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Case Study

Dental status and 3D reconstruction of the malocclusion of the famous singer Farinelli (1705–1782)

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SUMMARY

The famous castrato singer Carlo Broschi, better known as Farinelli (1705–1782), was exhumed by our research group in July 2006 to study his skeletal remains and reconstruct his osteobiography. He was castrated before puberty to preserve his high voice into adulthood. The osteological study has revealed several skeletal features probably related to the effects of castration (*Hyperostosis frontalis interna*, long limb bones, persistence of epiphyseal lines, osteoporosis) (Belcastro et al., 2011).

Here we present the study of the teeth and maxilla–mandibular region using classic and tomographic morphological methods. Considering the subject's age and the period during which he lived, his oral health conditions were good. On the basis of the very pronounced anomalous vestibular buccal wear, a overbite visualized by 3D reconstruction, was hypothesized. This facial disharmony is of particular interest when considering Farinelli's extraordinary singing qualities and stage presence.

1. Introduction

In this work we study the preserved remains of the oromasticatory apparatus of the famous castrato singer Carlo Broschi, better known as Farinelli (Andria, 1705 – Bologna, 1782), whose remains were exhumed in July 2006 from the Certosa, the monumental cemetery in Bologna (Italy). They were in the same grave as those of his great-niece Maria Carlotta Pisani, who died in 1850 (Mariotti et al., 2013). The first results highlighted several skeletal features probably related to the effects of castration (HFI, long limb bones, persistence of epiphyseal lines, osteoporosis) (Belcastro et al., 2011). The purpose of this work is to reconstruct the singer's hygienic and dental health conditions and eating habits, and discover some correlated behaviors. The preservation of the bones and teeth is very poor because Farinelli's remains were disinterred and moved twice after his original burial. Therefore we also performed a 3D reconstruction in order to better visualize his facial structure and permit a virtual manipulation of the fragile remains.

2. Materials

Few and fragmented facial bones of Farinelli's have been preserved (Fig. 1). Fig. 2 shows the preserved teeth. Farinelli's dental characteristics were compared with those of 49 males over 60 years of age (20 of whom between 70 and 79 years of age) of a modern (19th–20th c.) identified human skeletal collection from the Certosa cemetery (Bologna, Italy) (Facchini et al., 2006; Belcastro and Mariotti, 2012).

3. Methods

The dental characteristics were recorded following the criteria stated in Belcastro et al. (2004). Caries was recorded according to Powell (1985: 321): "only those cavities that would admit the tip of a dental explorer were scored as actual caries to eliminate false scoring of discolored but intact enamel." Periapical lesions were recorded only in the case of a perforating fistula (Brothwell, 1981). *Ante mortem* tooth loss (AMTL) was evaluated according to Lukacs (1989). The calculus and linear enamel hypoplasia (LEH) were scored as presence/absence. Chipping, i.e. *ante mortem* enamel or enamel and dentin fractures of the edges of the crown, was scored using a three-grade scale (Bonfiglioli et al., 2004). To distinguish

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Fig. 1. Right zygomatic bone: frontal view (A), maxillary bones: superior view (B), left mandibular ramus: lateral view (C), fragment of the right mandibular body with M1, M2, and M3: mesial view (D), left mandibular ramus: posterior view (E), fragment of the left mandibular body with M1, M2, and M3: lateral view (F).

ante mortem from *post mortem* damage we followed Milner and Larsen (1991). Occlusal tooth wear was scored as mild, moderate, or heavy, corresponding to Smith's degrees (1984): 1–2, 3–4, and 5–8, respectively. The frequency of the various dental features was calculated according to the type of tooth, jaw, and side (Fig. 3).

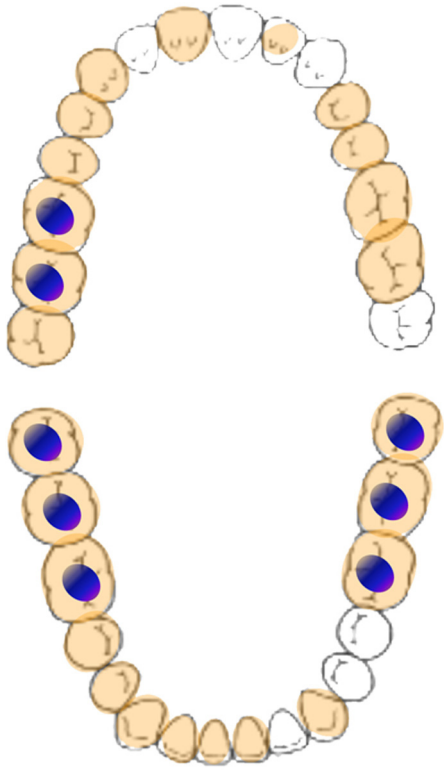

Fig. 2. Upper teeth: right I^1, C, P^1, P^2, M^1, M^2, M^3; left I^2, P^1, P^2, M^1, M^2. Lower teeth: right I_1, I_2, C^1, P_1, P_2, M_1, M_2, M_3; left I_1, C_1, M_1, M_2, M_3. In blue the teeth still in the alveoli, in orange the isolated teeth, in white the missing teeth. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)

Due to the poor preservation of the remains, we scanned a total of 20 skeletal fragments divided into three groups: (1) maxillary bone; (2) mandibular fragments; (3) 17 isolated teeth (Fig. 2). We used three different experimental systems (A–C) (Table 1), depending on sample size and resolution. Each system was based on a typical non-medical cone-beam geometry CT configuration with one X-ray source, a manipulator, and a planar detector. Parrec and ImgRec software programs were used for the reconstructions of all the scanned samples. Both are based on the Filtered Back Projection algorithm, and provide cross sections of the sample (slices). The stack of sections was then imported to a volume-rendering program (VGStudioMax2.1) which produces 3D representations of the data and merges different datasets. The latter function was used to load the CT volumes of different samples into a single rendering scene, thus permitting a virtual re-assembly and reconstruction of the maxillofacial region. In order to import the different datasets, scanned at different resolutions, with the correct proportions, volumes were re-sampled according to the voxel size ratio (Table 1). Re-assembly of the maxillofacial structure proved quite difficult because of the missing parts. We reconstructed the dental arches using a complete human skull as reference. Maxilla fragments served as the basis for the upper arch shape, while two pieces of the mandible were aligned to form the bottom arch. Neighboring teeth had been previously aligned with those fixed to the maxilla and mandible, and loose teeth were then placed according to the shape of the arch and occlusion. After some revisions, the final result of this operation was considered to be satisfactory (Figs. 4 and 5).

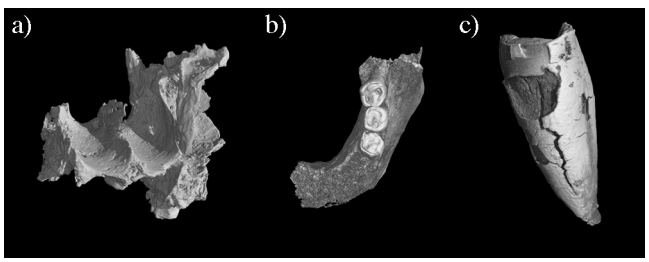

Fig. 3. Details observed with a microtomography scanner: (a) maxilla; (b) left mandibular fragment and (c) upper right I^1.