Izvorni znanstveni članak Acta med-hist Adriat 2013; 11(1);45-54
Original scientific paper UDK: 930.26:235.3(091)

THE USE OF PALEO-IMAGING AND MICROBIOLOGICAL TESTING IN THE ANALYSIS OF ANTIQUE CULTURAL MATERIAL: MULTISLICE COMPUTER TOMOGRAPHY, MAMMOGRAPHY, AND MICROBIAL ANALYSIS OF THE TROGIR CATHEDRAL COPE HOOD DEPICTING ST. MARTIN AND A BEGGAR

KORIŠTENJE PALEORADIOLOŠKE I MIKROBIOLOŠKE ANALIZE ANTIČKOGA KULTURNOG MATERIJALA: MSCT, MAMOGRAFIJA I MIKROBIOLOŠKA ANALIZA KAPULJAČE S LIKOM SV. MARTINA I PROSJAKA (TROGIR, HRVATSKA)

Mislav Čavka[1], Anja Petaros[2], Lovro Kavur[3], Jasenka Škrlin[4], Emilija Mlinarić Missoni[5], Ivor Janković[6], Boris Brkljačić[1]

[1] University Department of Diagnostic and Interventional Radiology, Dubrava University Hospital, Zagreb, Croatia

[2] Department of Forensic Medicine, Rijeka University School of Medicine, Rijeka, Croatia

[3] Department of Diagnostic and Interventional Radiology, Merkur University Hospital, Zagreb, Croatia

[4] University of Zagreb, Dubrava University Hospital, Department of Clinical Microbiology and Hospital Infections, Zagreb, Croatia

[5] Croatian National Institute of Public Health, Reference Centre for Diagnostics of Systemic Mycoses, Zagreb, Croatia

[6] Institute for Anthropological Research, Zagreb, Croatia

Address for correspondence: Anja Petaros, MD; Department of Forensic Medicine and Criminalistics, Rijeka University School of Medicine, Braće Branchetta 20, HR -51000 Rijeka- Croatia; e-mail: anja.petaros@yahoo.com

Summary

Paleoradiology is the study of biological and other materials from archeological settings through the use of various medical imaging techniques. Although it is most often used in the scientific study of ancient human remains, it can also be used to study metals, ceramics, paper, and clothes.

The aim of this study was to test two paleoimaging techniques (MSCT and mammography) in the analysis of an important Croatian liturgical vestment: the hood of a bishop's cope from St. Lawrence's Treasury in Trogir depicting St. Martin and a beggar. To ensure a safe environment for scientists participating in the analysis, a preliminary microbiological analysis was performed, which contributed to the database of microbiological flora found on Croatian archeological remains and relics studied to date.

Due to a great amount of metal filaments, the paleoradiological analysis did not produce satisfactory results. However, a digitally enhanced image clearly showed fine metal embroidery of the hood that was not so easily perceived by naked eye.

This article argues in favor of expanding paleoradiological studies on materials other than human remains and also of publishing unsatisfactory results, as important lessons for future development of techniques and methods to analyze ancient remains and seek answers about human historical and cultural heritage.

Key words: *paleoradiology, liturgical vestment, archaeology, Trogir, Croatia*

Introduction

Churches often serve an important function as protectors and holders of cultural material and treasures from different historical epochs. These possessions are not only important for the devotees (such as relics), but also for scientists and researchers, who can use them as source of information about religious, cultural, and folkloristic aspects of human life. Indeed, in their museums and libraries, churches preserve historically important resources such as gifts from rulers and kings, paintings, books, and important historical documents.

Among a variety of cultural materials stored in churches, the most interesting for a biomedical research are the bodily remains of saints or venerated persons, often referred to as relics. Relic analysis makes an important section of paleopathological and bioarcheological research (1). A number of research articles have addressed the topic of saints' relics, whether to complete biographical information about a saint with osteobiographical details or to confirm the origin of the remains.

Apart from relics, biomedical research can involve other material through imaging or microbiological testing. A special branch of radiology called paleoradiology plays an important part in such research, as it analy

ses ancient organic and inorganic material applying the principles used in regular medical imaging. Paleoradiology is a term that was first used in the *American Journal of Radiology* in 1987 (2). It stands for the use of imaging techniques in the evaluation and visualization of biological and other materials from archaeological sites. The main advantage of paleoradiology is that it allows a detailed reconstruction and analysis of remains, without disrupting the surface and form of the object (3). W. König was the first to use X-rays to study mummies (4) and also the first to use X-rays to analyze paintings in the beginning of the 20th century (5). One of the most common reasons for applying these techniques to masterpieces of art is to establish the stage of preservation prior to restoration or to verify the authenticity of an antique (5). Beside paintings, X-rays and other imaging techniques can also be used to study metals, ceramics, paper, and clothes (6).

The aim of this study was to test the usefulness and capabilities of two paleoradiological imaging techniques on clothes and to microbiologically test the hood of a bishop's cope depicting St. Martin and a beggar. This hood is an important historical masterpiece kept in the treasury of St. Lawrence's Cathedral in Trogir, Croatia. It is often referred to as the hood of Bela IV, the 13th century king of Hungary and Croatia (1235- 1270), who was famed for his determination and efforts to rebuild the nation after the Mongolian invasion and was called the "second founder of the Hungarian state". Legend has it that the hood was presented to the Trogir Cathedral by the nephew of King Bela IV. In the 15th century, the hood became part of a *pluviale* or a cope (7).

Material and methods

The imaging methods of choice was Multislice Computer Tomography (MSCT) and mammography. In order to ensure safety of researchers during imaging, we have also determined the overall number and species of microbial agents on the cope.

The microbiological study was conducted at the Department for Microbiology and Hospital Infections of the University Hospital Dubrava and at the National Research Laboratory for Systemic Mycoses of the Croatian National Institute of Public Health, Zagreb, Croatia. Seven swabs were taken from different sides of the hood in order to determine the presence of pathogenic microorganisms (bacteria and fungi). Samples

from the posterior left, middle, inner and upper part of the hood, as well as three swab samples from the anterior part were inoculated on four nutrient media: blood agar bases supplemented with 5–10% sheep blood, Mac-Conkey agar, brain heart infusion agar with vitamin K and haemin for the enrichment of anaerobes, and Sabouraud agar with chloramphenicol. The media were incubated at different temperatures over different times, as described in our previous study (8). Bacteria were isolated following routine microbiological protocol (9).

Paleoradiological testing was performed at the Department of Diagnostic and Intervention Radiology of the University Hospital Dubrava. The hood of St. Martin's cope was scanned with MSCT (Sensation 16; Siemens AG Medical Solutions, Erlangen, Germany), with collimation layers of 16 x 0.75 mm and "reconstruction increment" (RI) of 0.7 mm, 80 Kv and 240mA. 3D reconstructions were made in the coronal and sagittal plane, using Leonardo (Siemens AG Medical Solutions, Erlangen, Germany) and Aquarius (Terarecon Inc, San Mateo, SAD) workstations. The hood was also scanned with a digital mammograph (Mammomat Nova, Siemens AG Medical Solutions, Erlangen, Germany) – 35 kV i 142mA.

Results

The microorganisms determined by microbiological analysis belong to four genera: *Bacillus, Pithomyces, Sarcina,* and *Rhodotorula*. None are known pathogens. Most of them were the usual saprophytes found in nature (10), and similar species were previously found on other relics kept in Croatia (8,11). As none of the microbes posed a threat for the researchers, medical imaging and visual analyses continued as planned.

The hood clearly shows the figure of St. Martin on a horse (Fig. 1). According to a detailed report by the Croatian Conservation Institute, the figures of St. Martin, beggar, and the horse are embroidered with pearls, silk, metal threads, and semi-precious stones. The background is embroidered with metallic threads, semi-precious stones, and numerous strings of pearls.

MSCT and mammography produced less than satisfactory results. Metal embroidered in the hood absorbed X-beams in great measure, creating artifacts over the rest of the image and making detailed cloth analysis impossible. However, digital enhancement produced an image that clearly showed fine metal embroidery that was not so plain to see by the naked eye (Fig. 2-5).

Figure 1 - The hood of the Trogir Cathedral bishop's cope depicting St. Martin and a beggar

Slika 1. Kapuljača s likom sv. Martina i prosjaka

Discussion

Although Croatian churches keep a number of historically valuable liturgical items made of textile, local art history has largely neglected this part of the national heritage (12). Figurative embroidery of ceremonial vestments emerged in Croatia between the 15th and 16th century under the influence of the Serenissima and the Republic of Dubrovnik. This tradition includes our hood depicting St. Martin and a beggar. Because of its artistic and religious value, such textile materials were historically considered the greatest asset in every sacristy. Churches were competing to procure such luxurious ornaments.

Unfortunately, only a small part of this heritage has been preserved (12). Textile and paper are sensitive materials and require great care to

Figure 2: Hood mammography

Slika 2. Mamografska snimka kapuljače

withstand the ravages of time. Proper restoration and preservation requires careful analysis using as many means as available. This is where non-invasive paleoimaging could prove essential. The use of X-rays can provide important information regarding the manufacture of the material and reveal hidden components in the fabric. A number of review studies have shown the benefits of such techniques (13, 14).

Moreover, a number of preserved liturgical textile artifacts have been manipulated, original materials replaced by modern ones, and new interpretations and compositions introduced by modern embroiderers (12). The use of X- rays could help to determine the amount and stages of such manipulations without producing any further damage to the material.

To our knowledge, our study is the first to have used paleoradiology to analyze an important liturgical textile artifact dating back to the 15th century. Unfortunately, neither hard-beam (MSCT) nor soft-beam (mammography) technique produced useful images owing to a great amount of metal filaments in the cope and hood. However, digital 3D reconstruction provided a detailed view of metal embroidery. This could help art historians to estimate the time of the liturgical item or even identify the crafts-

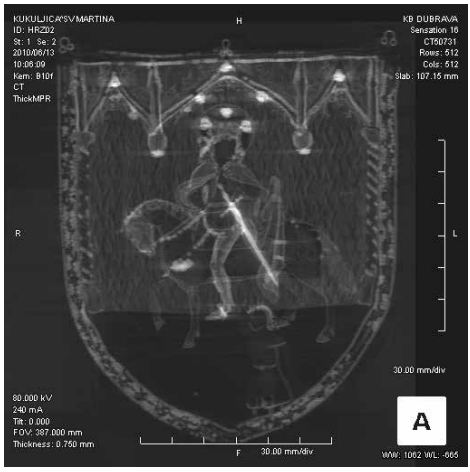

Figure 3 - MIP (maximum intensity projection) reconstruction in the coronal plane – sharp kernel (10 kernels, thickness 107 mm)

Slika 3. MIP (Maximum intensity projection) rekonstrukcija u koronarnoj ravnini – sharp kernel (10 kernela, debljina 107 mm)

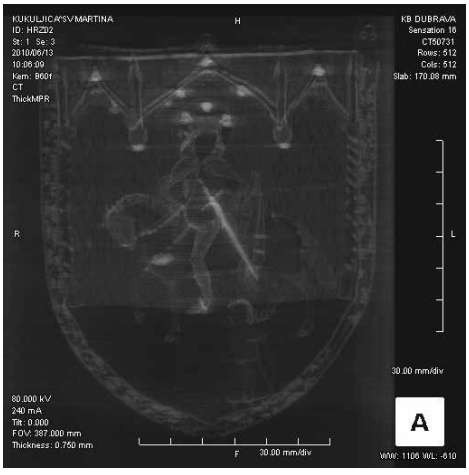

Figure 4 - MIP (maximum intensity projection) reconstruction in the coronal plane – soft kernel (10 kernels, thickness 107 mm)

Slika 4. MIP (Maximum intensity projection) rekonstrukcija u koronarnoj ravnini – soft kernel (60 kernela, debljina 107 mm)

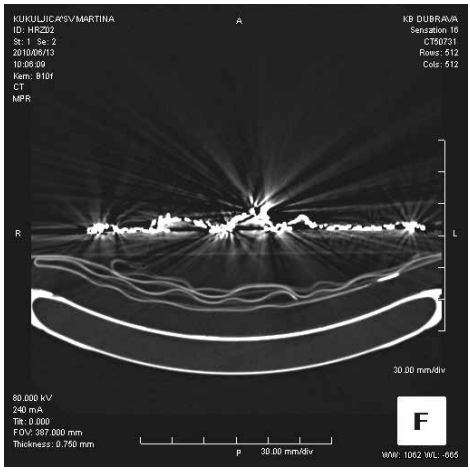

Figure 5 - Axial native layer with metal artifacts

Slika 5. Aksijalni nativni sloj s metalnim artefaktima

man who made it. The most famous workshops of the time were Italian (Venetian and Florentine), German, Polish, and Hungarian (12). These workshops collaborated, and craftsmen often moved from one place to another, teaching and learning the art of textile manufacturing and decoration. The making of our cope hood from Trogir was earlier attributed to workshops in Poland or Hungary, but today art historians are more likely to trace it back to the south German workshops(12, 15). In addition, digitally enhanced imaging can be useful in restoration and preservation of relics (16).

In conclusion, our study has confirmed the potential and the limitations of paleoimaging in the analysis of historical artworks, including textile. It has also emphasized the need for an interdisciplinary approach to such analysis. It showed how a method that is most often linked to medicine and diagnostics can be turned into a valuable tool for art historians, restaurateurs and archeologist in their pursuit for knowledge about the history and cultural heritage of different geographic regions, including the Adriatic and Central Europe.

References

1. Petaros A, Čavka M, Škorobonja A (2011) Relics as paleopathological evidence from the past: tooth relics. Bulletin of the International Association for Paleodontology 5: 28-35.
2. Notman DN, Anderson L, Beattie OB, Amy R (1987) Arctic paleoradiology: portable radiographic examination of two frozen sailors from the Franklin expedition (1845-1848). Am J Roentgenol 149: 347-350.
3. Zhou M, Zhang K (2009) The Application of Two-Dimensional Image Reconstruction for Relics' Preservation and Administration. SSME '09 Proceedings of the 2009 IITA International Conference on Services: 38-42.
4. Koenig W (1896) 14 Photographien von Roentgen-Strahlenaufgenommen im Physikalischen Verein zu Frankfurt a. M. Leipzig: Johann Ambrosius Barth.
5. Everette JA (1998) Radiology of Fakes and Forgery in Art. In: Brogdon BG (ed). Forensic Radiology. USA: CRC Press, 264-276.
6. Lang J, Middleton A. (2005) Radiography of Cultural Material. Oxford: Elsevier.
7. Lucić I (1979) Povijesna svjedočanstva o Trogiru. Split: Čakavski Sabor, 158-159.

8. Čavka M, Glasnović A, Janković I, Rajić Šikanjić P, Perić B, Brkljačić B et al (2010) Microbiological Analysis of a Mummy from the Archeological Museum in Zagreb. Coll Antropol 34: 803–805.

9. Isenberg HD, Garcia LC (2007) Clinical Microbiology Procedures Handbook. Washington: ASM Press.

10. Murray PR, Baron EJ, Jorgensen JH, Landry ML, Pfaller MA (2007) Manual of Clinical Microbiology. Washington: ASM Press.

11. Škrlin J, Kavur L, Missoni Mlinarić E, Janković I, Petaros A, Brkljačić B, Čavka M. Microbiological Analysis of the Mummy of St. Marcian. Coll Antropol 35: 923-924.

12. Demori Staničić Z (2008) Figural Artistic Embroidery of Liturgical Vestments from the Renaissance in Dalmatia and Istria. Rad Inst povij umjet 32:69-86.

13. O'Connor S, Brooks M (2007) X- radiography of Textiles, Dress and Related Objects. Oxford: Butterworth-Heinemann.

14. Brooks MM (2010) New insights into textile: the potential of X radiography as an investigative technique. Scientific analysis of ancient and historic textiles informing preservation display and interpretation postprints first annual conference. Archetype Publications: 168-176.

15. Fisković C (1965) Umjetničke veze Madžarske i Dalmacije u srednjem vijeku i renesansi. Mogućnosti 4-5:498.

16. Mazansky c (1993) CT in the study of Antiquities: Analysis of a basket-hilted Sword relic from a 400-year old Shipwreck, Radiology 186:55A-61A.

Sažetak

Paleoradiologija je znanstvena disciplina koja se u analizi arheološki značajnih bioloških i drugih materijala služi različitim medicinskim slikovnim metodama. Iako se danas najčešće primjenjuje u istraživanju ljudskih ostataka, paleoradiologija se može koristiti i u analizi metala, keramike, papira i odjeće.

Cilj je ovoga rada prikazati rezultate paleoradiološke (MSCT i mamografske) analize značajnoga hrvatskog obrednog crkvenog ruha: kapuljače biskupskog plašta s likom sv. Martina i prosjaka iz Trogirske riznice. Da bi se istraživačima osigurali sigurni uvjeti rada, izvedeno je mikrobiološko testiranje plašta, kojim su se nadopunili dosadašnji podaci o mikrobiološkoj flori hrvatskih arheoloških ostataka i relikvija.

Zbog velikog broja metalnih niti prisutnih u kukuljici, paleoradiološka analiza nije dala zadovoljavajuće rezultate. Ipak, digitalno poboljšanje slike omogućilo je bolje uočavanje samog stila figuralnoga metalnog veza kapuljače, koji je teže uočiti golim okom.

Naposljetku, studija obrazlaže značenje paleoradiologije u proučavanju nehumanoga arheološkog materijala kao i objavljivanje rezultata koji nisu posve zadovoljavajući, a bitni su za daljnji razvoj i poboljšavanje tehnika koje se koriste u istraživanju i arheološkog materijala i ljudske povijesti.

Ključne riječi: *paleoradiologija, liturgijsko obredno ruho, arheologija, Trogir, Hrvatska*

Acknowledgments

We wish to thank Petra Rajić Šikanjić of the Institute for Anthropological Research and Sandra Lucić Vujičić, Željka Mlinarić and Ksenija Škarić of the Croatian Conservation Institute for inspiring the idea to perform such a study and for their organizational skills and unconditional help, as well as anonymous reviewer for his helpful comments. We also would like to express our gratitude to Marija Hrenović of the University Hospital "Dubrava" for microbiological assistance.