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Virtual reconstruction of the *Australopithecus africanus* pelvis Sts 65 with implications for obstetrics and locomotion

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ABSTRACT

Characterizing australopith pelvic morphology has been difficult in part because of limited fossilized pelvic material. Here, we reassess the morphology of an under-studied adult right ilium and pubis (Sts 65) from Member 4 of Sterkfontein, South Africa, and provide a hypothetical digital reconstruction of its overall pelvic morphology. The small size of the pelvis, presence of a preauricular sulcus, and shape of the sciatic notch allow us to agree with past interpretations that Sts 65 likely belonged to a female. The morphology of the iliac pillar, while not as substantial as in *Homo*, is more robust than in A.L. 288-1 and Sts 14. We created a reconstruction of the pelvis by digitally articulating the Sts 65 right ilium and a mirrored copy of the left ilium with the Sts 14 sacrum in Autodesk Maya. Points along the arcuate line were used to orient the ilia to the sacrum. This reconstruction of the Sts 65 pelvis looks much like a "classic" australopith pelvis, with laterally flared ilia and an inferiorly deflected pubis. An analysis of the obstetric dimensions from our reconstruction shows similarity to other australopiths, a likely transverse or oblique entrance of the neonatal cranium into the pelvic inlet, and a cephalopelvic ratio similar to that found in humans today.

1. Introduction

The pelvis plays a key role in both locomotion and obstetrics, making it a particularly informative skeletal element for reconstructing the paleobiology of a hominin species. Pelvic morphology differs substantially between humans and apes (Weidenreich, 1913; Schultz, 1949; Robinson, 1972; Aiello and Dean, 2002), reflecting interspecific differences in body posture, locomotion, and obstetrics. Some of the morphologies related to bipedalism in the hominin pelvis are hypothesized to have made parturition more challenging—the "obstetrical dilemma" (Washburn, 1960, but see; Dunsworth et al., 2012; Warrener et al., 2015)—and many past studies have attempted to identify the relative importance of bipedality or childbirth on different pelvic morphologies (Rosenberg, 1992; Rosenberg and Trevathan, 1995; Kurki, 2011; Wells et al., 2012), including in fossils (Tague and Lovejoy, 1986; Simpson et al., 2008; Kibii et al., 2011). However, the hominin fossil record has yielded relatively little pelvic material compared to other regions of the skeleton, impeding our ability to test models of locomotor and obstetric evolution in early hominins. The limited fossil pelvic material that has been preserved usually needs extensive reconstruction before analysis, as the thin cortical bone and highly curved surfaces of the pelvis make it susceptible to deformation, distortion, and crushing during taphonomic processes.

The subjectivity involved in said reconstructions of distorted fossils can result in a large degree of variability in the interpretation of hominin pelvic material. The two "classic" australopith pelves, A.L. 288-1 and Sts 14, have themselves been reconstructed multiple times. The contrasting reconstructions of A.L. 288-1 by Lovejoy (1979; Tague and Lovejoy, 1986), Schmid (1983), and Häusler and Schmid (1995) show differences in the orientation of the iliac blades and the inlet shape, with implications for both locomotion and obstetrics. Berge and Goularas (2010) see these differing

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reconstructions as largely a function of the crushed and distorted sacroiliac joint in the A.L. 288-1 pelvis, illustrated clearly in Lovejoy (2005a:104, his Fig. 8). Sts 14 was originally reconstructed by Robinson (1972) only after dissolving away breccia using acetic acid and then using a substantial amount of plaster and glue, as well as a metal rod meant to reinforce the pubis (Day, 1973, 1978). Häusler and Schmid (1995) reconstructed Sts 14 by removing much of Robinson's plaster and instead physically mirror imaging the missing sections. They produced two reconstructions due to anatomical ambiguities at the sacroiliac joint and iliopubic angle, which Berge and Goularas (2010) attempted to correct for in their digital reconstruction.

These past attempts underscore that pelvic reconstructions, although enormously useful as a visual aid, represent morphological hypotheses. Teams working with the same set of fossils can produce different reconstructions and come to quite different conclusions (e.g., Ponce de León et al., 2008; Weaver and Hublin, 2009). One way to address the problem of reconstructive ambiguities in key fossils such as A.L. 288-1 and Sts 14 is to analyze and reconstruct additional fossil material with comparable anatomies, whereby a reconstruction of one fossil can be "checked" against another. Here, we study a partial but relatively unknown and mostly undistorted os coxae (i.e., an innominate or hipbone) from Sterkfontein Member 4, Sts 65, and provide a digital reconstruction that allows us to add to the ongoing dialogue about locomotion and obstetrics in *Australopithecus*.

Sts 65 is a right ilium and partial pubis of an adult hominin (Fig. 1). According to Tobias et al. (1977), it was recovered by John Robinson from Member 4 of Sterkfontein in the 1949 field season. Though the dates of the fossiliferous deposits at Sterkfontein have been contentious, recent work using U–Pb and U–Th techniques have allowed Pickering and Kramers (2010) to provide an age range for Member 4 of 2.0–2.6 Ma, using the flowstone bracketing the fossiliferous layers. Communication with the Ditsong Museum revealed little in the way of a specific day of discovery or stratigraphic provenance, as field notes from this season are unavailable or missing. Tobias et al. (1977) indicate that Sts 65 was recovered from the Sterkfontein main quarry (formerly called the 'Type Site'). Pickering and Kramers (2010) put the position of Broom's original excavations where Sts 5 was found at ~2.0 Ma, but the exact stratigraphic relationship between Sts 5 and Sts 65 is unknown. Although Sts 65 was not discovered with any associated craniodental remains, there is no reason to assume that it is not *Australopithecus africanus*. However, R. Clarke (1988, 2008, 2013) has proposed that there may be more than one species of australopith at Sterkfontein. This claim is difficult to assess until further material from this purported second species is described in more detail. Nevertheless, it is a consideration as we examine similarities and differences between Sts 65 and Sts 14.

Two other postcranial elements were originally associated with Sts 65, a proximal femur and a lumbar vertebral fragment. Wolpoff (1973) and McHenry (1974) note that the femur likely belongs to a baboon and we concur. Robinson (1972) mentions an associated lumbar vertebra, which consists only of the bases of the pedicles and the dorsal surface of the vertebral body. However, this lumbar vertebra is not currently curated with the pelvis at the Ditsong Museum and its whereabouts are currently unknown (as of 7/4/2013; Potze, pers. comm). Furthermore, Robinson (1972:113) writes that "This specimen is so fragmentary that there is no certainty that it actually belongs to *Homo africanus*, though I think it is likely that this is so." Given the uncertainty of both its taxonomic attribution and its current whereabouts, its utility in our study of the Sts 65 pelvis is limited.

Though the anatomy of Sts 65 has not been described in explicit detail, it is not without mention in the literature, mostly in contrast to the more complete Sts 14. Robinson (1972) devotes the most space to a discussion of Sts 65. Notably, in comparison with Sts 14, Robinson (1972) comes to the tentative conclusion that Sts 65 belongs to a male, citing a more flexed greater sciatic notch and the thickened iliac pillar (or acetabulocristal buttress). However, Wolpoff (1973), noting the presence of a preauricular sulcus, raises the possibility that Sts 65 is female, though he does also note that it is more "robustly developed" than Sts 14. Day (1978) also suggests that the pelvis is from a female, citing the "preauricular groove" as the primary piece of evidence. Lovejoy et al. (1973) mention Sts 65 in passing as part of a catalog of australopith pelvic material, though it is treated lightly in the body of the paper. McHenry (1975), as well as Häusler and Berger (2001), mention Sts 65 to note the presence of a pronounced iliac pillar, though they also observe that it is positioned differently in modern humans, as is the case in all australopiths. McHenry (1975) also reports some metrics on Sts 65, in the context of describing SK 3155. Both Arsuaga and Alonso (1983) and Arsuaga and Carretero (1994) describe the greater sciatic notch of Sts 65 as extremely open, a trait that they also ascribe to Sts 14, insinuating that both are likely female. Hager (1989) also identifies the sex of Sts 65 as female based on the posterior ilium, presumed pelvic inlet shape, and greater sciatic notch contour.

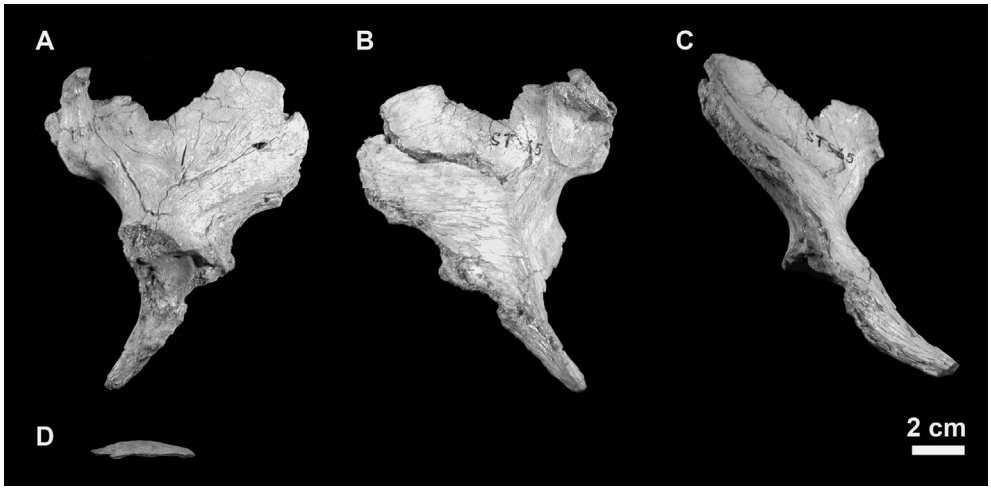

Figure 1. The Sts 65 pelvis. A) External view, B) Internal view, C) Anterior view, D) Piece of iliac crest.