Computer tomography vs. mecanichal cutting: How to play Doctor House with fossil teeth

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INTRODUCTION

Natural history collections must be preserved to be studied in present and future times, being the aim of curatorship. While technology is a major way to obtain new data and knowledge, technology is also an important tool to improve the preservation of science collections. We hereby present the use of Computed Tomography (CT) as proposition in order to improve the preservation of fossil horse's teeth, being an alternative method to the traditional mechanical cuttings used to obtain data of the occlusal design of the tooth.

Modern Equidae teeth are characterized by the high hipsodonty and molarization of its premolars (MacFadden, 1992) making it difficult to discriminate its anatomical position. It is common in fossil assemblages to find isolated horse teeth which are worn down differently. This difference in wear is used to classify to teeth. The classification is then used to discuss both occlusal design and measurements for taxonomical appointments, all this in addition with postcranial bone's descriptions and measurements. Furthermore, the occlusal design of the tooth varies along its height as they wear down. Usually, mechanical sections from some teeth of the collections are made to describe and measure the structures of the teeth at the same height (Eisenmann et al., 1988).

The mechanical cuts in teeth represent a destructive method and traditionally it is the common technique to observe planes cut in two to obtain the data of the cross-section (fig 1.). Furthermore, a restoration of the tooth after the cuts is not completely possible and alternative methodologies are welcomed to solve this question, especially when the material is scarce and has got heritage value. For this reason, the creation of casts before the cuttings is an alternative way to keep the original morphology of the tooth although the original material suffers changes.

As teeth have been mechanically sectioned by fossil horses investigators, fossil collection could multiply the number of registered units and multiply the documentation inquired around them. Another point to mention is that the methodology to cut a single tooth needs a lot of steps and time until a section is obtained (Klevezal et al., 1996).

The methodology presented here allows the investigators to view theoretical occlusal surfaces, and other planes, in a short process and with the use of unique software.

Fig. 1. lower tooth (middle left, MGB V229) and upper tooth (middle right, MGB V222) of a fossil equid from the lower Pleistocene of Cueva Victoria (Murcia, Spain), both mecanichally sectioned. Scale bar is 1 cm long.

METHODOLOGY

CT is a non-destructive technique, common in biomedical and industrial works to inspect rapidly the internal areas without manipulating the object (Fig. 2.). The CT's uses differential attenuation of X-rays passing through the fossils to differentiate between bone and other material like sediment, to produce two-dimensional images that reveal morphological details. Consecutive equidistant two-dimensional slices provide a three-dimensional digital map of the specimen that can be manipulated using a variety of image processing techniques and software.

Globally, the CTs create slices in the three coordinates (Axial, Coronal and Saggital) correlated with the three dimensions of the space obtaining digital cuttings of the bone or tooth where the user decides how many digital cuts are needed to study each tooth.

The subsequent work with the appropriate CT-software (i.e. Mimics©) makes it possible to take digital measurements of each 2D image with high resolution and obtaining a 3D-model. This 3D model offers the possibility to work over the tooth without manipulating the original material.

On the other hand, the output files obtained by the CT scanner are usually heavy and take up important computer weight and a workstation is usually required for optimal work reducing the time to process the data.

The slices obtained in the CT are in grey scale with the possibility to change the pixel unit between gray values or Hounsfield scale. This latter is referred to the attenuation of the X-rays and is the specifically pixel unit of CT-scan. Also, it is possible to create masks and pseudo-colors in the 2D and 3D images and models being useful tools to interpret the results.

Fig. 2. Preparation of a unique scanning session for 15 teeth from two Cal Guardiola and Carihuela Pleistocene sites through a medical CT in the Hospital Mútua de Terrassa.

RESULTS AND DISCUSSION

This method has been proved with some specimens of two fossil teeth assemblages collected in the sites of La Carihuela (Granada, Spain; Upper Pleistocene to Holocene (Fernández et al., 2007)) and Cal Guardiola (Terrassa, Spain; Latest Early Pleistocene (Alba et al., 2008)) both housed at the Institut Català de Paleontologia. The first assemblage was collected in a cave site while the second were excavated in an open air site. Resulting images were of high quality, permitting the study of their morphologies and making measures on them. After the CT scan, the 2D images and 3D models obtained have proved the potential uses of this methodology as the base of morphological descriptions, geometric morphometry or biomechanical approaches.

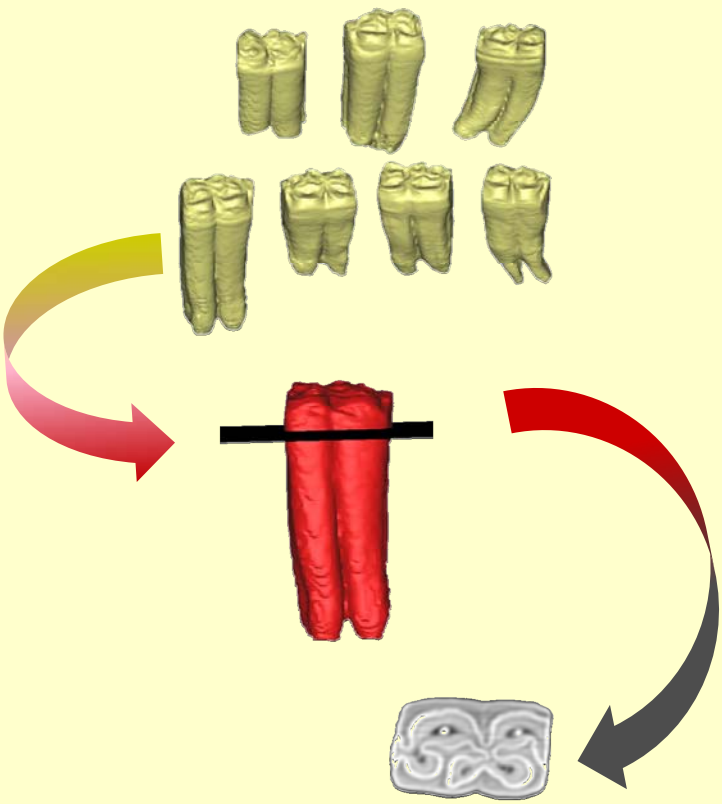

Fig. 3. 3D image of seven teeth scanned (up); one lower tooth and plane (in black) selected for a digital cutting (Middle); and resulting digital slice through the black plane (down).

CONCLUSIONS

The methodology presented here allows to describe teeth features and to make taxonomical inferences without any type of destructive action. With only one CT scanner we are able to obtain a complete data along all the height of a horse's tooth and not only a unique cut as is typical in the traditional mechanical methods. Additionally, acquiring data is a rapid process and it is easy to work with the software to process and interpret the results.

As demonstrated here, the use of new technologies is a helpful tool to the conservation of heritage collections as it permits research and preservation, when the manipulation of material is necessary.

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