# Taphonomic and Fossil Reconstructive Analyses of the Ngaloba (LH 18) Skull

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## Abstract

The Ngaloba specimen (LH 18) from Lateoli, Tanzania, includes a partial maxilla and largely intact cranial vault. LH18 represents an important stage in the mid-Pleistocene *Homo* fossil record (205 ± 17 ka or 290 ± 25 ka) and expresses several primitive and derived craniofacial features. Although the cranium was found in several pieces and underwent post-mortem deformation, reconstructions have allowed for morphological comparisons. Some researchers argue that Ngaloba's general maxillary shape, reduced prognathism, and reduced robusticity align the specimen with modern humans, while others argue that intermediate alveolar prognathism and short maxilla place it in the archaic grade. Taxonomic placement of LH 18 is further complicated by the ever-changing shape of the specimen. Here, we demonstrate four events in which a portion of the right zygomaticoalveolar crest is originally attached, then re-attached incorrectly, is absent, and then is re-attached and further rotated incorrectly. The left portion of the maxilla also demonstrates post recovery wear and breakage, with palate expansion. Through analyses of 3D surface and CT scans in Geomagic Design X, we qualitatively and quantitatively assess the various shapes the maxilla has taken. Implications for comparative studies utilizing this specimen are also discussed. While this research highlights recent changes in LH 18, it also demonstrates the importance of scanning original specimens, and the need for supporting proper curation techniques at museums. Accordingly, this research also demonstrates the particular needs of the National Museum of Tanzania to safeguard fossil specimens for future research.

## Introduction

The LH 18 maxilla was originally reconstructed by Magori and Day (1980) from several isolated teeth and maxillary components. Here, we identify three additional events in which important aspects of LH 18's anatomy have been altered (Fig 1A). Between 1980–1998, the palate was covered by foam and plastic, and a portion of the right zygomatico-alveolar crest (ZMA) and right zygomatic were inverted and rotated (Vienna CT, Fig 1D). Then, sometime between 1998–2010 (Schroeder scan, Fig 1C), the right portions of the ZMA and zygomatic go missing. Between 2010–2016 (Bergstrom scan, Fig 1B), the ZMA and zygomatic portion are again attached in an improper configuration and a small portion of the zygomatic is absent.

***The purpose of this project is to quantitatively ascertain how these events have altered the original anatomy of LH18.***

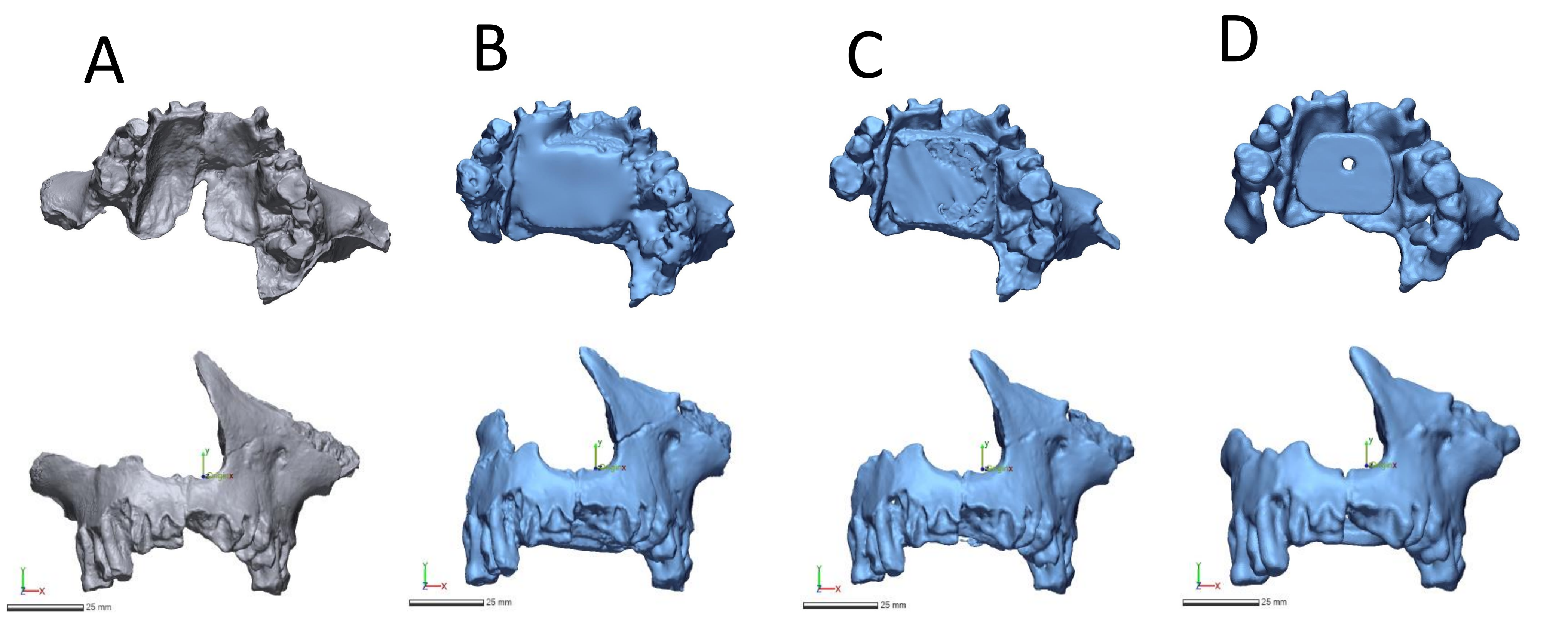


Figure 1: Top row: Inferior View, Bottom row: Anterior View. A. Cast scan, B. Bergstrom scan, C. Schroeder scan, D. Vienna scan

## Materials & Methods

One CT and three 3D laser scans were analyzed (Fig 1): University of Vienna CT Scan (1998); L. Schroeder's scan of the fossil (2010); K. Bergstrom's scan of the fossil (2016); and a scan of the first generation cast from the Kenyan National Museum.

The Vienna CT Scan was generated using a Siemens, SOMATOM Plus 40 at 1 mm thickness in 66 slices with a 0.51563mm Voxel height and width. A 3D digital isosurface was created from DICOMs in Amira V6.3.

All 3D laser scans were taken using a NextEngine Desktop Laser Scanner using similar scanning and processing protocal. Geomagic Control X (Cx) was used to compare topology of the models generated from the Vienna CT, Schroeder, and Bergstrom scans to the Cast scan **(Fig 2)** with a tolerance level of 1 mm.

## Results

As expected, results of the 3D comparison (**Table 1; Fig. 2**) demonstrate that all comparative scans show high degrees of deviation (min: 1mm to max: 7.76 mm) from the Cast scan. In fact, the deviation associated with the right ZMA was so extreme, that it did not register within Cx. Still, based on visual analysis, it is clear that that the ZMA and zygomatic portion have been rotated and inverted throughout the reconstructions. Aspects of the nasal margin appear to be within a stronger tolerance level, meaning that little to no change has affected this area (green areas in **Fig. 2**). The palate, right zygomatic, alveolar portion, and dentition demonstrate the most notable changes (red and yellow areas in **Fig. 2**) across all comparative scans.

## Discussion

Both quantitative and qualitative analyses indicate significant anatomical differences of LH18 over the last few decades, which can greatly impact phylogenetic interpretations and morphological comparisons.

There is a need for proper curation, reconstructive efforts, and storage facilities, and this project particularly highlights the need for casting departments in all museums. It is now the official policy of the National Museum of Tanzania (NMT) to no longer glue or reconstruct specimens if they come apart. However, one of the largest and most dangerous taphonomic agents within the museum are heat and moisture. Glue often melts under current conditions, creating ever-morphing fossils.

Lastly, this project highlights the benefits, but also complications, in sharing data. With sharing of data, these reconstructive efforts can be better understood for future analyses. However, if each scan of the fossil material used in this project was taken to represent the true anatomy of LH 18, problematic conclusions could be easily reached. It is only with responsible data sharing and understanding of the original material, that LH 18 can be accurately examined and understood within our own evolutionary record.

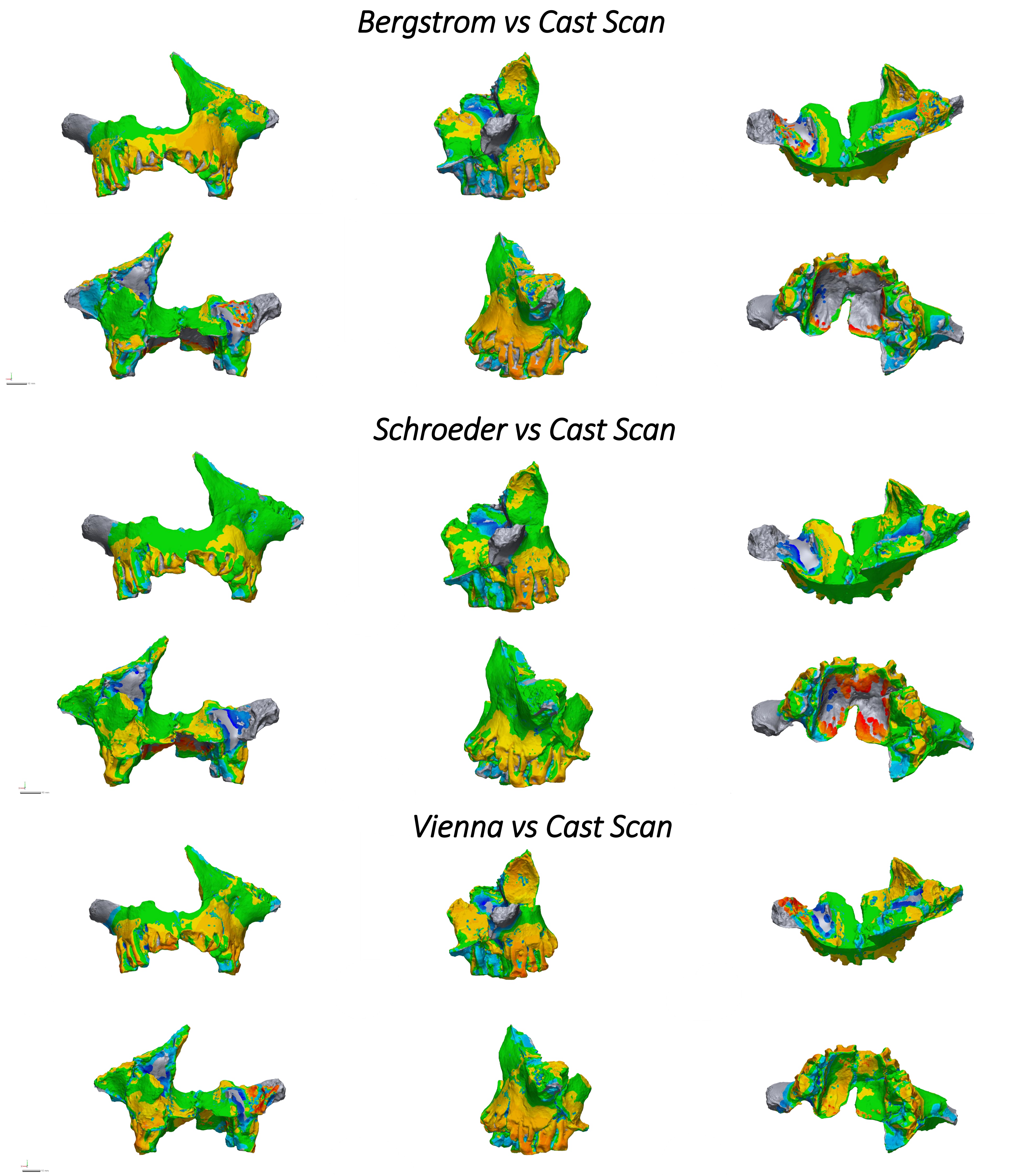


**Figure 2:** Cast overlaid on the Bergstrom, Schroeder, and Vienna scans. Heat map shows 1 mm tolerance level, with green demonstrating little to no deviation (0-1mm), blue under tolerance (-1- -7+mm), and yellow (1-3mm), orange (3-5mm) and red (5-7+mm) over tolerance

Table 1. 3D comparison results for variation among the scans.

| | Bergstrom Scan (2016) | Schroeder Scan (2010) | Vienna Scan (1998) |
|---|---|---|---|
| Minimum range of variation | -7.2655 | -7.2655 | -7.2644 |
| Maximum range of variation | 7.2655 | 7.2654 | 7.2646 |
| Standard Deviation | 2.2422 | 2.2373 | 2.4949 |
| In total % (Tolerance) | 36.7957 | 45.738 | 34.6188 |
| Out Total % (Tolerance) | 63.2043 | 54.262 | 65.3812 |
| Over Tolerance % | 44.6712 | 36.9407 | 45.3173 |
| Under Tolerance % | 18.5331 | 17.3213 | 20.0639 |

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