Computed tomography survey of supernumerary molars in extant orangutans with implications for studies of the primate fossil record

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Abstract

Supernumerary teeth have been reported in a wide range of fossil primate taxa including Eocene adapoids, Plio-Pleistocene hominins, and other non-human hominids. In modern humans, a review of the literature shows that polydontia is less common than agenesis, more frequent in males than in females, and generally occurs at frequencies of less than 5%. Within extant non-human hominids, however, percent incidence of supernumerary teeth varies, with the overall pattern being Pongo > Gorilla > Pan. Within the genus Pongo, values reported generally range between 6 to 20%. Results from a previous visual survey of specimens held at the Cleveland Museum of Natural History, the American Museum of Natural History, and the Smithsonian National Museum of Natural History, revealed a similar pattern between genera, and a percent incidence of 7.1% in orangutans (Campbell 2013). In these types of surveys, however, unerupted molars or other dental anomalies that are not externally visible will be missed thus potentially underestimating their occurrence. In this study we, examine 78 orangutan specimens from the Smithsonian National Museum of Natural History using Computed Tomography (CT) scans. Of these, 60 were represented by skulls, 11 by crania, and seven by mandibles. Results from this analysis showed a 10.3% incidence of specimens possessing supernumerary molars. Additionally, a previously unidentified supernumerary right mandibular fourth molar was found in a specimen of Pongo pygmaeus (USNM 142195). This specimen has been studied for over 100 years (Hrdlicka 1906) without the mandibular supernumerary being recognized. These results suggest that similar structures and anomalies may be missed in both modern and fossil specimens, including those that are well studied. Furthermore, this demonstrates the value of using modern digital imaging technology in identifying internal features and serves as an example of how readily accessible digital data can lead to new discoveries.

Introduction

Supernumerary teeth, or polydontia, are any dental elements beyond the normal complement of the dentition of a species. Although the presence and significance of polydontia has been widely discussed, the aetiology of their occurrence is still not well understood and several mechanisms for their development have been suggested. Several studies have hypothesized that the presence of a high incidence of supernumerary teeth, along with other anomalies, may be used as indicators of hybridization within several primate lineages (Ackermann 2007, 2010; Ackerman and Bishop 2010; Ackermann et al. 2006).

The study here presents the usefulness of Computed Tomography (CT) scan surveys in identification of supernumerary dental elements. Through a comparison of a previous visual survey (Campbell 2013), this study demonstrates that unerupted and internal morphologies have previously gone unnoticed in long studied specimens.

Methods and Materials

To assess the internal structures associated with supernumerary dentition, Computed Tomographic (CT) scans of 111 *Pongo* skulls, crania and mandibles were obtained from the Smithsonian National Museum of Natural History. Of these 111, sub-adults and specimens lacking dentition were excluded, resulting in a total of 78 specimens examined for this study.

CT scans were imported as Digital Imaging and Communications in Medicine (DICOM) files into InVesalius 3.0-Beta 4 (http://www.cti.gov.br/invesalius/) for initial examination. CT data were then segmented and rendered using AMIRA Version 5.6 (http://www.fei.com/software/amira-3d-for-life-sciences/) to extract supernumeraries identified within InVesalius.

Results

Of the 78 specimens examined here, seven individuals were reported as possessing supernumerary molars in a previous visual survey (e.g. Figure 1 and Figure 2) (Campbell 2013). A previously unreported supernumerary right mandibular fourth unerupted molar (Figure 3) was found in a specimen of *Pongo pygmaeus* (USNM 142195, Figure 4) in this Computed Tomography (CT) survey. The molar (Figure 5) is only visible using these noninvasive digital methods and consists of a fully formed crown with no associated roots (Figure 6).

Figure 1: USNM 142198, example of an erupted left supernumerary molar

Figure 2: USNM 142170, example of an erupted right supernumerary molar

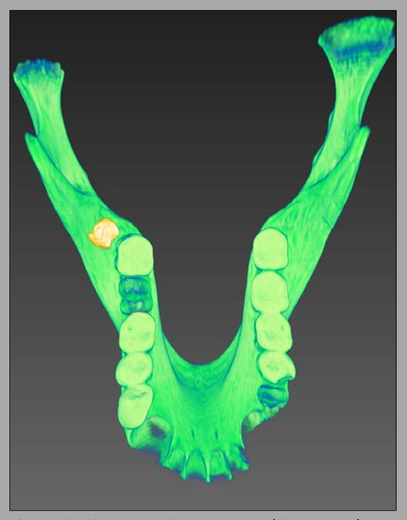

Figure 3: USNM 142195, Computed Tomography (CT) scan showing unerupted M_4 highlighted

Figure 4: USNM 142195, unerupted supernumerary not visible

Figure 5: USNM 142195, supernumerary M_4 digitally isolated

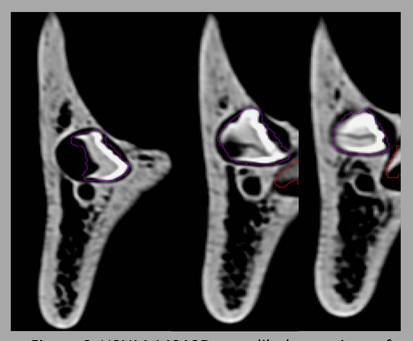

Figure 6: USNM 142195, mandibular sections of unerupted M_4 in crypt

Conclusions

Within extant non-human primates, low percent incidences of supernumerary teeth have been documented. However, this incidence could be increased with the use of Computed Tomography (CT) to visualize internal anomalies. As exemplified here, despite having been studied for over 100 years (Hrdlicka 1906), the presence of a supernumerary mandibular molar in USNM 142195 has never been reported.

As early as 1972, Lavelle and Moore recognized the value of technologies allowing for the examination of internal morphologies and advocated their use. Subsequently, CT scans and radiographic examination have revealed dental anomalies within the hominin fossil record and in archaeological populations (e.g. Ripamonti et al. 1999, Ceperuelo et al. 2015). Today, computed tomography provides an avenue for investigation of these internal morphologies and anomalies that is non-destructive in nature and therefore ideal to examine rare and fragile specimens.

As reported in dental literature (Mallineni 2014) and demonstrated by this study, supernumerary teeth may or may not be erupted and therefore computed tomography provides a much needed approach to the long studied dental anomalies within these collections.

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