4. Discussion and Conclusion**

Shanidar 5 is an adult male Neanderthal, previously estimated to have been aged over 40 years at death (Trinkaus, 1977, 1983b), and to date to approximately 46–50 ka (Solecki, 1971; Cowgill et al., 2007). The skeleton was only partially recovered during Solecki's excavations, and was missing the mandible and most of the teeth, both humeri, the left radius, parts of both hands, most of the vertebrae, portions of the pelvis, the lower right leg, and both feet (Trinkaus, 1983b). The newly discovered hominin remains from the area of the original Shanidar 5 discovery principally consist of elements from the lower limb (left hip region, right lower leg and foot) and a smaller number of fragments from the axial skeleton and wrist. The new remains are metrically and morphologically consistent with being from *H. neanderthalensis* rather than *H. sapiens*, and a lack of duplicated elements, partial articulation of some remains (pelvis-femur, tibia/fibula-tarsals), and generally large and robust morphology indicate a single individual is represented.

Furthermore, multiple lines of evidence strongly support the attribution of the remains to Shanidar 5. First, the physical location of the new remains was directly below and adjacent to the original

Shanidar 5 discovery (Figure 2). Second, the approximate articulation of the new finds, their degree of preservation, evidence of disturbance, and positioning among stones are also consistent with descriptions of the original finds. Third, the remains do not duplicate any of the skeletal elements previously described for Shanidar 5 (Figure 13), but complement and complete previously-described remains (e.g., the left femur). Fourth, the new remains and Shanidar 5 share a generally large and robust morphology with evidence of mild degenerative changes affecting some joints.

Unfortunately, it is not possible to directly compare or attempt to match the new remains with those from the previous excavations, as the latter were held in the Iraq Museum, Baghdad, and it remains unconfirmed whether they are still there following recent conflict in the region and known sacking of and damage to its museums. It was rare that the antimeres of the new remains was sufficiently well preserved for Shanidar 5 to allow direct metric and morphological comparisons with the published material, but the metric comparisons of the new left hamate with data on the right hamates from Shanidar Cave are consistent with the bone belonging to Shanidar 5, but not Shanidar 3. Fifth, the age at death estimated from the newly-described partial pubic symphysis, which must be treated cautiously given methodological limitations discussed above, is nonetheless consistent with estimates for Shanidar 5 obtained by other methods.

[FIGURE 13 NEAR HERE]

Finally, stature estimated from talus length using Pablos et al. (2013a) and stature and body mass estimated from talar head length (but not other talar measurements) using Will and Stock (2015), are highly consistent with those previously published for Shanidar 5. However, estimates based on other talar measurements (Will and Stock, 2015) and McHenry (1992) appear to significantly underestimate stature and body mass in this individual compared estimates derived from more standard techniques (Trinkaus, 1983b; Plavcan et al 2014). This may relate to small sample size in the reference samples, and/or the fact they are comprised of recent *H. sapiens* individuals who

differ in skeletal proportions from Neanderthals. Further work is required to evaluate methods for estimating body size from the talus in Neanderthals and other hominins.

The cumulative evidence suggests very strongly that the new remains from Shanidar Cave belong to Shanidar 5. The excavation of these remains using modern techniques and sampling for sediment micromorphology, palynology and other laboratory analyses will offer new insights into the burial process and taphonomic conditions under which the remains were deposited, enabling any new evidence to contribute to the debates regarding the circumstances (cultural or otherwise) by which this individual was deposited in the cave. Currently we can say little about cause of death.

Distinguishing between peri- and post-mortem breaks is possible (e.g., Villa and Mahieu, 1991; Sala et al., 2015) but would require a detailed analyses of all the old and new remains focussing on this question. Confirming death due to rock fall would still be challenging given that the remains are incomplete, often fragile and variably preserved. If rocks fell on the skeleton sometime after death, this could have led to the crushing of the remains that is observed, and the remains have clearly slumped and shifted from anatomical articulation, so it is also difficult to suggest what was their original position. However, we hope that micromorphological analysis of sediment blocks taken during the excavation of the new finds will help elucidate the circumstances of the placement of the Shanidar 5 remains in the context of the argument that the individual was killed by rockfall. The recent finds also offer new evidence regarding the age at death of Shanidar 5 and the potential for novel analyses, such as ancient DNA or bone microstructure, that were not possible on the original remains, which are now inaccessible. Finally, the new elements add to the available datasets on Neanderthal morphology, and contribute to strengthening future analyses and interpretations of these data.

## **Acknowledgements**

The new fieldwork at Shanidar Cave is directed by GB and is being undertaken with the permission of the Kurdistan General Directorate of Antiquities, which is warmly thanked, in particular the General Director Mala Awat and the Directorate's Representative on the project, Dlshad Abdulmutalb, for his continued support and input into the fieldwork. EP thanks Professor Erik Trinkaus for his advice and assistance, as well as Jay Stock and Asier Gómez for helpful discussion, and Adrián Pablos for discussions and for kindly sharing unpublished data. The financial support of the Leverhulme Trust (Research Grant RPG-2013-105 held by GB) is also gratefully acknowledged. We also thank the Editor, Associate Editor and two anonymous reviewers for constructive feedback which helped to improve the article.

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## Figure legends

**Figure 1. A: Map showing location of Shanidar Cave. B: Schematic stratigraphy from Ralph Solecki's excavations (1951-1960) at Shanidar Cave (reproduced with kind permission of R. Solecki, with modifications). C: Plan of Shanidar Cave showing the location of Solecki's excavations, the Neanderthal remains, and the 2015-2016 excavations.**

**Figure 2. Photograph of the Shanidar 5 lower limbs in situ (left), overlaid with a photo of the 2016 left hip remains in situ (right).** The images illustrate the matching topography of the rocks in both pictures and indicate that the 2016 left hip lay directly adjacent to the original Shanidar 5 lower limb finds. The skull (a) was on top of a rock, and the pelvis (not shown) and lower limb remains (b) underneath. The more distal section of the left femoral shaft found in 1960 (c) aligns closely with the proximal section of the shaft found in 2016 (d). Length of black scale bar in inset photo = 5 cm. (Black and white photograph: Trinkaus (1977, Figure 1), courtesy of R. Solecki).

**Figure 3. Remains of the right tibia, fibula, and talus as discovered at Shanidar Cave in 2015.** Left: the talus, tibia and fibula remains. North is towards the upper left corner of the picture, where there is also a rodent burrow that likely disturbed the rest of the right foot. Right: close-up showing the location of the burrow mentioned previously in relation to the talus (a). Arrow indicates the side of the rock, in front of which (i.e. in the region just out of frame in the lower right hand side of the photograph) the remains of the left proximal femur/pelvis were found in 2016. Scale in cm.

**Figure 4. Remains of the pelvis (a) and proximal femur (b) discovered at Shanidar Cave in 2016.**

North is to the left, and the base of the rock lying tight against the remains can be seen in the top of the image. The hatched area (bottom left) was removed as part of the block containing the right tibia and fibula during the previous excavation season.

**Figure 5. Adult thoracic vertebral body (SH16 269) from Shanidar Cave. Upper left: superior; upper right: inferior; below: left lateral.** Arrow indicates anterior extension of the inferior surface. Scale bar = 10 mm.

**Figure 6. Reconstructed left pubic symphysis (SH16 239.1) from Shanidar Cave.** Only three fragments forming part of the pubic symphysis itself are illustrated, and labels indicate: (a) continuous osteophytic outgrowth along dorsal border; (b) porosity and degeneration of ventral surface; and (c) osteophyte on ventral surface. Ventral is to the right, dorsal to the left and superior at the top of the image. Scale bar = 10 mm.

**Figure 7. Adult left hamate (SH15 590) from Shanidar Cave.** Clockwise from top left: capitate articular surface; triquetral articular surface; palmar view; distal view; and dorsal view. Scale bar = 10 mm.

**Figure 8. Bivariate plots of measurements from the SH15 590 left hamate from Shanidar Cave and comparative data from Neanderthals and *H. sapiens*.** Left: Articular length against hamulus



thickness. Right: Hamulus projection index against hamulus thickness. See Table 3 for detail of the comparative data.

**Figure 9. Adult left proximal femur (SH16 238) distal right tibial articular surface (SH15A 64.12) from Shanidar Cave.** A: proximal femur. Upper left: 3 femoral fragments preserving part of gluteal tuberosity (a). Upper right: 4 refitting fragments of the proximal femur showing the base of the lesser trochanter (c), pectineal line (b), and spiral line (d). Note that the fragment marked above with '\*' features in both images. B: inferior view of the right distal tibia. Lateral is to the left, anterior towards the top. Note the ankle flexion facet indicated by the arrow. Scale bar = 10 mm.

**Figure 10. The right talus (SH15A 69.1) and right navicular (SH15A 69.2) from Shanidar Cave.** A: talus in superior view (left) and inferior view (right). B: navicular, clockwise from top left: distal, proximal, dorsal and plantar views. Scale bar = 10 mm.

**Figure 11. Plot of navicular maximum thickness against minimum thickness comparing SH15A 69.2 with other Neanderthals and *H. sapiens*.** See Table 5 for details of the comparative data.

**Figure 12. Distal pedal phalanx (SH16A 591) from Shanidar Cave.** Clockwise from top left: dorsal, plantar and proximal views. Arrows indicate marginal osteophytes around the joint surface. Scale bar = 10 mm.

**Figure 13. Schematic representation of the skeletal remains attributed to Shanidar 5 from the excavations in 1960 and 2015–2016.** The areas marked as present (solid colour) are not necessarily complete, for example only the posterior part of the left femoral head and neck were recovered in 1960 by Ralph Solecki. Hatched areas denote fragmentary remains which could not be attributed to a specific side of the body. Note that there is no duplication of elements between the previously-described Shanidar 5 material and that recovered from our recent excavations.