Descriptive anatomy and three-dimensional reconstruction of the skull of the tetrapod *Eoherpeton watsoni* Panchen, 1975 from the Carboniferous of Scotland

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**Transformation Matrices for 3D reconstruction of the *Eoherpeton skull***

Transformation matrices in Amira for individual bones from original µCT data set of *Eoherpeton watsoni* to the 3D digitally reconstructed skull. The skull was originally assembled by aligning the midline ventral braincase elements and right-side palatal elements, building up the skull on the right side (any left side elements were mirrored across the midline and incorporated into the model), adding the skull roof and then vaulting the palate and making any necessary adjustments. The entire right side of the skull was then mirrored and moved as a single piece to create the left side of the skull. A similar process was used to retrodeform the lower jaw.

Due to the state of preservation of the specimen, retrodeformation was complex and some pieces required multiple transformations. These multiple deformation steps are denoted by semicolons (;).

Whole skull (moved to correctly align the basisphenoid and then applied to all elements): 0.840198 0.538836 -0.0610198 0 -0.542143 0.837173 -0.072242 0 0.0121574 0.0937786 0.995519 0 -38.6647 -70.4216 -15.0767 1

*Upper jaw (cranium):*

Parasphenoid: 0.931662 0.318859 -0.174173 0 -0.349801 0.916779 -0.192758 0 0.0982156 0.240511 0.965664 0 -4.79196 -17.4983 6.73266 1

Combined basisphenoid and parasphenoid to form a piece called ventral braincase: 1 0 0 0 0 0.996869 0.0790702 0 0 -0.0790702 0.996869 0 0.145862 13.5292 0.00094223 1

Right palate (right palatine [and teeth], right ectopterygoid [and teeth] and right pterygoid [main fragment]): 0.991389 0 -0.130947 0 0 1 0 0 0.130947 0 0.991389 0 -3.91058 -2.38419e-006 -2.28123 1

Left pterygoid fragment (with basal articulation): -1; 0.998458 0.0515494 0.0205595 0 -0.0489105 0.992396 -0.112948 0 -0.0262255 0.111769 0.993388 0 -35.4321 -13.049 0.534527 1

Left vomer (with teeth): -1; 0.969497 0.241816 0.0399896 0 -0.244826 0.963153 0.11134 0 -0.0115923 -0.117734 0.992977 0 -0.381617 15.0843 5.8021 1

The preceding three pieces were combined to form a piece called right whole palate: 0.839047 0.543286 0.0289843 0 -0.543295 0.833857 0.0975548 0 0.0288314 -0.0975999 0.994807 0 -2.75265 15.8687 1.57911 1

The vomer was then extracted, the transform applied, then it was further adjusted: 0.998504 -0.00836217 0.0540349 0 1.86265e-008 0.988236 0.152935 0 -0.0546779 -0.152706 0.986758 0 6.0963 17.401 2.05423 1

The posterior process of the pterygoid was then extracted, the transform applied, then it was further adjusted: 0.954847 0.248754 -0.162441 0 -0.211022 0.952734 0.218557 0 0.20913 -0.17441 0.962209 0 -2.5064 4.11088 -2.05364 1

The pterygoid flange was then extracted, the transform applied, then it was further adjusted: 0.778387 0.627112 0.0290774 0 -0.627377 0.778715 -1.04774e-008 0 -0.022643 -0.0182425 0.999577 0 -8.30121 14.2414 0.814095 1

The remainder of the palate was then extracted, the transform applied, then it was further adjusted: 0.839047 0.543286 0.0289843 0 -0.543295 0.833857 0.0975548 0 0.0288314 -0.0975999 0.994807 0 -2.75265 15.8687 1.57911 1

Pterygoid (quadrate ramus): 0.0123194 0.991668 -0.128235 0 -0.987218 -0.00831676 -0.159158 0 -0.158898 0.128556 0.978889 0 -6.95203 22.9254 -5.00019 1 (left side: -1 0 0 0 0 1 0 0 0 0 1 0 1.58411 0.486015 0 1)

Right skull roof (right postfrontal, parietal, intertemporal, supratemporal, tabular, postparietal): 0.970227 -0.00521931 -0.242137 0 -0.0241721 0.992689 -0.118255 0 0.240984 0.120587 0.963008 0 -36.5815 26.028 0.90591 1; 0.999999 0 0 0 0 0.993421 0.114526 0 0 -0.114526 0.993421 0 0.0403976 2.8681 -6.25371 1

Right premaxilla: 0.183677 0.953121 -0.24046 0 -0.701109 0.298486 0.647574 0 0.688991 0.0496443 0.723067 0 -106.827 3.05564 36.8971 1

Right maxilla (anterior part): 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 1 0 0 0 0 0.991299 -0.13163 0 0 0.13163 0.991299 0 7.62939e-006 -15.8973 0.483994 1

Right maxilla (posterior part): 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.941705 0.0442863 0.333518 0 -0.0908692 0.987936 0.12539 0 -0.323941 -0.148387 0.934366 0 19.9279 5.60263 18.4576 1

Right lacrimal: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.996939 0.0781173 -0.00292587 0 -0.0781719 0.996241 -0.0373131 0 3.53903e-008 0.0374276 0.999299 0 -1.80967 -1.25392 2.71913 1

Right jugal: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.923362 0.383913 0.00346777 0 -0.379825 0.914771 -0.137571 0 -0.055988 0.125711 0.990487 0 1.19847 -0.0889859 3.18133 1

Right quadratojugal: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.833953 0.55047 0.0387841 0 -0.530137 0.818695 -0.220659 0 -0.153219 0.163459 0.97458 0 5.66686 8.40903 7.59729 1

Extracted above five surfaces to form a piece called right lower face: 0.982826 0.184517 0.0020316 0 -0.184498 0.982404 0.0290181 0 0.00335848 -0.0288946 0.999577 0 4.03314 2.62158 -0.321625 1

Right nasal: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.962058 -0.201767 -0.183671 0 0.203295 0.97906 -0.0106724 0 0.181978 -0.027072 0.982929 0 -22.5192 -3.08794 0.866142 1

Right prefrontal: 0.58899 0.805316 -0.0674824 0 -0.787498 0.590693 0.175851 0 0.181476 -0.0504339 0.982099 0 -27.5316 27.65 -0.2239 1

Right frontal (anterior): 0.748278 0.662932 -0.0243869 0 -0.50518 0.593273 0.626751 0 0.429961 -0.456666 0.778835 0 -52.0766 67.276 18.3367 1; 0.58899 0.805316 -0.0674824 0 -0.787498 0.590693 0.175851 0 0.181476 -0.0504339 0.982099 0 -27.5316 27.65 -0.2239 1

Right frontal (posterior): 0.813416 0.551107 -0.186092 0 -0.561957 0.827136 -0.00679219 0 0.15018 0.1101 0.982507 0 -21.4216 12.4564 -4.48839 1; 0.996174 -0.0873941 1.04308e-007 0 0.0868004 0.989407 0.116364 0 -0.0101696 -0.115918 0.993206 0 -5.63087 10.5319 -3.32682 1

Right squamosal piece 1: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.812396 -0.582795 -0.0189881 0 0.572527 0.803412 -0.163523 0 0.110556 0.121974 0.986357 0 -30.1178 -25.6474 4.02239 1

Right squamosal piece 2: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.810803 -0.584414 -0.0325076 0 0.572529 0.80341 -0.163523 0 0.121683 0.113974 0.986005 0 -33.3072 -27.7125 2.90091 1

Right squamosal piece 3: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.812396 -0.582795 -0.0189881 0 0.572527 0.803412 -0.163523 0 0.110556 0.121974 0.986357 0 -30.1178 -25.6474 4.02239 1

Right squamosal piece 4: 0.932509 0.360822 -0.0152714 0 -0.360988 0.930035 -0.0686804 0 -0.0105788 0.0695584 0.997524 0 -21.7281 16.3217 -7.38346 1

Right squamosal piece 5: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.800694 -0.232333 0.552184 0 0.434441 0.859847 -0.268179 0 -0.412488 0.454622 0.789412 0 -21.7379 -22.7071 27.5818 1

Right squamosal piece 6: 0.926093 0.360816 -0.110283 0 -0.36041 0.932474 0.0242785 0 0.111596 0.0172631 0.993606 0 -25.4156 17.9022 -7.19422 1

Extracted all squamosal fragments and combined to form a piece called right squamosal: 0.774812 0.632191 0 0 -0.632191 0.774812 0 0 0 0 0.999999 0 3.56393 21.2893 -3.8147e-006 1

Right postorbital: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.680465 0.700743 -0.214306 0 -0.727919 0.680029 -0.0877148 0 0.0842686 0.215684 0.972821 0 -3.24141 2.1209 -1.90924 1

Right quadrate: 0.615723 0.787828 0.0144354 0 -0.771433 0.598975 0.214741 0 0.160533 -0.143358 0.976564 0 -24.7549 40.8694 -0.601387 1; 0.740597 0.570063 -0.355728 0 -0.486306 0.820049 0.301701 0 0.463702 -0.0504466 0.884552 0 0.832844 5.59496 -18.1239 1; 0.976333 0.216274 0 0 -0.216274 0.976333 0 0 0 0 1 0 7.41012 4.48941 -1.2453 1

Extracted everything except ventral braincase and created left side:

-0.998874 0 0.0474406 0 0 1 0 0 0.0474405 0 0.998875 0 0.436783 1.90735e-006 0.173058 1

*Lower jaw (mandible):*

Dentary (anterior main portion): 0.913604 0.385954 -0.12793 0 -0.393252 0.918695 -0.036752 0 0.103345 0.0838848 0.991101 0 1.61692 -12.6474 -13.5947 1

Dentary (middle main portion): 0.678057 0.732154 0.0647257 0 -0.73489 0.676896 0.0418018 0 -0.0132072 -0.0759101 0.997027 0 4.01668 18.8586 -5.67018 1

Dentary (middle main portion): 0.5041 0.863644 -2.90573e-007 0 -0.862423 0.503387 0.0531667 0 0.0459172 -0.0268012 0.998586 0 -11.5374 19.169 -8.82853 1

Dentary (posterior tip): 0.669936 0.692549 -0.267505 0 -0.668528 0.719444 0.188331 0 0.322884 0.0526646 0.944972 0 -23.0628 6.65367 -14.0212 1

Splenial: 0.919461 0.392552 0.0222061 0 -0.390294 0.918084 -0.0692092 0 -0.047555 0.0549676 0.997354 0 22.9852 -8.29824 -9.80757 1

Postsplenial: 0.919473 0.392908 -0.0138378 0 -0.39296 0.91735 -0.0636521 0 -0.0123152 0.0639625 0.997874 0 19.5916 -9.70721 -12.067 1

Postsplenial (posterior tip): 0.635584 0.769482 0.0626869 0 -0.762745 0.638421 -0.103139 0 -0.119384 0.0177387 0.992688 0 7.84254 14.9309 0.231998 1

Angular (main): 0.0291713 0.999551 -0.00689127 0 -0.998411 0.0288034 -0.0484496 0 -0.0482292 0.00829351 0.998802 0 -31.7234 22.1255 -3.9567 1

Angular (anterior process): 0.5041 0.863644 -2.98023e-007 0 -0.862423 0.503387 0.0531667 0 0.0459172 -0.0268012 0.998586 0 -11.5374 19.169 -8.82854 1

Angular (mesial lamina): 0.380183 0.871709 0.309169 0 -0.917958 0.39653 0.0107813 0 -0.113197 -0.287903 0.950946 0 -10.1772 29.0849 13.4229 1

Surangular: 0.155562 0.983833 -0.088737 0 -0.98773 0.156178 4.28408e-008 0 0.0138588 0.0876482 0.996055 0 -27.021 21.5883 -7.15119 1

Anterior coronoid: 0.913604 0.385954 -0.12793 0 -0.382988 0.922502 0.0480377 0 0.136557 0.00510755 0.990618 0 -2.93547 -1.5908 -12.7486 1

Middle coronoid (extrapolated segment): 0.678057 0.732154 0.0647256 0 -0.73489 0.676896 0.0418018 0 -0.0132072 -0.0759101 0.997027 0 4.01668 18.8586 -5.67018 1

Posterior coronoid: 0.505924 0.861761 0.0374974 0 -0.861695 0.502961 0.0671562 0 0.0390128 -0.0662875 0.997038 0 -10.5216 22.3575 -6.73415 1

Posterior coronoid (posterior tip): 0.512455 0.839523 0.180525 0 -0.849296 0.464457 0.250948 0 0.12683 -0.281919 0.951019 0 -17.7621 33.7018 2.11216 1

Prearticular (posterior main portion): 0.298298 0.953136 -0.0505279 0 -0.872608 0.29378 0.390194 0 0.38675 -0.0723027 0.919344 0 -23.0711 22.532 -1.99393 1

Prearticular (middle main portion): 0.653367 0.748161 -0.11562 0 -0.728563 0.662907 0.17248 0 0.205688 -0.0284565 0.978203 0 -3.88223 15.0613 -6.12619 1

Prearticular (anterior main portion): 0.652532 0.757581 -0.0166403 0 -0.757716 0.652579 -0.00312501 0 0.00849163 0.0146479 0.999856 0 2.30507 13.7315 -2.98303 1

Prearticular (anterior process): 0.317636 0.94807 -0.0165868 0 -0.946048 0.318043 0.0620169 0 0.0640713 -0.00400684 0.997936 0 -18.7488 18.4855 -2.98376 1

Extracted all surfaces and then created left lower jaw: -0.999369 0 0.0355026 0 0 1 0 0 0.0355026 0 0.999371 0 1.34523 1.52588e-005 0.0749359 1