



Supplementary Information for

Dental data challenge the ubiquitous presence of *Homo* in the Cradle of Humankind

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Supplementary Note 1

Context of discovery of the early Homo specimens

The mandible SK 15, which was found in Member 2 of Swartkrans and is the holotype of *Telanthropus capensis* (1), was later assigned to *H. erectus/ergaster* (2). The isolated premolar SK 18a, also from Member 2, was suggested to belong to SK 15 (3), even though the poor preservation of the premolar alveolae in the latter specimen prevents any confirmation. A few other specimens from Swartkrans Member 2 were attributed to *Homo*, including the permanent lower first molar crowns SKX 257 and SKX 258, antimeres of the same individual, and the permanent upper first molar SKX 268 associated with the deciduous upper second molar SKX 267 and fragmentary crown of the permanent upper canine SKX 269 (4). The crushed juvenile cranium SK 27 (5) and the partial cranium SK 847 (6) recovered in the Hanging Remnant of Member 1, as well as the partial juvenile mandible SKX 21204 from Lower Bank of Member 1 are generally considered to represent *H. erectus/ergaster* or *H. habilis* (5–8). The isolated lower third premolar SK 96 also comes from the same Member and was recently suggested to show a morphology resembling that of the Middle Pleistocene taxon *H. naledi* (9). The eleven deciduous and permanent teeth of KB 5223 from the Member 2 or 3 of Kromdraai represent a young individual that was attributed to either *Paranthropus* (7) or *Homo* (10). The site of Drimolen yielded a large assemblage of hominin remains, most of them being attributed to *P. robustus*, while a few specimens, including the four molars DNH 39, DNH 62, DNH 67 and DNH 70, were assigned to *Homo* (11, 12). For Sterkfontein, the specimen StW 151 comes from Member 4 (13). StW 19b and StW 87 are either from Member 4 or 5 (7). The stratigraphic relationship with Members 4 and 5 of the StW 53 infill, in which the eponym specimen was found, is unclear (7, 8, 13). A recent work by Couzens based on spatial modeling of stone artefacts suggests that StW 53 is best related to Member 4 (some breccia from this Member is still present in the southern part of the Type Site where StW 53 was found) (14). Many of the Sterkfontein specimens generally regarded as *Homo* and investigated here come from Member 5 (SE 255, SE 1508, StW 80-81) (2, 15–17). The recently found isolated molar StW 669 comes from an underground chamber (Milner Hall) in Sterkfontein Cave, in deposits that are correlated to Member 5 (18). It has been attributed to *Homo* based on size and external morphology (19). In this study, we also identified the molar Sts 9 coming from either Member 4 or 5 in the eastern area of the Type Site as likely belonging to early *Homo*.

Supplementary Note 2

Analysis of non-metric features of the enamel-dentine junction

Studies based on scoring of dental traits have shown substantial variation for the presence/absence and degree of development of a number of features in post-canine teeth, notably between Pleistocene *Homo* groups and recent modern humans (20, 21). For example in Holocene humans, three-cusped M²s (i.e., lacking the hypocone) are not recorded in Sub-Saharan African populations whereas it occurs more

frequently in western Eurasians (up to 34%) (21). Four-cusped M_2 s (i.e., lacking the hypoconulid) are relatively frequent, between 17% and 75% in sub-Saharan groups, and up to 95% in western Eurasian groups (21). In comparison, three-cusped M_2 s are not recorded in Pleistocene groups so far and four-cusped M_2 s are only rarely found in fossil hominins (21).

In the southern African sample investigated here, all the upper molars have the four main dentine horns corresponding to the paracone, protocone, metacone and hypocone. DNH 62 and the upper molars of StW 151 show a lingual cingulum that is only recorded in one *Homo* specimen of our comparative sample (NG0802.1) (22), but is more common in *Australopithecus* (e.g., MLD 44, Sts 21, Sts 52) and *Paranthropus* (e.g., SK 105, SK 831a, SK 832) (Figs. S1-S3). Most of the upper molars show a well-developed hypoparacrista enclosing a small mesial fovea (only DNH 39, DNH 62 and StW 669 do not show any delimitation of a mesial fovea). This feature is recorded on the EDJ of most of the non-*Homo* comparative specimens. The M_3 s of StW 53 shows a small accessory fovea enclosed by a marked crest at the mesiobuccal corner of the crown, a singular feature that is not found in any other specimen studied here.

All P_3 s have a continuous transverse crest at the EDJ level while among the P_4 s, only SK 18a (if it is a P_4) and SKX 21204 have one (Figs. S4-S5). The P_3 s tend to show a buccolingually narrower occlusal basin than the P_4 s, but SK 18a has an intermediate morphology between the P_3 and P_4 shapes, making its metamerism assessment challenging. Among the P_3 s, StW 80 shows unique morphology, with a high protoconid but minute metaconid dentine horn, and a buccolingually expanded distal fovea (with a marked postprotocristid) compared with the mesial fovea. A hypoconid dentine horn is barely discernible in SK 18a, SKX 21204 and StW 80, while it is slightly more developed in SK 96. The P_4 specimens exhibit a similar overall pattern, but differ in mesiodistal/buccolingual proportions. A small hypoconid dentine horn is detectable in the P_4 of SKX 21204 and a buccal shelf is also visible (Fig. 1). Besides StW 80, the features found in SK 18a, SK 96, StW 87, StW 151 and SKX 21204 are commonly found in each of the three hominin genera of the comparative sample (Figs. S4-S5) and are thus of little taxonomic value.

The EDJ of the lower molars display variable occlusal outlines and central basin shapes (Fig. S6). All the purported *Homo* specimens share with *Australopithecus* and *Paranthropus* the presence of the five main dentine horns corresponding to the protoconid, metaconid, hypoconid, entoconid and hypoconulid. Four teeth show a complete but low mid-trigonid crest (DNH 67, KB 5223, Sts 9 and the left M_3 of SK 15). Three M_1 s (KB 5223, SKX 257 and StW 151) show a buccal cingulum-like feature with deep fossae between the protoconid and hypoconid, and between the hypoconid and hypoconulid (Fig. S6).

We analyzed the frequency and development of eight non-metric dental features of the molar EDJ in the comparative sample (Table S6). Compared with *Australopithecus* and *Paranthropus*, Early to Middle Pleistocene *Homo* shows the absence or a low degree of expression of cusp 5 in the M_3 s, of the Carabelli trait in the M_2 s, of the distal accessory cusp in the M_3 s, and of the protostylid for all lower molar positions, as well as higher frequency of the lingual accessory cusp (tuberculum intermedium) in the M_1 s (Figs. S1-S8; Table S2). In this respect, the M_3 s of SK 847, StW 19b and both antimeres of StW 53 show a cusp 5, the M_2 s of StW 669 and SE 1508 do not exhibit a Carabelli trait, only the M_3 of StW 53 does not have a distal accessory cusp, most M_2 s and M_3 s display no lingual accessory cusp (except DNH 67, SKX 257 and

StW 80), and eight of the twelve lower molars do not express a protostylid at the EDJ. The developed, shelf-like protostylid of the M₁s KB 5223 and SKX 257 resembles the morphology seen in australopiths, while such expression is not recorded in any Early to Middle Pleistocene *Homo* specimen (Fig. S6).

Supplementary Material and Methods

Materials

We investigated the EDJ of 37 southern African post-canine teeth that were previously attributed to early *Homo*, as well as of one isolated lower molar, Sts 9, generally attributed to *Australopithecus* but recognized here as *Homo* (SI Appendix, Supplementary Note 1 and Table S1). We compared this assemblage with Late Pliocene to Early Pleistocene southern African australopiths, including the holotypes of *Australopithecus* (Taung 1, representing *A. africanus*) (23) and *Paranthropus* (TM 1517 representing *P. robustus*) (24). The *Australopithecus* specimens included in this study also sample specimens from Makapansgat that were attributed to *A. prometheus*, such as MLD 2 (25). We also used African and Asian Early to Middle Pleistocene *Homo* specimens as reference for the taxon. There are a number of eastern African specimens that could be relevant to compare with purported early *Homo* specimens from South Africa, however, many are unavailable for study, their taxonomic attribution to *Homo* is similarly debated, and/or there is a lack of tissue contrast in tomographic scans between enamel and dentine tissue that prevents imaging of the EDJ. Therefore, a large part of the comparative *Homo* sample also includes late Early Pleistocene to mid-Middle Pleistocene African and Asian specimens (see SI Appendix Table S2).

Methods

All the southern African specimens were scanned using X-ray microtomography with the X-Tek (Metris) XT H225L industrial microCT system at the South African Nuclear Energy Corporation (Necsa; 26), the Nikon Metrology XTH 225/320 LC dual source microCT system at the Evolutionary Studies Institute, or the BIR Actis 300/225 FP or SkyScan 1172 microtomographic scanners of the Max Planck Institute according to the following parameters: 70-135 kV voltage; 60-420 mA current; a 0.5-1.2 mm Cu filter or 0.1-3.6 mm Al filter. The final volumes were reconstructed with an isotropic voxel size of 10-30 μm for isolated teeth and 40-60 μm for jaw fragments. Most of the comparative sample was scanned by X-ray microtomography with similar parameters, except for 11 *H. erectus* teeth (Sangiran 7-3b, 7-3c, 7-3d, 7-13, 7-17, 7-20, 7-26, 7-53, 7-64, 7-65, 7-89) from Sangiran, Indonesia, that were imaged by neutron microtomography at the ANTARES imaging facility located at the FRM II reactor of the Technical University of Munich, Germany (for technical details see ref. 27). The final virtual volumes of these specimens were reconstructed with an isotropic voxel size of ~ 21 μm . For all specimens, image stacks were imported into Avizo v.8.0 (FEI Visualization Sciences Group), and the images were segmented using semiautomatic procedures and an adaptation of the half-maximum height method (28–30). All the EDJ surfaces were generated using the ‘constrained smoothing’ option.

Non-metric traits at the EDJ were assessed using scoring systems developed in the frame of previous studies to investigate the frequency of the Carabelli’s feature, the upper and lower molar accessory cusps (C5, C6 and C7, protoconule), the mid-trigonid crest and the protostylid (Table S6). The protoconule, fifth

and sixth cusp dentine horns (UM C5 and UM C6), and Carabelli trait presence/absence and expression in the upper molars were assessed following Ortiz et al. (31):

- Protoconule and UM C5

- 0 = dentine horn is absent
- 0.5 = indecisive category
- 1 = dentine horn is present and very small
- 2 = dentine horn is small
- 3 = dentine horn is medium-sized
- 4 = dentine horn is large
- 5 = dentine horn is very large

- UM C6

- 0 = absent
- 1 = a dentine horn is present

- Carabelli trait

- 0 = the mesiolingual aspect of cusp 1 is smooth
- 1 = a groove is present or the lingual cingulum is reduced to one or two short furrows or a single pit which may be fairly deep.
- 2 = a pit is present or the lingual cingulum decreases further in length and prominence. There are usually between 3-7 vertical furrows on the protocone which sometimes branch at the occlusal end
- 3 = a small [or medium-sized] Y-shaped depression is present or the cingulum decreases further in length and prominence but the cusps are larger
- 4 = a large Y-shaped depression is present or the cingulum is usually shorter in length but carries one or more cusps which may break the continuity of the furrow
- 5 = a small dentine horn without a free apex occurs (the distal border of the cusp does not contact the lingual groove separating cusps 1 and 4) or a complete lingual cingulum is present extending from the mesio-buccal corner of the crown traversing the lingual surface of the protocone in an oblique cervical direction and terminating in the occluso-lingual groove.
- 6: a medium-sized cusp with an attached apex making contact with the medial lingual groove is present
- 7: a large cusp is present

The lower molar mid-trigonid crest was scored following Bailey et al. (32):

0 = absent or weakly expressed ridges on either or both of the mesial cusps.

1 = moderately expressed ridges on both protoconid and metaconid dentine horns that do not join at the sagittal sulcus and are widely spaced.

2 = presence of a crest whose height dips and/or is much reduced at the sagittal sulcus but remains continuous.

3 = presence of a crest that remains high from dentine horn tip to dentine horn tip. There may be only a slight dip at the sagittal sulcus.

The presence/absence and expression of the distal accessory dentine horn (DAC, often referred to as cusp 6 or tuberculum sextum) and of the lingual accessory dentine horn (LAC, generally named cusp 7 or tuberculum intermedium) were scored following Davies et al. (33):

- DAC

absent

interconulid type = can be single, double or triple

hypoconulid type = can be single or double

entoconid type = single

- LAC

absent

interconulid type = single

metaconid type = can be single or double

entoconid type = single

Because of the vast degree of variation of the protostylid at the EDJ level (34), we simply scored it as follows:

0 = absent or very subtle reliefs, sometimes with a groove between the protoconid and hypoconid (no fovea, shelf and/or crest on the buccal aspect of the trigonid)

1 = weak expression (whether it is represented by a fovea, shelf and/or crest on the buccal aspect of the trigonid)

2 = marked expression (whether it is represented by a fovea, shelf and/or crest on the buccal aspect of the trigonid).

We used a diffeomorphic surface matching (DSM) approach to analyze the EDJ conformation. This landmark-free, mesh-based approach relies on the construction of average surface models, and the difference between surfaces is interpreted as the amount of deformation needed to align them by using diffeomorphic shape matching (35, 36). The metric of currents used in DSM analyses takes all data points into account and does not assume a point-to-point correspondence between samples which allows direct comparison of surfaces that have different number of sample points (37). Moreover, this metric takes into account the local orientation of a surface (i.e., the normals) to strengthen the measure of shape dissimilarities (this metric does not only measure how distant two surfaces are, but also how their respective local orientations differ) (37). The deformations between surfaces are mathematically modeled as smooth and invertible functions (i.e., diffeomorphisms). From a set of surfaces, an atlas of surfaces is created. The method estimates an average object configuration or mean shape from a collection of object sets (here the EDJ surfaces) and computes the deformations from the mean shape to each specimen. In addition, a set of initial control points located near its most variable parts, and a set of momenta parameterizing the deformations of the mean shape to each individual are estimated (37–42). When comparing a group of closely related taxa (as it is the case here), it is assumed that the inaccuracy (noise) introduced by comparing whole surfaces is small compared to the information that can be extracted (signal). Compared with landmarks, correspondence between surfaces is not strictly homologous. The assumption about signal to noise ratio has been evaluated in previous studies, showing that DSM can distinguish the EDJ of various hominin groups, even better than with landmark-based analyses, suggesting that DSM can offer reliable accuracy and precision, of a similar order than landmark-based analyses (39, 41). For each dental position, the EDJ surfaces decimated to 50000 polygons were manually oriented, then superimposed using the rigid and uniform scale option (corresponding to a shape alignment, removing size) of the 'Align Surfaces' module in Avizo v.8.0 (Visualization Sciences Group Inc.). This was done by minimizing the root mean square distance between the points of each specimen to corresponding points on the reference surface using an iterative closest point algorithm. We used the Deformetrica v. 4.3 software (<https://www.deformetrica.org>) (36, 37) to generate a global mean shape (GMS) with a set of diffeomorphisms relating the GMS to each individual and the output (control points and deformation momenta) used to perform the statistical analyses to explore the EDJ shape variation and to classify the data. The number of resulting shape variables (p) varies between 1575 and 2646, depending of tooth position. The output data were imported in R with the package RToolsForDeformetrica v.0.1 (43). Using the packages ade4 v.1.7-6 (44) and Morpho v.2.8 (45) for R v.4.0.4 (46), we first computed principal component analyses (PCA), followed by between-group principal component analyses (bgPCA) using all PCs based on the deformation moments and using the following three groups assigned with equal prior probabilities: Early-Middle Pleistocene *Homo*,

Australopithecus and *Paranthropus*. The southern African purported *Homo* specimens were then projected a posteriori into the bgPCA morphospace. We followed the recommendations of Cardini and Polly (47) by computing the cross-validated bgPCA (cv-bgPCA) to assess the validity of the standard bgPCA group discrimination using the package Morpho v.2.8 (45). Our results show that the bgPCA and cv-bgPCA discriminate the three groups in a similar way (Figs. 2-3; *SI Appendix*, Figs. S9-S10). Statistical results show that for cv-bgPCA, R^2 ranges between 0.50 and 0.72 depending on tooth position and $p < 0.001$ for all tooth positions. The R^2 coefficient is thus far above zero (even if potentially inflated by small sample size), indicating that group separation is unlikely to be spurious (47). We also performed cross-validated canonical variates analyses (CVA) using the same groups as for the bgPCA using the R package Morpho v.2.8 (45). Since CVA computation requires the number of variables to be much smaller than the number of specimens, we computed the CVA based on a subset of the first PC scores (5-13) showing the highest degree of correct classification (screening the correct classification results and selecting the minimum number of PC scores enabling to reach the optimum of correct classification) (48). This choice of the PC scores subset is a compromise between including a sufficient proportion of overall shape variation and limiting the number of variables to avoid unrealistic and unstable levels of discrimination (49). We also assessed the structure of data and results, notably to test whether group separation in the analyses is not spurious (47). The amount of variance (R^2) explained by group differences in the raw shape data was estimated by computing a permutational analysis of variance (ANOVA; 1,000 permutations) based on the Euclidean distance between the means (40, 47) and implementing a Holm correction for multiple pairwise tests using the *vegan* v.2.5-7 (50) and *pairwiseAdonis* v.0.3 (51) packages. The results show statistical distinction of the three groups in the full shape space for all tooth positions but for M³s (*SI Appendix*, Table S3). Correct classification for each group and overall classification resulting from the cv-bgPCA and cross-validated CVA are reported in the *SI Appendix* Table S4. Altogether, bgPCA, cv-bgPCA and CVA analyses are consistent with each other and confirm that the groups observed in the bgPCA are unlikely to be spurious (52). Classification of the specimens was done using distances to the means and check for outliers relative to the most likely group was conducted for both CVA and bgPCA (the latter was computed using a multivariate normal model).

Allometry was tested using permutational multivariate analysis of covariance (MANCOVA; 10,000 permutations) (53) in which the explanatory variables are the EDJ area and the groups (genera), and the dependent variables are the PC scores (*SI Appendix*, Table S5).

Geochemical analysis of three specimens were conducted in this study (KB 5223 from Kromdraai, and SK 96 and SKX 268 from Swartkrans; SAHRA permit IDs 2538 and 2539). The three fossil teeth were sectioned with a high-precision diamond saw and polished to 10 μm smoothness. Laser-ablation combined with inductively coupled plasma-mass spectrometry (LA-ICP-MS) was used for trace elemental mapping analyses of the samples according to the previously published protocol (54, 55). The GARG ESI NW213 instrument coupled to an Agilent 7700 ICP-MS system set at Southern Cross University were used to map the samples by rastered laser beam along the tooth surface in a straight line. The laser spot size was 40

μm , laser scan speed of $80 \mu\text{m}\cdot\text{s}^{-1}$, laser intensity of 80%, and an ICP-MS total integration time of 0.50 s produced data points that corresponded to a pixel size of approximately $40\times 40 \mu\text{m}$. Certified standard reference materials (NIST610, NIST612 and NIST614) were used to assess signal drift and absolute concentrations. Elemental maps were constructed using the R Shiny application “shinyImaging” (56) (<http://labs.icahn.mssm.edu/lautenberglab>). The app transforms individual laser line csv files for each isotope into counts per second (cps) matrix (number of ablation lines multiplied by the number of ablation spots per ablation line). For each element, the gas blank collected during the first 10s of each laser lines was subtracted from the RasterStack and elements were normalized to ^{43}Ca . Background around the teeth (signal arising from the encasing resin or air) was converted to white coloration (no intensity) to increase clarity of the figures by isolating the dental tissue from its surroundings. Color scales were applied using the linear blue-red Lookup Table.



Fig. S1. The M¹ EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).

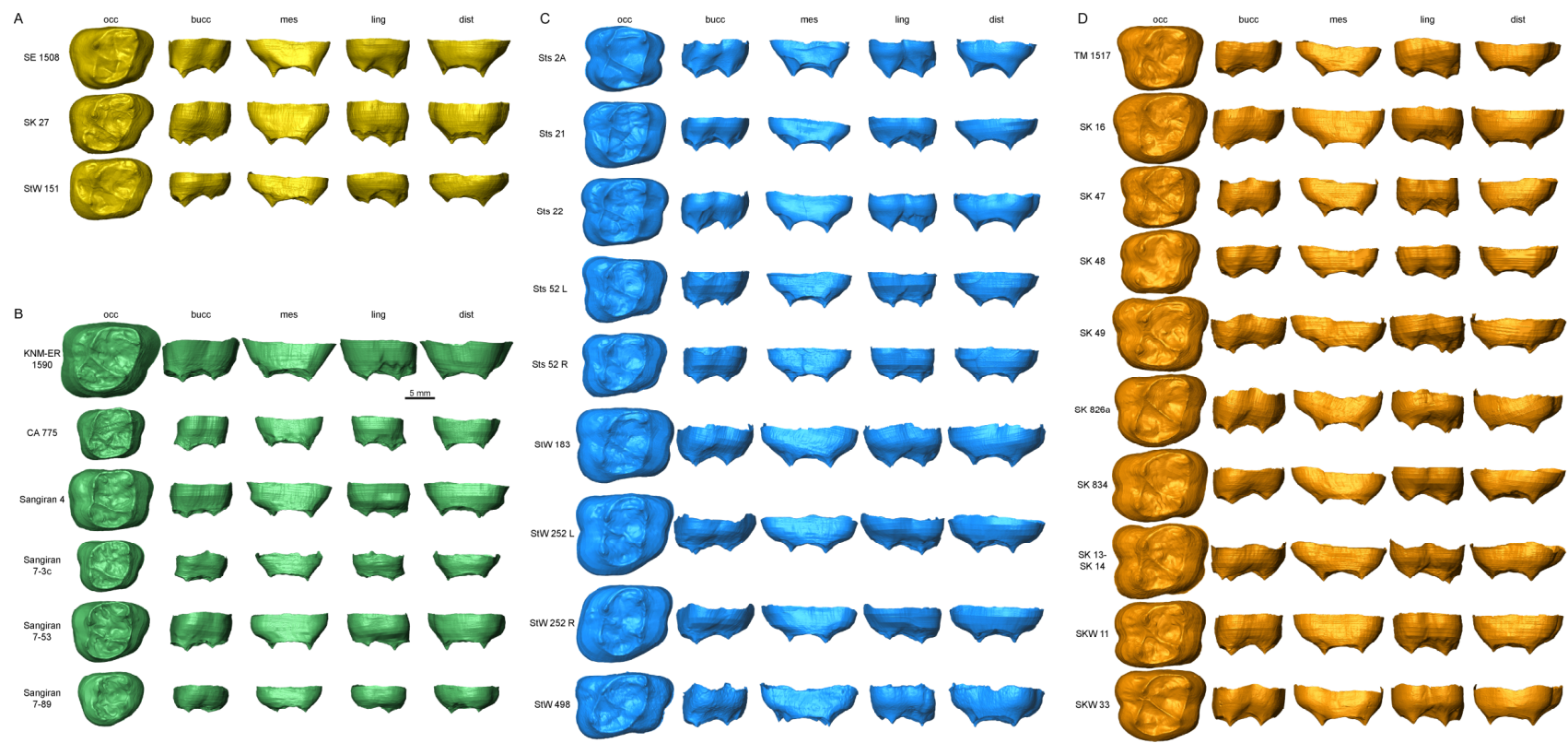


Fig. S2. The M² EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).

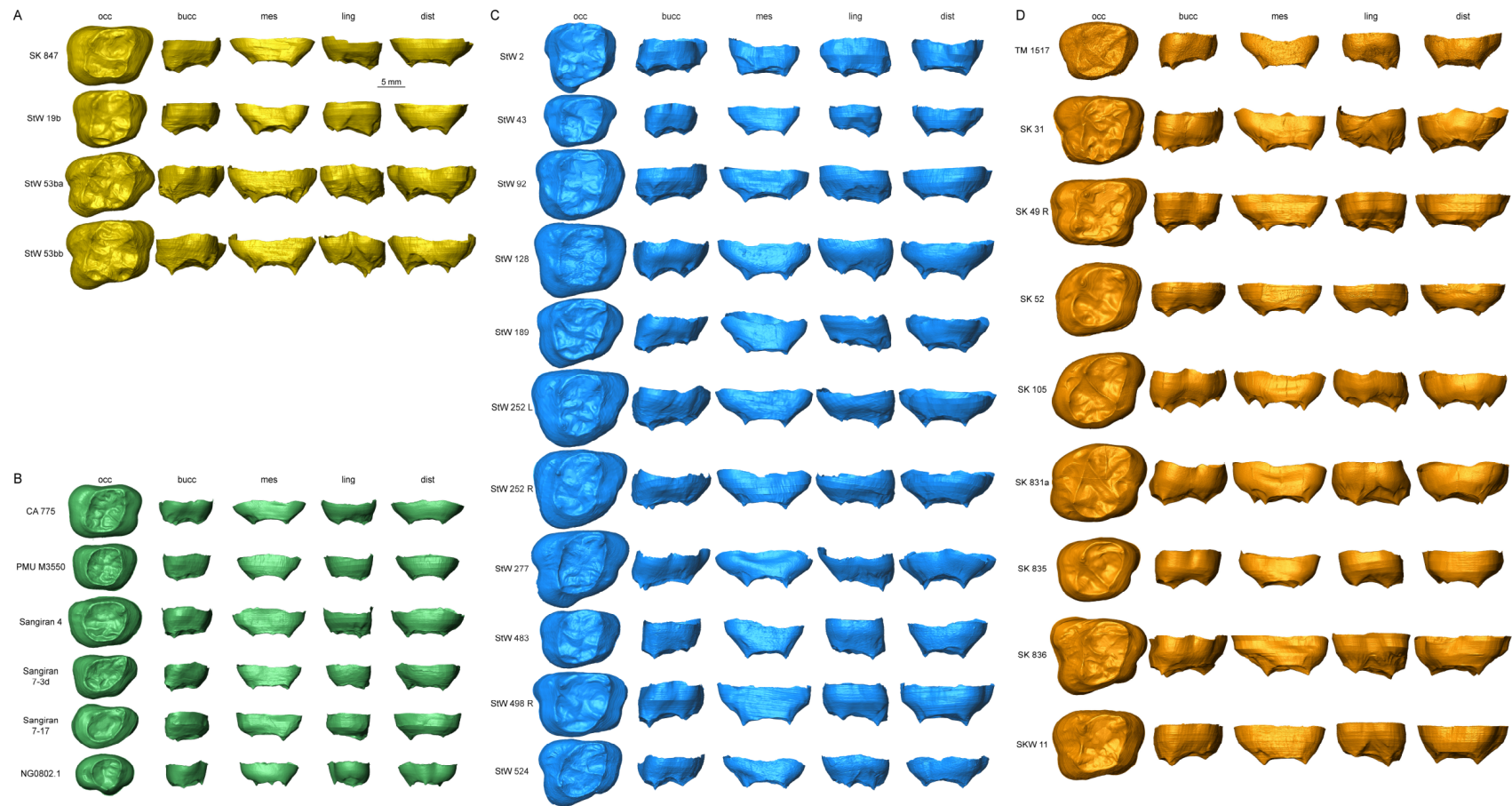


Fig. S3. The M³ EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).

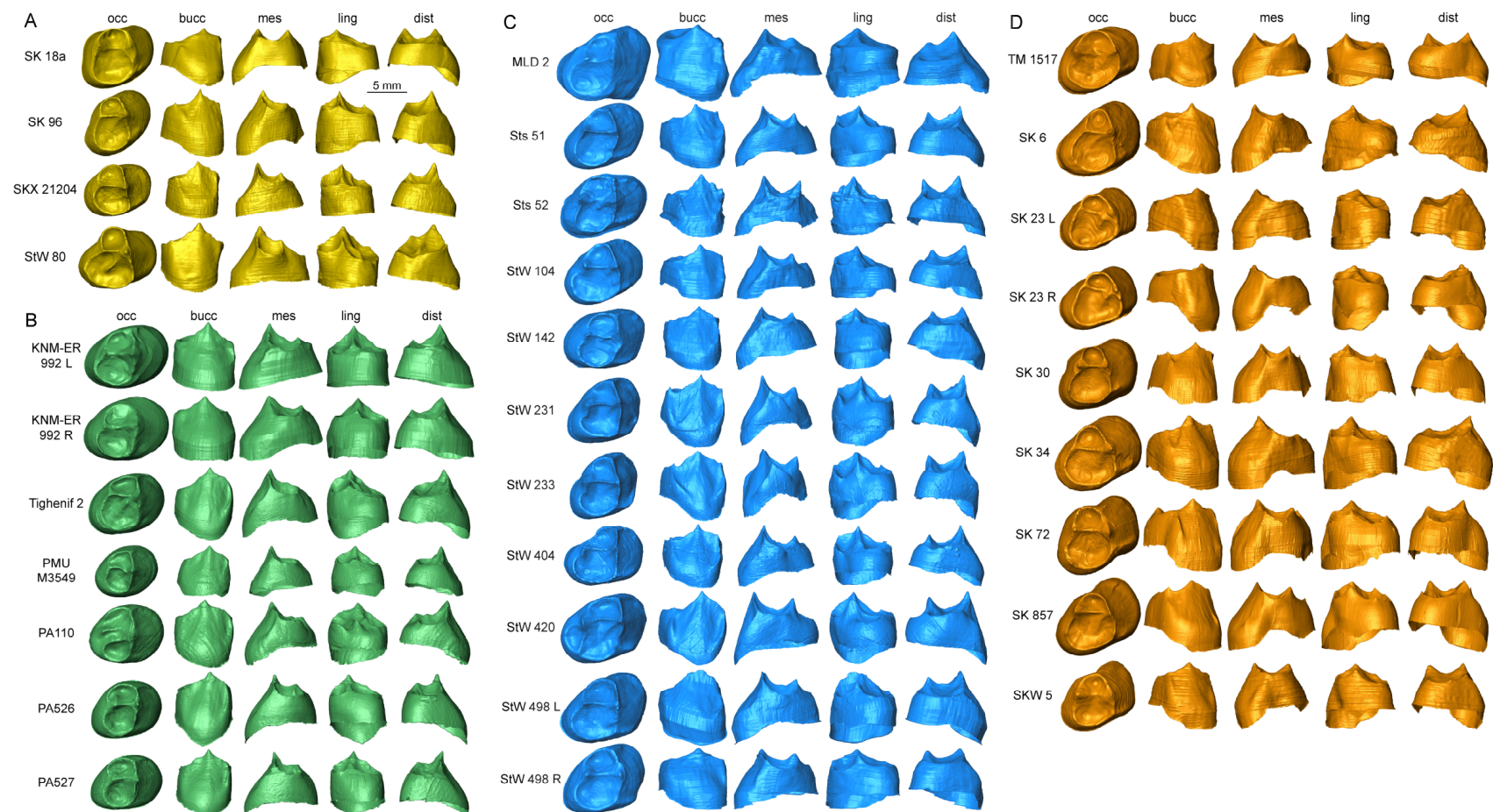


Fig. S4. The P₃ EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).

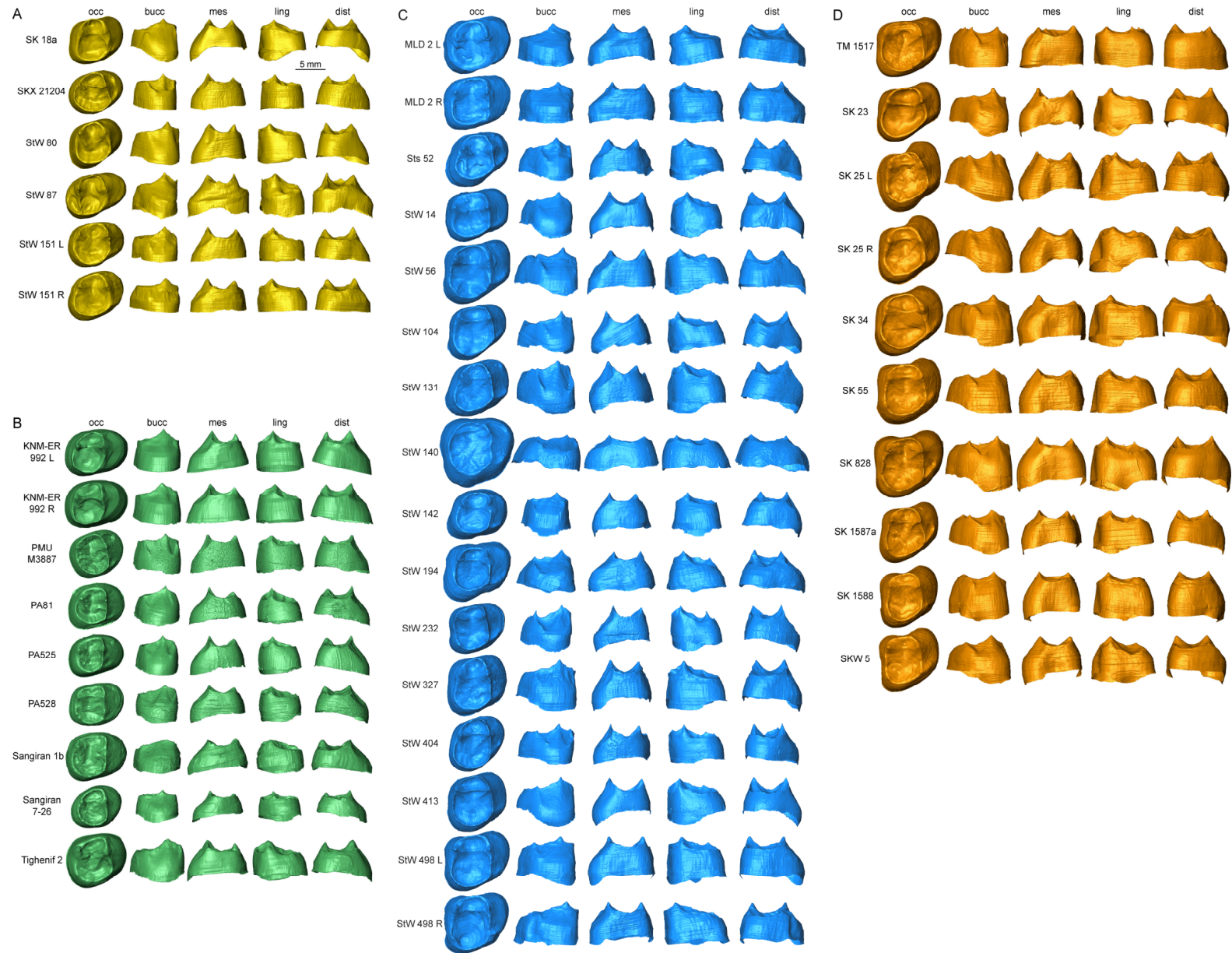


Fig. S5. The P4 EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).

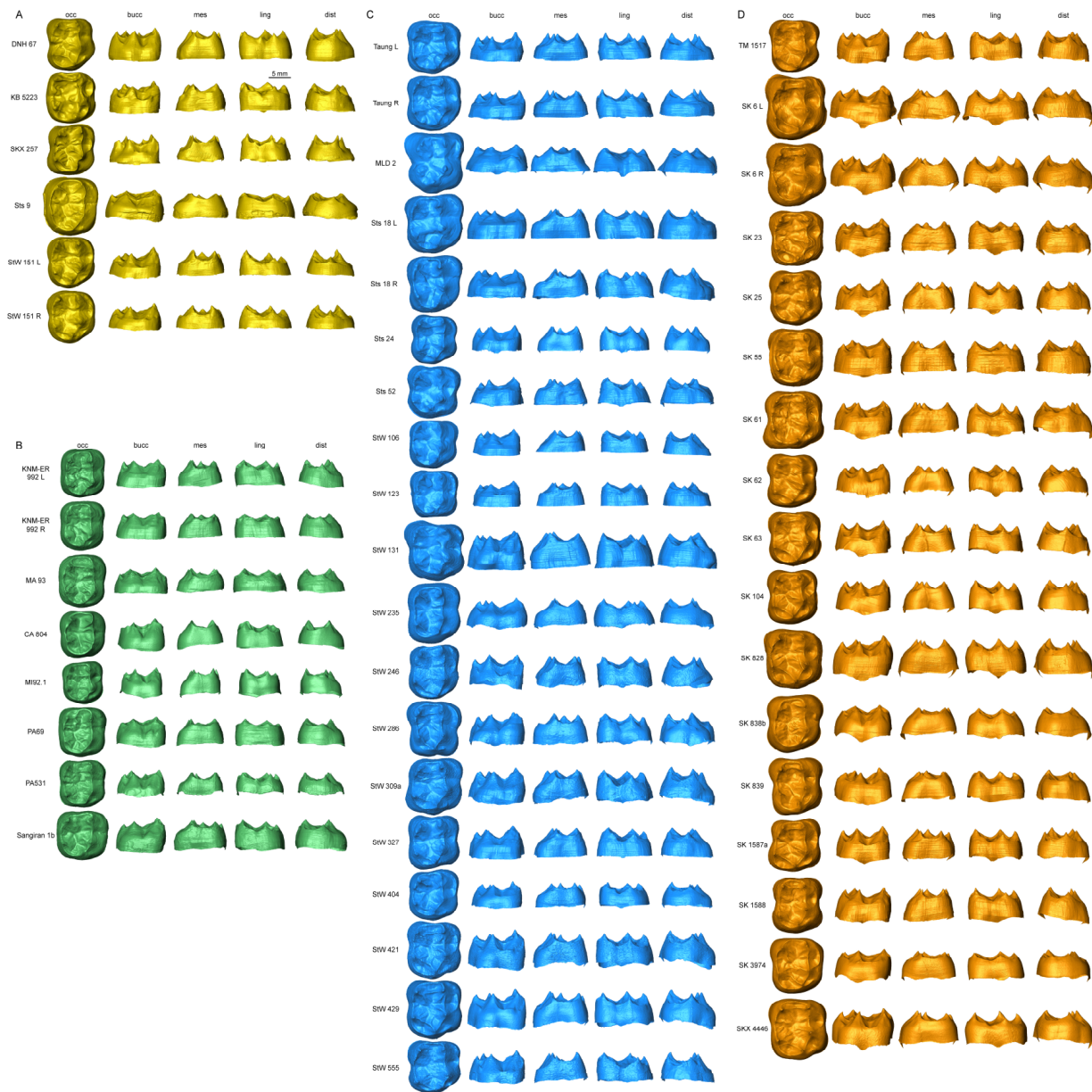


Fig. S6. The M₁ EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).



Fig. S7. The M₂ EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).

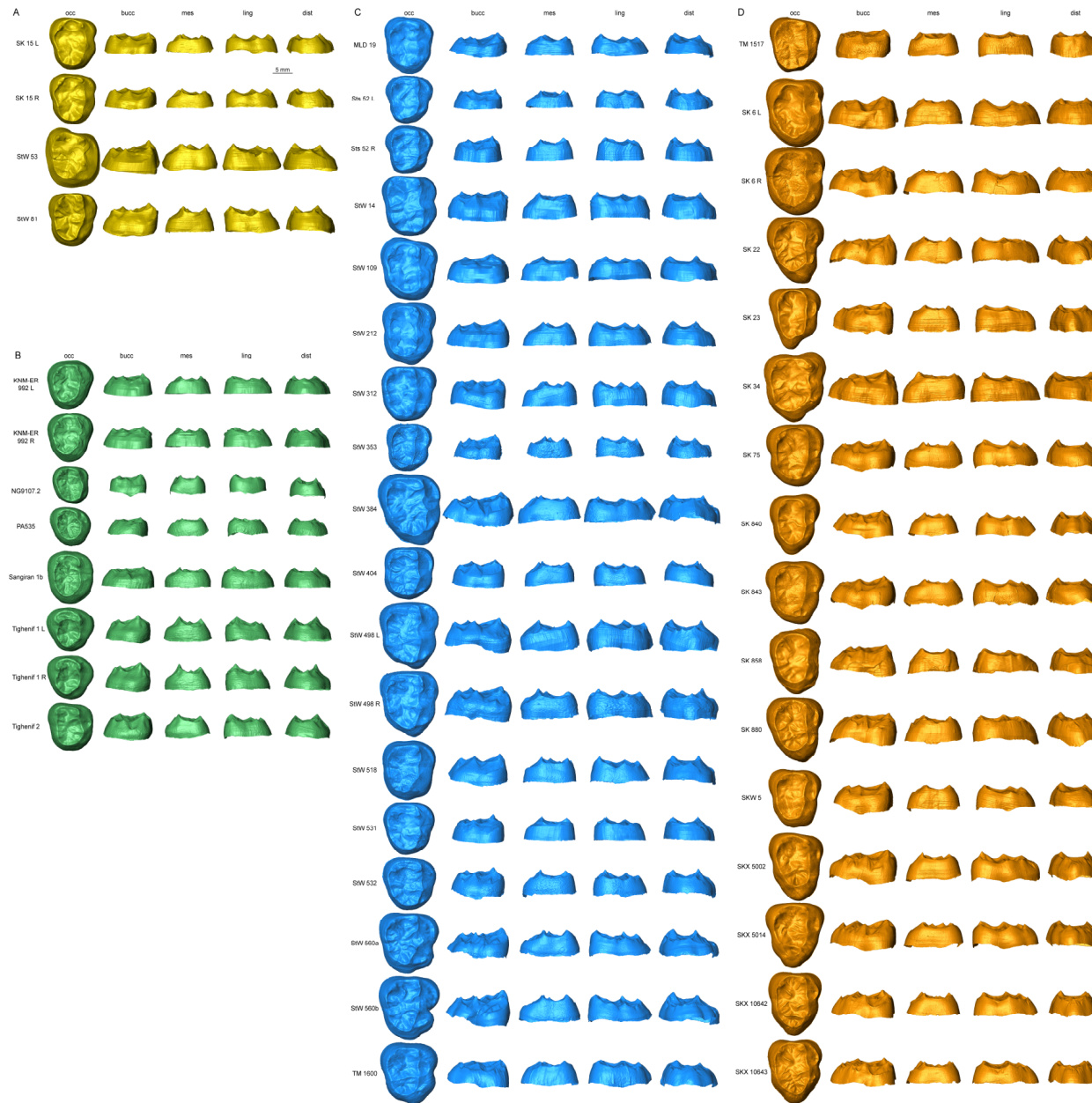


Fig. S8. The M₃ EDJ of the purported early *Homo* specimens from southern Africa (A) compared with those of Early to Middle Pleistocene *Homo* (B), *Australopithecus* (C) and *Paranthropus* (D).

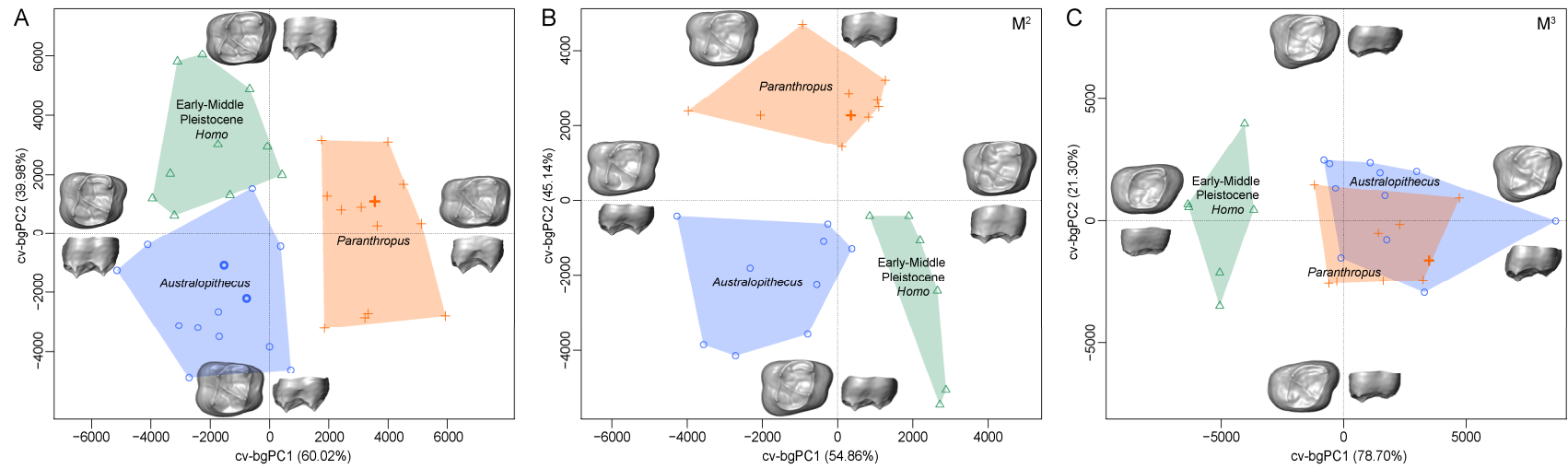


Fig. S9. Bivariate plot of the cross-validated between-group principal component analysis (cv-bgPCA) scores based on the dense surface matching (DSM) deformation fields for the M¹ (A), M² (B) and M³ (C). Symbols highlighted in bold represent the holotype specimens of *Australopithecus* (Taung) and *Paranthropus* (TM 1517).

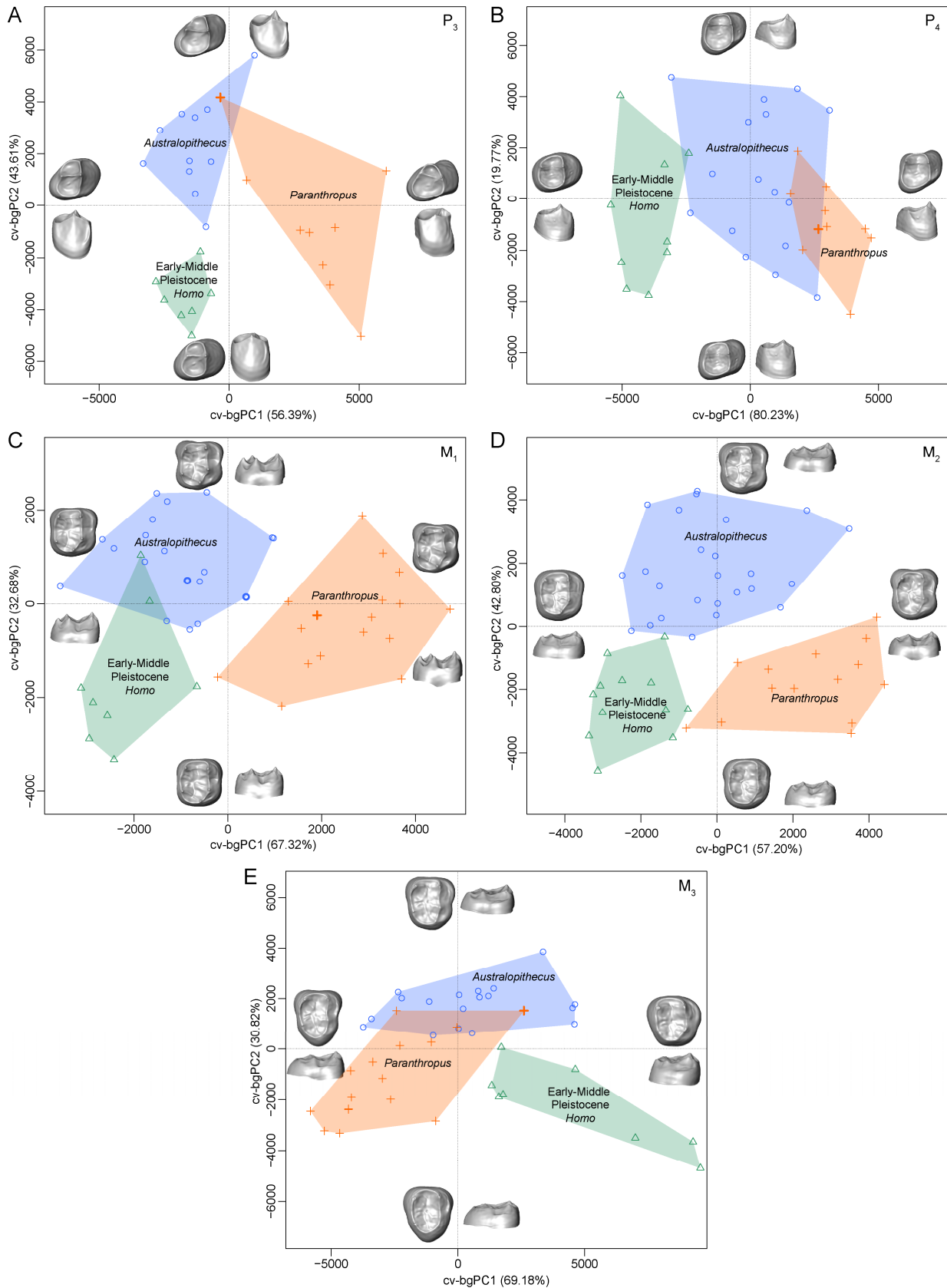


Fig. S10. Bivariate plot of the cross-validated between-group principal component analysis (cv-bgPCA) scores based on the dense surface matching (DSM) deformation fields for the P₃ (A), P₄ (B), M₁ (C), M₂ (D) and M₃ (E). Symbols highlighted in bold represent the holotype specimens of *Australopithecus* (Taung) and *Paranthropus* (TM 1517).

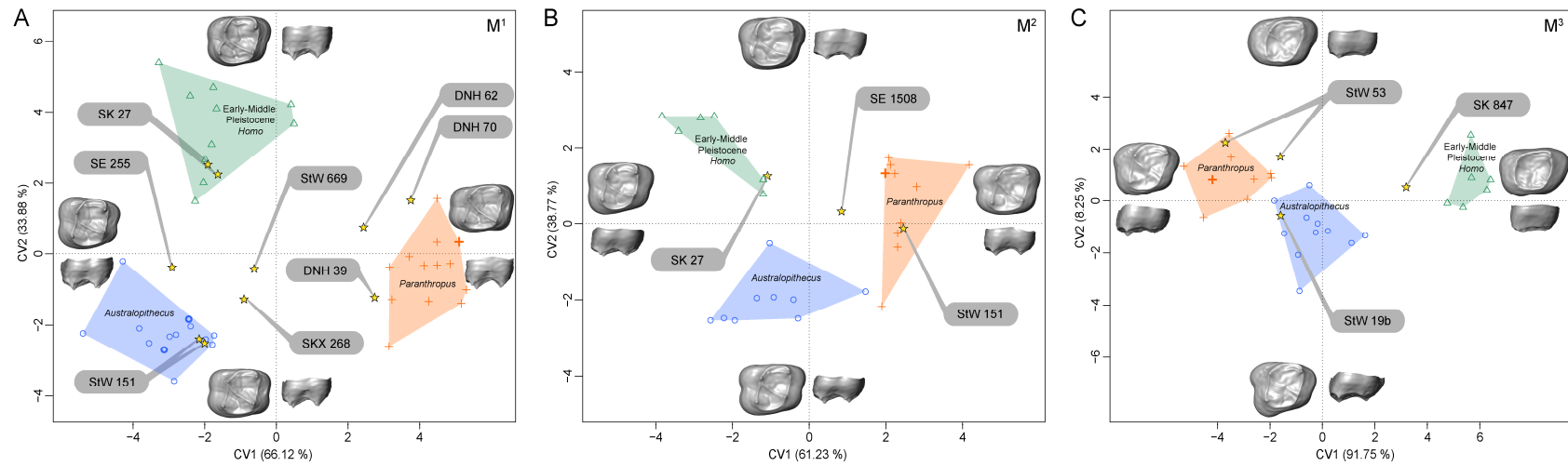


Fig. S11. Bivariate plot of the canonical variate analysis (CVA) scores based on subsets of PC scores for the M¹ (A), M² (B) and M³ (c). Symbols highlighted in bold represent the holotype specimens of *Australopithecus* (Taung) and *Paranthropus* (TM 1517).

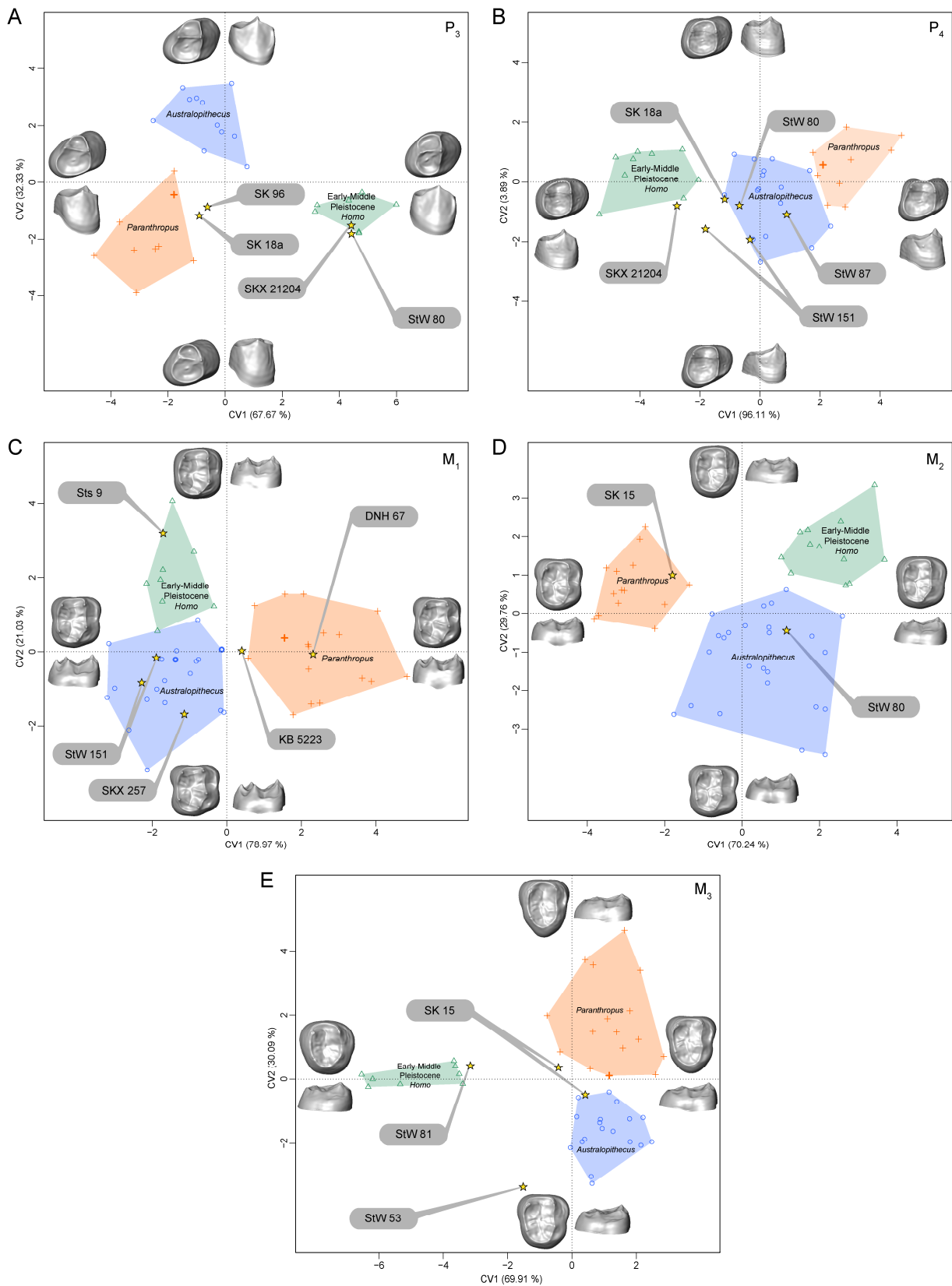


Fig. S12. Bivariate plot of the canonical variate analysis (CVA) scores based on subsets of PC scores for the P₃ (A), P₄ (B), M₁ (C), M₂ (D) and M₃ (E). Symbols highlighted in bold represent the holotype specimens of *Australopithecus* (Taung) and *Paranthropus* (TM 1517).

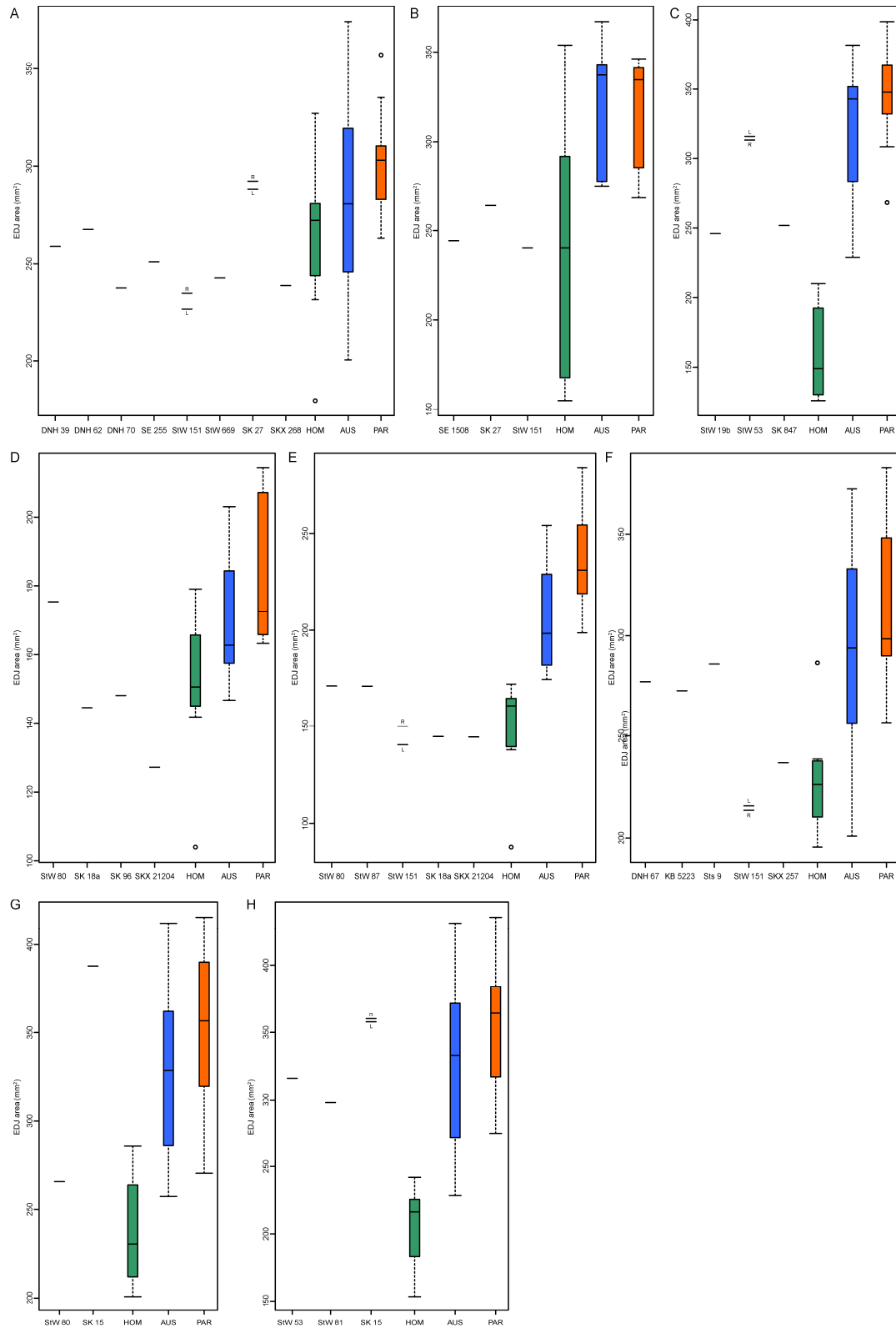


Fig. S13. Box and whisker plots of the EDJ area (used as a proxy for tooth size) of the purported southern African M¹ (A), M² (B), M³ (C), P₃ (D), P₄ (E), M₁ (F), M₂ (G) and M₃ (H) compared with those of Early to Middle Pleistocene *Homo* (HOM), *Australopithecus* (AUS) and *Paranthropus* (PAR). The boxplots show the median, the 25th and 75th percentiles (upper and lower hinges), and the range (lower and upper whiskers).

Table S1. List of the investigated southern African specimens previously attributed to *Homo* (with the exception of Sts 9 that was recognized as *Homo* in this study).

specimen	tooth	site	stratigraphy	description	attribution to <i>Homo</i>
DNH 39	RM ¹	Drimolen	Main Quarry	12	12
DNH 62	LM ¹	Drimolen	Main Quarry	12	12
DNH 67	RM ₁	Drimolen	Main Quarry	12	12
DNH 70	LM ¹	Drimolen	Main Quarry	12	11
KB 5223	LM ₁	Kromdraai B	Member 3/2?	57	57
SE 255	RM ¹	Sterkfontein	Member 5 (Extension Site)	2, 58	16
SE 1508	RM ²	Sterkfontein	Member 5 (Extension Site)	2, 58	16
StW 19b	RM ³	Sterkfontein	Member 4/5?	13	7
StW 53	LM ³ , RM ³ , LM ₃	Sterkfontein	Member 4/5? (StW 53 Infill)	6	59
StW 80	RP ₃ , RP ₄ , RM ₂	Sterkfontein	Member 5 (West)	17	17
StW 81	RM ₃	Sterkfontein	Member 5 (West)	17	17
StW 87	RP ₄	Sterkfontein	Member 4?	13	7
StW 151	LM ¹ , RM ¹ , RM ² , LP ₄ , RP ₄ , LM ₁ , RM ₁	Sterkfontein	Member 4	60	60
StW 669	RM ¹	Sterkfontein	Millner Hall (STK-MH1 T1)	18	18, 19
Sts 9	RM ₁	Sterkfontein	Member 4/5? (Type Site)	61	this study
SK 15	RM ₂ , LM ₃ , RM ₃	Swartkrans	Member 2	1	1
SK 18a	LP ₃ or LP ₄	Swartkrans	Member 2	3	3
SK 27	LM ¹ , RM ¹ , RM ²	Swartkrans	Member 1 (Hanging Remnant)	5	5
SK 96	LP ₃	Swartkrans	Member 1 (Hanging Remnant)	61	9
SK 847	LM ³	Swartkrans	Member 1 (Hanging Remnant)	6	6
SKX 257	RM ₁	Swartkrans	Member 2	4	4
SKX 268	RM ¹	Swartkrans	Member 2	4	4
SKX 21204	RP ₃ , RP ₄	Swartkrans	Member 1 (Lower Bank)	4	4

Table S2. List of the comparative microtomographic (microCT) data of dental remains attributed to *Australopithecus* (AUS), Early and Middle Pleistocene *Homo* (HOM), and *Paranthropus* (PAR).

specimen	tooth	site	taxonomic attribution	Chronology	ref. of microCT data
MLD 44	M ¹	Makapansgat (South Africa)	AUS	Late Pliocene	this study
Sts 2A	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 24	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 30	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52 L	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52 R	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 57	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 252	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 183	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 283	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 450	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Taung L	M ¹	Taung (South Africa)	AUS	Late Pliocene	this study
Taung R	M ¹	Taung (South Africa)	AUS	Late Pliocene	this study
TM 1601e	M ¹	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
CA 770	M ¹	China	HOM	Middle Pleistocene	62
CA 771	M ¹	China	HOM	Middle Pleistocene	62
#Ish25	M ¹	Ishango (D.R. Congo)	HOM	Early Pleistocene	63
KNM-ER 808	M ¹	Koobi Fora (Kenya)	HOM	~1.5 Ma	this study
KNM-ER 1590 L	M ¹	Koobi Fora (Kenya)	HOM	~1.5-1.4 Ma	64
KNM-ER 1590 R	M ¹	Koobi Fora (Kenya)	HOM	~1.5-1.4 Ma	64
NG91-G10 n°1	M ¹	Ngebung (Indonesia)	HOM	early Middle Pleistocene	22
Sangiran 4 L	M ¹	Sangiran (Indonesia)	HOM	Early Pleistocene	39, 65
Sangiran 4 R	M ¹	Sangiran (Indonesia)	HOM	Early Pleistocene	39, 65
Sangiran 7-3b	M ¹	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
SK 13-14	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 16	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 48	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study

SK 49	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 52	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 89	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 102	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 829	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 832	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 838a	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKW 11	M ¹	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
TM 1517	M ¹	Kromdraai (South Africa)	PAR	initial Early Pleistocene	this study
Sts 2A	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 21	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 22	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52 L	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52 R	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 183	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 252 L	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 252 R	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498	M ²	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
CA 775	M ²	China	HOM	Middle Pleistocene	62
KNM-ER 1590M	M ²	Koobi Fora (Kenya)	HOM	~1.5-1.4 Ma	64
Sangiran 4	M ²	Sangiran (Indonesia)	HOM	Early Pleistocene	39, 65
Sangiran 7-3c	M ²	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
Sangiran 7-53	M ²	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
Sangiran 7-89	M ²	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
SK 13-14	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 16	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 47	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 48	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 49	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 826a2	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study

SK 834	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKW 11	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKW 33-14129	M ²	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
TM 1517	M ²	Kromdraai (South Africa)	PAR	initial Early Pleistocene	this study
StW 2	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 43	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 92	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 128	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 189	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 252 L	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 252 R	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 277	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 483	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 524	M ³	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
CA 772	M ³	China	HOM	Middle Pleistocene	62
M3550	M ³	Zhoukoudian (China)	HOM	~0.8-0.7 Ma	39, 65
NG0802.1	M ³	Ngebung (Indonesia)	HOM	Middle Pleistocene	22
Sangiran 4	M ³	Sangiran (Indonesia)	HOM	Early Pleistocene	39, 65
Sangiran 7-3d	M ³	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
Sangiran 7-17	M ³	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
SK 31	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 49	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 52	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 105	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 831a	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 835	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 836	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKW 11	M ³	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
TM 1517	M ³	Kromdraai (South Africa)	PAR	initial Early Pleistocene	this study

MLD 2	P ₃	Makapansgat (South Africa)	AUS	Late Pliocene	this study
Sts 51	P ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52	P ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 104	P ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 142	P ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 231	P ₃	Sterkfontein(South Africa)	AUS	~2.8-2.2 Ma	this study
StW 233	P ₃	Sterkfontein(South Africa)	AUS	~2.8-2.2 Ma	this study
StW 404	P ₃	Sterkfontein(South Africa)	AUS	~2.8-2.2 Ma	this study
StW 420	P ₃	Sterkfontein(South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498 L	P ₃	Sterkfontein(South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498 R	P ₃	Sterkfontein(South Africa)	AUS	~2.8-2.2 Ma	this study
KNM-ER 992 L	P ₃	Koobi Fora (Kenya)	HOM	~1.5 Ma	this study
KNM-ER 992 R	P ₃	Koobi Fora (Kenya)	HOM	~1.5 Ma	this study
M3549	P ₃	Zhoukoudian (China)	HOM	~0.8-0.7 Ma	39
PA110	P ₃	Zhoukoudian (China)	HOM	~0.5-0.3 Ma	42, 66 67
PA526	P ₃	Xichuan (China)	HOM	Middle Pleistocene	42, 66 67
PA527	P ₃	Xichuan (China)	HOM	Middle Pleistocene	42, 66
Tighenif 2	P ₃	Tighenif (Algeria)	HOM	~1.0 Ma	68
SK 6	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 23 L	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 23 R	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 30	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 34	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 72	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 857	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKW 5	P ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
TM 1517	P ₃	Kromdraai (South Africa)	PAR	initial Early Pleistocene	this study
MLD 2 L	P ₄	Makapansgat (South Africa)	AUS	Late Pliocene	this study
MLD 2 R	P ₄	Makapansgat (South Africa)	AUS	Late Pliocene	this study
Sts 52	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study

StW 14	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 56	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 104	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 131	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 140	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 142	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 194	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 232	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 327	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 404	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 413	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498 L	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498 R	P ₄	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
KNM-ER 992B L	P ₄	Koobi Fora (Kenya)	HOM	~1.5 Ma	this study
KNM-ER 992B R	P ₄	Koobi Fora (Kenya)	HOM	~1.5 Ma	this study
M3887	P ₄	Zhoukoudian (China)	HOM	~0.8-0.7 Ma	39, 65
PA81	P ₄	Changyang (China)	HOM	~0.2 Ma	42, 66 67
PA525	P ₄	Xichuan (China)	HOM	Middle Pleistocene	42, 66 67
PA528	P ₄	Xichuan (China)	HOM	Middle Pleistocene	42
Sangiran 1b	P ₄	Sangiran (Indonesia)	HOM	Early Pleistocene	65,69
Sangiran 7-26	P ₄	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
Tighenif 2	P ₄	Tighenif (Algeria)	HOM	~1.0 Ma	68
SK 23	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 25 L	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 25 R	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 34 L	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 55	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 828	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 1587a	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 1588	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study

SKW 5	P ₄	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
TM 1517	P ₄	Kromdraai (South Africa)	PAR	initial Early Pleistocene	this study
MLD 2	M ₁	Makapansgat (South Africa)	AUS	Late Pliocene	this study
Sts 18 L	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 18 R	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 24	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 106	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 123	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 131	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 235	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 246	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 286	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 309a	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 327	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 404	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 421	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 429	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 555	M ₁	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Taung L	M ₁	Taung (South Africa)	AUS	Late Pliocene	this study
Taung R	M ₁	Taung (South Africa)	AUS	Late Pliocene	this study
CA 804	M ₁	China	HOM	Middle Pleistocene	62
KNM-ER 992 L	M ₁	Koobi Fora (Kenya)	HOM	~1.5 Ma	70
KNM-ER 992 R	M ₁	Koobi Fora (Kenya)	HOM	~1.5 Ma	70
MA 93	M ₁	Mulhuli Amo (Eritrea)	HOM	~1.0 Ma	71
MI92.1	M ₁	Miri (Indonesia)	HOM	Middle Pleistocene	72
PA69	M ₁	Zhoukoudian (China)	HOM	~0.8-0.7 Ma	73
PA531	M ₁	Xichuan (China)	HOM	Middle Pleistocene	73
Sangiran 1b	M ₁	Sangiran (Indonesia)	HOM	Early Pleistocene	65, 69
SK 6 L	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study

SK 6 R	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 23	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 25	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 55	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 61	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 62	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 63	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 104	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 828	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 838b	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 839	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 1587a	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 1588	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 3974	M ₁	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKX 4446	M ₁	Swartkrans (South Africa)	PAR	~1.4 Ma	this study
TM 1517	M ₁	Kromdraai (South Africa)	PAR	initial Early Pleistocene	this study
MLD 2 L	M ₂	Makapansgat (South Africa)	AUS	Late Pliocene	this study
MLD 2 R	M ₂	Makapansgat (South Africa)	AUS	Late Pliocene	this study
Sts 52 L	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52 R	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 3	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 14	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 61	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 72	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 109	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 120	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 133	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 213	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 234	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 295	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study

StW 322	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 327	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 384	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 404	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 519	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 520	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 534	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 560d	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 560e	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
TM 1600	M ₂	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
CA 808	M ₂	China	HOM	Middle Pleistocene	62
KNM-ER 992 L	M ₂	Koobi Fora (Kenya)	HOM	~1.5 Ma	70
KNM-ER 992 R	M ₂	Koobi Fora (Kenya)	HOM	~1.5 Ma	70
MA 93	M ₂	Mulhuli Amo (Eritrea)	HOM	~1.0 Ma	71
PA70	M ₂	Zhoukoudian (China)	HOM	~0.8-0.7 Ma	73
PA533	M ₂	Xichuan (China)	HOM	Middle Pleistocene	this study
Sangiran 1b	M ₂	Sangiran (Indonesia)	HOM	Early Pleistocene	65, 69
Sangiran 7-20	M ₂	Sangiran (Indonesia)	HOM	Early Pleistocene	27
Sangiran 7-64	M ₂	Sangiran (Indonesia)	HOM	Early Pleistocene	this study
Sangiran 7-65	M ₂	Sangiran (Indonesia)	HOM	Early Pleistocene	27
SMF-8865	M ₂	Sangiran (Indonesia)	HOM	Early Pleistocene	65
Tighenif 2	M ₂	Tighenif (Algeria)	HOM	~1.0 Ma	68
SK 1	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 6 L	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 6 R	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 23 L	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 23 R	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 25 L	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 34 R	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study

SK 843	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 858 R	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 1587a	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 1587b	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 3976	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKW 5 L	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKX 4446	M ₂	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
MLD 19	M ₃	Makapansgat (South Africa)	AUS	Late Pliocene	this study
Sts 52 L	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
Sts 52 R	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 14	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 109	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 212	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 312	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 353	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 384	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 404	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498 L	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 498 R	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 518	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 531	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 532	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 560a	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
StW 560b	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
TM1600	M ₃	Sterkfontein (South Africa)	AUS	~2.8-2.2 Ma	this study
KNM-ER 992 L	M ₃	Koobi Fora (Kenya)	HOM	~1.5 Ma	70
KNM-ER 992 R	M ₃	Koobi Fora (Kenya)	HOM	~1.5 Ma	70
NG9107.2	M ₃	Ngebung (Indonesia)	HOM	Middle Pleistocene	22
PA535	M ₃	Xichuan (China)	HOM	Middle Pleistocene	this study
Sangiran 1b	M ₃	Sangiran (Indonesia)	HOM	Early Pleistocene	65, 69

Tighenif 1 L	M ₃	Tighenif (Algeria)	HOM	~1.0 Ma	68
Tighenif 1 R	M ₃	Tighenif (Algeria)	HOM	~1.0 Ma	68
Tighenif 2	M ₃	Tighenif (Algeria)	HOM	~1.0 Ma	68
SK 6 L	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 6 R	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 22	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 23	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 34	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 75	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 840	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 843	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 858	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SK 880	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKW 5	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKX 5002	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKX 5014	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKX 10642	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
SKX 10643	M ₃	Swartkrans (South Africa)	PAR	~2.2-1.8 Ma	this study
TM 1517	M ₃	Kromdraai (South Africa)	PAR	initial Early Pleistocene	this study

Table S3. Results of the permutational ANOVA testing the group structure in the shape data. AUST: *Australopithecus*; HOM: Early and Middle Pleistocene *Homo*; PAR: *Paranthropus*. Significant values are highlighted in bold.

tooth	groups compared	R ²	adjusted <i>p</i> -value
	AUST vs. HE	0.17	<0.01
M ¹	AUST vs. PROB	0.15	<0.01
	HE vs. PROB	0.20	<0.01
	AUST vs. HE	0.20	<0.01
M ²	AUST vs. PROB	0.16	<0.01
	HE vs. PROB	0.21	<0.01
	AUST vs. HE	0.21	<0.01
M ³	AUST vs. PROB	0.07	0.11
	HE vs. PROB	0.24	<0.01
	AUST vs. HE	0.23	<0.01
P ₃	AUST vs. PROB	0.23	<0.01
	HE vs. PROB	0.31	<0.01
	AUST vs. HE	0.15	<0.01
P ₄	AUST vs. PROB	0.10	<0.01
	HE vs. PROB	0.33	<0.01
	AUST vs. HE	0.08	0.02
M ₁	AUST vs. PROB	0.11	<0.01
	HE vs. PROB	0.17	<0.01
	AUST vs. HE	0.11	<0.01
M ₂	AUST vs. PROB	0.11	<0.01
	HE vs. PROB	0.21	<0.01
	AUST vs. HE	0.14	<0.01
M ₃	AUST vs. PROB	0.11	<0.01
	HE vs. PROB	0.22	<0.01

Table S4. Cross-validated bgPCA and CVA proportions of correctly classified individuals using shape data and *Australopithecus* (AUS), Early and Middle Pleistocene *Homo* (HOM), and *Paranthropus* (PAR) used as a priori groups.

	HOM		AUS		PAR		overall accuracy	
M¹	bgPCA: 10/10	CVA: 10/10	bgPCA: 12/13	CVA: 13/13	bgPCA: 13/13	CVA: 13/13	bgPCA: 97.2%	CVA: 100.0%
M²	bgPCA: 5/6	CVA: 6/6	bgPCA: 9/9	CVA: 8/9	bgPCA: 10/10	CVA: 9/10	bgPCA: 96.0%	CVA: 92.0%
M³	bgPCA: 6/6	CVA: 6/6	bgPCA: 8/11	CVA: 10/11	bgPCA: 6/9	CVA: 7/9	bgPCA: 76.9%	CVA: 88.5%
P₃	bgPCA: 7/7	CVA: 7/7	bgPCA: 10/11	CVA: 11/11	bgPCA: 7/9	CVA: 7/9	bgPCA: 88.9%	CVA: 92.6%
P₄	bgPCA: 8/9	CVA: 9/9	bgPCA: 11/16	CVA: 13/16	bgPCA: 8/10	CVA: 9/10	bgPCA: 77.1%	CVA: 88.6%
M₁	bgPCA: 6/8	CVA: 7/8	bgPCA: 19/19	CVA: 18/19	bgPCA: 16/17	CVA: 16/17	bgPCA: 93.2%	CVA: 93.2%
M₂	bgPCA: 12/12	CVA: 12/12	bgPCA: 24/25	CVA: 23/25	bgPCA: 13/14	CVA: 14/14	bgPCA: 96.1%	CVA: 96.1%
M₃	bgPCA: 6/8	CVA: 8/8	bgPCA: 15/18	CVA: 18/18	bgPCA: 12/16	CVA: 13/16	bgPCA: 78.6%	CVA: 92.9%

Table S5. Results of permutational multivariate analysis of shape (all PC scores) covariance using EDJ area as covariate and genera as groups. Significant values are highlighted in bold.

Tooth	Source of variation	Model with interaction (PCs~EDJ _{area} *groups)		Model without size (PCs~groups)	
		R ²	p-value	R ²	p-value
M¹	EDJ area	0.05	0.02		
	groups (genera)	0.22	<0.01	0.22	<0.01
	interaction	0.06	0.09		
M²	EDJ area	0.09	<0.01		
	groups (genera)	0.19	<0.01	0.25	<0.01
	interaction	0.06	0.60		
M³	EDJ area	0.15	<0.01		
	groups (genera)	0.09	0.17	0.21	<0.01
	interaction	0.09	0.13		
P₃	EDJ area	0.06	0.03		
	groups (genera)	0.29	<0.01	0.31	<0.01
	interaction	0.03	0.95		
P₄	EDJ area	0.14	<0.01		
	groups (genera)	0.11	<0.01	0.21	<0.01
	interaction	0.04	0.73		
M₁	EDJ area	0.07	<0.01		
	groups (genera)	0.12	<0.01	0.15	<0.01
	interaction	0.05	0.18		
M₂	EDJ area	0.07	<0.01		
	groups (genera)	0.12	<0.01	0.17	<0.01
	interaction	0.04	0.38		
M₃	EDJ area	0.10	<0.01		
	groups (genera)	0.12	<0.01	0.19	<0.01
	interaction	0.05	0.31		

Table S6. Presence/absence and degree of expression frequencies of the upper molar cusps 5 and 6 (UM C5 and UM C6), protoconule, Carabelli trait, and lower molar distal accessory cusp (DAC), lingual accessory cusp (LAC), mid-trigonid crest and protostylid assessed on the EDJ. The darker green cells are those with higher frequencies. AUST: *Australopithecus*; HOM: Early and Middle Pleistocene *Homo*; PAR: *Paranthropus*. Significant values are highlighted in bold. Ent: entoconid type; Hld: hypoconulid type; Int: interconulid type; Med: metaconid type (for more information regarding scoring of each trait, see Supplementary Material and Methods).

UM C5		n	M ¹ (%)				M ² (%)				M ³ (%)			
taxon	(M ¹ , M ² , M ³)		0	0.5	1	2	0	0.5	1	2	0	0.5	1	2
AUST	14,9,11		92.9	7.1	0.0	0.0	88.9	11.1	0.0	0.0	27.3	9.1	45.5	18.2
HOM	10,7,6		90.0	10.0	0.0	0.0	100.0	0.0	0.0	0.0	83.3	0.0	16.7	0.0
PAR	12,10,9		91.7	0.0	8.3	0.0	90.0	10.0	0.0	0.0	44.4	22.2	33.3	0.0
UM C6		n	M ¹ (%)		M ² (%)		M ³ (%)							
taxon	(M ¹ , M ² , M ³)		0	1	0	1	0	1						
AUST	14,9,11		100.0	0.0	100.0	0.0	100.0	0.0						
HOM	10,7,6		100.0	0.0	100.0	0.0	100.0	0.0						
PAR	12,10,9		100.0	0.0	100.0	0.0	77.8	22.2						
protoconule		n	M ¹ (%)				M ² (%)				M ³ (%)			
taxon	(M ¹ , M ² , M ³)		0	0.5	1	2	0	0.5	1	2	0	0.5	1	2
AUST	14,9,11		78.6	21.4	0.0	0.0	100.0	0.0	0.0	0.0	72.7	27.3	0.0	0.0
HOM	10,7,6		50.0	10.0	30.0	10.0	50.0	50.0	0.0	0.0	50.0	33.3	16.7	0.0
PAR	12,10,9		58.3	25.0	16.7	0.0	100.0	0.0	0.0	0.0	55.6	22.2	22.2	0.0
Carabelli trait		n	M ¹ (%)				M ² (%)				M ³ (%)			
taxon	(M ¹ , M ² , M ³)		0	1	2	3	0	1	2	3	0	1	2	3
AUST	14,9,11		28.6	28.6	28.6	14.3	11.1	33.3	55.6	0.0	9.1	72.7	18.2	0.0
HOM	10,7,6		30.0	50.0	20.0	0.0	83.3	0.0	16.7	0.0	50.0	33.3	16.7	0.0
PAR	12,10,9		25.0	58.3	16.7	0.0	30.0	70.0	0.0	0.0	11.1	33.3	44.4	11.1
DAC		n	M ₁ (%)				M ₂ (%)				M ₃ (%)			
taxon	(M ₁ , M ₂ , M ₃)		none	Ent	Int	Hld	none	Ent	Int	Hld	none	Ent	Int	Hld
AUST	19,25,18		84.2	0.0	15.8	0.0	56.0	0.0	32.0	12.0	22.2	66.7	0.0	11.1
HOM	8,12,8		75.0	0.0	12.5	12.5	41.7	0.0	33.3	25.0	75.0	0.0	25.0	0.0
PAR	17,14,16		47.1	0.0	47.1	5.9	7.1	7.1	85.7	0.0	0.0	6.3	93.8	0.0
LAC		n	M ₁ (%)				M ₂ (%)				M ₃ (%)			
taxon	(M ₁ , M ₂ , M ₃)		none	Med	Int	Ent	none	Med	Int	Ent	none	Med	Int	Ent
AUST	19,25,18		89.5	0.0	5.3	5.3	76.0	16.0	0.0	8.0	55.6	16.7	27.8	0.0
HOM	8,12,8		37.5	62.5	0.0	0.0	66.7	8.3	25.0	0.0	50.0	25.0	25.0	0.0
PAR	17,14,16		94.1	5.9	0.0	0.0	92.9	7.1	0.0	0.0	81.3	0.0	18.8	0.0
mid-trigonid crest		n	M ₁ (%)				M ₂ (%)				M ₃ (%)			
taxon	(M ₁ , M ₂ , M ₃)		0	1	2	3	0	1	2	3	0	1	2	3
AUST	19,25,18		47.4	15.8	36.8	0.0	40.0	40.0	20.0	0.0	16.7	55.6	22.2	5.6
HOM	8,12,8		25.0	37.5	25.0	12.5	50.0	33.3	16.7	0.0	50.0	37.5	12.5	0.0
PAR	17,14,16		11.8	35.3	52.9	0.0	28.6	71.4	0.0	0.0	68.8	31.3	0.0	0.0
protostylid		n	M ₁ (%)			M ₂ (%)			M ₃ (%)					
taxon	(M ₁ , M ₂ , M ₃)		0	1	2	0	2	0	1	2				
AUST	19,25,18		0.0	10.5	89.5	4.0	32.0	64.0	0.0	22.2	77.8			
HOM	8,12,8		75.0	12.5	12.5	58.3	25.0	16.7	75.0	25.0	0.0			
PAR	17,14,16		0.0	0.0	100.0	0.0	28.6	71.4	12.5	6.3	81.3			

Table S7. Results of the permutational ANOVA testing the group differences based on size (log EDJ surface area). AUST: *Australopithecus*; HOM: Early and Middle Pleistocene *Homo*; PAR: *Paranthropus*. Significant values are highlighted in bold.

tooth	groups compared	R ²	adjusted <i>p</i> -value
	AUST vs. HE	0.06	0.52
M¹	AUST vs. PROB	0.02	0.57
	HE vs. PROB	0.19	0.15
	AUST vs. HE	0.37	0.03
M²	AUST vs. PROB	0.01	0.86
	HE vs. PROB	0.37	0.02
	AUST vs. HE	0.79	<0.01
M³	AUST vs. PROB	0.09	0.18
	HE vs. PROB	0.86	<0.01
	AUST vs. HE	0.19	0.10
P₃	AUST vs. PROB	0.12	0.13
	HE vs. PROB	0.35	0.04
	AUST vs. HE	0.54	<0.01
P₄	AUST vs. PROB	0.27	0.01
	HE vs. PROB	0.71	<0.01
	AUST vs. HE	0.32	<0.01
M₁	AUST vs. PROB	0.07	0.11
	HE vs. PROB	0.64	<0.01
	AUST vs. HE	0.59	<0.01
M₂	AUST vs. PROB	0.05	0.16
	HE vs. PROB	0.71	<0.01
	AUST vs. HE	0.55	<0.01
M₃	AUST vs. PROB	0.08	0.12
	HE vs. PROB	0.79	<0.01

Table S8. Results of the bgPCA (left) and CVA (right) of size (log EDJ area) showing typicality probabilities of the investigated specimens. For each specimen, typicality probabilities are shown only for the group to which that specimen is affiliated. AUST: *Australopithecus*; HOM: Early and Middle Pleistocene *Homo*; PAR: *Paranthropus*.

	HOM	AUS	PAR
M¹			
DNH 39	-0.92	-/-	0.97/-
DNH 62	-0.91	-/-	0.73/-
DNH 70	0.81/0.50	-/-	-/-
SE 255	-0.75	0.87/-	-/-
SK 27 L	-/-	-0.95	0.22/-
SK 27 R	-/-	-/-	0.17/0.94
SKX 268	0.86/0.52	-/-	-/-
StW 151 L	0.42/0.32	-/-	-/-
StW 151 R	0.71/0.46	-/-	-/-
StW 669	0.99/0.60	-/-	-/-
M²			
SE 1508	0.41/0.76	-/-	-/-
SK 27	-0.46	0.35/-	-/-
StW 151	0.65/0.83	-/-	-/-
M³			
SK 847	0.07/-	-0.17	-/-
StW 19	0.14/-	-0.13	-/-
StW 53 L	-/-	-0.99	0.66/-
StW 53 R	-/-	-0.97	0.57/-
P₃			
SK 18a	-0.82	0.80/-	-/-
SK 96	-0.97	0.96/-	-/-
SKX 21204	0.73/0.23	-/-	-/-
StW 80	-/-	-0.77	0.42/0.77
P₄			
SK 18a	0.32/0.97	-/-	-/-
SKX 21204	0.33/0.96	-/-	-/-
StW 80	-0.27	-/-	0.49/-
StW 87	0.64/0.81	-/-	-/-
StW 151 L	-0.83	0.50/-	-/-
StW 151 R	-0.27	-/-	0.50/-
M₁			
DNH 67	-/-	-0.77	0.70/-
KB 5223	-/-	-0.69	0.82/-
SKX 257	-0.79	0.60/-	-/-

Sts 9	-/-	-/0.94	0.49/-
StW 151 L	0.85/0.73	-/-	-/-
StW 151 R	0.92/0.68	-/-	-/-
M₂			
SK 15	-/-	-/-	0.89/0.44
StW 80	0.34/0.37	-/-	-/-
M₃			
SK 15 L	-/-	-/-	0.73/0.92
SK 15 R	-/-	-/-	0.65/0.89
StW 53h	-/-	0.29/0.97	-/-
StW 81	0.54/-	-/0.69	-/-

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