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Janković, Stipan; Anđelinović, Šimun; Primorac, Dragan; Vilović, Katarina; Kero, Darko; Štambuk, Snježana; Mihanović, Frane; Ursić, Luka; Jelenić, Marijan; Kružić, Ivana; ...

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RESEARCH ARTICLE

Anthropological individualization of relics from sarcophagus stored in Vodnjan monastery, Vodnjan, Croatia

Željana Bašić[1], Ivana Kružić[1], Marijan Jelenić[2], Luka Ursić[3], Stipan Janković[4], Frane Mihanović[4], Snježana Štambuk[1], Darko Kero[3], Katarina Vilović[3], Dragan Primorac[3, 5], Šimun Anđelinović[3, 6]

[1] University of Split, University Department of Forensic Sciences, Split, Croatia

[2] Parish Church of St. Blaise, Vodnjan, Croatia

[3] University of Split School of Medicine, Split, Croatia

[4] Department of Health Sciences, University of Split, Split, Croatia

[5] Eberly College of Science, The Pennsylvania State University, University Park, PA, USA

[6] Clinical Department for Pathology, Legal Medicine and Cytology, University Hospital Center Split, Split, Croatia

Correspondence to:
Luka Ursić
University of Split School of Medicine,
Šoltanska 2, 21000 Split, Croatia
luka.ursic@mefst.hr

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Aim: To develop a methodology for the estimation of the preservation of human skeletal remains – the relics in the Vodnjan assembly; to estimate the minimum number of individuals (MNI), sex, and age; to evaluate the physical state of their remains, and to individualize the remains to verify the list of saints allegedly buried at the monastery.

Methods: Standard crime scene investigation and forensic anthropology methods were used, including trace evidence marking, photography, minimum number of individuals (MNI) estimation, sex, age, stature estimation, pathological and traumatic changes examination, individuation, and individualization by the comparison to the biography.

Results: The total sample of the bones in the Vodnjan relic collection was very poorly preserved. The MNI in the sarcophagus was twenty-two. Of those, three were female, twelve were male, and seven were subadults.

Conclusion: The forensic approach to the documentation and analysis of relics was appropriate for this kind of skeletal material. The final identification was not possible because of the poor preservation of skeletal material and the lack of hagiographical (antemortem) data. However, the forensic anthropology approach enabled us to create osteobiographies, and after the comparison with the existing antemortem data, we could not exclude that the remains belonged to the named saints.

Introduction

Academic painter Gaetano Gresler arrived at Vodnjan from Venice on June 23rd, 1818. Gresler was an avid collector of sacral art; he managed to acquire a substantial number of sacred relics and paintings, as many Venetian monasteries and churches were being foreclosed by the French administration after the fall of the Venetian Republic. He brought some of his collection to Vodnjan, including the relics of saints that he later gifted as an inheritance to the Vodnjan church of Saint Blaise (Tomić, 1998; Jelenić, 2000; 2004). These relics have been kept in church since then, and in 2008, a committee for their analysis was formed. Currently, the relics are stored in a new wooden sarcophagus, in the Parish Church of St. Blasius in Vodnjan. The total length of the sarcophagus is 8 meters, including the internal shelves. The relics were placed there by the parish church pastor Marijan Jelenić (Jelenić, 2000; 2004; Župa Vodnjan, 2021). The affiliated bones were stored in separate glass boxes and other bones were stored in different containers (**Figure 1**).

Figure 1. Sacrophagus with three compartments, with the relics visible inside.

Anthropological analyses are crucial in investigating populations that left little to no written trace, which was the case with the Vodnjan relics. In such instances, determining the life conditions individuals were exposed to, the age at death, the quality of nourishment (abundance or shortage of food), the intensity of physical labor, and other factors can provide key data for fully reconstructing the image of the life of an individual in the past. The scientific discipline of bioarchaeology, which studies osteological findings at archaeological sites, aids in determining those factors, either at the level of an individual or a whole community. It shares its history and methodology with physical anthropology, paleodemography, paleopathology, and forensic anthropology, so a bioarchaeologist goes beyond

observing and describing the osteological materials themselves, and considers them in a wider archaeological, ecological, and demographical context (Šlaus, 2006). Such multidisciplinary analyses were key in developing the methodology for the Vodnjan relics.

The primary goal of the research was to catalog the relics to determine the exact number of human bones, body parts, and their personal affiliation, so that the relics could be stored properly in separate reliquaries and exhibited. The secondary goal of the research was to discover the link between the bones and the list of saints found in the sarcophagus, containing 31 names. Historically, falsification of relics was common (Arnautova, 2018; Butler, 2007; Charlier et al., 2010; Gillingham, 2010), so the aim of this research was to confirm or challenge the authenticity of the relics.

Materials: skeletal remains and historical data

The scientific processing began in Vodnjan, in the northeastern part of Saint Blaise's church. Firstly, mummified bodies kept in the church were analyzed. The results of these analyses were published in separate papers and will not be discussed here further (Kružić et al., 2018; Marić et al., 2020; Mihanović et al., 2017). Besides the analysis of the mummified bodies, an analysis of the relics (bones) kept in a wooden sarcophagus in the Vodnjan church was also performed.

The relics were originally placed in the wooden sarcophagus with three compartments, coated from the front outer side by a patterned golden cloth and from inside by the another patterned cloth of golden color. The sarcophagus was frontally closed with a glass plate that was removed to enable access to the relics (**Figure 2**). The relics were co-mingled with other materials: the heavier bones were laid atop of lighter ones, which might have damaged parts of the bone material. Everything was very dusty and dirty, and on the bottom of the box, there were mouse feces and insects' pupae (**Figure 3**).

Figure 2. Sarcophagus before analysis. The bones were kept in a disorderly state, mixed with various artefacts. The glass sheet which kept them protected from external factors can be seen in front of the sarcophagus.

Figure 3. Harming conditions in the wooden sarcophagus. As can be seen in the photograph, the bones were covered in dust and other material, which might have further damaged them.

The relics were initially stored in two different altars at the Benedictine monastery church of St. Lawrence in Venice in 1510 by Abbess Maria Lando, and were transferred to Vodnjan by Gaetano Gresler as previously explained. Gresler created a list that enumerated 19 saints to whom the relics allegedly belonged; this list was found in the sarcophagus and marked as VD-C097/10 (**Table 1**).

Table 1. Gaetano Gresler's list of Saints (numbered VD-C097/10)

Name on Gaetano Gresler's list (VD-C097/10) in Latin:	Presumed Saints
"…Sanctorum Laurentii, Donati, S. Viti, Alexandri Papae, Scti Stephani Protomaryris, Pauli Eremitiae, Simeonis Confesoris, Theonisti, Thabrae, et Thabratae."	St. Lawrence, St. Donatus, St. Vitus, St. Alexander (the Pope), St. Stephen the Protomartyr, St. Paul the Hermit, St. Simeon the Confessor*, St. Theonistus, St. Tabra, St. Tabratha
"…Sanctorum Apostolorum Thomae, Andrae, Jacobi, Bartholomaei, Mathiae."	St. Thomas the Apostle, St. Andrew the Apostle, St. Jacob the Apostle†, St. Bartholomew the Apostle, St. Matthew the Apostle
"…Sanctorum Florentii, Vindemiali, Benedicti atque Platonis."	St. Florentius, St. Vindemial, St. Benedict, St. Plato

* Unclear which one; as a Saint under the same name existed in the 1st Century, in the 5th Century, and in the 17th Century.
† Unclear which one, either St. Jacob the Older or Younger.

The unknown saints were covered by the inscription *"et aliorum Sanctorum"*, which translates to "and other saints" (VD-C097/10). The saints are likewise mentioned on other lists, parchments and inscriptions present in the sarcophagus (**Figure 4**, lists numbered VD-B118/10 and VD-B120/10).

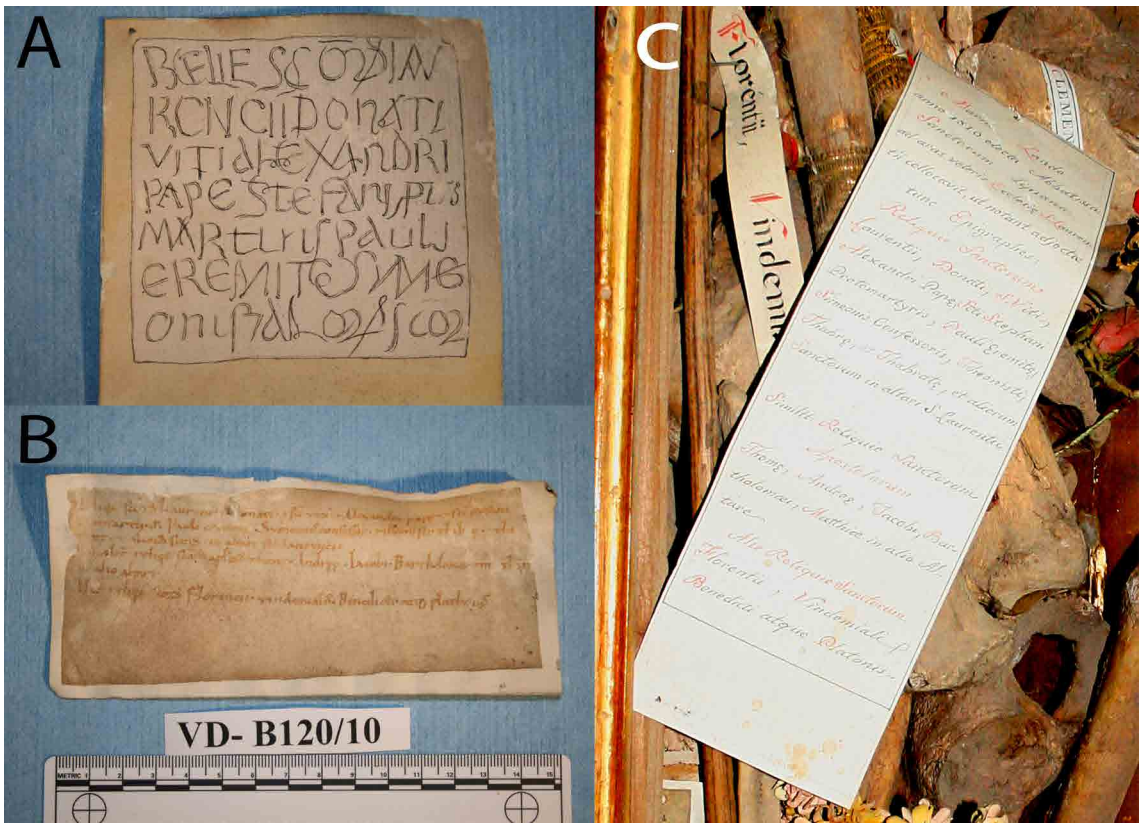

Figure 4. Photographs of three lists with the names of the Saints in the sarcophagus: a) VD-B118/10; b) VD-B120/10; c) VD-C097/10.

In a detailed analysis in Vodnjan and Split, additional inscriptions on the relics were found, including a lead plate and three small parchments from different historical periods. These inscriptions mentioned six more Saints for a total of 25; this can be seen in **Table 2**.

Table 2. Gaetano Gresler's list of Saints (numbered VD-C097/10)

Saint(s)' names on inscription or list in Latin (list number)	Presumed Saint(s)
"…SS(anctorum) M(artiru)m Jacobi Intercisi, Felicis, et Fortunati…" (inscription on rib bone VD-C009/10)	St. Jacob Intercisius, St. Felix, St. Fortunato
"s…idiae Martyris…" (inscription on right femur, VD-C003/10)	St. Lydia
"S. CLEMENTIS MART." (inscription on hip bone fragment VD-C005/10);	St. Clement I (the Pope)
"Bti Seregoli" (VD-A594/10)	St. Servulus
"Ste Crispine"	St. Crispina
"S. Mauri Mart…" (parchment attached by a red seal to the fibula fragment VD-C006/10)	St. Mauro
"JAERONCII"	Unknown - St. Jerome / St. Gerontius / St. Jerome the Bishop
"Scti Justi martyris"	St. Just
"SYMEONIS SALONIS CONF."	St. Simeon the Confessor, 1st Century

These relics consisted of more than 700 bones in various states of preservation. The bones were stored in a wooden sarcophagus divided into three compartments, along with other materials, such as inscriptions on paper and metal. Paper flowers, ribbons, and other objects were found in all three compartments. In 2010, they underwent a 15-day anthropo-

logical analysis. In that short period of time, it was not possible to make personal identification, and for that reason, the relics were additionally analyzed at the Clinical Department of Pathology, Legal Forensic Medicine and Cytology and the University Department of Forensic Sciences, University of Split. Hagiographies (biographies of saints) were used to determine historical facts and use them in the individualization process. Further DNA analysis could provide better results, but that methodology was rejected as it would damage the relics, which was not possible because of their sacral value.

Methods

Labeling and photographing of the bones

During the analysis, every bone was given its number in ascending order. Each of the three compartments of the sarcophagus was marked with VD (Vodnjan) and additional letters specific to each section: VD-A, VD-B, and VD-C. After the numeration, detailed photographs of the remains in their original state were taken. All the bones were also scanned using multi-slice computed tomography for further scientific research. First, the analysis of the part of the sarcophagus marked VD-C was performed, followed by VD-B and VD-A. Before a relic was taken out from the sarcophagus, it was photographed *in situ* with the associated number in ascending order, to record its position in the sarcophagus (**Figure 5**). Afterwards, the photographs were taken with the photo evidence scale in front of the sarcophagus.

Figure 5. Example of photographs in situ. All bones and relics were photographed in their original position before they were taken out for further analyses.

Following the photographic documentation, each bone was wiped with a dry cloth to remove impurities, which was required for the anthropological analysis. The marking of the bones was performed on their least visible parts in which no pathological or traumatic changes or any morphological characteristics of the bones important for anthropological analysis had been found. A small section of a bone had been marked with a thin layer of colorless varnish, on which the mark allotted to the bone was written with a marker (**Figure 6**). It was then taken out of the box, after which another layer of colorless varnish was deposited (Waring, 2010).

Figure 6. An example of marking the bones. The colorless varnish can be seen below the marking on the bone.

Anthropological analysis of the bones

Each bone was analyzed anthropologically by determining the taphonomic characteristics, i.e. the change of bone due to environmental conditions (climate, soil composition, influence of animals), individual factors (size of the body, age at the moment of death), and cultural factors (burial method, embalming) (Grauer, 1995). The state of preservation of the bone remains was then estimated (from very bad to excellent) according to the percentage of their completeness and the degree of damage. Also, interventions on the bones, such as seals, ribbons, or inscriptions, were described in detail. All the bones were measured using an osteometric board, a caliper, and a tape measure. If possible, sex and age were estimated, and pathological and traumatic changes of the bones were recorded.

After the anthropological analysis, photographs of bones were taken beside an evidence scale. Bone fragments were photographed from at least two views, while the other bones were photographed from at least six views: anterior, posterior, medial, lateral, distal, and proximal. Photographs of specific characteristics of each bone were taken (such as mor-

phological characteristics, pathological or traumatic changes), and all the rest that was found on the bone (seals, ribbons, inscriptions, etc.) (Bass, 1981; Maresh, 1970; Meindl, Lovejoy, Mensforth, & Don Carlos, 1985; Moore-Jansen & Jantz, 1990; Ortner, 2003; Phenice, 1969; Trotter & Gleser, 1958; Ubelaker, 1999; Walker, 1995). More than 12,000 photographs were taken (**Figure 7**).

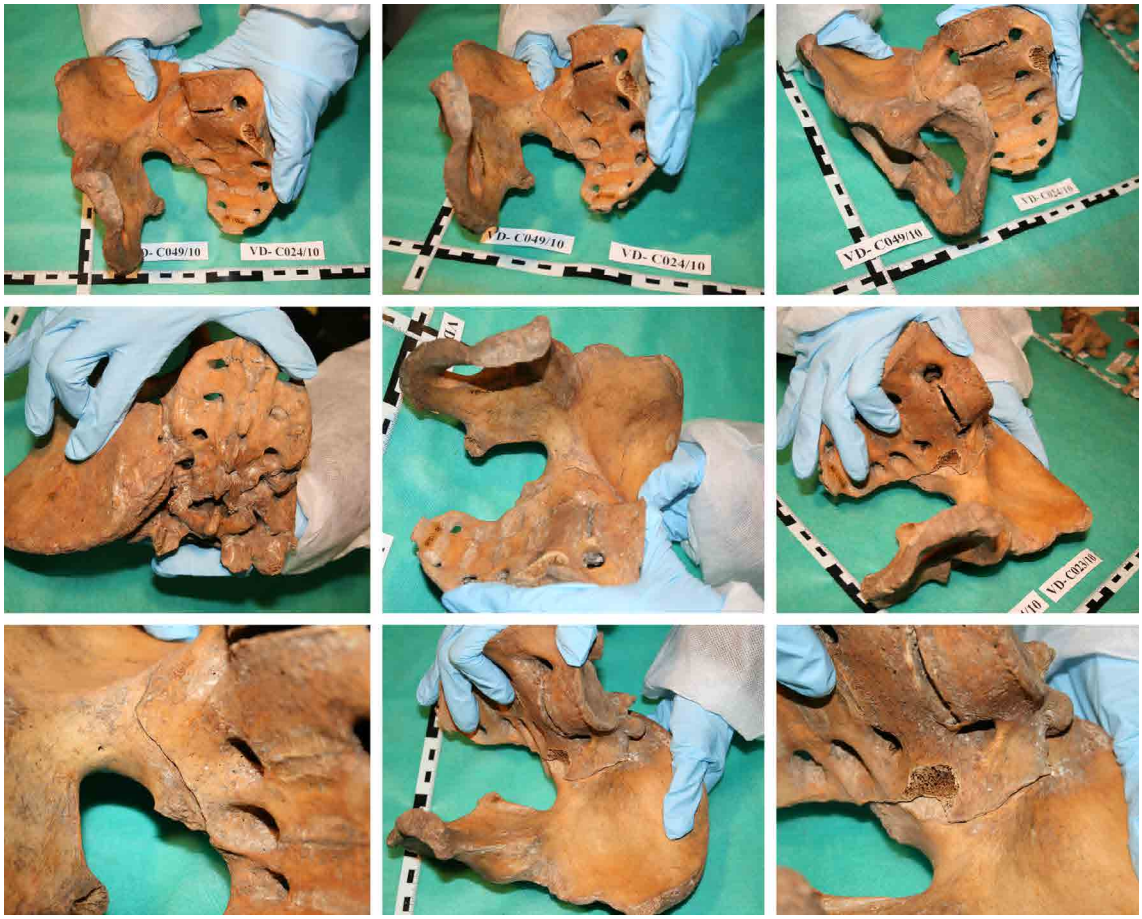

Figure 7. An example of the photographing method; each bone found was photographed from at least six views, and detailed photos of morpohological or pathological characteristics were taken.

The anthropological analysis was divided into the following steps: assembly documentation (photographing and labeling), estimation of the degree of bone preservation, estimation of the minimum number of individuals (MNI), biological profile estimate (sex, age, stature, habitual activities, pathological and traumatic changes) and, if possible, individuation. Only non–destructive methods of anthropological analysis could be applied due to piety and the sacral importance of the relics. DNA analysis could not be performed for the same reason.

Methodology for the estimation of the degree of bone preservation

A total of 670 bones and bone fragments belonging to unknown persons of different origins, initially buried at different burial sites through various rituals, were analyzed. Both the percentage of the bone (or the whole skeleton) preserved and the degree of bone surface damage are important for the strength of anthropological analysis (Anđelinović,

Drnasin, Anterić, Škorić, & Bečić, 2010; Anterić, Bašić, Škorić, & Anđelinović, 2011; Bašić, Anterić, Škorić, Vilović, & Anđelinović, 2014; Brothwell, 1981; Janaway, Wilson, Caffell, & Roberts, 2001; Stojanovski, Seidemann, & Doran, 2002; Šlaus, Novak, Bedic, & Strinovic, 2012). Therefore, developing a precise, unequivocal, and understandable terminology during the initial analysis of Vodnjan relics and the preparation of the relic catalog was crucial.

Importantly, we developed a novel approach for calculating the degree of bone preservation.

To successfully determine the MNI and to perform the process of individuation, a procedure for estimating the degree of preservation of skeletal material (in this case an isolated bone) was implemented. We first calculated the MNI using the method developed by Adams and Byrd (2008). We then proceeded to develop a novel approach for estimating the degree of bone preservation. This was necessitated by the situation found *in situ*: the severely fragmented bones were co-mingled and various bone taphonomic conditions were altered many times (at the burial, after the exhumation, transport, and exhibition in different churches). Moreover, various interventions were visible on the bones (exposure to fire, cut marks, inscriptions in bones, fabric coverage on the bone, sealings, etc.).

The most useful methodology for this research was the one introduced by Bello, Thomman, Signoli, Dutour, and Andrews (2006), although some modifications had to be made. Their methodology was, in essence, grading bones looking at the whole skeleton (class 1 = 0% of bone preserved to class 6 = 100% of bone preserved), and at the bone cortex (class 1 = 0% of sound cortical surface to class 6 = cortical surface completely sound). Their class one (100% of bone preserved) was not applicable in this case as no complete skeletons were available for the analysis. When analyzing only one bone, a class one designation cannot be used, especially when human skeletal remains are co-mingled and skeletons are not completely preserved (for example, when only one bone remained from a single person, as was the case with the Vodnjan relics). We also found that the approach of grading those bones which were more than 95% preserved and to which the degree of postmortem damage is less than 5% with a grade 5 was more than satisfactory for anthropological analysis. However, the approach of separately grading the percentage of material present and the degree of postmortem bone damage was not adequate for this research. Therefore, we introduced a novel approach: a cumulative index (CI) for the categorization of the degree of bone preservation that multiplies the grade for the percentage of the bone present (PBP) (**Table 3**) and the grade for the postmortem bone damage (PBD) (**Table 4**). The following formula was applied:

$$CI = PBP \times PBD$$

The CI degrees and gradation for bone preservation from very poor to excellent are shown in **Table 3**.

To better understand the approach, we have developed the rating for a single skeleton burial; the skeletal cumulative index (SCI) for which the following formula should be applied:

$$SCI = \sum CI / 206^*$$

*if an entirely preserved skeleton is found and it consists of more than 206 bones this number should be substituted with the exact number of bones. For children, this number should also be adjusted.

Table 3. Categorization of the osteological material by the percentage of bone present

GRADE FOR PBP*	% OF THE BONE PRESENT
5	95–100
4	75–94
3	50–74
2	25–49
1	1–24

* Percentage of bone present.

Table 4. Categorization of the osteological material by the degree of postmortem bone damage

GRADE FOR PBD*	% OF THE POSTMORTEM BONE DAMAGE
1	95–100
0.8	75–94
0.6	50–74
0.4	25–49
0.15	1–24

* Postmortem bone damage.

For determining the CI for the total skeletal inventory of an excavation site, the formula for the excavation site cumulative index (ESCI) should be applied:

$$ESCI = \sum SCI / TNS,$$

where TNS stands for a total number of skeletons.

If analyzing the assembly of co-mingled human remains, the following formula for calculation of co-mingled CI (CMCI) should be applied:

$$CMCI = \sum CI / TNB,$$

where TNB stands for a total number of bones.

For determining the SCI/ESCI/CMCI grades, **Table 5** should be used.

The first objective of the analysis was to determine the percentage of bone present. If more than 95% of bone was present, then the bone was graded with grade 5. If less than 25% of bone was present, then the bone was graded with grade 1. Examples of bones from the Vodnjan sarcophagus graded into these five categories are given in **Figure 8**.

After determining the percentage of the bone present, a degree of postmortem bone (cortex, surface) damage was evaluated. If more than 95% of bone was undamaged (only 5% of bone damaged), then the bone was graded with grade 1. If more than 75% of bone was damaged (less than 25% of bone intact), then the bone was graded with 0.15. Examples of bones from the Vodnjan sarcophagus graded into five categories are given in **Figure 9**.

Table 5. Categorization of the osteological material by the degree of bone/skeleton/excavation site/co-mingled remains preservation

CI/SCI /ESCI/CMCI*	DEGREE OF PRESERVATION
4.0–5	excellent
3.2–3.99	very good
1.8–3.19	good
0.8–1.79	poor
0.15–0.79	very poor

* CI = Cumulative Index for the categorization of the bone preservation; SCI = Skeletal Cumulative Index for the categorization of the preservation of a whole skeleton; ESCI = Excavation Site Cumulative Index for the categorization of the preservation of an entire skeletal assembly; CMCI = Co-mingled Cumulative Index for the categorization of the preservation of co-mingled human remains.

By multiplying these two categories (percentage of the bone present and the degree of postmortem bone damage), the degree of bone preservation as a CI was calculated. For example, if 40% of bone was present (grade 2) and no postmortem bone damage was observed (grade 1), then the degree of bone preservation (CI) is 2 (2 multiplied with 1), meaning that the bone is well preserved.

Figure 8. Examples of bones (humeri) graded according to the percentage of bone present: a) grade 5; b) grade 4; c) grade 3; d) grade 2; e) grade 1.

If the bone is preserved more than 95% (grade 5), and more than 70% of bone has postmortem damage (grade 0.15), then the degree of bone preservation (CI) is 0.75 (5 multiplied with 0.15), meaning that the bone is very poorly preserved. Examples of bones from the Vodnjan sarcophagus graded into five categories (CI) are given in **Figure 10**.

Figure 9. Examples of bones (humeri) graded based on the degree of postmortem damage: a) grade 1; b) grade 0.8; c) grade 0.6; d) grade 0.4; e) grade 0.15.

Figure 10. Examples of bones (humeri) graded based on the degree of bone preservation: a) excellently preserved; b) very well preserved; c) well preserved; d) poorly preserved; e) very poorly preserved.

Methodology for sex determination

Sex estimation on the Vodnjan relics was challenging since the bones were intermingled. Thus it was necessary (if possible) to estimate sex for each bone and later to individualize the bones. Such sex estimation is challenging, and its success is lower, since sex differences can in this case, only be estimated by observation of bone robustness, of muscle and ligament attachments, as well as bone measurements (Krogman & Iscan, 1986). In children, sex was not estimated since their sex-specific morphological characteristics visible on bones were not yet fully developed (**Figure 11**).

Figure 11. VD-B032, a child pelvis, morphological sex characteristics are not fully expressed.

Methodology for age determination of the osteological remains

Since in the Vodnjan samples there was no whole skeleton preserved, age was estimated for each bone, whereby several other anthropological methods were used (Iscan & Steyn, 2013; Langley, Jantz, Ousley, Jantz, & Milner, 2016; Moore-Jansen & Jantz, 1990; White, Black, & Folkens, 2011).

Methodology for the estimation of stature on skeletal remains

Stature estimation from the skeletal remains from Vodnjan was calculated from the lengths of completely preserved long bones according to Trotter and Gleser (1958).

Results

The results of the anthropological analysis of the Vodnjan relics were divided into two parts. The first results included the degree of bone preservation analysis and the MNI, sex, and age estimation for the relics in the sample. The anthropological analysis was done on skulls, mandibles, upper and lower limb long bones, pelvises, and sacra. The second results came from the attempt at the individualization of the bones based on the anthropological analysis and its comparison to hagiographical data of the saints whose names were found on the list in the Vodnjan sarcophagus.

The degree of bone preservation

Calculating the degree of bone preservation (CI) enabled us to categorize the bones into five categories from very poor to excellent which were important criteria for individuation. Also, it gave us an opportunity to evaluate the total degree of preservation of all the analyzed bones in each sample. Animal bones, identified by the methods proposed by Adams and Crabtree (2009), were not included in the study, and neither were the 43 additional items found (paper inscriptions, glass vessels, stones, metal plates, etc.). The CMCI was calculated, and the total sample was poorly preserved (CMCI = 1.78). The results of the grading of the degree of preservation of the osteological material using CI are presented in **Table 6**.

Table 6. Number of bones graded by degree of preservation (CI/SCI/ESCI/CMCI)

DEGREE OF PRESERVATION (CI/SCI/ESCI/CMCI)*	NUMBER OF BONES ACCORDING TO DEGREE OF PRESERVATION
Excellent (4.0–5)	103
Very good (3.2–3.99)	63
Good (1.8–3.19)	101
Poor (0.8–1.79)	89
Very poor (0.15–0.79)	307

* CI = Cumulative Index for the categorization of the bone preservation; SCI = Skeletal Cumulative Index for the categorization of the preservation of a whole skeleton; ESCI = Excavation Site Cumulative Index for the categorization of the preservation of an entire skeletal assembly; CMCI = Co-mingled Cumulative Index for the categorization of the preservation of co-mingled human remains.

Depending on the calculated degree, it is possible to quantify one´s ability to determine the "actual" frequency of analyzed bone changes. Due to poor preservation of skeletal remains, it was not possible to observe changes in bones, and therefore the frequency of an observed attribute in a sample could be artificially larger or smaller than the real frequency. It is important that anthropologists have a unique method of determining the degree of preservation of human skeletal remains. This approach could enable researchers to compare data much more transparently by having information about the preservation status of skeletal remains.

The minimum number of individuals, sex, and age estimation

The MNI, sex, and age on the Vodnjan sample was estimated by examining the skulls, mandibles, upper and lower limb long bones, pelvises, and sacra. They were reassembled by age (subadults and adults), sex, dimensions, morphological characteristics, and pathological changes.

According to skulls, the MNI is 10, six males, two females and two children (**Table 7**).

Table 7. MNI, sex, and age estimation for skulls

Skull	Estimated sex	Estimated age at death
VD-A074/10	male	30–39
VD-B036/10	male	35–74
VD-B037/10	male	70–89
VD-B038/10	male	30–39
VD-B044/10	male	65–69
VD-C036a/10	male	>50
VD-B033/10	female	20–29
VD-C001/10	female	25–34
VD-C033/10	child	6–11
VD-A065	child	0–1

According to mandibles, the MNI is seven, five males, one female and one child (**Table 8**).

Table 8. MNI, sex, and age estimation for mandibles

Mandible	Estimated sex	Estimated age at death
VD-A013/10	male	35–49
VD-A050/10	male	>50
VD-A054/10	male	>50
VD-C036/10	male	40–54
VD-C051/10	male	65–74
VD-C035a/10	female	25–34
VD-A058/10	child	6–11

According to humeri, the MNI is 12, nine males, two females and one child (**Table 9**).

Table 9. MNI, sex, and age estimation for humeri

Humerus	Estimated sex	Estimated age at death
VD-A031/10 L	male	22–29
VD-A079/10 D	male	25–34
VD-A143/10	male	/
VD-B005/10	male	>45
VD-B011/10 D	male	17–21
VD-B012/10 L and VD-C018/10 D	male	30–44
VD-B041/10 D	male	35–44
VD-C039/10 L	male	25–34
VD-C042/10	male	>45
VD-A070/10 D	female	22–29
VD-C013/10 L and VD-C054/10 D	female	25–34
VD-A010/10 D	child	<15

According to ulnae, the MNI is nine, six males and three females (**Table 10**).

Table 10. MNI, sex, and age estimation for ulnae

Ulna	Estimated sex	Estimated age at death
VD-A003/10 L andVD-A186/10 D	male	> 40
VD-C008/10 L	male	25–34
VD-A071/10 D	male	25–34
VD-C037/10 L	male	25–34
VD-C043/10 L and VD-B014/10 D	male	30–44
VD-A408/10	male	30–44
VD-C045/10 L	female	25–34
VD-A026/10	female	20–24
VD-A258/10	female	30–44

According to radii, the MNI is seven, five males and two females (**Table 11**).

Table 11. MNI, sex, and age estimation for radii

Radius	Estimated sex	Estimated age at death
VD-A002/10 L and VD-A079/10 D	male	>40
VD-C038/10 L	male	25–34
VD-A062/10 L	male	25–34
VD-A071/10 D	male	25–34
VD-A076/10 and VD-A384/10 L	male	30–44
VD-A043/10	female	>35
VD-A049/10 D	female	17–22

According to sacra, the MNI is five, two males, one female, and two children (**Table 12**).

Table 12. MNI, sex, and age estimation for sacra

Sacrum	Estimated sex	Estimated age at death
VD-A075/10	male	>40
VD-C024/10	male	30–39
VD-A085/10	female	25–34
VD-A336/10	child	/
VD-A452/10	child	/

According to pelvises, the MNI is 11, five males, one female, three children and two adults of unknown sex (**Table 13**).

Table 13. MNI, sex, and age estimation for pelvises

Pelvis	Estimated sex	Estimated age at death
VD-B029/10 + VD-B076/10 L	male	35–44
VD-B031/10 D	male	25–34
VD-C005/10	male	>30
VD-C023/10 L and VD-C049/10 D	male	30–39
VD-C050/10 L	male	40–49
VD-B040/10 L	female	<35
VD-A027/10	child	/
VD-A150/10	child	<8
VD-A034/10	child	/
VD-B032/10	unknown	<20
VD-C029/10 L	unknown	20–23

According to femora, the MNI is 16, six males, three females, and seven children (**Table 14**).

Table 14. MNI, sex, and age estimation for femora

Femur	Estimated sex	Estimated age at death
VD-B008/10 D	male	>45
VD-A072/10 L	male	>45
VD-B013/10 D	male	>55
VD-A069/10 L	male	>45
VD-A073/10 D	male	35–44
VD-C022/10 D	male	20–25
VD-B009/10 L	female	30–44
VD-B025/10 L	female	20–29
VD-C003/10	female	/
VD-A004/10 D and VD-A006/10 L	child	1.5–2
VD-A030/10 L	child	5.5–6.5
VD-A066/10 D	child	6–8
VD-A078/10 D	child	6.5–8
VD-A388/10 D	child	0–1
VD-A431/10 D	child	<16
VD-C004/10	child	<15

According to tibiae, the MNI is 11, five males, two females and four children (**Table 15**).

Table 15. MNI, sex, and age estimation for tibiae

Tibia	Estimated sex	Estimated age at death
VD-A063/10	male	25–34
VD-B004/10 L	male	>45
VD-B024/10 D	male	>45
VD-B030/10 L	male	>45
VD-C053/10 L	male	30–44
VD-C002/10 D	female	20–29
VD-B027/10 D	female	>45
VD-A145/10	child	<15
VD-A005/10 L	child	4.5–5.5
VD-A007/10 L	child	3–4
VD-A008/10	child	>8

According to fibulae, the MNI is five, four males and one child (**Table 16**).

Table 16. MNI, sex, and age estimation for fibulae

Fibula	Estimated sex	Estimated age at death
VD-B002/10 D	male	>45
VD-B003/10 L	male	>45
VD-C007/10 D	male	20–29
VD-C040/10 D	male	25–34
VD-C006/10	child	<17

The results of MNI estimation showed that the assembly consisted of nineteen people, nine males, three females and seven children (**Table 17**).

Table 17. MNI in the Vodnjan assembly

SEX	MNI									
	SKULL	MANDIBLE	HUMERUS	ULNA	RADIUS	SACRUM	PELVIS	FEMUR	TIBIA	FIBULA
MALE	6	6	9	6	5	2	5	6	5	4
FEMALE	2	1	2	3	2	1	1	3	2	0
UNKNOWN/ ADULT	0	0	0	0	0	0	2	0	0	0
CHILD	2	2	1	0	0	2	3	7	4	1
TOTAL	10	8	12	9	7	5	11	16	11	5

Individualization of the relics from the Vodnjan sarcophagus

After the anthropological analysis of individual bones and the MNI estimation, it was necessary to perform the individualization, one of the most challenging tasks in forensic anthropology. The experience of identifying the remains of many victims of the Homeland

War gave Croatian scientists and anthropologist the valuable experience in this field of forensic procedures (Andelinović et al., 2005; Brkic et al., 1997; Definis-Gojanović, Ivanovic, Drmic Hofman, Galic, & Andelinovic, 1995; Primorac et al., 1996; Slaus et al., 2009; Slaus et al., 2007; Slaus, Strinović, Petrovecki, & Vyroubal, 2007). The families of victims whose bodies were cast into unmarked graves had only one wish – to find and identify the remains of their loved ones and to give them a dignified burial. In the identification process, two main prerequisites must be fulfilled: specific characteristics of the unknown person should be found and compared with the antemortem data to whom it is presumed the remains belong. When analyzing the body, this process is simpler than when dealing with skeletal remains, especially those from the mass graves, where a series of methods should be applied for reliable identification. The first step is to perform anthropological analysis for primary screening, and afterwards, other identification methods. The important role in this process has the comparison of postmortem and antemortem data. The most reliable identification method is DNA analysis.

However, when dealing with the ancient skeletal material, medical documentation is rarely present, as are living relatives. In best cases, we can find distant relatives whose DNA is recombined through generations, which lowers the reliability of geneaology research. In these cases, the focus is on the anthropological analysis, which can result in the conclusion that the remains do not belong to a particular person. Moreover, by using same methods, we can assume that remains belong to a specific person by comparing the results of the analysis with historical sources. Such was the case with the Vodnjan relics.

The MNI in this sarcophagus was estimated by anthropological methods: there were, at minimum, nineteen people: nine males, three females and seven children. Although all the bones were anthropologically analyzed, only those bones that were preserved more than 50% were considered. After the anthropological analysis was performed, the hagiographies were examined and relevant data extracted to distinguish historical facts from legends. The most relevant data were those that could be confirmed by the evidence present on bones. The lifestyle, diseases, and habitual activities can to a greater or lesser degree change the bones. Also, death, especially if violent, can leave evidence of the mechanism and cause of death. All these data can bring us closer to the answer to whether the remains could belong to a particular individual or not.

St. Maura, martyr

On the found list of saints, three women were mentioned: St. Lydia, St. Maura the martyr, and St. Crispina. The anthropological analysis of the skulls, ulnae, and femora also revealed that minimally three female individuals were located among the relics in the sarcophagus. Some of the bones belong to a younger woman, whose age at death was estimated to 20 to 29 years, while others belong to somewhat older females. The analysis of the hagiographies revealed that it is possible that the youngest woman is St. Maura. According to her hagiography, St. Maura was a nanny of St. Fusca. One of the most important information is that St. Maura was killed as a young woman – according to certain hagiographies, when she was around 23 years old (Basil, 2016; Benedictine Monks of St. Augustine's Abbey, 1921; Čulina, Lesac, & Škrobonja, 2014; Dugac, 1998/1999; *The Roman*

Martyrology, 1918). As a small number of remains belonged to females, it was relatively easy to exclude those belonging to a young female. Nevertheless, the hagiography does not contain enough data relevant for a definitive individualization.

The bones that could be attributed to the same person were a femur, which could be articulated or associated to pelvic bones, tibia, and tali based on re-articulation and morphological characteristics (**Figure 12**). All the bones (VD-B025/10, VD-C002/10, VD-C067/10, VD-C076/10 and VD-B040/10) belong to the young woman who was during life subjected to moderate physical activity and adequate food intake. Signs of childbirth or violent death were not found. As St. Maura was a nanny in a noble family, it could be expected that she had had satisfying life conditions. The lack of childbirth marks on pelvis corresponds to the hagiography of St. Maura (Basil, 2016; Benedictine Monks of St. Augustine's Abbey, 1921; Čulina et al., 2014; Dugac, 1998/1999; *Martyrologium Romanum*, 2004; *The Roman Martyrology*, 1918).

Figure 12. a) Pelvic bone, VD-B040/10; b) Femur, VD-B025/10; c) Tibia and tali, VD-C002/10, VD-C067/10, and VD-C076/10.

Besides these bones, two fragments of ulna and radius (VD-A026/10 and VD-A049/10) also belonging to the younger woman were found (**Figure 13**). They show similar morphological characteristics as the above-mentioned bones of lower extremities. However, we cannot conclude that these upper and lower limb bones belong to the same person based only on their morphological characteristics, but the possibility cannot be excluded. If the DNA analysis was used, we could test if these belonged to the same person.

Figure 13. a) Part of ulna, VD-A026/10; b) Part of radius, VD-A049/10.

A humerus (VD-A070/10) also belongs to a female whose age at death is estimated at 20– 29 years (**Figure 14**).

Figure 14. Humerus, VD-A070/10.

In the compartment VD-B, one skull belonging to young female was found (**Figure 15**). The skull was gracile, with mildly pronounced muscular attachments. No skeletal markers of subadult stress or pathological and traumatic changes were found. It is possible that it also belongs to St. Maura.

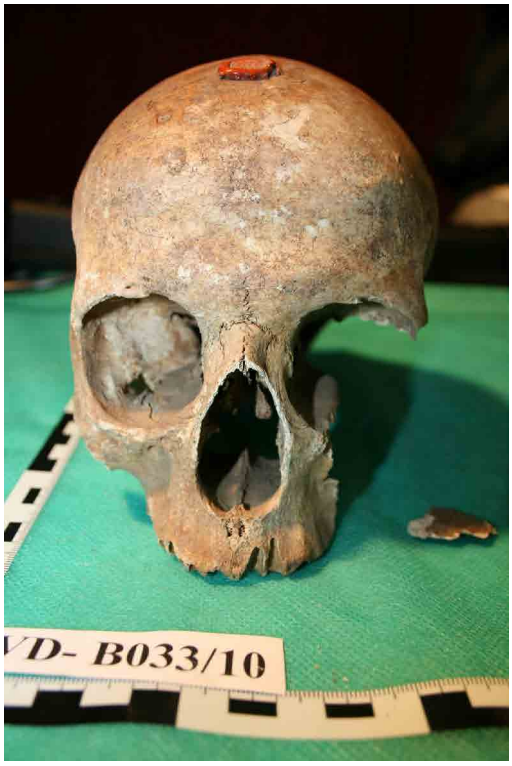

Figure 15. Skull of a female, estimated to be 20–29 years old at the time of death, VD-B033/10.

Based on the anthropological analysis, we can assume that all these bones belonged to a female in her twenties, and based on morphological characteristics, they probably belonged to the same woman. The results of the anthropological analysis neither proved nor disproved the possibility that these remains belonged to the named saint. To expand on this, if these remains belong to the named saint, it would be recommendable to perform C14 analysis (radiocarbon dating) that could confirm or disprove the assumption that these bones are from the 3rd century AD.

St. Lydia and St. Crispina

From all the bones from sarcophagus, eleven belong to females and are well-preserved. According to the results of the anthropological analysis, the estimated age at the time of death for six bones is 25–34 years, and for four of them, it is estimated at more than 35 years. The estimated age at the time of death could not be given for one bone due to a lack of any indicative factors. After separation, some of them were rearticulated; a skull with mandible (VD-C001/10 and VD-C035a/10) belonging to a person whose age was estimated to 25–34 years, and humeri with ulna (VD-C013/10, VD-C 054/10 and VD-C045/10) of to a person whose age at death was estimated at 25–34 years (**Figure 16**). An inscription on the mandible states that the remains belong to an unknown saint: "*Rel. Mascilae cujus Nom. Sanct. Ejus ignorat.prius exist in Ec D Ane Ab olim Can Reg SS Salv venet*". Another bone, sacrum (VD-A085/10) belongs to a female younger than 35 years (**Figure 17**). We could not

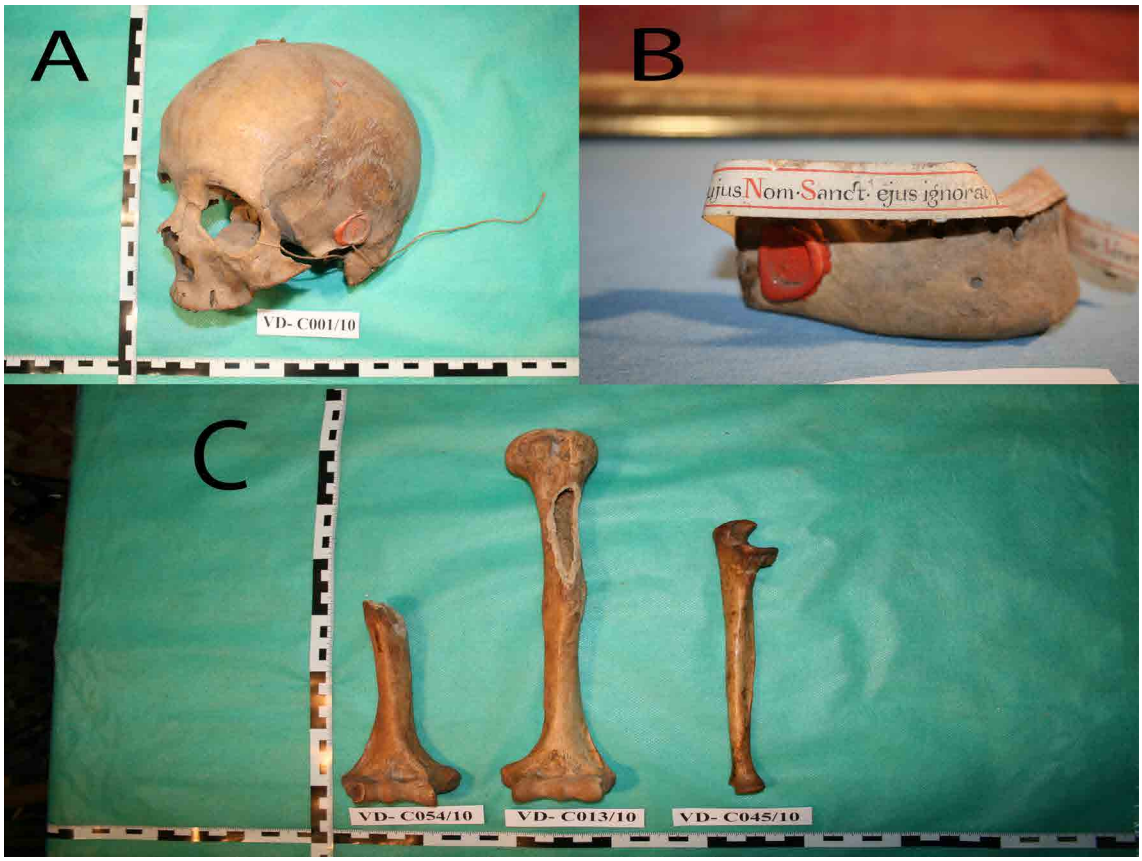

Figure 16. a) Female skull, VD-C001/10; b) Female mandible with inscription, VD-C035a/10; c) Humeri and ulna belonging to a female, VD-C013/10, VD-C045/10 and VD-C054/10.

Figure 17. Female sacrum, VD-A085/10.

exclude that these bones all belong to the same woman. The confirmation that they do or do not belong to the same person could be given after the DNA analysis.

The remaining bones belong to a female older than 35 years: ulna (VD-A258/10), radius (VD-A043/10), femur (VD-B009/10) and tibia (VD-B027/10) (**Figure 18**). Only a DNA analysis can prove that they all belong to a same person, while the anthropological analysis cannot exclude that possibility.

The right femur (VD-C003/10), although damaged and fragmented, is very interesting as it has a seal, a golden fabric, and a partial inscription. Unfortunately, the inscription is not entirely preserved, but we can assume that on it is written „*s...idiae Martyris*“ (**Figure 19**, VD-C003/10). From forensic and anthropological standpoint, we can estimate that it belongs to a female, and we cannot exclude that it belongs to St. Lydia. There are two saints under this name; the first is Saint Lydia, a 2nd Century Saint who was allegedly martyred in Illyria during the reign of Emperor Hadrian (Basil, 2016; *The Roman Martyrology*, 1918). Some versions of her hagiography say that Hadrian threw her along with her husband and other Christians, into hot oil (Benedictine Monks of St. Augustine's Abbey, 1921). The second Saint known as Lydia was Lydia Purpuraria, who lived in the 1st Century in the city of Thyatira, in Asia Minor (Turkey). She was famously the first female Saint Paul converted to Christianity in Europe (Basil, 2016; Benedictine Monks of St. Augustine's Abbey, 1921; *Martyrologium Romanum*, 2004).

Their hagiographies give us no information about their age at the time of their deaths. Even information such as the method of death (Lydia was allegedly thrown into hot oil (Benedictine Monks of St. Augustine's Abbey, 1921)) is not useful due to the degree of preservation of the bones. Other relevant information about the age at death, pathological

Figure 18. a) Female ulna, VD-A258/10; b) Female radius, VD-A043/10; c) Female femur, VD-B009/10; d) Female tibia, VD-B027/10.

Figure 19. The female femur with inscription, VD-C003/10.

changes, and cause of death cannot be established due to bone fragmentation, and additionally because the bone is covered with fabric and paper. Further analysis should include C14 to show if the remains belong to the person from the 1st century.

It is not possible to conclude which bones belong to St. Crispina of Thagara because her hagiography does not provide anthropologically relevant data, besides that she was decapitated during the reing of emperor Diocletian (beginning of 4th Century) (Basil, 2016; Benedictine Monks of St. Augustine's Abbey, 1921; Farmer, 2004; *Martyrologium Romanum*, 2004; Schenk, 2017; *Thurston & Attwater's Lives of the Saints*, 1990). Decapitation leaves clear cutting marks on cervical vertebrae, but vertebrae with these signs were not found in the assemblage. Thus, we cannot answer if the bones belong to this saint. The C14 analysis could answer if the bones are from the 4th century, which would give us additional information.

In conclusion, besides the bones of St. Maura (whose age at death is known), two other females are buried in the sarcophagus, one whose age at death is estimated at 25–34 years and another estimated at more than 35 years. As the hagiographies of St. Crispina and St. Lydia do not provide data about their age at death, we cannot determine to which saint they belong to, except for the femur fragment with inscription.

St. Clement

On the posterior side pelvic bone fragment (VD-C0005/10), two red seals can be found, connected with a paper inscription on which *"S.CLEMENTIS MART."* is written (**Figure 20**). Beneath the acetabulum edge, a third seal was found. Forensic and anthropological analysis revealed that it belongs to an adult, and based on osteodegenerative changes, to an adult older than 30 years. The morphological features and dimensions showed that it probably belongs to a male.

The saint known as "Clement the Martyr" is most likely pope Clement I., who lived in the 1st Century and was the third successor of St. Peter. Little is known about him; however, according to legend, his relics were deposited by St. Cyril and St. Methodius in Rome (Basil, 2016; Benedictine Monks of St. Augustine's Abbey, 1921; Farmer, 2004; *Martyrologium Romanum*, 2004; *Thurston & Attwater's Lives of the Saints*, 1990). We know of two more eponymous Saints; one martyred besides St. Apellius and St. Lucius (1st Century) and another besides St. Celsus (unknown date, of Roman origin) (Benedictine Monks of St. Augustine's Abbey, 1921). Of those, very little is known, and no relevant information can be provided, so they can be excluded. We could not find any anthropological evidence that these bones do not belong to St. Clement the Martyr, St. Peter's successor. The C14 analysis will bring us closer to the answer if this bone belongs to a person from the 1st century AD.

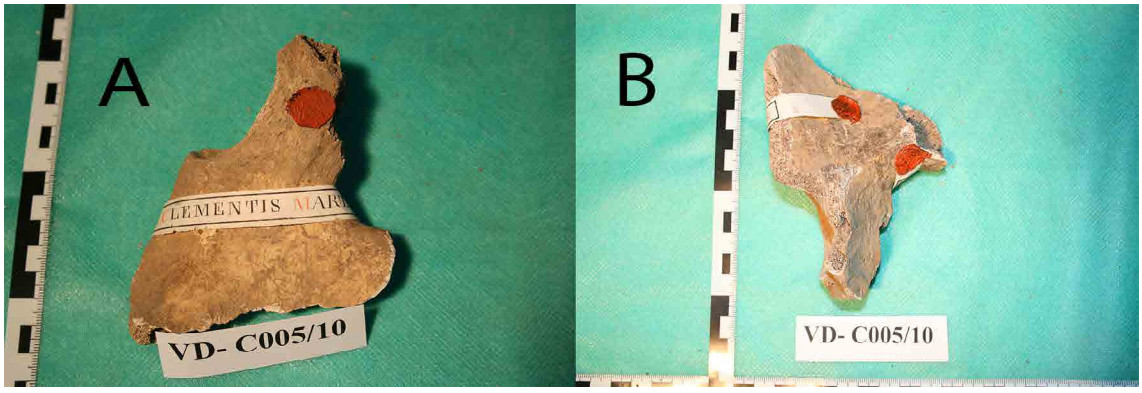

Figure 20. a) Posterior side of the pelvic bone, VD-C005/10; b) Anterior side of the pelvic bone, VD-C005/10.

St. Jacob (James) Intercisus, St. Felix and St. Fortunato

On rib fragment, VD-C009/10, an inscription was found: *"An(no) D(omin)i 1809. Extracta fuit Reliq(uia) ex Urna in quo invenientur Corp(ora) SS(anctorum) M(artiru)m Jacobi Intercisi, Felicis, et Fortunati existential(es) in Civit(at)e Medoaci (?) Mens(is) 9 Oct(obris)"* (**Figure 21**). Two red seals, one paper inscription, and two ropes (red and golden) were found. On the inscription, this rib, as well as other bones which were previously attached to it, were mentioned to belong to these three saints. The anthropological analysis could not estimate

to which of these saints the rib belonged to, but we could conclude that it belongs to a male and that there are no visible pathological and traumatic changes. Also, we did not find any signs of postmortem interventions or probable cause of death. The C14 analysis would bring us closer to the answer if this bone belongs to a person from the 4th century AD. To match this bone with other from the sarcophagus, DNA analysis should be performed.

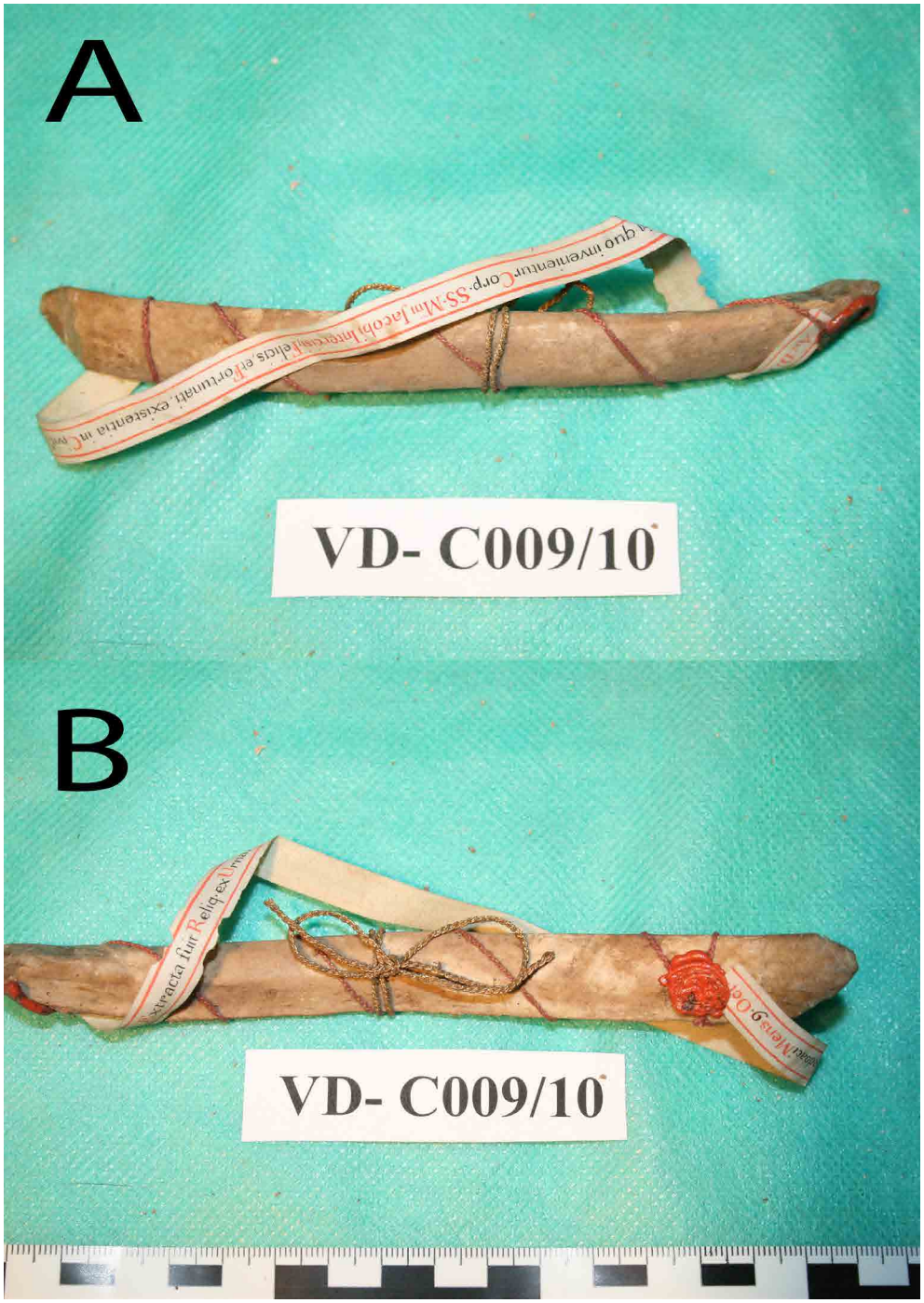

Figure 21. a) Rib, anterior view, VD-C009/10; b) Rib, posterior view, VD-C009/10.

There are many saints bearing the name "Felix". Two of them – Felix of Thibiuca and Felix, the Roman martyr mentioned besides St. Adactus – suffered during the time of Emperor Diocletian, the former being beheaded (Farmer, 2004). One Saint Felix was allegedly the brother of Saint Fortunatus, both of whom were martyred during Diocletian's reign in the late 3rd Century (Benedictine Monks of St. Augustine's Abbey, 1921; *Martyrologium Romanum*, 2004; *The Roman Martyrology*, 1918). As the two names occur together, these saints are the ones to most likely be taken into consideration. Eponymous saints are also mentioned in a group of Saints martyred in North Africa (5th/6th Century) along with Saint Servulus (Benedictine Monks of St. Augustine's Abbey, 1921), who can also be found in the sarcophagus. Certain hagiographies place a Saint Felix in Istria (*The Roman Martyrology*, 1918), while the Bollandists (a famous group critically studying hagiographies) claim that this was an error that should be read as Syria (Benedictine Monks of St. Augustine's Abbey, 1921). Jacob (anglicized in some sources as James) Intercisus (Persia, 5th Century), whose name means "cut to pieces", or "mutilated", was sentenced to death by being cut to pieces, only to be finally decapitated (Benedictine Monks of St. Augustine's Abbey, 1921; *Martyrologium Romanum*, 2004). Nevertheless, these data, along with the anthropological analysis of the bones, cannot lead us to any conclusions about the individuation.

St. Florentius

A list found in the sarcophagus contains the name *"S. Florencii"*. Numerous saints exist under this name (Benedictine Monks of St. Augustine's Abbey, 1921; *Martyrologium Romanum*, 2004; *The Roman Martyrology*, 1918) and it is hard to assume which one it is. It is not clear if this is Saint Florentius or Saint Florian. It could be Florentius, the member of the famous Theban legion (4th Century), or Florentius, the Saint stoned to death under Emperor Diocletian (4th Century); however, their hagiographies provide no usable anthropological data for this analysis (Benedictine Monks of St. Augustine's Abbey, 1921; *Martyrologium Romanum*, 2004; *The Roman Martyrology*, 1918). It could also be Florian, who is usually depicted as a young, smooth-faced, elegantly dressed nobleman from the Middle Ages, as previously assumed by Jelenić (2000). We have indeed found bones belonging to a young male whose age at death was estimated at 20–29 years (**Figure 22**). Two bones were thought to belong to the same person: a fibula (VD-C007/10) and a femur (VD-C022/10). The anthropological analysis could not exclude the possibility that they belong to the same person, and we could not precisely define to which saint the author of the list was referring to, nor could we determine this based on their hagiographies.

Also, two humeri were found; one of them (**Figure 23**, VD-B011/10) belongs to a person whose age at death was estimated at 17–21 years. The second humerus (**Figure 24**, VD-A031/10) belongs to a person with achondroplasia whose age at death was estimated at 20–29 years, so it cannot belong to St. Florentius. Another bone belongs to younger man, but likewise cannot be attributed to St. Florentius. Thus, these bones belong to three young males, and according to biographies of the saints from the list, there are also three young saints in the assembly.

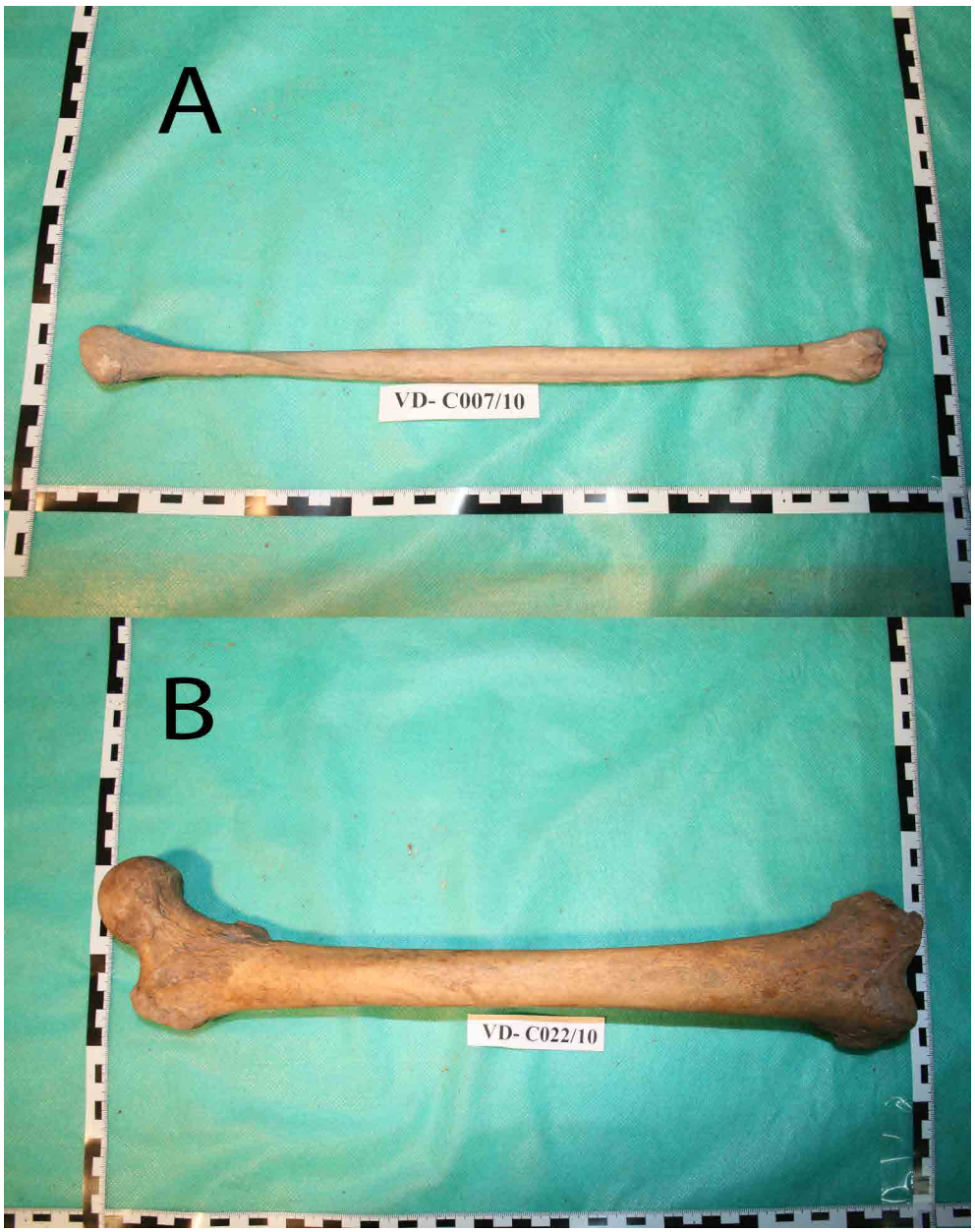

Figure 22. a) Fibula of a young man, VD-C007/10; b) Femur of a young man, VD-C022/10.

The minimum number of males younger than 34 years in this assembly is four. The following bones were estimated at the 25–34 years of age: fibula (VD-C040/10), tibia (VD-A063/10), pelvic bone (VD-B031/10), three ulnae (VD-C008/10, VD-A071/10, and VD-C037/10), two radii (VD-C038/10 and VD-A062/10), and two humeri (VD-A079/10 and VD-C039/10). One ulna (VD-C037/10) was rearticulated with radius (VD-C038/10) (**Figure 25**).

There is a possibility that some of the listed bones also belong to St. Florentius, as the finding of osteoarthritic changes can be associated with age, but also with physical activity. The hagiographies of many of the saints found on the list in the sarcophagus do not provide data on their age of death. Thus, we cannot exclude the possibility that some of the bones do belong to those saints. To affiliate bones to each other and particular saints with higher certainty, it is necessary to perform the DNA and C14 analysis.

Figure 23. Humerus of a male, estimated to be 17–21 years of age at the time of death, VD-B011/10.

Figure 24. Humerus of a person with achondroplasia, VD-A031/10.

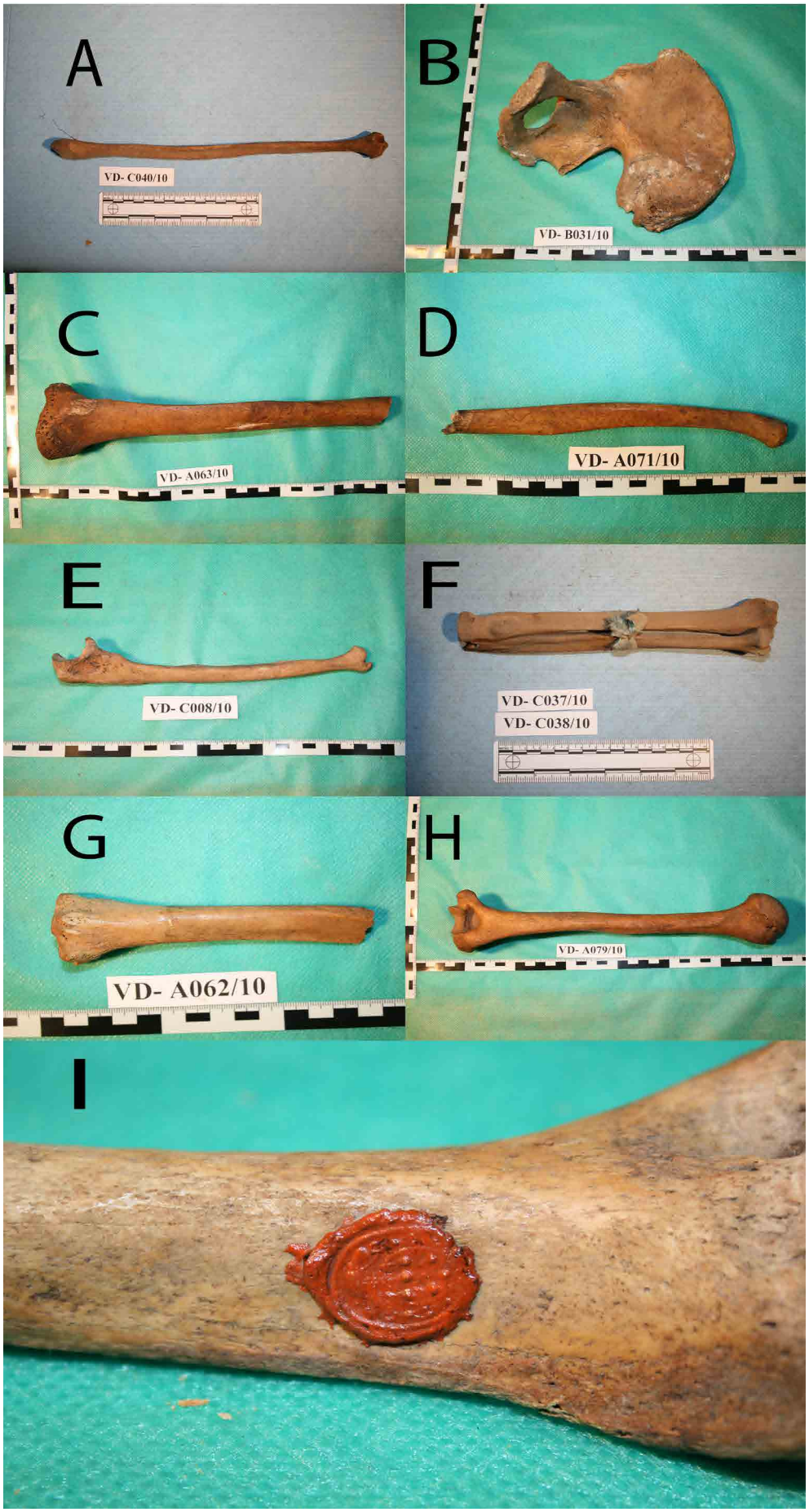

Figure 25. Bones belonging to individuals younger than 34 years (MNI=4): a) Fibula, VD-C040/10; b) Pelvic bone, VD-B031/10; c) Tibia, VD-A063/10; d) Ulna, VD-A071/10; e) Ulna, VD-C008/10; f) Radius and ulna, VD-C037/10 and VD-C038/10; g) Part of tibia, VD-A062/10; h) Humerus, VD-A079/10; i) Humerus with seal, VD-C039/10.

Unknown saint with achondroplasia

During the anthropological analysis, a humerus (VD-A031/10) was found (see **Figure 24** above). From bone length, the stature was estimated to 142.06±4.05 cm. Morphological characteristics suggest that it belongs to a male whose age at the time of death is estimated to be 20–29 years. The bone morphology and characteristics indicate that the bone belonged to a person with achondroplasia (a disproportionate dwarf). Bones show marks of mild osteoarthritic changes and inflammation of periosteum. Other bones that could belong to this saint were not found in the skeletal inventory.

Pope (St.) Alexander

The only saint whose age at death is known (he was middle-aged) is Pope (St.) Alexander. While the authenticity of his martyrdom is questioned (he is thought to have been confused with an eponymous saint), it is assumed he was pope during the beginning of the 2nd Century – more precisely, during the reign of Emperor Hadrian (Basil, 2016; Benedictine Monks of St. Augustine's Abbey, 1921; *Martyrologium Romanum*, 2004; *Thurston & Attwater's Lives of the Saints*, 1990). According to anthropological analyses, the following bones belong to at least two middle-aged males (**Figures 26–30**): a tibia (VD-C053/10), femur (VD-A073/10), pelvic bone of one individual (VD-B029/10 and VD-B076/10), pelvic bones and sacrum that belong to the other individual (VD-C023/10, VD-C049/10 and VD-C024/10), paired left and right ulnae (VD-C043/10 and VD-B014/10) and one that belongs to other person (VD-A408/10), radii (VD-A076/10and VD-A384/10), three humeri, two belong to one person (VD-B012/10 and VD-C018/10) and one to the other person (VD-B041/10) and two skulls (VD-A074/10 and VD-B038/10). Bones VD-B012/10, VD-C018/10, VD-C043/10 and VD-B014/10 probably belong to the same person.

Figure 26. Bones belonging to middle-aged men, could not be attributed to one person: a) Part of tibia of a middle-aged man, VD-C053/10; b) Femur of a middle-aged man, VD-A073/10; c) Pelvic girdle of a middle-aged man, VD-C049/10, VD-C024/10 and VD-C023/10.

Figure 27. a) Pelvic bone of a middle-aged man, VD-B029/10; b) Pelvis fragment of a middle-aged man, VD-B076/10; c) Part of ulna of a middle-aged man, VD-A408/10.

Figure 28. a) Humerus of a middle-aged man, VD-B041/10; b) Skull of a middle-aged man, VD-A074/10; c) Skull of a middle-aged man, VD-B038/10.

Figure 29. Part of radii of a middle-aged man, paired: a) VD-A076/10; b) VD-A384/10.

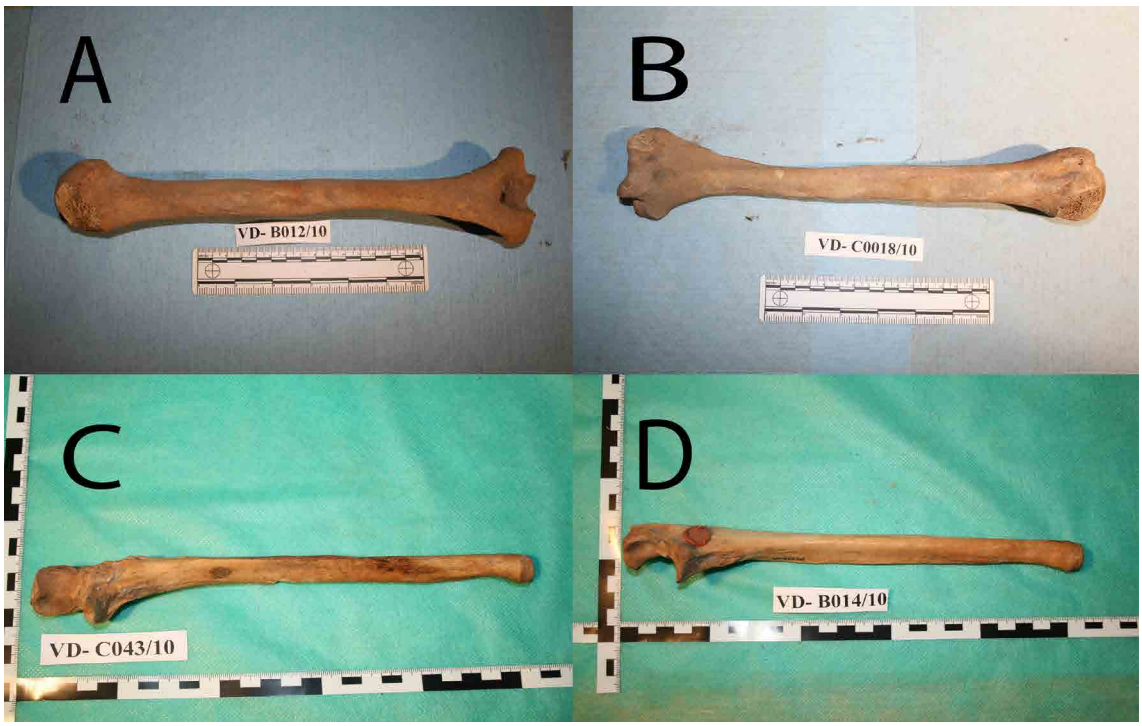

Figure 30. a) humerus of a middle-aged man, VD-B012/10; b) Humerus of a middle-aged man, VD-C018/10; c, d) Ulnae of a middle-aged man, paired: c) VD-C043/10: d) VD-B014/10.

In conclusion, the minimum number of middle-aged men buried in the sarcophagus is two. The third group of bones belongs to individuals older than 40 years; the MNI of individuals of that age according to mandibles is six (**Figure 31**). According to their biographies, a minimum of ten saints died in older age, but without further accurate historical data, followed by DNA analysis and C14, individualization is not possible. The anthropological analysis did not show any traumatic and pathological changes that could indicate the cause of death, and without further analysis, the cause of death cannot be determined. Also, no signs of antemortem (healed or in the healing process) or perimortem (at the time of death) interventions were present. Some of the specific morphological features were found on bones, but we could not connect them to the hagiographies. Further information about the lives of these saints could be helpful for the additional affiliation of the bones to a specific saint.

Based on the abovementioned findings and on the comparison of anthropological and biographical data we can conclude that the minimum number of males in the assembly is 12, four younger, two middle-aged and six elderlies. Thus, the number of males, from the initial MNI estimation rose from nine to twelve due to detailed anthropological analysis.

St. Maurus, martyr

The information from the hagiographies did not provide the total number of children, but some of the bones could be affiliated with a particular person. On the fibula fragment, VD-C006/10, between two seals with relief, the name of St. Maurus the martyr was mentioned (**Figure 32**). This saint becomes a martyr as an “innocent child” (*Martyrologium Romanum*, 2004). Despite the postmortem damage to the cortex, the anthropological analysis revealed that bone fusion did not start (the epiphysis and diaphysis did not fuse), which means that

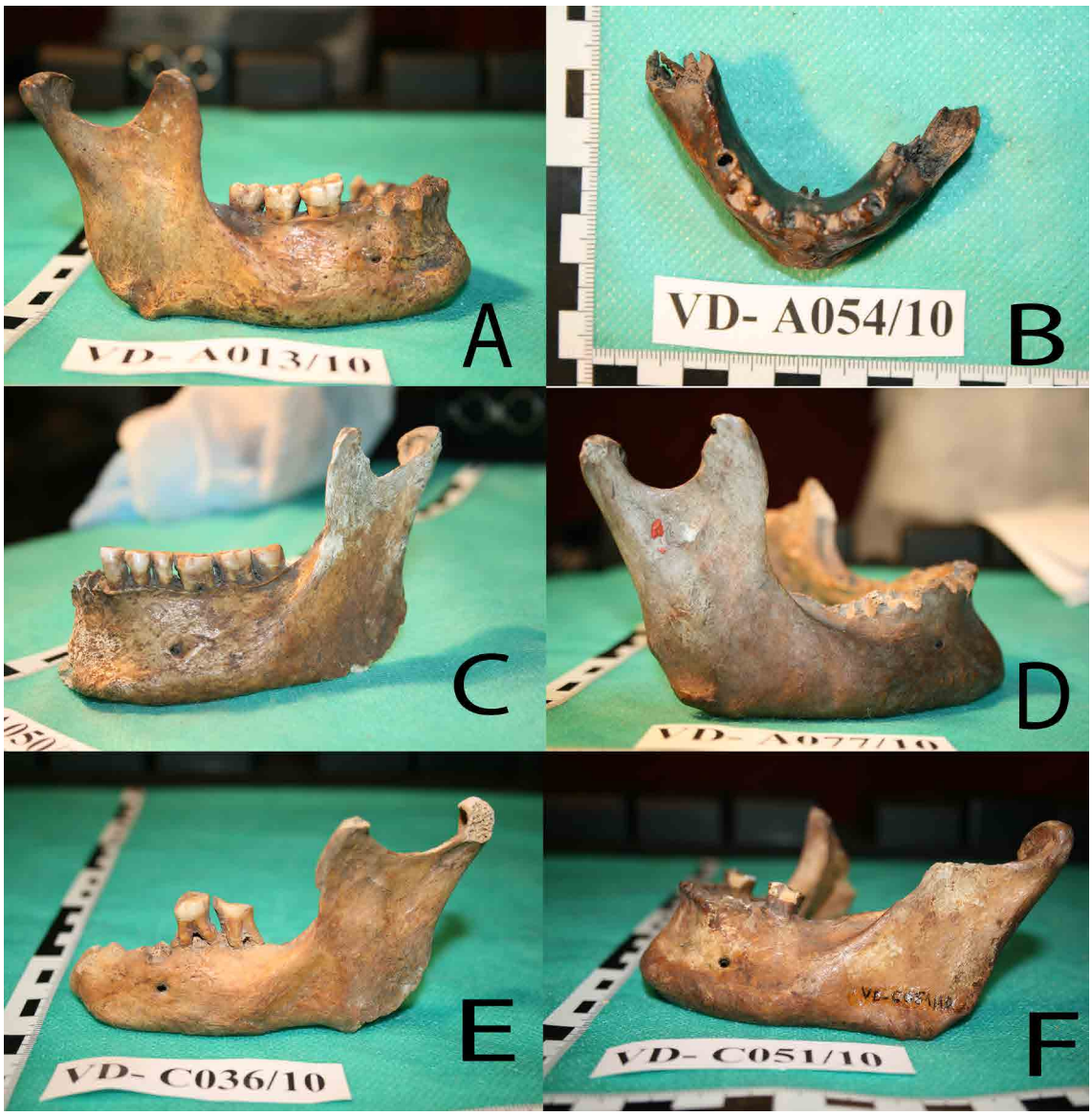

Figure 31. a) Mandible, VD-A013/10; b) Part of mandible, VD-A054/10 c) Part of mandible, VD-A050/10 d) Mandible, VD-A077/10 e) Part of mandible, VD-C036/10 f) Mandible, VD-C051/10.

the bone belongs to a young person under 16 years of age. Although sexual dimorphism is not fully expressed in children, we can assume that this bone belongs to a male as the muscular attachments are well expressed.

There are other bones in the sarcophagus for which we anthropologically determined that they belonged to children. Without the DNA analysis, we cannot confirm with certainty that they belonged to the same person.

Also, a skull and mandible (VD-C033/10 and VD-A058/10) were found (**Figure 33**). Based on the deciduous and permanent teeth eruption, we could conclude that they belonged to a child whose age at death was 6–11 years.

The skeletal assembly contained a humerus (VD-A010/10) and femur (VD-C004/10) which belong to a child younger than 15 years, and we could not conclude if they can be affiliated to St. Mauro or St. Vitus (**Figure 34**).

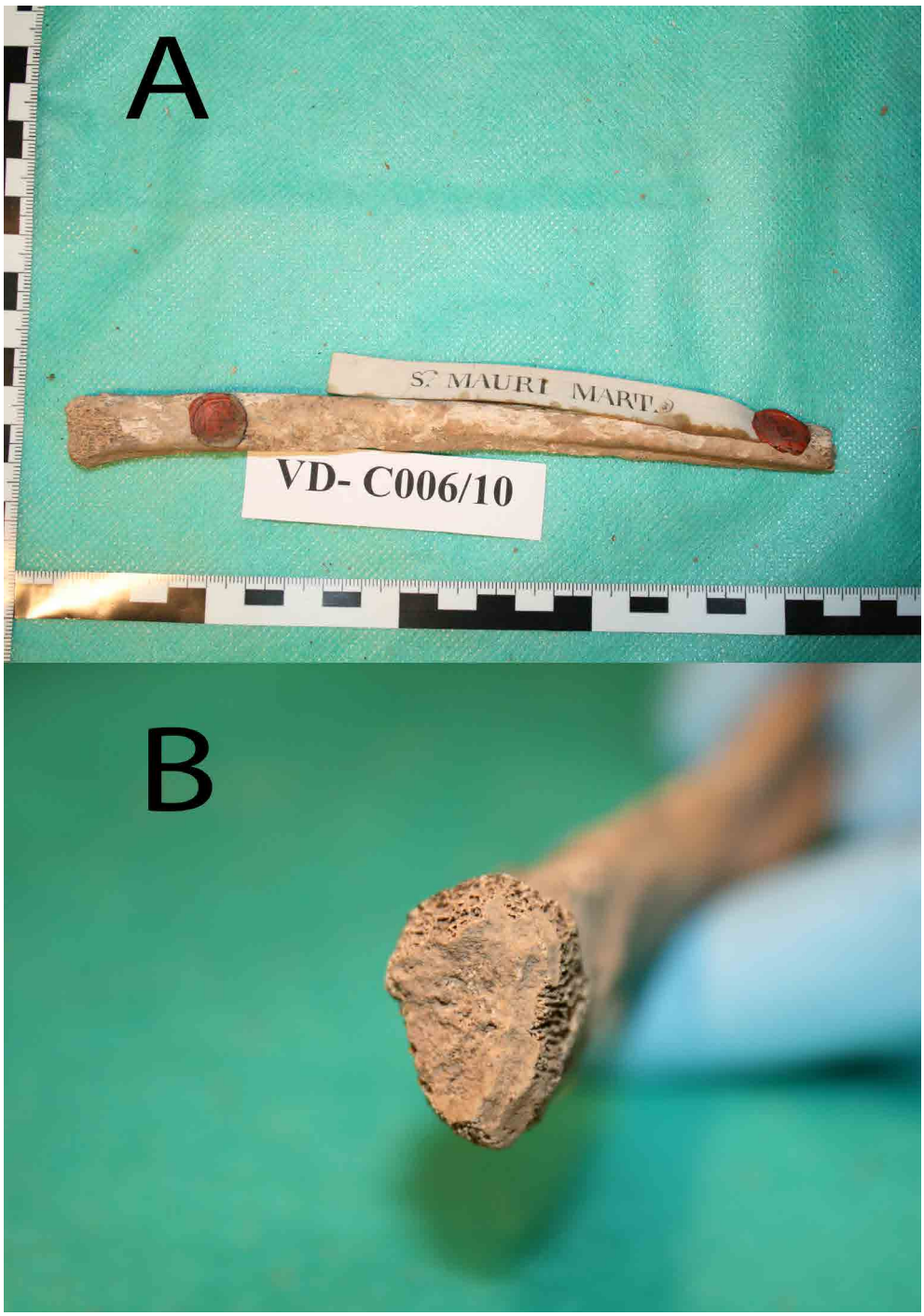

Figure 32. a) Fibula, VD-C006/10; b) Unfused epiphysis and diaphysis on fibula, VD-C006/10.

Innocent children

The inscription about the innocent children was found on the group of bones binded by a ribbon (VD-A004/10, VD-A005/10, VD-A006/10, VD-A007/10, VD-A008/10). The anthropometrics showed they belong to four children. Two femora (VD-A004/10 and VD-A006/10) belonged to a child aged 1.5–2 years. On both bones periostitis in active phase was visible. Three other bones belong to three children of different age: left tibia (VD-A005/10) to a child whose age is estimated at 4.5–5.5 years, left tibia (VD-A007/10) to a child 3–4 years of age, and a fragment of the tibia (VD-A008/10) to a child older than eight years. On a piece of the tibia (VD-A008/10), periostitis in active phase was visible. As the precise age of these

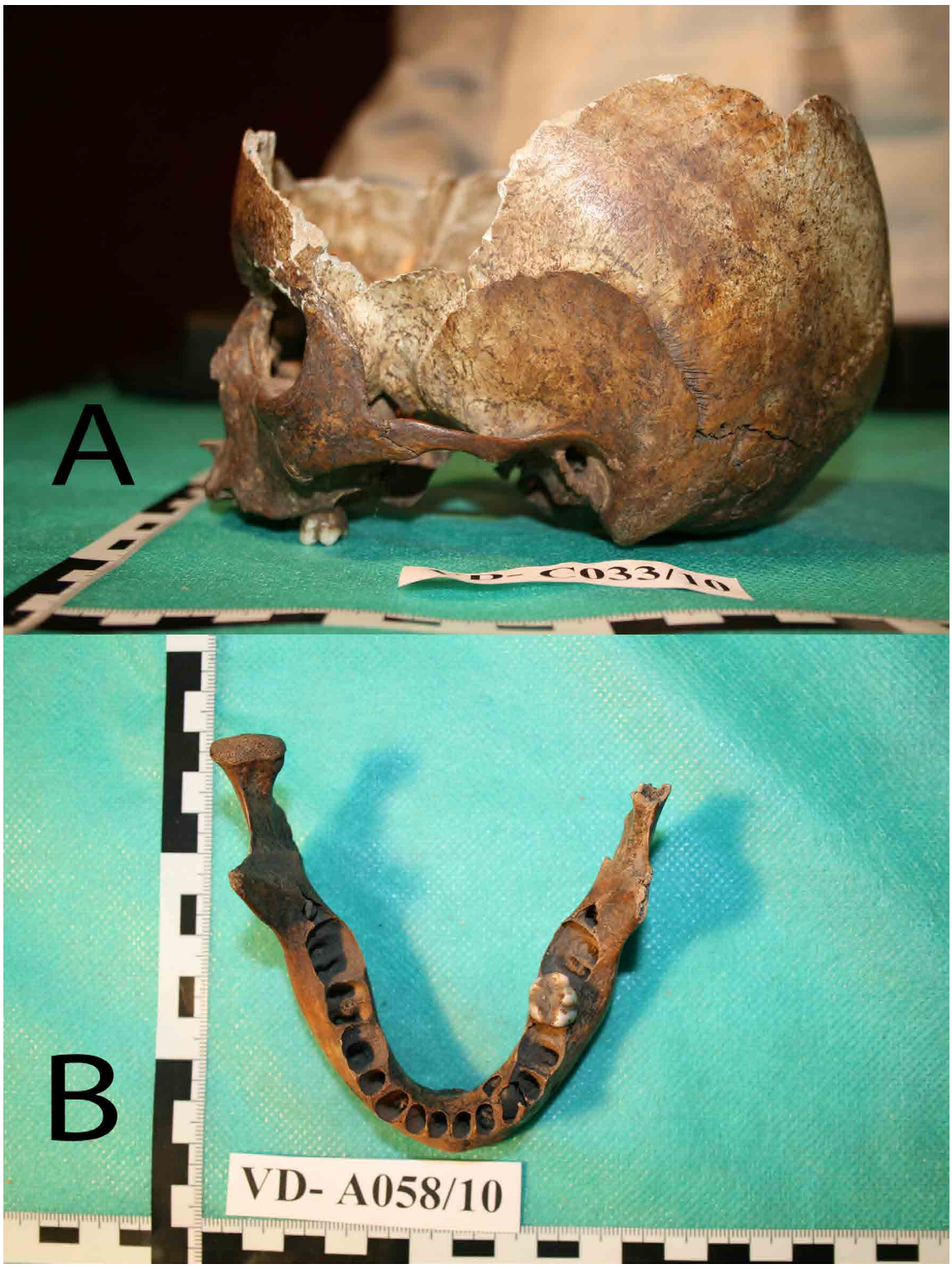

Figure 33. a) Skull of a child estimated to be 6–11 years old at the time of death, VD-C033/10; b) Mandible of a child, estimated to be 6-11 years old at the time of death, VD-A058/10.

Figure 34. a) Child humerus, VD-A010/10; b) Child femur, VD-C004/10.

children is not known, it cannot be excluded that these bones belong to St. Mauro and St. Vitus, whose age at death is estimated to 6–11 years (**Figure 35**).

Also, another two femora were found: VD-A066/10 and VD-A078/10, they belong to two children whose age at death is estimated at 6–8 years, according to length and morphology (**Figure 36**).

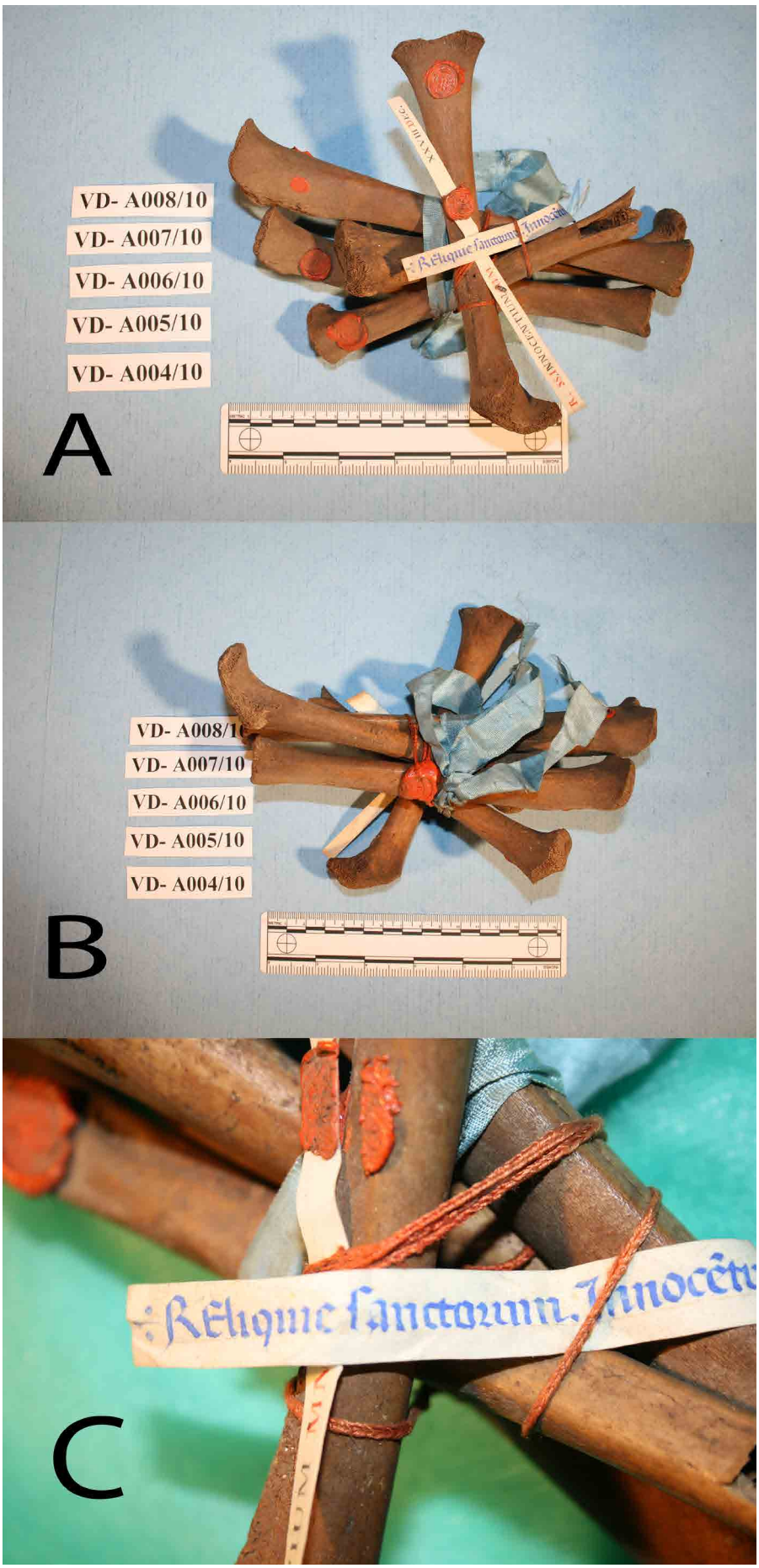

Figure 35. Children's bones a) and b) attached with ribbon, VD-A004/10, VD-A006/10, VD-A005/10, VD-A007/10 and VD-A008/10; c) Detail of ribbon and seal, VD-A004/10, VD-A006/10, VD-A005/10, VD-A007/10 and VD-A008/10.

Figure 36. a) Right child femur, VD-A066/10; b) Left child femur, VD-A078/10.

Right femur, VD-A030/10, belonging to a child aged 5.5–6 years was found (**Figure 37**).

Two bones belonging to a newborn were found: a skull fragment (VD-A065/10) and a femur (VD-A388/10) (**Figure 38**). Periostitis in active phase was visible on the femur, which, if found on all of the bones, might indicate that the child at the time of death had an unhealed infection (these signs were not found on other bones in sarcophagus). The anthropological analysis could not reveal any other data.

Figure 37. Right femur, belonging to a child whose age at the time of death is estimated at 5.5–6 years, VD-A030/10.

Besides the bones of adults described here, we have found vertebrae, ribs, phalanges, pelvic bones, and sacra belonging to children, but these bones could not be affiliated to a particular child. The DNA analysis could answer some of these remaining questions. In conclusion, the remains of seven children are in the sarcophagus (MNI for children = 7): a child younger than one year, a child aged at 1.5–2 years, a child aged 3–4 years, a child aged 4.5–5.5 years, two children aged 6–8 years and one child (St. Mauro or St. Vitus) aged to 6–11 years.

The comparison of the available hagiographical and osteobiographical data that resulted from our analysis is summarized in **Table 18**.

The detailed anthropological analysis concluded that the MNI in sarcophagus is 22 (three female, twelve male, and seven subadults). These data were gathered from additional observations such as age estimation, pathological changes, and by affiliating bones to a particular person.

Discussion

This study partially confirmed the assumptions that the remains from Vodnjan parish church belong to specific saints from the list found *in situ*. In the process of individuation, we found that the MNI in the assembly is 22, and after the comparison of the hagiographies and osteobiographies we found no evidence that these remains could not belong to the named saints. The final identification could not be reached, as only non-destructive methodologies were allowed on this material. So, additional analysis such as DNA analysis as well as C14, stable isotope analysis and other techniques that needed sampling could

Figure 38. a) Skull fragment of a newborn, VD-A065/10; b) Femur of a newborn, VD-A388/10.

not be used. In addition to individuation and comparison of hagiographies and osteological analysis, this study introduced a new methodological approach to the analysis of relics and confirmed the usefulness of the application of forensic anthropology methodology on the ancient remains.

The Vodnjan relic analysis showed that the forensic approach to identifying and individualizing the relics was appropriate; it resulted in a detailed catalouge and the calculation of the MNI, as well as the individualization through the osteobiography-hagiography comparison. Few studies deal with a large assembly of co-mingled remains, so we needed to develop a novel methodology for the estimation of the degree of preservation of human skeletal remains. The methodology described here has been applied for the first time and still needs to be validated by its application in future studies.

Table 18. Comparison of available hagiographical and osteobiographical data

Saint	Available data	Hagiographical data	Osteobiographical data
St. Maura, martyr	Approximate age at death	25	20–29
	Life conditions and occupation	Good life conditions, nanny by profession	No physiological stress markers
	Manner of death	Killed, manner unknown	Not visible
	Other characteristic	Dark skin	Not visible
St. Lydia	Approximate age at death	Unknown	Two sets of bones: 25–34 years and more than 35
	Life conditions and occupation	Good life conditions, merchant by profession	No physiological stress markers
	Manner of death	Tortured, put in hot oil	Not visible
	Other characteristics	Unknown	Not visible
St. Crispina	Approximate age at death	Unprecise, young	Two set of bones: 25–34 years and more than 35
	Life conditions and occupation	Good life conditions, noble family, gave childbirth	No physiological stress markers
	Manner of death	Decapitation	Not visible
	Other characteristics	Curly hair, African?	Not visible
St. Clement	Approximate age at death	Unprecise, older adult¬?	More than 30
	Life conditions and occupation	Unknown, bishop and pope	Not visible
	Manner of death	Thrown into the ocean with an anchor tied around his neck	Not visible
	Other characteristics	Unknown	Not visible
St. Jacob (James) Intercisus	Approximate age at death	Unprecise, middle aged?	Adult
	Life conditions and occupation	Good life conditions, worked in the emperor's court	None
	Manner of death	Tortured, cut to pieces	None
	Other characteristics	Unknown	None
St. Felix and St. Fortunato (brothers)	Approximate age at death	Probably young adults	Adults
	Life conditions and occupation	Merchant, lived a part of their lives in the woods	None
	Manner of death	Tortured, decapitated	None
	Other characteristics	None	None
St. Florentius	Approximate age at death	Unprecise, died young	Younger than 24
	Life conditions and occupation	Good life conditions, nobleman, Theban legion	Mild osteoarthritis
	Manner of death	Unknown	Unknown
	Other characteristics	Unknown	None
Unknown saint with achondroplasia	Approximate age at death	Unknown	20–29
	Life conditions and occupation	Unknown	Osteodegenerative changes, infection
	Manner of death	Unknown	None
	Other characteristics	Unknown	Achondroplasia, height 142.06 ± 4.05 cm
Pope (St.) Alexander	Approximate age at death	Around 40	Older than 40
	Life conditions and occupation	Unknown, but was pope	None
	Manner of death	Burnt on bonfire or drowned	None
	Other characteristics	Unknown	None
St. Maurus, martyr	Approximate age at death	Unprecise, young (subadult)	Younger than 15
	Life conditions and occupation	Unknown	None
	Manner of death	Tortured/unknown	None
	Other characteristics	Unknown	None

Table 18. Continued

Saint	Available data	Hagiographical data	Osteobiographical data
St. Vitus	Approximate age at death	Unprecise, young (subadult)	Younger than 15
	Life conditions and occupation	Unknown	None
	Manner of death	Tortured, burnt on bonfire	None
	Other characteristics	Unknown	None
Innocent children	Approximate age at death	Child	Child

Analyses of such a large amount of human remains allegedly belonging to saints are rare, as previous research was only limited to case studies of a single saint. For example, the multidisciplinary study of the alleged remains of Joan d'Arc (Charlier et al., 2010) did not attempt to answer the question of their legitimacy. One single-saint study examined the alleged remains of Mary Magdalene by performing a hair analysis and a facial reconstruction. Due to the inability to use destructive techniques, this study remained inconclusive in determining the relics' authenticity (Charlier et al., 2019). Similar results came from the analysis of the relics of St. Paul, where non-destructive anthropological analysis performed using computed tomography could not exclude the possibility that the remains belong to the alleged saint (Mihanović et al., 2017). A study on the alleged remains of St. Brigitte and her daughter Katarina using DNA analysis and radiocarbon dating discovered that these two skulls were not maternally related and that they lived in a different period than the named saints (Nilsson et al., 2010).

As can be seen, these studies were almost exclusively performed on a single body or several body parts. Studies analyzing larger number of relics are scarce. One study that analyzed a larger sample of saints' remains (Van Strydonck, Ervynck, Vandenbruaene, & Boudin, 2009) and used both anthropological and C14 analysis did conclude that, for the most part, the anthropological analysis and the C14 analysis did not contradict the identification of the saints. Among those, some other authors have used destructive methods for bone analysis and at least partly confirmed the affiliations to the saints (Taavitsainen, Oinonen, & Possnert, 2015).

As we could not use such destructive methods in our analysis due to the sacral value of the relics, we were limited to using non-destructive anthropological analyses during the individualization process.

Adequacy of the novel methodology for the calculation of the degree of bone preservation

The main aim of this research was the protection and cataloging of the relics stored in a wooden sarcophagus in Vodnjan parish church.

After the cataloging, the anthropological analysis was performed, and although the material was from an archaeological context, the methods of forensic anthropology were used to successfully complete the task. The nature and the origin of the material required, the implementation of the novel approach for the estimation of the level of bone preservation, and the methodology that we have developed performed well on Vodnjan sample. It is yet

to be seen if forensic scientists will benefit from using this approach in forensic cases.

Adequacy of the methodology for the process of individuation and individualization

The second aim was to individuate and individualize the remains using standard osteological/anthropological methods that could lead us to the creation of the osteobiography of every individualized person. If the osteobiography and hagiography coincided, then we could conclude that there is a possibility that the bones belong to a specific saint; that is, we could not exclude that they belong to a specific saint. The main finding of this research is that the anthropological analysis can connect the osteobiographies and the hagiographies from the Vodnjan parish church list of saints.

Strengths and limitations of the methodology

This is a one-of-a-kind analysis of a larger number of co-mingled bodies that allegedly belonged to saints. The fact that we have developed the unique criteria for state of bone preservation, as well as managed to attribute specific bones to the same individual and make a comparison to biographies, gives an insight to possibilities of biological and forensic anthropology in a somewhat different context. The limitation of the anthropological analysis in this context is the lack of exact antemortem data such as in forensic cases, which was due to the scarcity of data in the hagiographies. Because of this, the process of identification could not be performed. Moreover, as these are sacred relics, the Church required only nondestructive procedures. We were limited from conducting other, more detailed analyses which could have enabled us to attribute bones to individuals, including DNA and C14 radiocarbon dating. These methods could have allowed us to make more definitive conclusions on the individuation and individualization of the bones.

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ORCID

Željana Bašić https://orcid.org/0000-0002-8327-1978

Ivana Kružić https://orcid.org/0000-0002-2285-2189

Luka Ursić https://orcid.org/0000-0003-2469-2948

Darko Kero https://orcid.org/0000-0002-8091-6347

Šimun Anđelinović https://orcid.org/0000-0002-9017-5634

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