Bioarchaeological study of the skeletal remains attributed to Saint Ceccardo from Luni, patron of Carrara (Tuscany)

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Abstract *Aim:* The research focused on the multidisciplinary study of the skeletal remains attributed to Saint Ceccardo from Luni, patron of Carrara (Tuscany, Italy), with the aim of clarifying the period in which he lived, reconstructing his biological profile, and verifying the circumstances of his death. *Material and Methods:* The skeleton, almost complete and well-preserved, was studied by using the classical anthropological and paleopathological methods implemented by X-ray and CT scan; the latter allowed 3D rendering of the skull and physiognomic facial reconstruction. C14 dating and stable isotope analyses were also performed. *Results:* The biological profile evidenced a fairly robust adult male of short stature. Enamel hypoplasia, Harris lines, *cribra cranii* and *orbitalia*, diffuse periosteal reactions were present, but no perimortal lesions were observed. Paleonutritional analysis indicates a consumption of C3 plants and a high dietary protein intake. Radiocarbon dating places the death of Saint Ceccardo between the 8th and the 10th centuries. *Discussion:* The presence of several stress markers evidences physiological stress occurrences in both childhood and adulthood. On the other hand, isotope analysis indicates a good nutritional intake, in agreement with the saint's episcopal rank. The absence of bone lesions does not support the tradition of martyrdom or murder, as attested by historical sources. Radiocarbon dating agrees with the historical sources that refer to Saint Ceccardo as bishop of Luni in the 9th century. *Conclusion:* The bioarcheological study of the remains attributed to the martyrs, saints, and blessed of the Catholic Church is a relevant field of research. It enriches the historical sources with solid scientific data, it allows to gain information on health status and living conditions, and it sometimes offers new perspectives on hagiographic investigation.

Keywords: canonical recognition, paleonutrition, stress markers, radiocarbon dating, facial reconstruction, Early Medieval Age

Introduction

In February 2021 the canonical recognition of Saint Ceccardo from Luni, martyr of the Catholic Church and patron of the town of Carrara (northern Tuscany, Italy), took place in the Church of Sant'Andrea Apostolo, where his relics are preserved.

The biography of Saint Ceccardo is controversial and the years in which he lived, his origins, the place and circumstances of his death have long been debated by historians.

Since the mid-20th century, the remains have been laying in a marble sarcophagus with a Latin epigraph reporting: "HIC IACET CORPUS DIVI CECARDI MARTIRIS EPI LUNESIS" (Here the body of Saint Ceccardo bishop of Luni lies). Another inscription on the same ark reports that the saint was martyred in the year 600 (Lambruschi, 2020), but this data is discussed by historians because there were no persecutions in Luni in that period, and the bishop's name was Venanzio (Galleni Pellegrini, 2011). Luni was an important Roman colony located near Carrara and, in antiquity,

the two cities had close commercial relations due to the precious white marble (Bini et al., 2006)

According to the Bollandist Daniel Papebroch (1628-1714), the saint died near the marble cave of Carrara between 892 and 895 AD (Formentini, 1928; Lambruschi, 2020). The more recent historiography identifies Ceccardo with *Sicheradus Silitraldi*, cleric of Lucca in 816 and then bishop of Luni, where he was murdered or martyred in 860, during the Norman invasion and destruction of Luni (Lallai, 1998; Lambruschi, 2020).

The ancient popular tradition reports that Ceccardo was killed by decapitation in Carrara in the place which later took the name of "Saint Ceccardo district". It is believed that a water spring, still present nowadays, started to flow from the exact spot where the saint's head fell. The small church of *San Ceccardo ad Acquas,* placed above the spring, was built in 1474 (Lallai, 1998). According to another version, the saint was killed by a jealous husband with a wooden stick or by brigands with a stirrup leather; according to another version, his head was cut off because he was trying to convert heretics, as reported in some prayers dedicated to him (Galleni Pellegrini, 2011).

It is not easy to extricate the different versions of the life and death of Saint Ceccardo. In the *Martiriologio Romano* (2004), he is reported as a martyr and bishop of Luni and Sarzana, unjustly killed by some quarrymen at the marble caves of Carrara.

In 1599 Giovanni Battista Salvago (1560-1632), bishop of Luni and Sarzana (1590-1632), reported to have found the body of Saint Ceccardo in a marble arch inside the Church of Sant'Andrea Apostolo and, since then, the history of the remains of the saint has been known (Lavagnini, 1969). After this first recognition, two more are attested in 1782 and in 1949 (Lavagnini, 1966).

Nowadays, however, the official history and the popular tradition of Saint Ceccardo coexist in Carrara, and each year, on the 16th of June, the probable date of his death, the faithful celebrate the saint with honours in a procession (Galleni Pellegrini, 2011).

The aim of this study is to clarify the period in which Saint Ceccardo lived, his biological profile and to verify the circumstances of his death.

Material and Method

In 1949 the skeletal remains of the Saint were transferred from the marble arch to a zinc case and the body was replaced with a headless dummy, dressed with clothes and episcopal vestments. The dummy was exposed inside a glass case under the altar that was dedicated to him in the Church of Sant'Andrea Apostolo in Carrara. The cranium is instead preserved in a precious silver reliquary of the 15th century (Lambruschi, 2020).

For the bioarchaeological study, the post-cranial skeletal remains were removed from the case, the cranium was taken out of the reliquary and a provisional laboratory was set up in the church baptistery. The anthropological examination of the skeletal remains was performed to reconstruct the saint's biological profile. Determination of the sex was based on the morphological characteristics of the skull and pelvis (Ferembach et al., 1980). The age at death was estimated on the basis of the modifications of the pubic symphysis and auricular surface of the pelvis (Lovejoy et al., 1985; Katz & Suchey, 1986; Buikstra & Ubelaker, 1994), and on the changes of the sternal end of the 4th rib (Iscan et al., 1984). Skeletal measurements were collected and robustness indexes were calculated following the indications of Martin and Saller (1957-62). The stature was calculated by using the anatomical method of Fully 1956, corrected by Raxter et al. (2008). Ancestry was evaluated on the basis of cranial nonmetric variations (Hefner, 2009).

Stress markers related to nutritional deficiency or diseases were evaluated, such as c*ribra cranii* and *orbitalia*, enamel hypoplasia, and Harris lines (Goodman & Rose, 1990; Stuart-Macadam, 1991; Reid & Dean, 2000; Reid & Dean 2006). These were detected on the tibia and the femur by x-ray (Papageorgopoulou et al., 2011).

Dentoalveolar diseases, including carious lesions, abscesses, periodontal disease, dental wear and calculus deposits were also assessed (Brothwell, 1981; Strohm & Alt, 1998; Hillson, 2000; Minozzi & Canci, 2015). The development of muscle attachments, osteoarthrosis, and other pathological alterations were detected to obtain information on the saint's health and living conditions (Lovell, 1997; Mariotti et al., 2007; Wal-

Figure 1. Skeletal remains of San Ceccardo. Some bones are lighter than others.

dron, 2009; Weston, 2012). The study was implemented by Computerized Tomography (CT) on the skull (General Electric-medical system light speed VCT 64 slices scanner), whereas the post-cranial bones were examined by X-ray.

Stable isotope analysis and radiocarbon dating were performed on the same small bone sample from a rib. Chemical pre-treatments were performed on the sample at the iCONa "Sample Preparation Laboratory for Isotopic Measurements" of the Department of Environmental, Biological and Pharmaceutical Sciences and Technologies of the University of Campania "L. Vanvitelli". The measurement of the isotopic ratios of carbon and nitrogen was performed by a Delta Plus isotope ratio mass spectrometer (IRMS), while the measurement of the radiocarbon content was carried out by accelerator mass spectrometry (AMS).

To realize the facial reconstruction, CT scan images of the skull were processed with RadiAnt DICO Viewer software and then with InVasilius 3.1 software for the 3D rendering model for printing (Fig.6A). Virtual skull reconstruction resulting from the elaboration was printed in PLA bioplastic with the 3D printer Prusa i3 mk3ing (Fig.6B). The 3D printed skull was used to model the physiognomic reconstruction of the saint by means of the "Manchester protocol" (Neave & Prague, 1997). Reconstruction of the soft tissues was performed by the application of finely mouldable material (plasticine), by modelling each muscle directly on the printed skull reproduction. The magnitude of the various muscle thicknesses was based on standard values for white men and from a personal database (Ricci S.) (Rhine et al., 1984). After the muscles, ocular globes were also inserted, and chin, mouth, nose and ears were modelled (Stephan et al., 2003; Wilkinson et. al., 2003; Wilkinson & Mautner, 2003). A negative mould of the model was created with silicone gum; then a positive cast in resin material was realized and, finally, the cast was carefully painted and characterized taking into account the individual's age at death.

Results

Anthropological and paleopathological studies

The skeleton of Saint Ceccardo is almost complete and well-preserved (Fig. 1). The following bones are absent: the left clavicle, the sixth cervical vertebra, the sixth rib, the left patella, some bones of the hands, most of the feet bones and almost all the anterior teeth. The right tibia, some vertebrae and small bones of the hands and feet are lighter than the others, which are brownish (Fig. 1). Furthermore, some patches of waxy and reddish material, probably sealing wax, can be observed on the surface of some bones, including jaws (Figg. 2A, C; 3A).

The skeletal remains belong to a male individual aged 30-45 years. The stature has been estimated between 158 and 160 cm. The skull has a slightly elongated shape (dolichocrany), with morphological characteristics of the Caucasian ancestry (Fig. 2A).

A diffuse porosity was observed on the ectocranial plate of the frontal, parietal, and occipital bones (*cribra cranii*) and in the orbital roofs (*cribra orbitalia*). On the cranial vault, the porosities are evaluated to be degree 3 (cribrotic), while the porosities of the orbits are degree 2 (porotic), both in the reparative phase; no expansion of diploe was observed through CT images.

On the external surface, on the right side of the frontal bone, a small depression (6 mm in diameter)

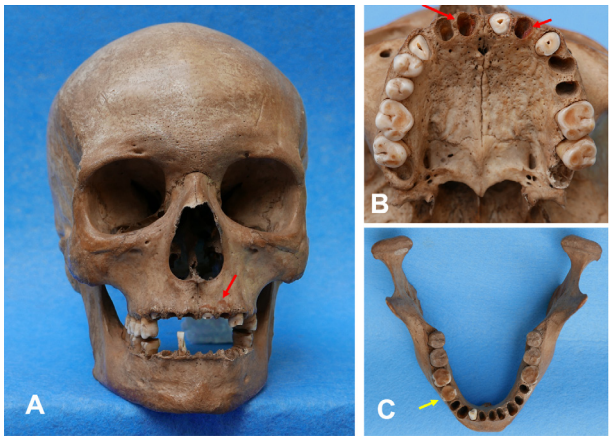

Figure 2. A: the skull of San Ceccardo, the red arrow indicates the reddish substance; B: the maxilla: the red arrows indicate the reddish substance inside the sockets; C: the mandible: the yellow arrow shows the deciduous second molar.

testifies a traumatic event, probably due to the impact of a small object. The lesion, completely healed, occurred long before death (Lovell, 1997).

The maxillary and mandibular bones are complete and well-preserved, but most of the anterior dentition was lost post-mortem, perhaps removed as a relic. In the maxilla only the first and second molars on the left (Fig. 2B), and from the first premolar to the second molar on the right are present.

In the mandible all six molars are present, whereas all the anterior teeth and premolars (Fig. 2C) are missing, with the exception of the right lateral incisor, whose crown is only partially preserved. On the right, the deciduous second molar occupies the space of the second premolar; x-ray confirmed congenital agenesis of the permanent second premolar.

No dental caries, nor ante-mortem tooth loss are present, while an apical abscess is observable in correspondence of the upper right third molar. Dental wear affects the occlusal surfaces of the posterior teeth and some patches of exposal dentine are visible, in agreement with the age of 30-40 years. A slight alveolar resorption between 2-4 mm on the upper and lower molars accompanied by small deposits of subgingival calculus suggests an early stage of periodontal disease (Strohm & Alt, 1998). On the only preserved anterior tooth (Md RI2), a slight linear enamel hypoplasia testifies an episode of nutritional stress or illness occurred in childhood at about 3 years of age. Traces of non-specific stress episodes, suffered in childhood, were also evidenced by the presence of almost two Harris lines in the tibias, observed by X-ray in the proximal and distal portion of the diaphysis (Fig. 3B).

Perforation of the body of the sternum, a rather rare congenital anatomical variant, was observed. The spine is complete and well-preserved, with the exception of the sixth cervical vertebra that is missing. No cervical vertebrae show traumatic signs or lesions. Ossification of the yellow ligaments is present in almost all the thoracic vertebrae and a slight osteophytosis (about 1-2 mm) affects the upper ventral edge of the vertebral body of the last three lumbar vertebrae (Fig. 3A). No traces of osteoarthritis were found in the other joints, except for a slight marginal lipping on the condyles of the right femur (Fig. 4B).

The skeleton shows a fair degree of robustness, as testified by the long bone indexes (i.e. humeral platibrachy and femoral platimery), with well-marked muscle attachments especially in muscles like the pectoralis major and the deltoid (development degree 3 and 2, respectively), which are involved in the shoulder and arm movements. In the lower limbs, the most developed attachments regard the gluteus maximus and the soleus muscles (development degree 2 and 3, respectively), implicated in the hip and foot extension movements.

Periosteal new bone apposition affects almost all the long bones of the lower limbs, mainly situated in the metaphyseal areas and along the diaphysis. A sim-

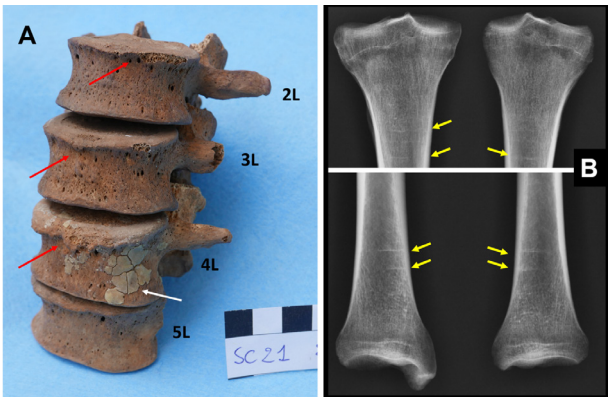

Figure 3. A: lumbar tract of the spine showing some waxy patches (white arrow) and a slight osteophytosis affecting the superior edge of vertebral bodies (red arrows); B: X-ray of both tibias showing the Harris lines (yellow arrows).

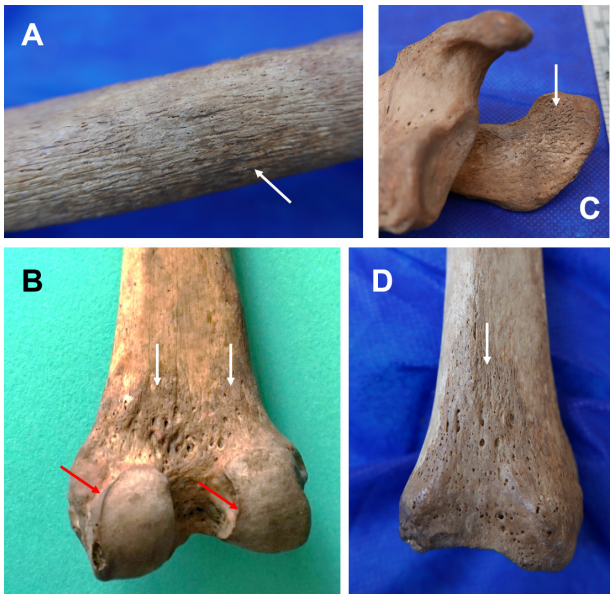

Figure 4. Periosteal reaction (white arrows). A: diaphysis of the right femur; B: posterior surface of the proximal end of the right femur, a slight marginal lipping is observable around the articular surface (red arrows); C: acromion of the left scapula; D: lateral view of the distal end of the right tibia.

ilar alteration also affects the acromial inferior surface of the scapulae and a portion of the ischiatic surface of the coxal bones (Fig. 4). The disorganized appearence with unremodeled edges of the new bone apposition (woven bone) and the presence of multiple large foramina indicate abnormal periosteal vascularization; the remodelling process indicates healed lesions (lamellar bone) in some points. The mixed features suggest that the disease process was healing at the time of death (Roberts & Manchester, 1997; Weston, 2008).

Stable isotope analysis

Analysis of the stable carbon and nitrogen isotopes provide information on the nutritional intake of an individual in the last years of life. The δ13C and δ15N values in the bone collagen of Saint Ceccardo are -19.3‰ and 9.6‰ respectively. In Figure 5 the values are inserted in a graph with respect to the isotopic reconstruction typical of some reference ecosystems. Despite the absence of an appropriate animal baseline, necessary for a correct interpretation of human isotopic data, the δ13C and δ15N values related to the saint suggest a nutritional profile characterized

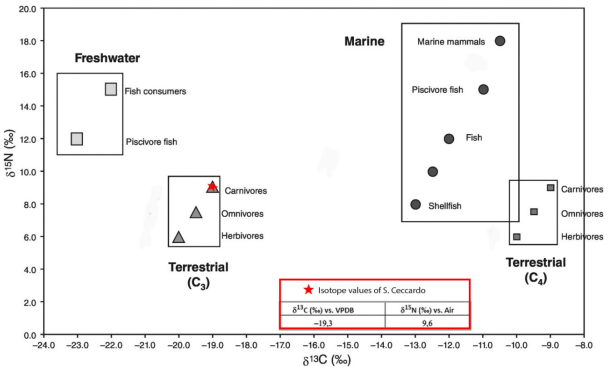

Figure 5. Isotope values in the bone collagen of Saint Ceccardo (red star) with respect to the isotopic reconstruction typical of some reference ecosystems (graph modified from Richards, 2020).

by a terrestrial diet, with the consumption of C3 plants and a good intake of terrestrial proteins. A terrestrial carnivorous diet is indeed characterized by a δ13C value around -18/20‰ and a δ15N value about 9/11‰, as in Saint Ceccardo's case.

Radiocarbon dating

The results of radiocarbon analyses and the curves of calibration indicate the period between 771 and 977 AD as the most probable dating (89.1% probability).

Facial reconstruction

The facial reconstruction technique makes it possible to reconstruct the physiognomic features of a face on the basis of cranial morphology. In recent years many scientific papers, concerning facial reconstruction, have indicated techniques that severely limit the "artistic freedom" of the performer, in an attempt to obtain repeatable results (Lebedinskaya, 1998; Wilkinson, 2004; De Greef et al., 2006). One of the problems is to identify the real values of soft tissue thickening. In this case, the magnitude of the various muscle thicknesses derived not only from standard values, but also from an experimental database (Ricci S.: personal data) (Rhine et al., 1984). The utilized values were obtained from a sample of 125 adult subjects from modern male individuals, measured by means of CT scan and NMR (Nuclear Magnetic Resonance) at the U.O.C. (Unità Operativa Complessa), Neuroimmagini e Neurointer-

ventistica, Azienda Ospedaliera Universitaria Senese (Siena). On this basis, new values have been proposed for each craniometric point, applicable to a "caucasoid" skull type.

Discussion

The skeletal remains of Saint Ceccardo are well-preserved and almost complete. In the past, some missing bones were removed from the skeleton to make relics, used to found altars dedicated to the Saint in some churches of the diocese of Massa Carrara and Pontremoli, as reported in the documents preserved in the diocesan archive of S. Andrea Apostolo. The lighter colour of some bones with respect to others may depend on the exposure to light; indeed, the discoloration of the bone tissue confirms a different placement of these elements in the past, as also indicated by the presence of residues of candlewax, resulting from the exposure of the Saint's remains to the prayers of the faithful (Galleni Pellegrini, 2011). Some red waxy material on the maxillary bones, also observed in previous recognitions, gave rise to an alleged miraculous event. In 1625 Giovanni Salvago, bishop of Luni, reported that some blood gushed from the socket of a tooth he was trying to extract from the alveolus to make a relic. In 1949, chemical analyses excluded the blood origin of the red deposit, as reported in a document from the diocesan archive; we therefore suppose that it might have been sealing wax, perhaps used as a glue, to fix the teeth to their alveolar processes.

The reconstruction of the biological profile depicted Saint Ceccardo as a fairly robust man, aged between 30-45 years, with an estimated stature of around 158-160 cm, shorter than the average stature of medieval Italian populations (Giannecchini & Moggi-Cecchi, 2008).

The presence of some stress markers, such as enamel hypoplasia and Harris lines, indicate nutritional deficiencies or diseases suffered in childhood. Moreover, the diffuse porosities observed on the cranial vault and in the orbital roofs indicate a previous pathological process. While there is still debate on the aetiology of the *cribra cranii* and *orbitalia,* these are generally considered as a manifestation of anaemia or vitamin deficiencies (in particular, vitamins B, C, and D). The healing stage of the porosities with no accompanying thickening of the diploe suggests that the disorder affected him in juvenile age (Walker et al., 2009; Zuckerman et al., 2014; Brickley, 2018).

The pathological condition even in adulthood is suggested by the diffuse periosteal reaction mainly localized in more vascularized areas, such as the metaphysis of long bones. This bone alteration represents a nonspecific response of the periosteum to many possible insults. In this case, the multifocal nature of the periosteal new bone production suggests a systemic disorder, probably of infective origin. The mixed presence of active and healed lesions indicates that the process was healing when the Saint died (Ortner, 2003; Weston, 2012). On the other hand, the results of stable isotope analysis indicate a good nutritional profile with consumption of C3 plants (represented by most plant species of temperate climates, such as wheat, barley, oats, rye, fruits and vegetables) and a good intake of terrestrial proteins (probably meat and dairy products).

Evaluation of the dental health status of Saint Ceccardo is limited by the loss of several teeth. However, the preserved posterior teeth present no carious lesions, with the possible exception of the right upper third molar (post-mortem loss), where the presence of an abscess might be due to a carious lesion (Hillson, 2000). This agrees with the isotopic analysis, which attested a high consumption of proteins in the diet, and can also be correlated with marked dental wear, since the abrasiveness of food naturally cleans the teeth by removing food and bacteria and thus reducing the number of occlusal caries (Larsen, 1997). The presence of alveolar resorption and calculus indicate scarce oral hygiene, a condition that was largely common in past populations.

The development of muscle attachments, the ossification of yellow ligaments, and the slight osteoarthritic changes in the right knee joint, indicate a moderate physical activity during life, with particular regard to the movement of shoulders and arms and of legs during walking.

No perimortal lesion was observed that could support the tradition of martyrdom or murder. In particular, all the cervical vertebrae are intact and, although the sixth cervical is missing, there are no signs

of decapitation, as reported by the legend. The only sign of a traumatic event was that of a blunt blow on the skull, occurred long before his death. However, it cannot be excluded that perimortal lesions might have involved only soft tissues, leaving no traces on the skeletal apparatus.

The most interesting result derives from carbon-14 dating, which excludes the hypothesis that Saint Ceccardo died in 600 AD, as reported in the epigraph on the marble sarcophagus where he was laying. Instead, carbon-14 dating agrees with and confirms the historical sources that indicate Saint Ceccardo as bishop of Luni in the 9th century.

In the reconstruction of Saint Ceccardo's face, the results obtained can be considered very close to what must have been his original physiognomy, although the colour and distribution of hair and beard, as well as the colour of the eyes, are a merely artistic interpretation (Fig. 6C).

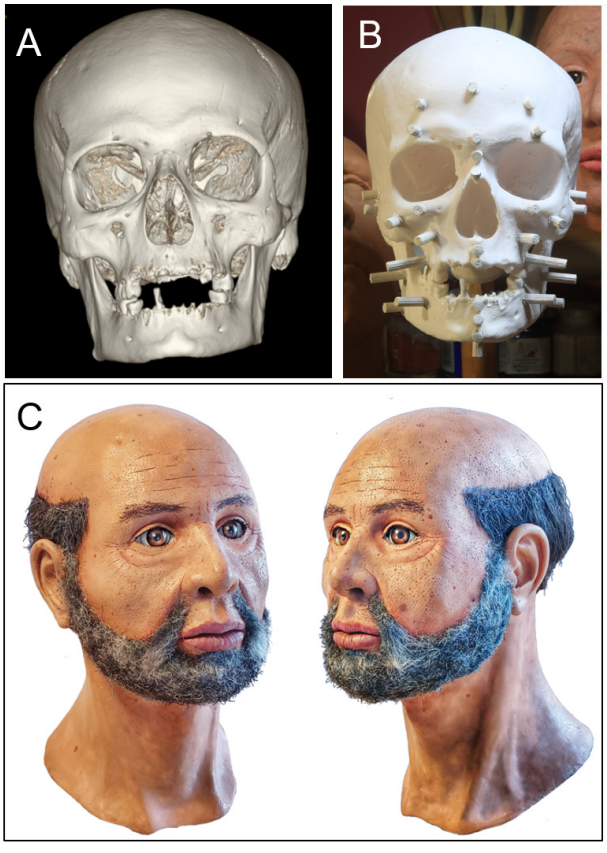

Figure 6. Facial reconstruction of Saint Ceccardo. A: 3D rendering from CT images; B: plastic printed skull during the first phases of facial reconstruction; C: result of the Saint's face.

Conclusions

The canonical recognition of remains attributed to martyrs, saints and blessed of the Catholic Church is a precious opportunity to carry out anthropological, paleopathological, radiological, biochemical and bio-molecular studies, as in the case of Saint Ceccardo from Luni. The multidisciplinarity of the studies allows not only to reconstruct the biological profile, but also to obtain information on the life and health conditions of these important figures.

The study of Saint Ceccardo's skeletal remains allowed us to reconstruct the profile of a robust adult man of short stature, belonging to the Caucasian ancestry.

In spite of some episodes of stress during childhood and some modest pathological conditions before death, his nutritional profile was good, in line with the dietary resources of a wealthy person of episcopal rank.

No traces of perimortal lesions supporting the hypothesis of martyrdom by beheading were observed, but this does not exclude that he may have been injured with lesions affecting the soft tissues only.

The results of radiocarbon dating agree with the historical sources, according to which Saint Ceccardo was bishop of Luni during the 9th century.

Finally, the facial reconstruction provides a realistic image of the saint, functional to the adoration of the faithful.

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