Pictorial essay:

THE ELONGATED SKULL OF NAZCA TRIDACTYL MUMMY 'MONTSERRAT'

A study using CT scan with 3D reconstruction and digital virtual cranial endocast.

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- 'Montserrat' is a very well preserved, desiccated and complete mummy found in the Peruvian desert in Nazca. CT scans had confirmed 'Montserrat' to be a pregnant tridactyl hominid. Her internal anatomy can be well identified. Even evidences of brutal bone and internal organ trauma sustained pre-morbid were evident.
- 'Montserrat' possessed an elongated skull. However the skull should not be studied in isolation because 'Montserrat' also had unusual anatomical features including strange facial features not found in human including absence of pinnae of ears, sloping face, large eye sockets with large slanting eyelids and absence of visible nostrils. Furthermore, tridactyls in hands and feet are present.
- 'Montserrat' had 4 subcutaneous metallic implants of different shapes on her head that were unique amongst the fossil collection.
- 'Montserrat' is not a single specimen. There are a group of tridactyls with elongated skull e.g. 'Maria'. Many isolated elongated fossil skulls had been recovered in the Nazca area. The biological, cultural and archaeological significances remain to be determined.
- This study will shred light on the external and internal anatomy of 'Montserrat' skull using various advanced CT reconstruction and segmentation techniques, including digital virtual cranial endocast with an attempt to compare with modern human skull.
- Acknowledgment: the author wished to thank Tridactyls.org for permission to assess and use the DICOM CT dataset available on their website. The 3D reconstructed CT scans of modern human skull belongs to a 47 years old Chinese female.

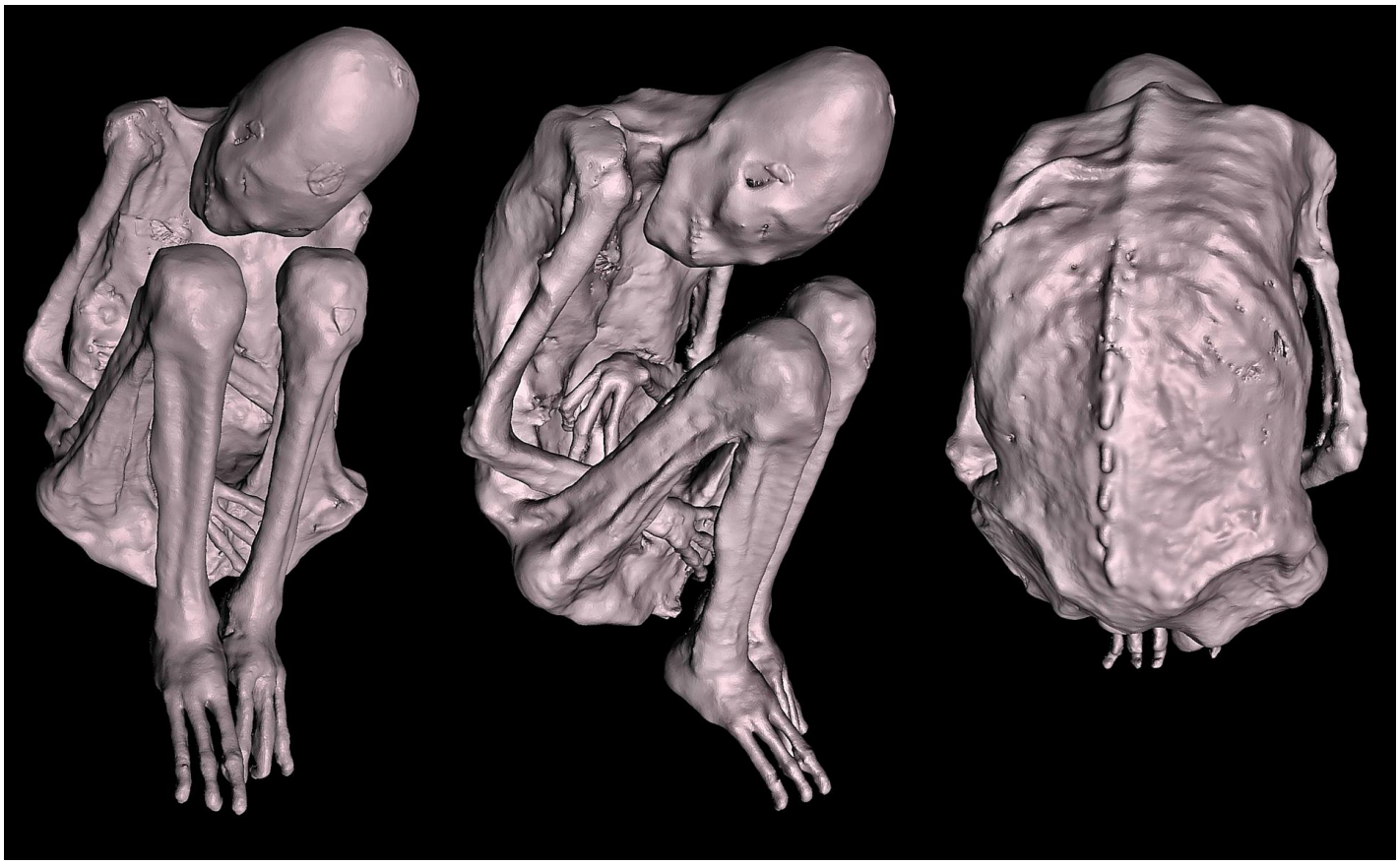

Figure 1: 3D CT scan of ‘Montserrat’ showing its surface anatomy in frontal, anterior oblique and back projections (left, middle and right images). She adopted a foetal position. Tridactyl is evident in hands and feet.

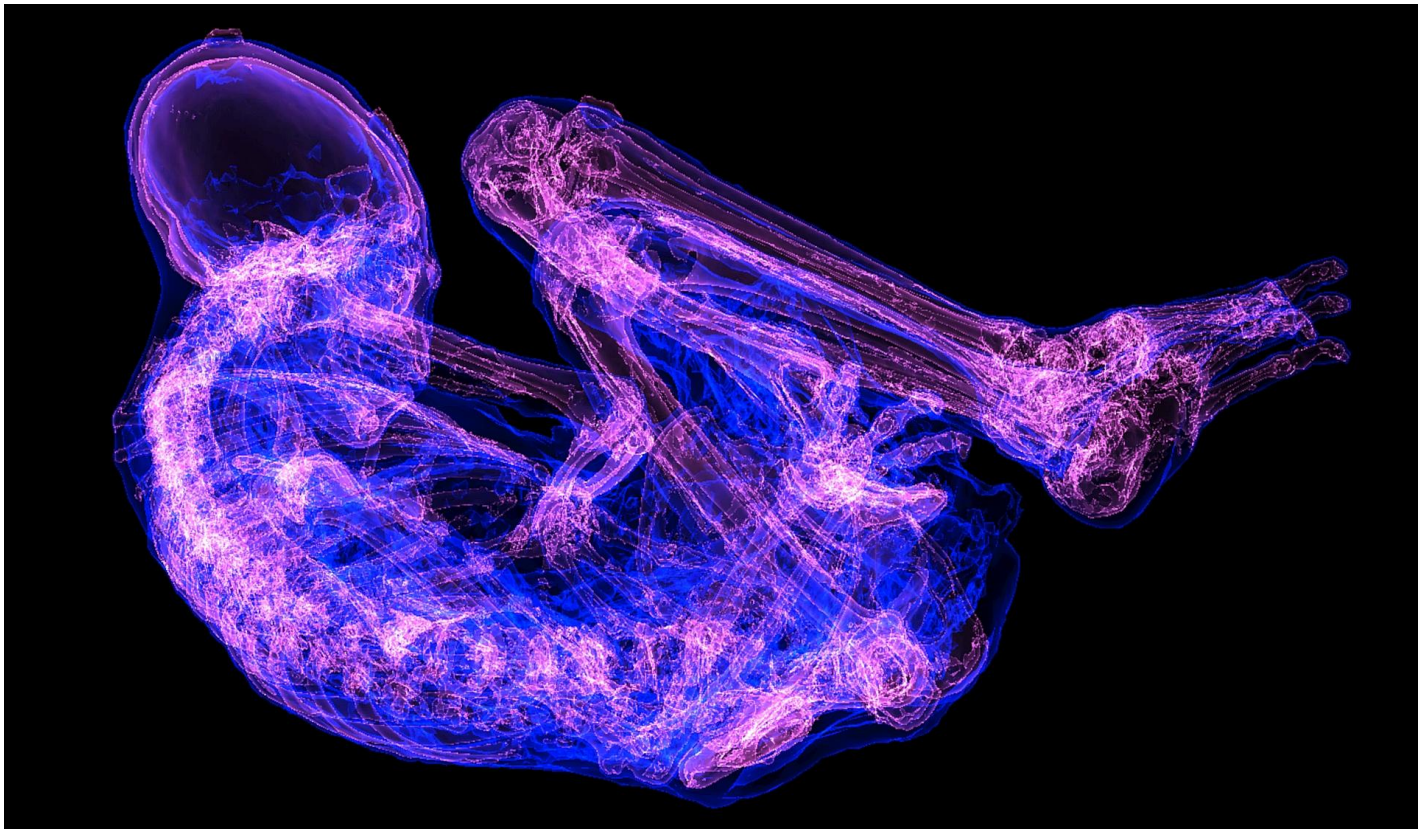

Figure 2: 3D CT scan of ‘Montserrat’ showing skin and bones in semi-transparency.

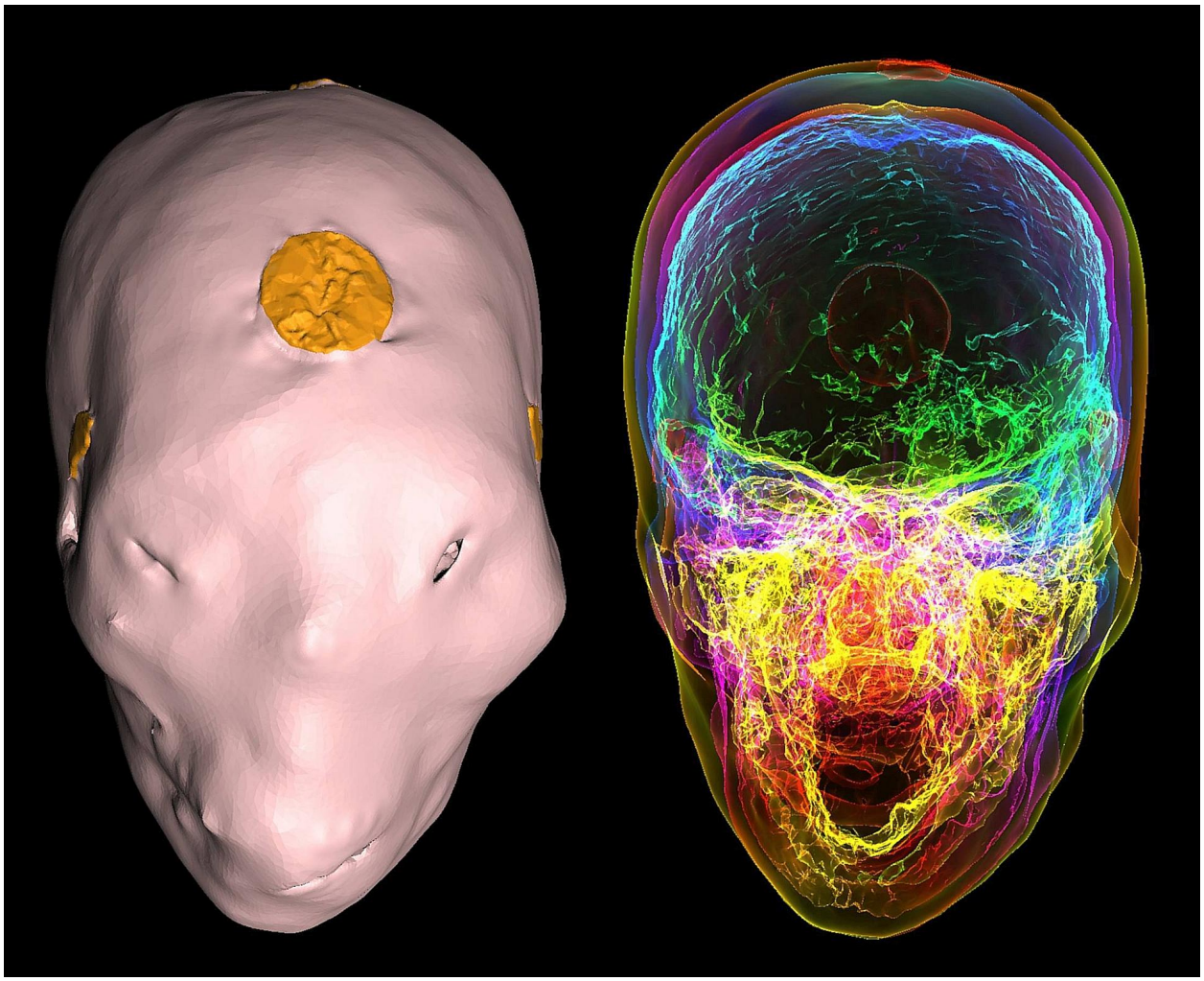

Figure 3: 3D CT scan of ‘Montserrat’ showing unusual facial feature. In left image, elongated sloping forehead with sloping face are noted. There are widely separated slanting eyelids. No nostril can be identified on the small nose. There is facial asymmetry with deviation of the upper and lower jaws towards the right side. The mouth is asymmetrical with no opening found on its right side. A semi-transparent view including bones is shown on the right in false colours.

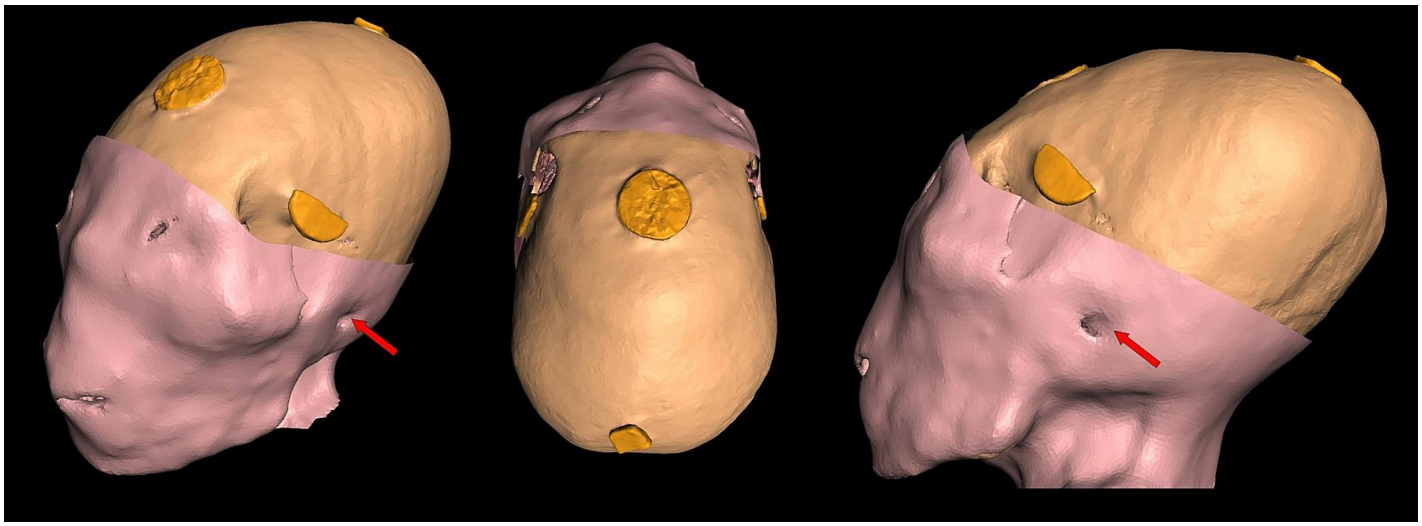

Figure 4: 3D CT scan of ‘Montserrat’ showing cut away view of scalp exposing bone and metallic implants. Note the elongated head with vertex shifted posteriorly and superiorly. There is no pinna in the ear with exposed external auditory canal (red arrow).

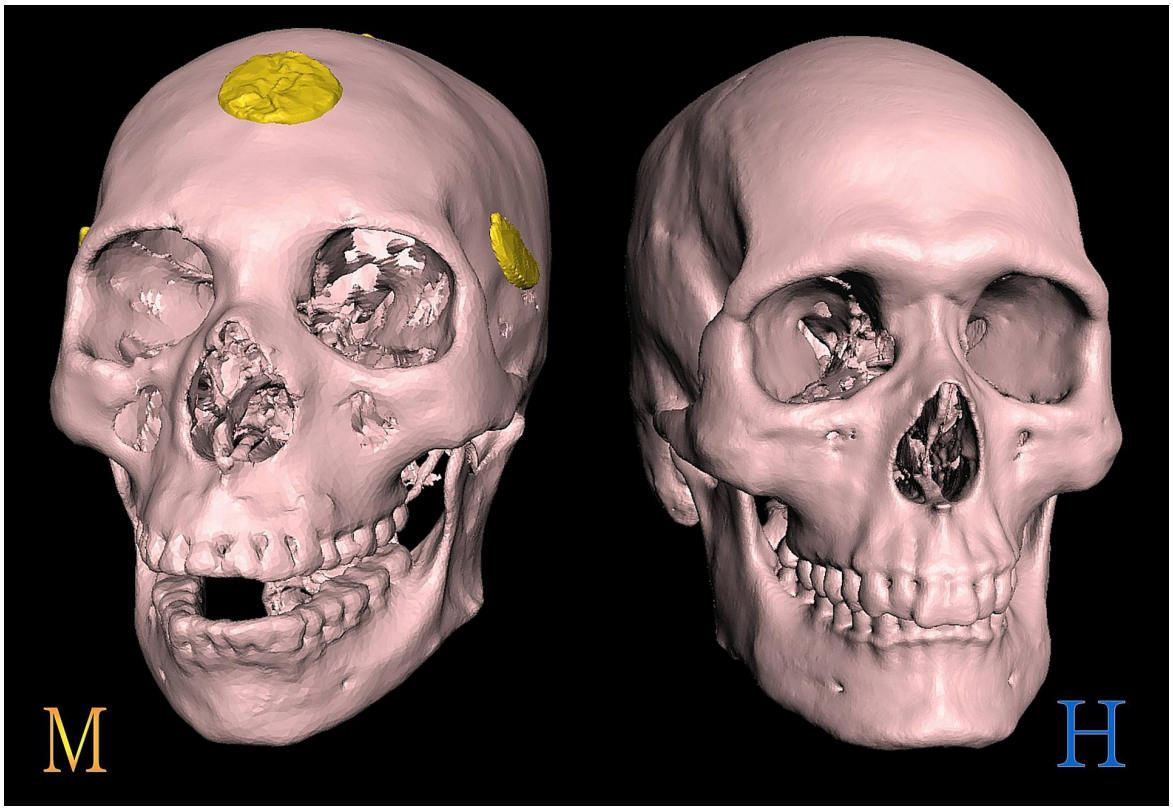

Figure 5: (M='Montserrat' H=modern human) Side-by-side comparison of frontal view of skull. There are striking differences in facial features. In 'Montserrat', the orbits are enlarged, the facial and frontal bones are sloping and elongated. Upper and lower jaws are prominent and protruding. The nasal cavity is enlarged particularly in its lower compartment. On the other hand, modern human shows more prominent supra-orbital ridge and nasal bones are more distinct.

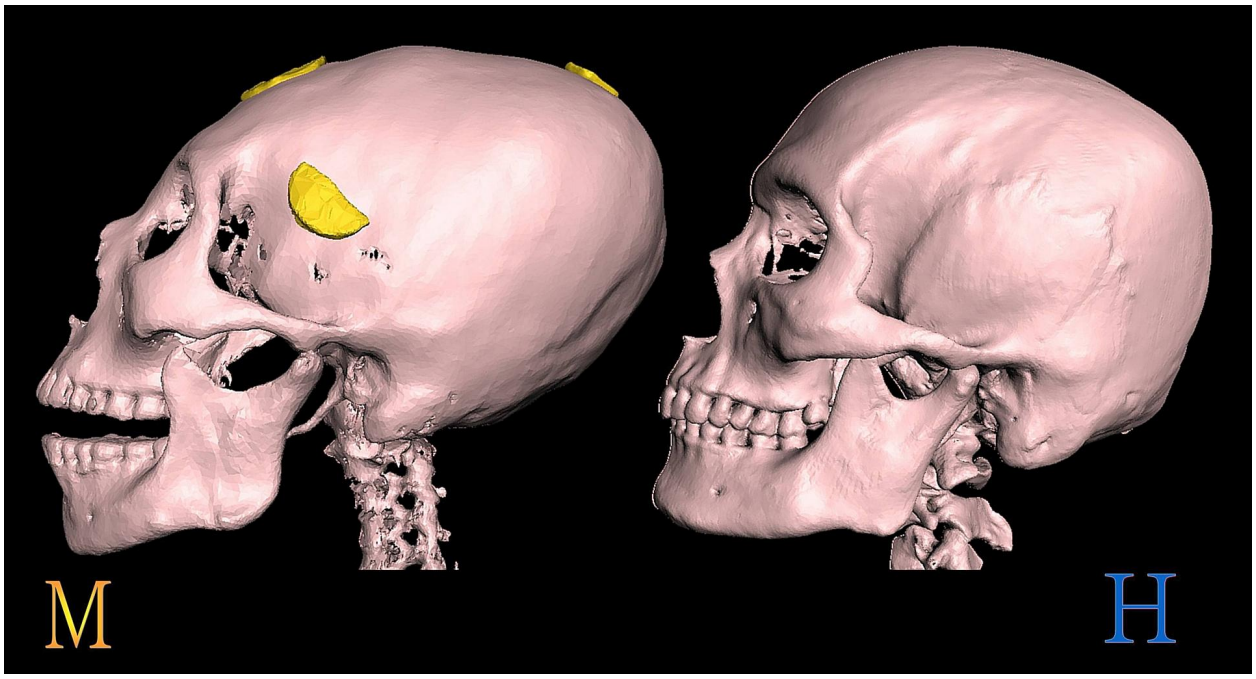

Figure 6: (M='Montserrat' H=modern human) Side-by-side comparison of lateral view of skull. The sloping elongated facial and frontal bones with protruding jaws in 'Montserrat' are clearly evident. The occipital bone is flattened. The vertex is shifted superiorly and posteriorly in the elongated skull. Note the absence of temporal suture in 'Montserrat'.

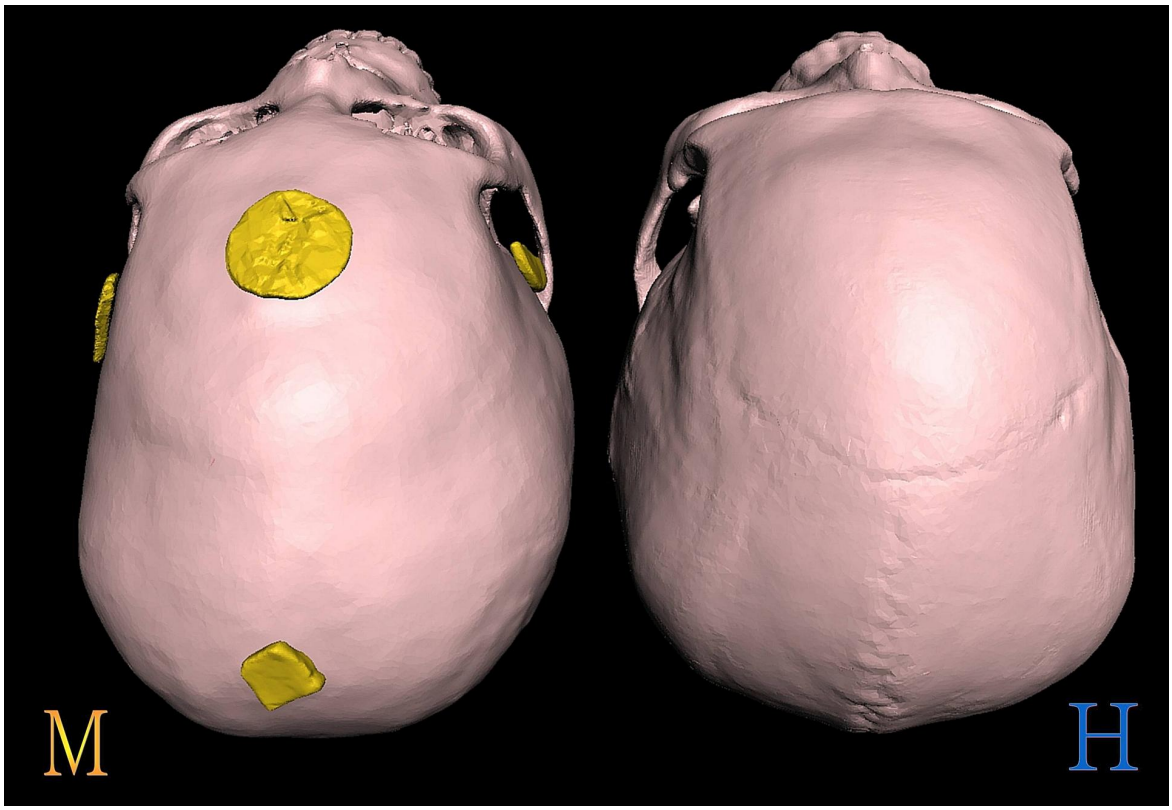

Figure 7: (M='Montserrat' H=modern human) Side-by-side comparison of top view of skull. 'Montserrat' skull is elongated but appears less broad with narrower frontal region. Note the absence of sagittal suture and less distinct coronal sutural marking in 'Montserrat'.

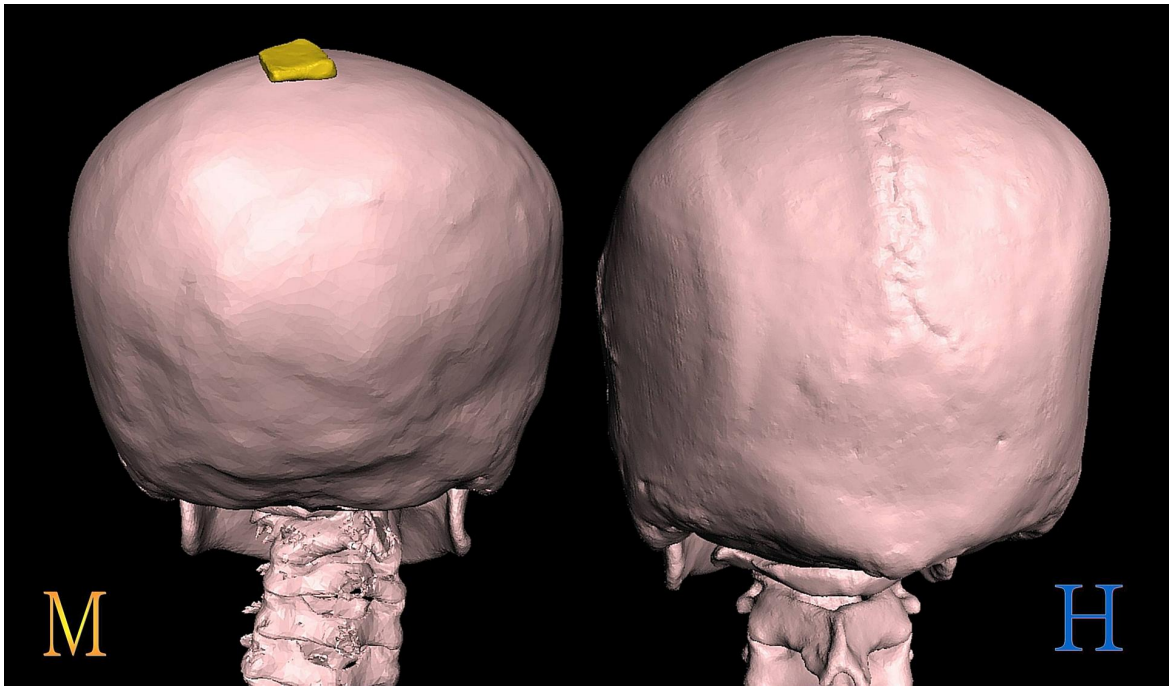

Figure 8: (M='Montserrat' H=modern human) Side-by-side comparison of back view of skull. 'Montserrat' skull has more shallow occiput. External occipital protuberance is indistinct. The lambdoid suture is visible. Again note the absence of sagittal suture.

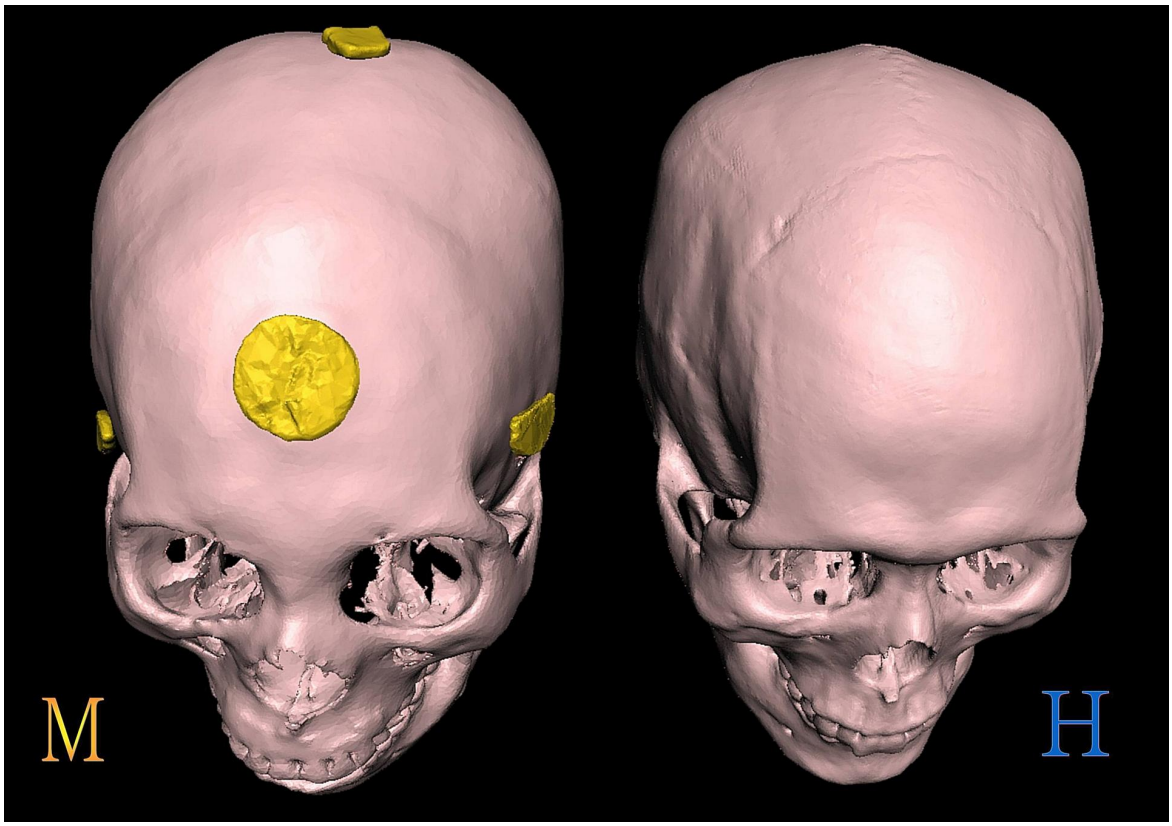

Figure 9: (M='Montserrat' H=modern human) Side-by-side comparison of a view looking down forehead. Enlarged orbits in 'Montserrat' are evident. Nasal cavity is enlarged.

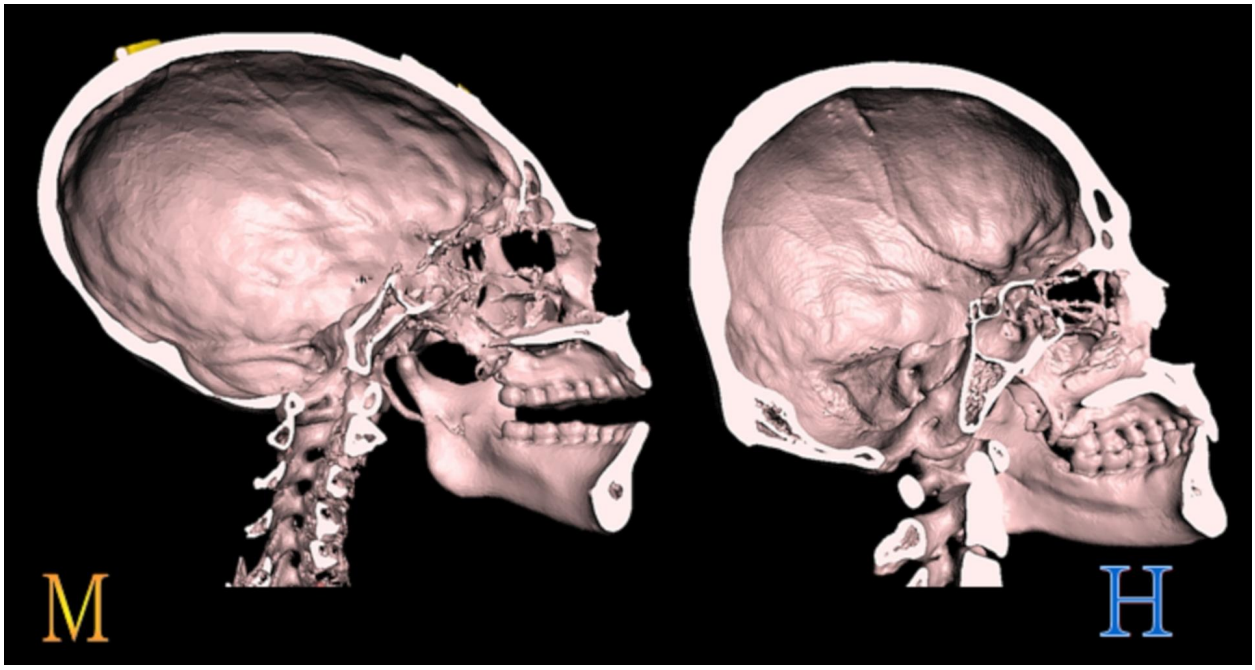

Figure 10: (M='Montserrat' H=modern human) Side-by-side comparison of midline sagittal section of skulls. Note the thinner cranial bones in 'Montserrat'. Other bones also appear more slender. The petrous bone appear smaller but internal structures (not shown) are preserved. Groove for middle meningeal vessels are similarly present. The posterior fossa is shallow and small in 'Montserrat'.

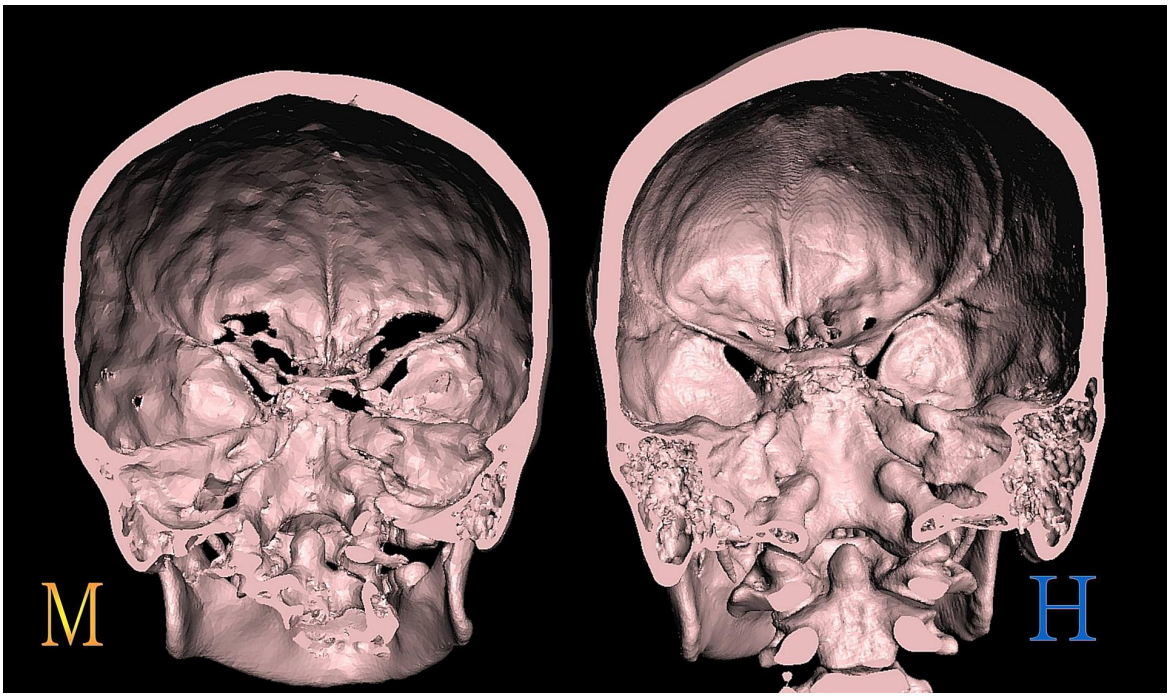

Figure 11: (M='Montserrat' H=modern human) Side-by-side comparison of coronal section of skulls looking towards the front. Bones appear thinner and the anterior and middle cranial fossae show decrease in height in 'Montserrat'.

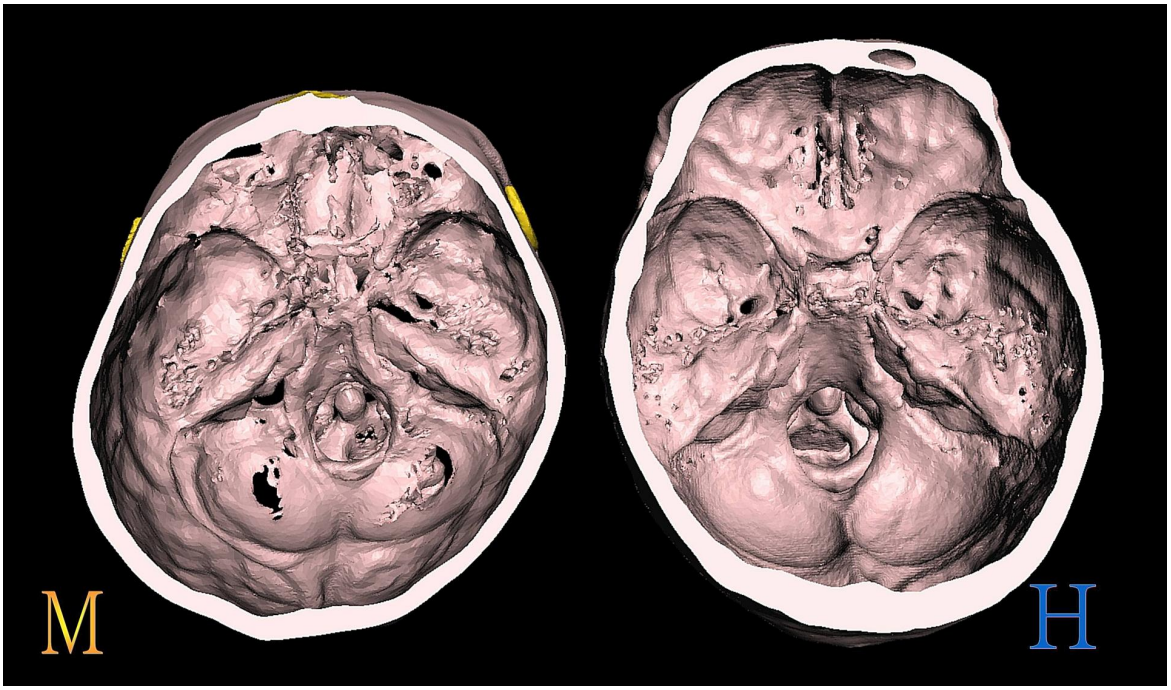

Figure 12: (M='Montserrat' H=modern human) Side-by-side comparison of inside of skull base. Skull base in 'Montserrat' is notable smaller. Foramen magnum shows similar configuration. There is thinning of occipital bone bilaterally resulting in gapping artefact in 'Montserrat'. The orbital plates of frontal bone are also smaller.

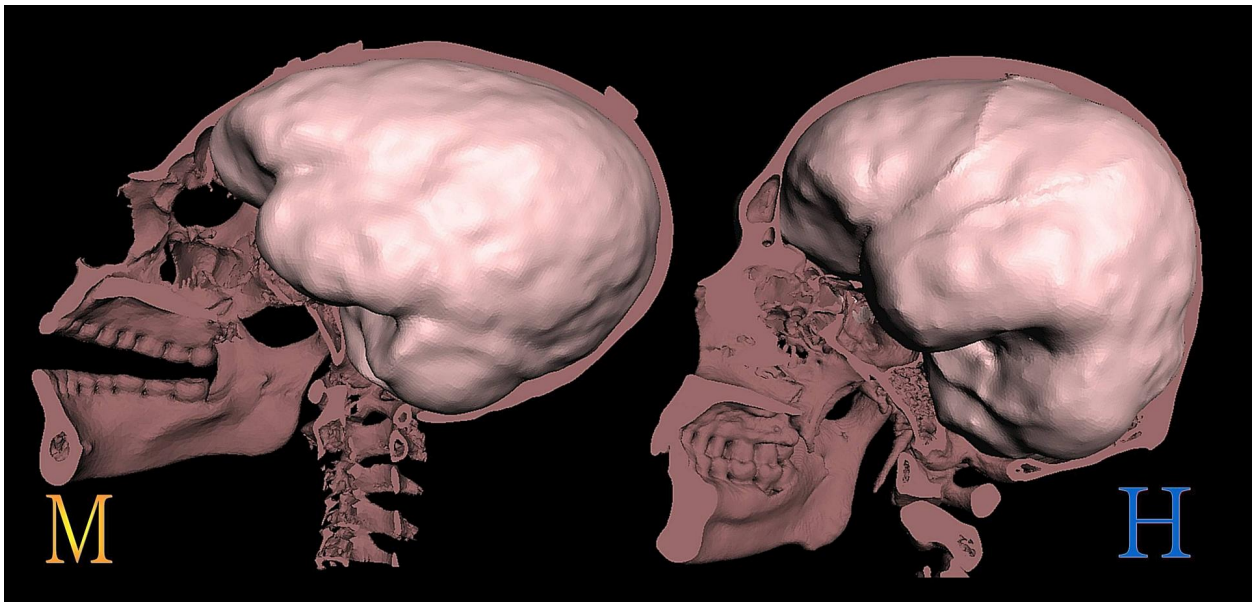

Figure 13: (M='Montserrat' H=modern human) Side-by-side comparison of virtual endocasts in sagittal section of skulls. The digital endocasts were based on the inner skull table as reference. Note the relatively smaller frontal compartment and smaller posterior fossa in 'Montserrat'.

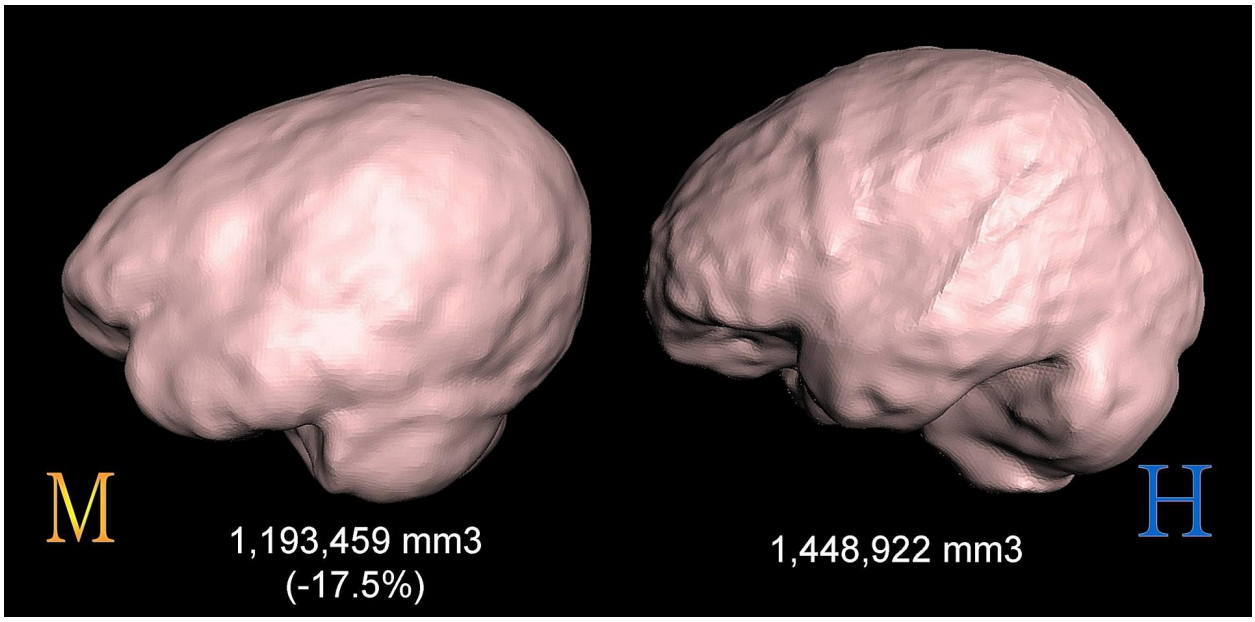

Figure 14: (M='Montserrat' H=modern human) Side-by-side comparison of left side view of virtual endocasts. Direct volume measurement on the 3D models showed a reduction of 17.5% of the cranial capacity of 'Montserrat' comparing with modern human. Another tridactyl mummy 'Maria' with elongated skull showed a volume of 1,195,356 mm3 and similar to 'Montserrat'.

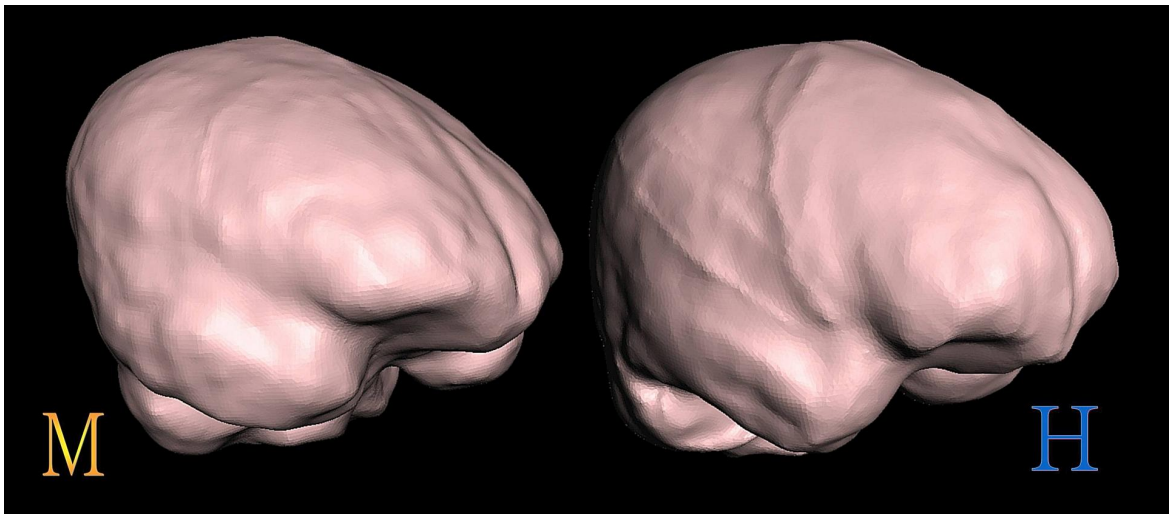

Figure 15: (M='Montserrat' H=modern human) Side-by-side comparison of right anterior oblique view of virtual endocasts.

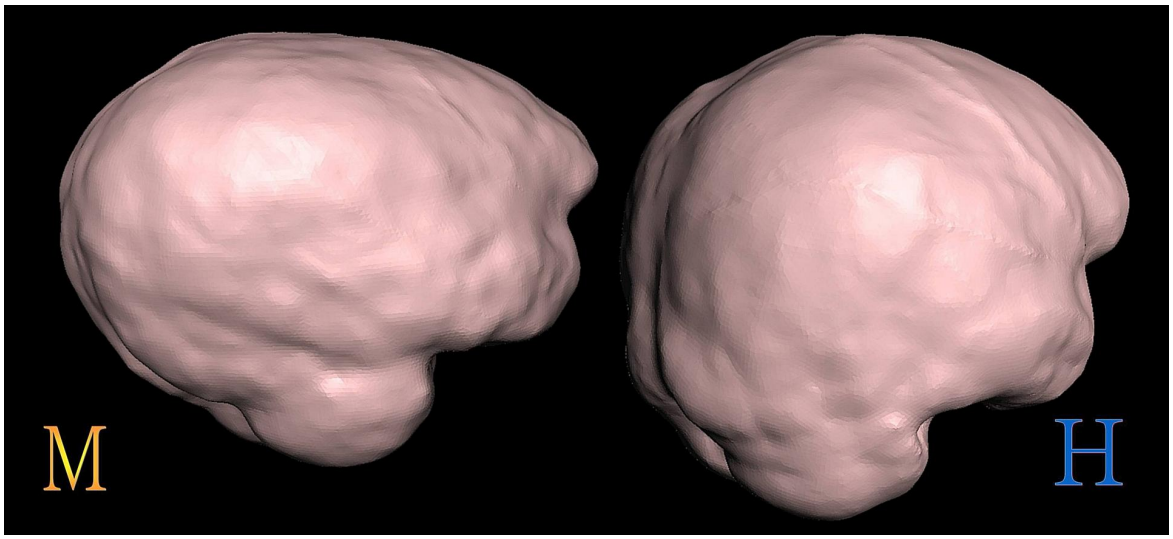

Figure 16: (M='Montserrat' H=modern human) Side-by-side comparison of right posterior oblique view of virtual endocasts.

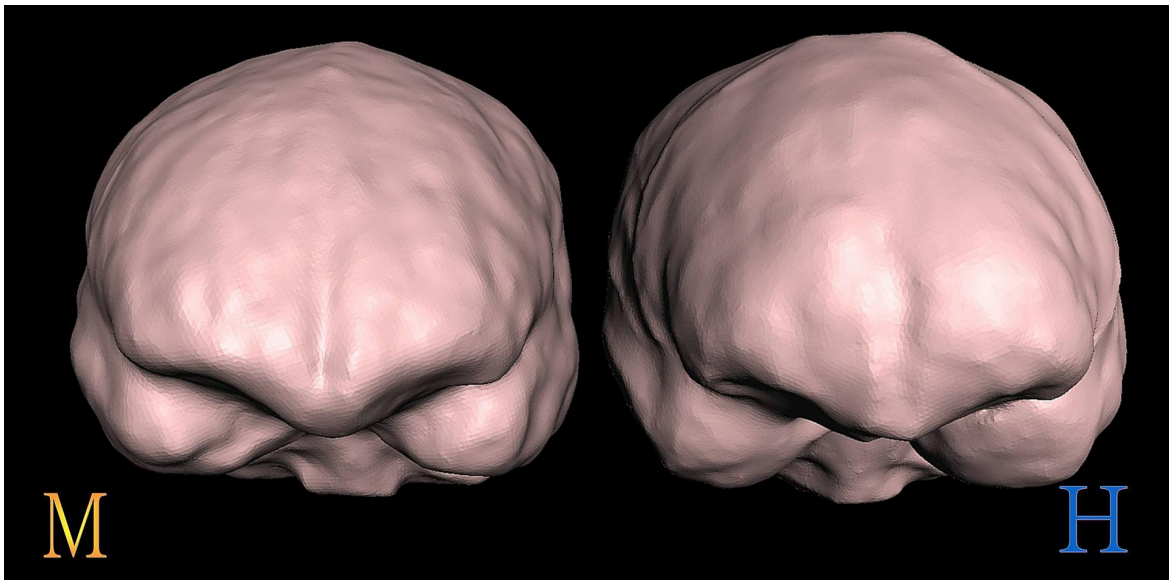

Figure 17: (M='Montserrat' H=modern human) Side-by-side comparison of front view of virtual endocasts.

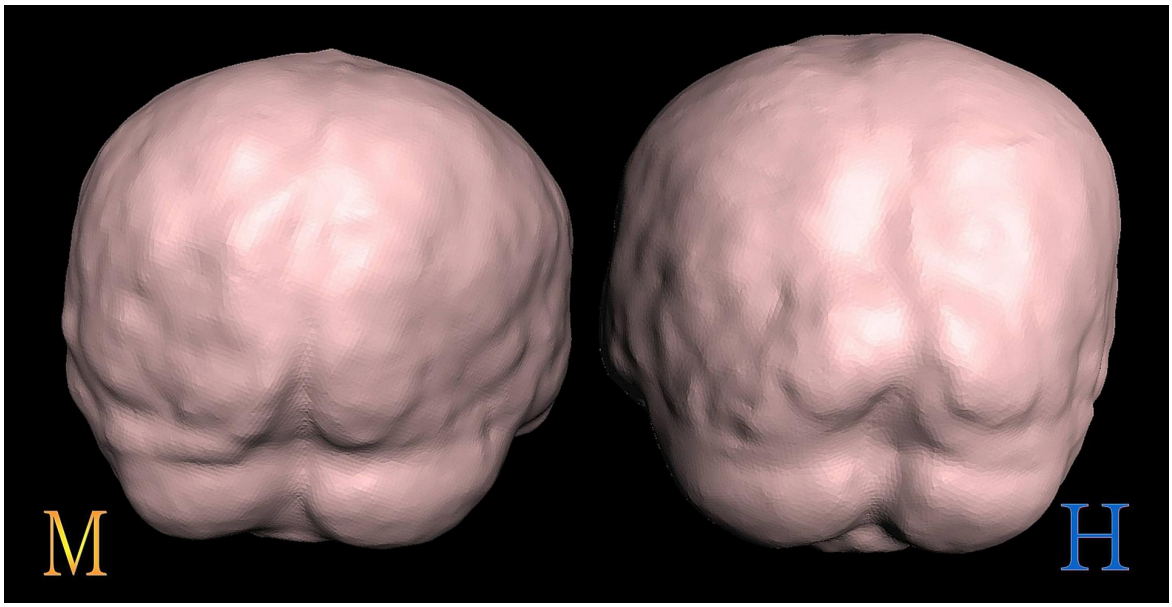

Figure 18: (M='Montserrat' H=modern human) Side-by-side comparison of back view of virtual endocasts.

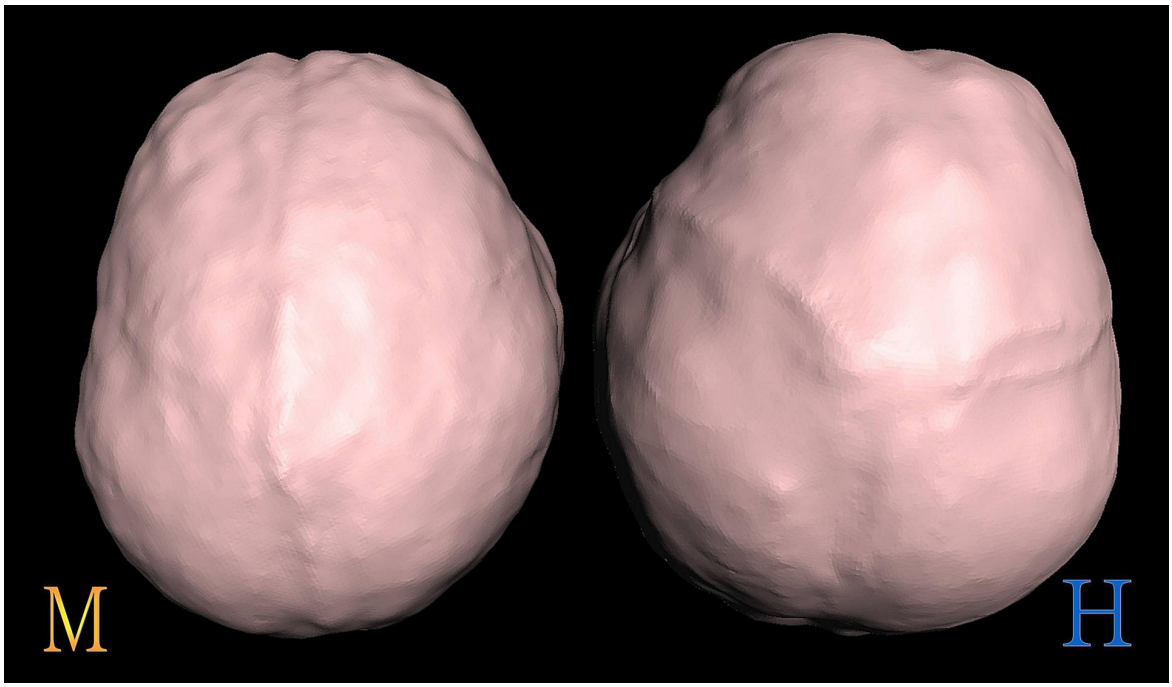

Figure 19: (M='Montserrat' H=modern human) Side-by-side comparison of top view of virtual endocasts.

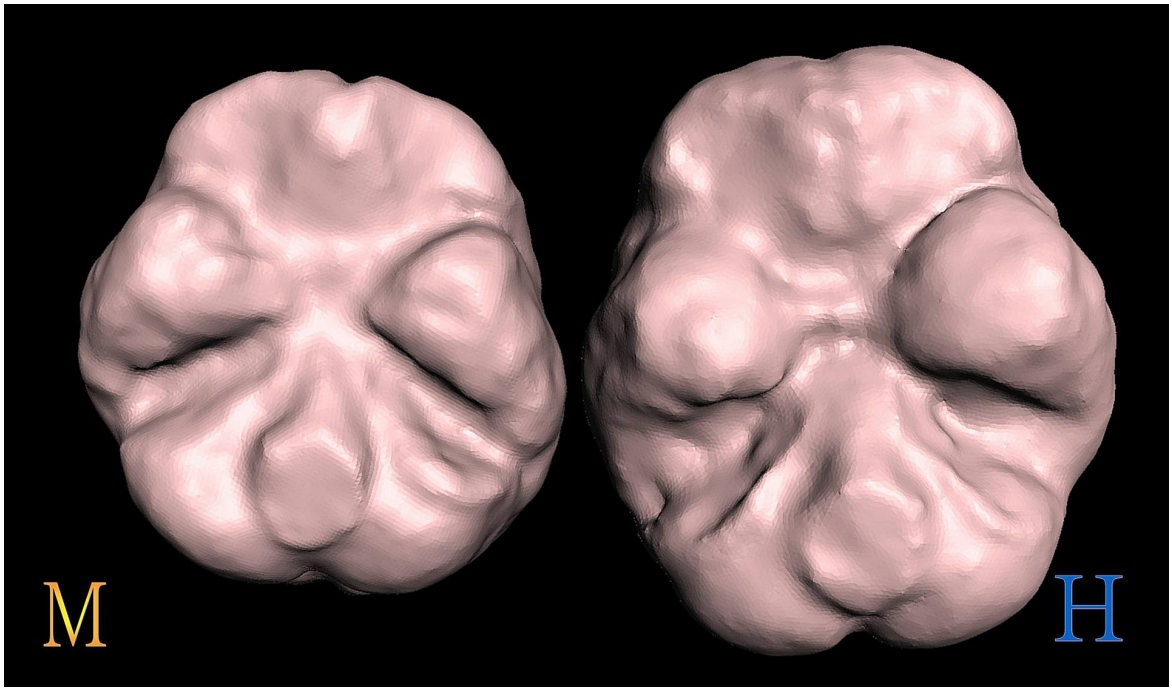

Figure 20: (M='Montserrat' H=modern human) Side-by-side comparison of basal view of virtual endocasts.

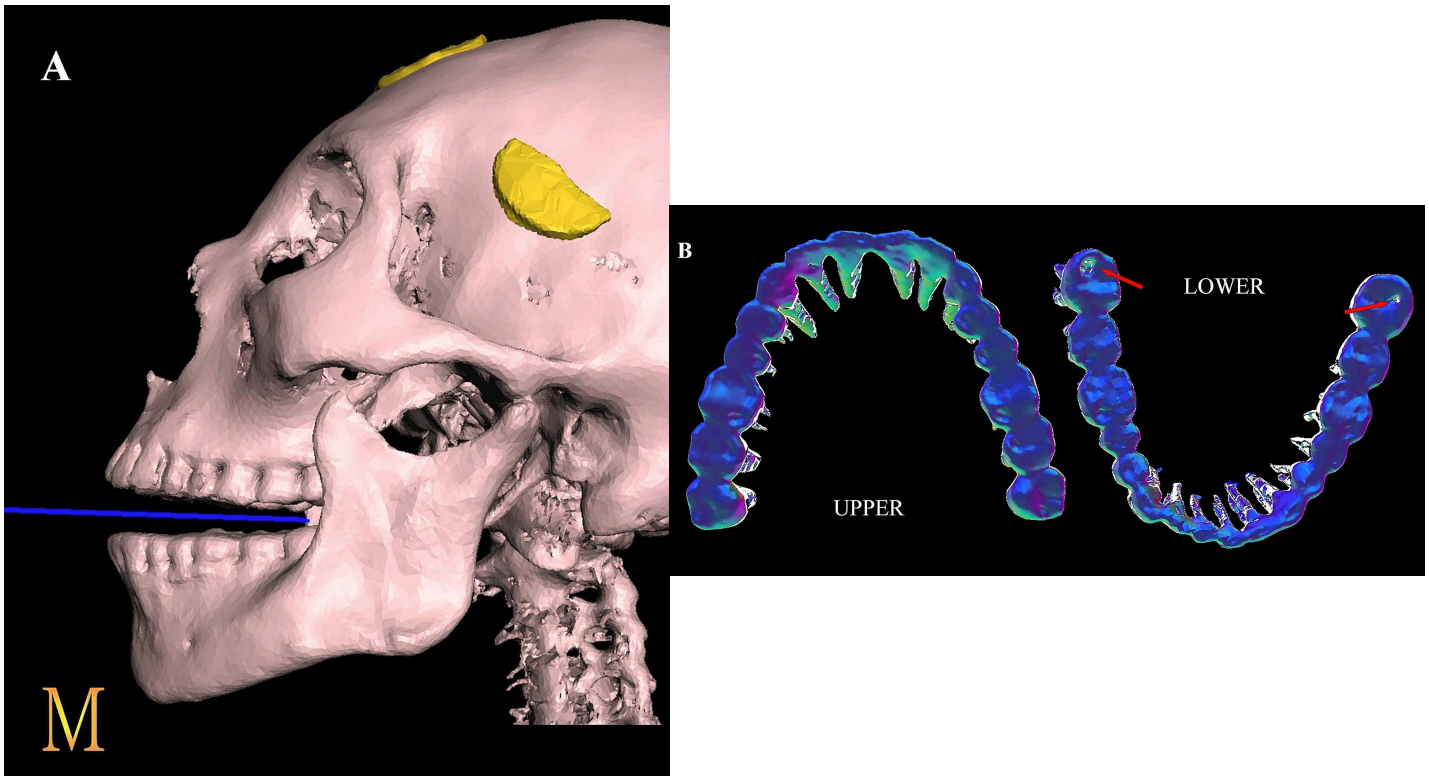

Figure 21a: (M='Montserrat') Lateral view of jaw of 'Montserrat' showing upper and lower teeth conforming to a flat plane (in blue) with relatively large and flat biting surfaces.
Figure 21b: Biting surfaces of upper (left) and lower (right) sets of teeth of 'Montserrat'. Dental caries are noted in bilateral lower third molars (arrows). Dental configuration of 2 incisors-1 canine- 2 premolars-3 molars (total 32 teeth) in each quadrant is similar to human.

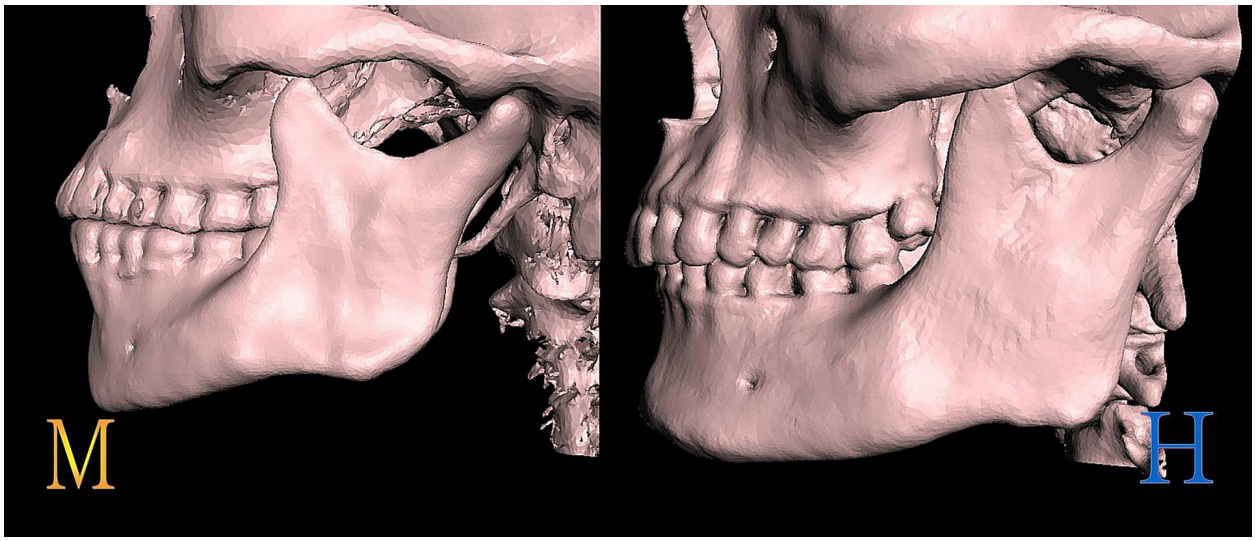

Figure 22: (M='Montserrat' H=modern human) Side-by-side comparison of lateral views of lower jaws. Note the apposing biting surfaces in the simulated closed mouth view in 'Montserrat' and the overlapping teeth in modern human.

CONCLUSION

- The ‘artificial cranial deformation’ theory for elongated skulls found in Nazca is a grossly over-simplified explanation without scientific basis. It cannot explain the complex craniofacial deformities found in ‘Montserrat’ e.g. smooth non-stepping skull enlargement, absence of sagittal suture, enlarged orbits, sloping orbital and facial bones, enlarged nasal cavity, abnormal jaw and specific dental configuration found in ‘Montserrat. The explanation for elongated skull should not be taken in isolation and should also takes into context the presence of various other associated bony and soft tissue anomalies found in ‘Montserrat’ including tridactyls, slanting eyelids, absence of nostril, absence of pinna in both ears etc. Genetic abnormality would be a more acceptable cause.
- Aligning anatomically correct 3D skull models generated from CT scans of ‘Montserrat’ and a randomly selected modern human in a side-by-side manner permits direct visual comparison of differences in sizes and shapes of various structures in the skulls.
- Through creation of a digital virtual endocast based on 3D reconstruction of the CT dataset targeting the inner skull table and using direct volume measurement utilising computer software, accurate depiction of the volume and shape of the cranial cavity can be made. In terms of accuracy for volume measurement of the complex shape of the cranium, this direct volume measurement capability surpasses anthropometric measurements that relies only on a few surface anatomical points to estimate the internal cranial volume.
- Contrary to current belief, this study proofs that the skull bone of ‘Montserrat’ is thinner and more slender than modern human. Furthermore, the cranial volume as measures on virtual endocast of ‘Montserrat’ is about 18% smaller than modern human.
- The scientific findings bring disruptive understanding of the elongated skull of the tridactyl Nazca mummies.

ABOUT DR. FUNG

Dr. K H Fung is a retired radiologist with over 40 years of experience in diagnostic radiology. His special interests include 3D medical visualization, interventional radiology and neuro-intervention.
Dr. Fung is also an artist in the domain of intersection of art and science utilising his expertise in 3D medical visualization. Dr. Fung was the first place co-winner in the '2007 International Science & Engineering Visualization Challenge' organized by Science magazine and National Science Foundation (USA).
His artworks had been exhibited in museums in various countries including USA, Europe, China, Australia and Hong Kong.
He had current exhibits in 2025 in the Hong Kong Museum of Medical Sciences (featuring stereoscopic 3D and 4D medical imaging and art) and in Nina Park (featuring the Nina wood fossils collection) in Hong Kong.
Through his collaboration with Science Photo Library, his interdisciplinary artworks bridging art and science had been made available to various international renowned digital media, magazines, books, and journals.

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