Andrea Piccioli
Valentina Gazzaniga
Paola Catalano

Bones

Orthopaedic Pathologies in Roman Imperial Age

Contributors
C. Caldarini
S. Marinozzi
M.S. Spinelli
F. Zavaroni

SOCIETÀ ITALIANA DI ORTOPEDIA E TRAUMATOLOGIA
SIOT

Springer

Bones

Mollia non rigidus caespes tegat ossa nec illi,
terra, gravis fueris: non fuit illa tibi.

Marcus Valerius Martialis, Epigram V, 34

Andrea Piccioli • Valentina Gazzaniga
Paola Catalano

Bones

Orthopaedic Pathologies in Roman Imperial Age

Contributors:
C. Caldarini
S. Marinozzi
M.S. Spinelli
F. Zavaroni

Springer

Andrea Piccioli
Oncologic Center "Palazzo Baleani"
Azienda Policlinico "Umberto I"
Rome
Italy

The Italian Society of Orthopaedics and Traumatology (SIOT)
Rome
Italy

Valentina Gazzaniga
Department of Sciences and
Medico Surgical Biotechnologies
History of Medicine Unit
Sapienza-Università di Roma
Rome
Italy

Paola Catalano
Anthropological Service
Soprintendenza Speciale per il Colosseo
il Museo Nazionale Romano e
l'Area Archeologica di Roma
Rome
Italy

The volume Authors would like to thank Roberta Aronica, English Professor at University "Campus Bio-Medico" of Rome, for the linguistic revision of the book.

ISBN 978-3-319-19484-4   ISBN 978-3-319-19485-1 (eBook)
DOI 10.1007/978-3-319-19485-1

Library of Congress Control Number: 2015951818

Springer Cham Heidelberg New York Dordrecht London

Printed on acid-free paper

Springer International Publishing AG Switzerland is part of Springer Science+Business Media (www.springer.com)

Foreword 1

I am really pleased that this major, somewhat unbelievable scientific volume is issued under my presidency. SIOT's support to this editorial project, which started during the previous administration, now ends under my management.

I have followed the Project since its birth, and on more than one occasion I got carried away by the researcher's typical excitement, stepping in during the study of complicated cases, and helping my friends and co-workers to decipher particularly difficult diagnoses.

Giving a definite diagnosis to bone macroscopic lesions is unbelievably complicated in the field of paleopathology. There are indeed many diseases that need a differential diagnosis with one another, and that may look like macroscopically similar bone lesions: infectious diseases, such as osteomyelitis, metabolic or haematological diseases, consequences of traumas with no consolidation, or degenerative diseases, or finally primary and secondary neoplastic lesions.

The in-depth study of many cases has allowed to identify better and better diagnostic criteria, increasingly minimizing the potential error deriving from the skeleton's state of preservation and post-mortem lesions. In fact, the post-mortem degradation process of the bone tissue over the centuries can produce lesions macroscopically resembling bone pathological lesions; the great professional skills of Dr. Paola Catalano and of her collaborators from the Anthropological Service of "Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma" have been crucial to the success of this work. Their major expertise has led us in what was a great novelty for us. I can only congratulate all the authors on this magnificent work, which has the added value of novelty and great number of examined subjects and is thus an excellent and culturally essential product to increase the currently available knowledge on ortho-traumatological diseases and on the living habits in ancient Rome. Finally, heartfelt thanks to friend and associate Andrea Piccioli, who has once again proven how our Scientific Society, a mirror of the national orthopaedic Community, is culturally and scientifically energetic.

Rodolfo Capanna
President of the Italian Society of
Orthopaedics and Traumatology

Foreword 2

When I was the President of the Italian Society of Orthopaedics and Traumatology and Andrea Piccioli suggested the possibility of conducting a project with the Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma, with the aim of connecting scientifically, from a paleopathological point of view, the two branches of Orthopaedics and Anthropology to meet the common purpose of studying the bone, I was pleasantly surprised, but also uncertain, because it all seemed extremely complicated. His enthusiasm and firm determination, together with the accurate outline of a substantial draft called "Written on bones", persuaded me. The project aimed at assessing the variety and incidence of the different ortho-traumatological morbid pictures in a sample of nearly 2,000 individuals who had lived in Imperial Rome, coming from the several digging expeditions of the suburban burials of the Capital City; it was submitted to the Board of Directors of our Scientific Society, SIOT, and was immediately met with a unanimous enthusiastic recognition. Every orthopaedist's passion in tracking down bone diseases in subjects living so many centuries earlier came alongside the astonished curiosity to observe "prodigious" healings of complicated lesions, such as the post-traumatic ones, without any surgery. Moreover, I found that SIOT had the duty to commit to such a project, given the privileged position of Rome in the world's history, which gave this city the unique chance of having such a huge amount of bone remains to be investigated, and which were therefore homogeneous for historical period and geographical site. I appreciated the clarity of subdivision of the pathologies in four main categories, according to their aetiology: traumatic, degenerative, oncologic, and metabolic/infectious. In the last few years, I have been able to appreciate the authors' scientific accuracy and absolute ability to "enter" a world which is so very different from the one we are confronted with every day. The result is stunningly more striking than our most ambitious expectations. The selection and presentation of cases is done with great accuracy, and the discussion has a very high scientific standard. The collaboration of such high-level professionals in the various fields: ortho-traumatological, anthropological, and medical historical has made this volume strikingly interesting and unique in its category.

Paolo Cherubino
Past-President of the Italian Society of
Orthopaedics and Traumatology

Introduction 1

I strongly wanted to publish this book, but I owe it to the unconditional support of the Italian Society of Orthopaedics and Traumatology (SIOT) and to its Board of Directors, who have shared in the enthusiasm for a scientific project which has later become a long and challenging work.

My long-standing job as an orthopaedic surgeon has allowed me to get to know the hidden dangers involved when the bone is affected by a pathology, be it of traumatic, metabolic, oncological, or degenerative origin. I have also experienced complications and failure, even when great effort and major commitment had been applied. It was this personal history in a job carried out with great dedication that made me look in awe at the bone remains 'offered' to us and to our study by Paola Catalano, head of the Anthropological Service of the 'Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma'. I have seen the amazing healing processes shown on the bones in some cases, and the diseases that had left their signs on them throughout the centuries, as a wonderful heritage only known by anthropologists and palaeopathologists, and I wanted to share it with my fellow orthopaedists and with everyone who was interested in what actually remains of us and of our pathologies after thousands of years. The study of nearly 2,000 subjects has been long and full of difficulties, but the sole idea of the incredible material we were handling, and the desire to show it, has driven us to keep working and get to the end. Rome is clearly a privileged and unique city for this kind of research, a bridge between past and present, where rare examples of remains are so abundant, as to run the risk of being underestimated or studied with superficiality or segmentation. We have made sure to avoid this by involving many different professionals and attempted to give an in-depth picture of what we have discovered, observed and studied.

Some finds were so 'peculiar' that they clearly suggested a good knowledge of the bone healing techniques; we sought the collaboration with medical historians to understand and analyse the evolution of medical and orthopaedic knowledge in Imperial Rome, and Valentina Gazzaniga of the Unit of Medical History, "Sapienza Università Roma" and her staff have been indispensable in this.

I like to think that we have taken a picture of a faraway era, which has shown us the stories of human beings and of their diseases, surprising and moving us. I hope the same pleasure and amazement we felt during the course of our work will reach our readers.

Rome, Italy Andrea Piccioli

Introduction 2

In recent years many excellent books have been written on the history of diseases and medicine in Ancient Rome. All are the result of very high specialized competences; medical historians have direct and qualified sources in A.C. Celsus and C. Galen, both reliable witnesses of the high level of competence of Greek Hippocratic medicine in Rome. Historical studies can also use ancient literature, historiography and archaeology as their secondary sources. On the other hand, ancient Rome provides the palaeopathological approach with a quantity of bone remains much higher than any other ancient Mediterranean societies and materials from events almost unique in the history of the ancient world, such as the dreadful eruption of Vesuvius dating 79 A.C.

Given this availability of numerous and reliable sources, it is surprising that the historical and palaeopathological approaches have often been independent from each other and not crossed paths, with the exception of particular cases i.e. *The Healing Hand*, by G. Majno (The Harvard University Press, 1975) or the more recent *I fuggiaschi di Ercolano* by L. Capasso (Roma, L'Erma di Bretschneider, 2001). It is even more surprising in Imperial Rome, a city rich in biological samples, bones and skeletons offered to the study of anthropologists, medical historians, physicians and palaeopathologists. The invitation to a scientific collaboration coming from Andrea Piccioli, an orthopaedist who is attentive and curious to the social, historical and anthropological dimensions of ancient diseases, and from Paola Catalano, who is a great expert of physical anthropology in Republican and Imperial Rome, appeared to me as a lucky and, in a certain way, long expected chance.

The subsequent almost daily interaction among different disciplines, which studied the same materials simultaneously – but according to deeply different methodological perspectives – produced (at least in my opinion) some interesting achievements. First of all, the documentation of the high degree of orthopaedic competence of the 'medical marketplace' in Imperial Rome: many fractures healed in really difficult conditions, highly functional tools for the reduction of bone dislocations, and optimal degrees of orthopaedic technical skills. In addition, the chance to enrich the Imperial age 'pathocenotic' picture by means of first-hand materials – direct ancient voices, speaking bones. Finally, the possibility to document aspects of social history such as a level of medical assistance, cure and care high enough to allow the survival of individuals with severe injuries, bone diseases and malformations.

Last, but not least, common interests in ancient Roman pathological history gave birth to new friendships: not a little thing, in our hurried world forgetful that what we are now is what we were yesterday.

Rome, Italy Valentina Gazzaniga

Introduction 3

On any day of the year, while exiting the darkness of the metro station in front of the Colosseum, one finds oneself confronted with the breathtaking view of this majestic monument and the surrounding remains of Imperial Rome, dotted with swarming crowds of tourists with their noses up in the air and their cameras at hand. Whenever I have the chance to work at the Roman Forum, I like to try and guess which country those people come from. Whatever their nationality, they all share a tangible fascination that enraptures people from all over the world when visiting Ancient Rome. That same captivating fascination is what I also feel, despite having worked for the Soprintendenza for the past 30 years, when engaged in my particular discipline: physical anthropology. Together with my collaborators, we are involved in the excavation, recovery, conservation and analysis of human skeletal remains unearthed during the numerous interventions of preventive archaeology conducted by the 'Soprintendenza Speciale per il Colosseo', il 'Museo Nazionale Romano' e l' 'Area Archeologica di Roma' (see Sect. 2.1).

But what do these skeletons represent? Considering the elevated number of recovered human remains and the detailed documentation available, they describe significant samples of the population of Imperial Rome. It is the analysis of those samples of Roman population that accounts for the importance of the present volume. Unfortunately, anthropological investigations, and in particular palaeopathological ones, are frequently carried out in a sensationalistic and out of context manner, in pursuit of what is defined in journalism as a 'scoop'. The purpose of this work is, conversely, to contribute to the exemplification of the actual living conditions in the largest city of the Ancient World, and to identify the diseases that affected its inhabitants, trying to determine at least the ones that left distinctive marks on the skeletal remains. A vast amount of material was analysed, involving the expertise of many different professionals. The results were then evaluated from a medical-historical point of view, in an effort to establish some of the social and historical features of an extremely diverse and complex city where, for the great majority of the population, life must not have been easy.

Rome, Italy — Paola Catalano

Acknowledgements

We all have ambitious ideas in life, and to make them come true we need determination but above all valuable people sharing our ideas. This is why first of all we dutifully thank the Italian Society for Orthopaedics and Traumatology (SIOT) and the Board of Directors 2012–2014 who approved the project and supported it with logistic and financial resources, and specifically the President (2012–2014) Paolo Cherubino and the current President (2014–2016), Rodolfo Capanna.

Thanks to the SIOT's representative (2012–2014) Pietro Bartolozzi, who cherishes past scientific mysteries. His encouragement has been essential.

A special thanks goes to the archaeologists involved in this project without whom this work would not have been possible: the Soprintendenti Francesco Prosperetti and Maria Rosaria Barbera and the colleagues: Anna Buccellato, Laura Cianfriglia, Francesco di Gennaro, Roberto Egidi, Paola Filippini, Stefano Musco and Rita Paris. For the anthropological research we would like to thank the collaborators: Giordana Amicucci, Andrea Battistini, Flavio De Angelis, Stefania Di Giannantonio, Romina Mosticone, Walter Pantano, Lisa Pescucci and Flavia Porreca; for x-rays Marco Celentano; for assistance for English scientific terminology Christina Danielli; and for panoramic photographic documentation Mario Letizia.

Thanks to the Rector of Sapienza Università di Roma, Eugenio Gaudio.

Special thanks to the General Manager Domenico Alessio and the Chief Medical Officer Amalia Allocca of the Azienda Policlinico Umberto I°. Thanks to Francesco Vaia and Raffaele Gallocurcio of the Azienda Policlinico Umberto I°.

Eurosanità and the clinic "Villa Stuart" have given a major help in the imaging. Bruno Turchetta has been invaluable as always.

Special thanks to Alberto Corrado Di Martino, a friend and associate from the University "Campus Bio-Medico" of Rome, who has been a precious help in advice and revision.

Thanks to Rossella Nicodemo for assisting in the references. Thanks to Elena Cristofari, Luca Faia, Francesca Calbi and Sally Titcomb.

Finally, thanks to Carla Massi, Paolo Scotto and Alberto Guarnieri, whose advice has been essential as always.

Contents

Part II Clinical Cases

Contributors

Carla Caldarini Collaborator of Anthropological Service, Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma, Rome, Italy

Rodolfo Capanna Department of Orthopaedics and Traumatology CTO Careggi Hospital, Florence, Italy

The Italian Society of Orthopaedics and Traumatology (SIOT), Rome, Italy

Paola Catalano Anthropological Service, Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma, Rome, Italy

Valentina Gazzaniga Department of Sciences and Medico Surgical Biotechnologies, History of Medicine Unit, Sapienza-Università di Roma, Rome, Italy

Silvana Giannini Department of Radiology of "Villa Stuart Sport Clinic", "Foro Italico" University of Rome, Rome, Italy

Silvia Marinozzi Department of Molecular Medicine, History of Medicine Unit, Sapienza-Università di Roma, Rome, Italy

Andrea Piccioli Oncologic Center "Palazzo Baleani" Azienda Policlinico "Umberto I", Rome, Italy

The Italian Society of Orthopaedics and Traumatology (SIOT), Rome, Italy

Maria Silvia Spinelli Department of Orthopaedic and Traumatology, Catholic University Hospital of Rome, Italy

The Italian Society of Orthopaedics and Traumatology (SIOT), Rome, Italy

Federica Zavaroni Collaborator of Anthropological Service, Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma, Rome, Italy

Part I

Materials and Methods

1 The Study of Ancient Bone Remains

Carla Caldarini, Paola Catalano, Valentina Gazzaniga, Silvia Marinozzi, and Federica Zavaroni

1.1 Funerary Archaeology and Field Anthropology

Carla Caldarini, Paola Catalano, and Federica Zavaroni

Bio-archaeological studies and historical documents are a great tool to reconstruct the lifestyle and health conditions of the ancient populations, and to understand the correlation between man and the environment over the course of time. The Anthropological Service has taken part in the environmental protection activity of the Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma. This has contributed to outline the biological history of Roman society, in particular that of the Imperial age. In the last decades, new excavation methods applied to the human skeletal remains have helped to collect valuable information on Roman sepulchres, especially those found in the Suburb, because of the large number of civil buildings built after the urban development. These data, together with those deriving from in-depth laboratory investigation, are helping to understand the complex biological landscape of the ancient Roman population with its bio demographic and social processes.

What did the Suburb look like during the Imperial age? As Rodolfo Lanciani [1] wrote: "In its best days, Rome was practically one with the nearby towns of Veii, *Nomentum*, Tivoli, Palestrina, Tusculum and *Bovillae*. Villas, vineyards, rural estates with country houses shaped both small and large areas creating a wide populated park around Rome".

In recent years, the investigation on a large number of broad excavations held by the Soprintendenza, has been throwing light on wide areas whose countless archaeological contribution had been ignored [2]. The anthropological material, firstly collected during the systematic excavation of the necropolis [3] and then through laboratory investigation [4] is a considerable help to understand how the funeral services were held and how life was in the Urbs and in its surroundings, in an attempt to analyse funeral customs and everyday lifestyle through a chronological and socio-historical perspective which has been overlooked for a long time [5].

Moreover, an inter-disciplinary analysis allows to establish a connection between the everyday life conditions, the diseases, and the specific therapies of the communities that the anthropological finds belonged to. This book is an example of the valuable contribution given by medical historians and pathologists to this aim.

The anthropological analysis of a burial must begin "in the field", at the time when it is found (Fig. 1.1). Taphonomy is the branch of knowledge which studies the processes (chemical, physical and biotic) that the body experiences between the individual's death and the body's discovery, based on the reconstruction of the action and interaction of the different factors which have interfered with it, from the moment of the deposition until its finding.

A. Piccioli et al., *Bones: Orthopaedic Pathologies in Roman Imperial Age*,
DOI 10.1007/978-3-319-19485-1_1

Fig. 1.1 Burial during excavation

The information obtained through the taphonomic study of skeleton, reported case by case on an appropriate database, need a careful examination of the position of every skeletal element and the record of the condition of every joint. This is how the deposition can be defined as primary or secondary. In a primary deposition, the body has been buried, immediately after its death, in its ultimate place, where it decayed; at the time of unearthing, the skeleton must be in its original burial position, accepting for changes of position due to the action of taphonomic agents or secondary handling. Further changes of positions after the burial can be detected, whether designed, as in profanation, or accidental, linked to natural causes, as either the passage of animals or water damage [6]. A secondary deposition refers to a burial performed at two or more different times: the finding of the skeleton, and so the definitive deposition, happens in a different place from the one of the decay. The bones may have moved from their earlier position simply due to gravity, which pulls the bones down during the decomposition of the corpse, because of the absence of the soft tissues and ligaments which normally hold them together.

These movements can therefore be interpreted in order to reconstruct the original position of the body, thus highlighting the funerary practices of deposition: for instance, we will be able to determine the presence of perishable funeral structures (as cushions, coffins or dressings), or whether the deposition occurred in the ground, and so the decomposition took place in a restricted space, or in a sarcophagus, with the decomposition in a hollow space.

During the excavation process, experts should not only collect taphonomic information, but also determine, when possible, the gender and age at death of the subject, detect any pathological alterations and perform some measurements, because the frequent frailty of the finds can cause a serious loss of information, if the findings are recorded after the exhumation. This is the reason why most of the methods which will be briefly described below are usually applied in the field first and then in a laboratory in a more thorough and detailed way [7].

1.1.1 Determination of Sex

The parts of the skeleton showing features with the highest degree of sexual dimorphism are the skull (Fig. 1.2a, b) and the pelvis (Fig. 1.3a, b); in particular, the latter is structured in women to cope with pregnancy and birth giving. Because a subject rarely shows all the typical features of its gender, we have considered a combination of

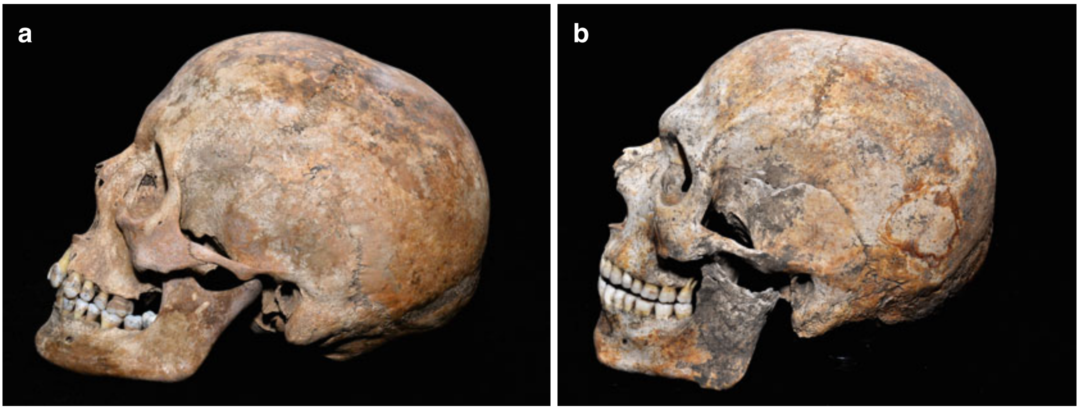


Fig. 1.2 (**a**) Female skull. (**b**) Male skull

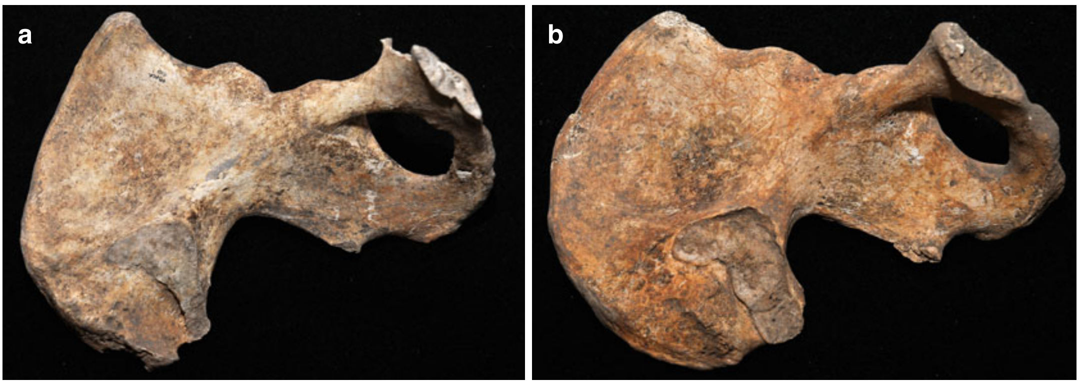


Fig. 1.3 (**a**) Female coxal bone. (**b**) Male coxal bone

features, taking into account their importance in the diagnosis, as described by various authors [8–11]. For some subjects, a gender diagnosis is sometimes impossible, because the findings are fragmented and incomplete.

1.1.2 Estimation of Age at Death

Various methods are used to calculate the age of death in adults, considering individual variability. The skeleton of an adult does not suffer great changes over time, so the age cannot be determined through the analysis of a single criterion; therefore, it is estimated applying several different methods and balancing the various findings, thus obtaining a time range in which the age of the subject under study is likely to be found.

One of the most noteworthy methods commonly used is the study of the degree of tooth wear, because the occlusal surface of the teeth gets thinner with age (Fig. 1.4a, b). Other factors determine tooth wear: the diet, the presence of dental-alveolus pathologies and some jobs involving the use of teeth [12].

The degree of welding of the ectocranial sutures has also been detected, based on the progressive fusion of the cranial sutures, until a complete obliteration, generally occurring in older age (Fig. 1.5a, b). Amongst all, Meindl and Lovejoy's method was used [13]. Then the auricular surface of the ileum was examined: in young subjects, the auricular surface is characterized by wavelet and diagonal rifts and the bone tissue is granular; with ageing, the diagonal rifts and the scratches decrease, the grainy quality of the bone

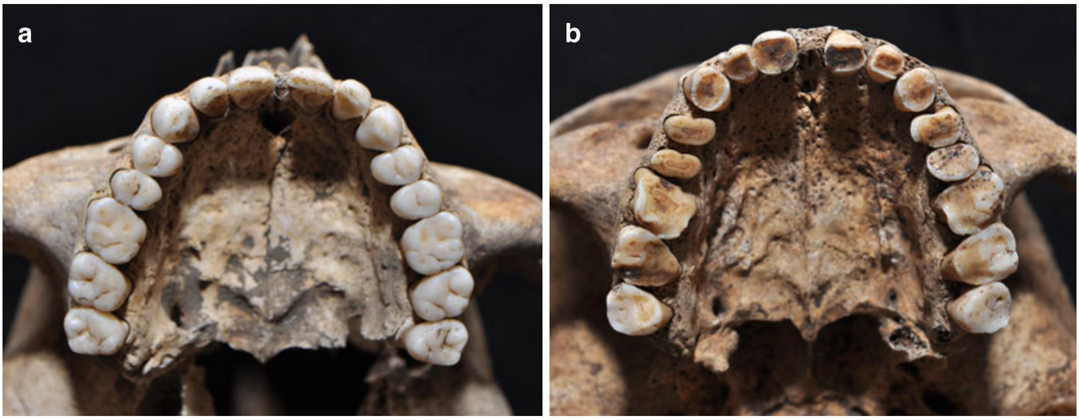


Fig. 1.4 (**a**) Mild dental wear. (**b**) Severe dental wear

Fig. 1.5 (**a**) Non-ossified ectocranial sutures. (**b**) Ossified ectocranial sutures

tissue is gradually replaced by small areas of dense and compact tissue and by porous portions, the margins becoming irregular and torn. In old age, the surface shows porous and eroded areas, the margins are irregular and in the retro-auricular area strong bone protrusions and osteophytes can be observed. Amongst all we used Lovejoy et al.'s method [14].

Moreover, the morphology of the pubic symphysis has been detected – in young subjects it is wrinkled, while with ageing it becomes irregular, with porosities, erosions and ossifications. We used Burns' method [15]. Then, the sternal end of the ribs has been examined – under 15 years of age the surface is flat and mildly wavy; with ageing it alters until it assumes a V shape, while the margins rise. After 55 years of age, the degenerative process prevails, until the margins fray and the porosity increases. Iscan et al. [16] studied these phenomena, but the method is difficult to apply due to the extreme frailty of the ribs.

The diagnosis of sub-adult's age at death (less than 20-year-old dead subjects) has been determined by the examination of the degree of development and dental eruption: this method identifies the different development phases and the dental eruption, an almost constant feature up to 14–16 years of age. We have used Ubelaker's chronology of dental eruption [17]. In addition, we have detected the size of the diaphyses of the long bones, and compared the values obtained with some charts based on the tight connection between the length of the long bones (measured without epiphyses) and the subject's age. However, it is important to bear in mind that measurements are always affected by the individual and population variability [18]. Considering the degree of ossification of the growth cartilage, we can estimate the subject's age if it is less than 24 years: in most cases, at this age the diaphysis and epiphysis of the bones, which compose the skeleton, are completely fused. In this study we used the standards given by Krogman e Iscan [19], France e Horn [20], Suchey et al. [21], Ubelaker [18], Iscan [22].

Fig. 1.6 Femur measurement with an osteometric board

1.1.3 Osteometry

All the bones which were intact enough to be measured were analysed osteometrically in a laboratory, in order to evaluate the length, width, section and circumference. We followed Martin and Saller's measurement procedure [23]. For every measurement we have indicated Martin's number and the commonly used abbreviation. The measurements are expressed in millimetres (mm) and taken with appropriate anthropometric instruments, such as the osteometric board (Fig. 1.6), the round curved compass to measure width and length, the digital calibre to measure sections and the millimetre strip to measure the circumference.

We used the osteometric dimensions to elaborate the height [24, 25] and the main indices of strength and section of the long bones, to try to highlight morphometric differences due to dynamic and environmental factors, such as stress from physical exercise or nutritional deficiency.

The main indices are as follows:

1.1.3.1 Cranial Indices

Cephalic index (horizontal) ($8/1 \times 100$): ratio between width and maximum length. This determines the elongated (*dolichocranium*) or short (*brachycranium*) shape of the skull.

Height index (vertical-longitudinal) ($17/1 \times 100$): ratio between the height measured at the bregma and the maximum length. This determines the degree of flatness of the cranial vault.

Frontal transverse index ($9/10 \times 100$): ratio between the minimum and maximum frontal diameter. This determines more or less the diverging shape of the superior forehead.

Fronto-parietal index ($9/8 \times 100$): ratio between the minimum and maximum frontal width.

Gnathic index (alveolar) ($40/5 \times 100$): ratio between the length of the face and the nasion-basion length. This determines the degree of face prognathism.

Orbital index ($52/51 \times 100$): ratio between the height and length of the orbit. This determines more or less a circular shape of the orbit.

Nasal index ($54/55 \times 100$): ratio between width and height of the nose. This determines a longer or shorter shape of the piriform aperture (long and narrow: leptorrhine; short and large: camerrhine or platyrrhine).

1.1.3.2 Post-cranial Indices

Strength index of the clavicle ($6/1 \times 100$): ratio between the circumference measured in the mid-diaphysis and maximum length.

Humerus diaphysic index ($6/5 \times 100$): ratio between the minimum and maximum diameter measured in the mid-diaphysis. When the value of the index is close to 100 the two diameters are equal and the diaphysis is round shaped (euribrachy): when the minimum diameter is considerably smaller than the maximum, we have a flatness of the humerus (platibrachya), maybe caused by intense workload of the biceps and deltoid muscle.

Humerus strength index ($7/1 \times 100$): ratio between minimum circumference and maximum length.

Radius diaphyseal index ($5/4 \times 100$): ratio between the sagittal and transverse diameter measured in mid-diaphysis. The smaller the values, the more protruding the interosseus crest due to greater pronation and supination movements of the forearm.

Ulna olenyc index ($13/14 \times 100$): ratio between the superior transversal and the superior dorso-volar diameters; this shows the transversal flatness in the superior section of the ulna.

Ulna diaphyseal index ($11/12 \times 100$): ratio between the dorso-volar and the transversal diameters; the smaller the values, the more protruding the interosseous crest.

Ulna strength index ($3/1 \times 100$): ratio between minimum circumference and maximum length.

Femur pillar index ($6/7 \times 100$): ratio between the antero-posterior and transverse diameters, measured at mid- diaphysis. A high index means a strong development of the *linea aspera* (pilaster), often linked to thigh muscular work.

Femur platimetric index ($10/9 \times 100$): ratio between the antero-posterior and transverse diameters measured below the lesser trochanter. An index lower than 85 means the antero-posterior crushing of the diaphysis superior third (platimery) generally linked to a strong development of the trochanters due to a great biomechanical stress.

Femur strength index ($(6+7)/2 \times 100$): ratio between the sum of the antero-posterior and transverse diameters and the physiological length. A value higher than 12.5 means a good strength of the lower limb.

Tibia diaphyseal index ($9/8 \times 100$): ratio between the sagittal and transversal diameters measured at mid- diaphysis.

Tibia knemic index ($9a/8a \times 100$): ratio between the sagittal and transversal diameter measured at the nourishing passage. A value lower than 65 indicates the diaphysis flattening in a medio-lateral direction (platicnemia); the crushing is generally due to the work of the calf muscles, maybe due to a prolonged and intense use of the legs.

1.1.4 Dento-alveolar Diseases

The anthropological study has also covered the state of the dento-alveolar complex. The study of the oral pathologies is really important in anthropology because of the great amount of information that can be obtained; from the conditions of the teeth, we can obtain data on the eating and hygiene habits of the subjects. Any presence of tartar, dental decay, abscesses, parodontopathies and *intra-vitam* losses has been recorded.

Tartar, made of limestone deposits due to plaque mineralization, has been quantified in three degrees: small, average and large amount.

Dental decay easily develops when saliva is slightly acidic. Organic acids derive from carbohydrate fermentation due to bacteria in the plaque. If acidity is high, especially in a sugar-rich diet, it can break down the tooth mineral, and lead to enamel and dentin perforation. Dental decay is classified depending on location (occlusal, buccal, lingual, mesial, distal), severity (superficial, affecting the dentin, perforation or affecting the crown) and affected tooth area (crown, neck, root).

An abscess is caused by an inflammation reaching the tooth canal through decay, wear and tear or fracture. A tooth abscess can be detected through a drainage canal at the root apex. Also in this case we have recorded presence and position (buccal, lingual, apical).

Parodontopathies are caused by inflammatory processes involving the tissues surrounding and supporting the tooth; they cause a progressive decrease of the alveolar margin, exposing the root and allowing for bacterial penetration. The alveolar re-absorption can occur evenly and with the same extension in most teeth, or it can be localized around a single tooth. Moreover, a dental pocket can occur at the neck or at root level, inclined to an apical extension and leading to an abscess as a final outcome [26]. The alveolar re-absorption is classified as light when the junction-cement and alveolar margin is below 4 mm and as severe when the distance is greater.

Finally, there is an alveolar re-absorption and a bone remodelling where the tooth has been lost (*intra-vitam* loss).

1.1.5 Non-specific Stress Index

Many factors affecting metabolism, such as diseases, acute or chronic nutritional deficiencies, due to either a lack of consumption (direct) or of absorption (indirect), lead to an alteration of the bone tissue diagnosed through a macroscopic examination. The anthropological study has also detected these alterations (non-metrical indices on functional stress and on disease).

Porotic hyperostosis is a macroscopic porosity seen on the orbital roof (*cribra orbitalia*) and/or on the external surface of the cranial vault (*cribra cranii*). This alteration is related to anaemic states of different aetiology. For instance, hereditary haemolytic anaemias, anaemias following infectious or parasitic diseases, or anaemias due to an iron deficiency [27].

Exostosis is a bone formation in the external hearing canal and can appear as an irregular bone mass. Several clinical studies [28] have shown the onset of exostoses with a prolonged water exposition. Some types of dermatitis, traumas, haemorrhages and senile changes can lead to external otitis and so to exostoses.

Auricular osteophytosis, is due to light inflammation of the external ear. It manifests itself as a slight bone proliferation around the external acoustic meatus, leading to the formation of an irregular edge with small-size osteophytes. Both diseases, when present, have been indicated with a degree of severity: mild for up to 2 mm formations, severe for more than 2 mm formations.

Enamel hypoplasia manifests itself as lines or little wells on the teeth surface, and it is caused by the interruption or slowing down of the enamel formation during the amelogenesis, that is the growth phase of the permanent teeth (the period from birth to 6–7 years of age). These alterations are caused by non-specific stress factors (such as malnutrition or diseases), so they are useful indicators of the health condition and quality of life of a population [29].

Periostitis is an inflammation of the periosteum. The pathology can be mainly observed on the tibia surface, due either to microtraumas or venous stasis [30].

1.1.6 Musculoskeletal Markers, Arthropaties, Traumas

The bone tissue remodelling due to intense physical exercise or hard work is defined through ergonomic markers or MSM (musculoskeletal stress markers) [31] and MOS (markers of occupational stress). Among them, we can find enthesopaties, arthropaties, non-metrical stress and trauma markers.

Entheses (from the Greek enthesis, "introduction") are areas of muscular and ligament insertion [32]; in the absence of a specific biomechanical stress, they manifest on the bone as imprints (wrinkles, protrusions, cracks), and they represent variable indicators of strength. Under stress, the same points of insertion can show osseous proliferations and/or erosions, defined as osteophytosis and osteolysis. These alterations are due to a non-specific pathological state of the enthesis, generally called enthesopaty, which can be present or absent, while the strength signs are always recognizable.

These modifications can have a mechanical, metabolic or inflammatory origin.

Osteophytosis and osteolysis are also due to age or idiopathic factors of the bone's response to different stimuli: the border between a healthy and a pathological form is difficult to define.

Arthritis is a degenerative pathology of the joints of the post-cranial skeleton and of the intervertebral discs of the rachis, occurring with a marginal opening (lipping), osteophytosis, porosity and eburnation. These alterations are the result of a discrepancy between requested work and work capacity of the joint. Arthritis location, age of onset, spread and development have a multifactorial origin; even though the causes can have a systemic nature (ageing, hereditary factors, sex, obesity, etc.) and/or a local one (overload and joint dynamics alterations), biomechanical stress is the necessary condition for the development of arthritis.

As arthritis gets worse, and leads to a direct contact between the bone surfaces, these can become shiny (eburnation) and show stripes parallel to the direction of the joint movement, often accompanied by porosities [33].

Other types of non-metric markers of functional stress, defined as "discreet" MOS (Markers of Occupational Stress) [34] include all the extensions of the joint surfaces (squatting and Poirier optional facet, sacroiliac and Allen fossae), the lack of fusion of the ossification centres (acromial bone) and the vastus medialis muscle notch (also called Messeri patella), due to overload.

A Poirier's facet [35] is an extension of the articular surface of the head of the femur on the anterior surface on the neck, maybe due to a contact between the caput femoris and the margin of the acetabulum cavity, when the limb flexes and extends. A further etiologic factor can be a hard and repeated stress of the iliopsoas muscle, which presses on the medial margin of the cerebral prominence.

Both a prolonged crouched posture and a repeated flexion of the foot, when marching on rough ground [36], can cause the development of optional facets (squatting facets) at the level of the tibio-talar joint [7]. These features occur as an interruption of the continuity of the anterior margin of the tibial distal epiphysis.

The optional sacroiliac facets are round areas, localized at the level of the first or second sacral foramen, sometimes having their equivalent on the iliac tuberosities. These modifications are generally connected to loads carried on the back, with an increase of lumbar lordosis [7].

The Allen fossa, situated on the anterior face of the femoral neck, is connected to extensions and flexions of the limb [31]; it is the outcome of the contact of the rectus muscle tendon on the anterior part of the femoral neck. Its presence is due to an upright posture [33], associated to ambulation on steep ground [37–39].

Bipartite acromion, the potential outcome of an over use and load of the rotator cuff [40], is the lack of fusion of the acromion with the scapular spine.

Messeri patella [41, 42] is the result of the modification of the kneecap morphology. A frequent flexion of the legs or a habitual crouched position involves the quadriceps muscle tendon; its over stress leads to a lesion of the superior–lateral surface of the basis.

When studying the rachis, Schmörl hernias (the extroflexion of the inner fleshy nucleus from the vertebral body) have been taken into account. These nodes are related to traumas, ponderal overloads during adolescence or pre-existing conditions (infections, rickets and osteoporosis). These lesions are mainly found on the central portion of the lumbar vertebrae plateau and on the lower thorax [43]. The spinal column has also shown some osteophytoses, fractures and fusion of the bodies.

Among the most easily detectable alterations in the anthropological samples, traumatic lesions provide information on the environment and on the characteristics and hardness of the work carried out. The environment can cause particular physical traumas, recognizable on the skeleton: for instance, a high frequency of both wrist and ankle fractures can be due to working on irregular ground.

The bone remains have shown some traumatic lesions, such as fractures, dislocations, haematomas or pulled muscles. These have been recorded on an appropriate database, separating fractures/dislocations from tendon/muscle traumas.

Traumas are classified into accidental (due to life style), deliberate (due to violence), ritual, punishment (amputation) and therapeutic (surgical); their frequency, localization and severity can provide "traumatological patterns", useful for the analysis of the socio-cultural features of the ancient populations. Fractures are complete or partial interruptions of the bone structure integrity, leading to a healing process seen in new formations (osseous callus).

A dislocation is a permanent relocation of the joint surfaces. It is called complete when the loss of connection between the two surfaces is absolute. When partial contact remains, it is called incomplete or sub dislocation. Its aetiology can have a traumatic origin if occurring after a violent trauma which moves the ends of the bones; innate if due to a malformation of the ends of the bones; degenerative (pathological) if due to capsular ligament lesions.

1.1.7 Skeletal Markers of Working Activity

These markers increase in number and intensity with age, but also respond to mechanical stress [44]. The data regarding these alterations can be a useful parameter to trace a population's lifestyle [45, 46], thus contributing to the identification of load patterns and work division based on gender [47–49], or social status.

The muscular–skeletal stress markers have been recorded considering Hawkey [50] and Mariotti [51, 52] with three grades of development for every enthesis. The first grade (1), characterized by a weak and average development, is divided into three sub types: light (1a), low (1b) and average development (1c). The second (2) corresponds to a marked manifestation and the third (3) to a really strong development of the tract. These grades are all physiological: absent or normal modification.

Enthesopathies, when present, are divided in proliferative osteophytic forms (OF) (Figs. 1.7 and 1.8) and erosive, osteolytic forms (OL) (Fig. 1.9). The suggested pattern for their classification includes three grades that define the pathological stages. The first corresponds to light porosities and exostoses smaller than 1 mm; the second one to several areas of erosion and exostoses between one and four mm in size; the third one to marked exostoses, bigger than four mm. When there is no enthesis, or in case of a bad preservation status, the examined skeletal section has

Fig. 1.7 Enthesophytes at the insertion of the ulna triceps brachii. (Grave 176 Castel Malnome)

Fig. 1.8 Enthesophytes at the origin of the tibial soleus muscle (Grave 146 Castel Malnome)

Fig. 1.9 Erosion at the insertion of the costo-clavicular ligament (Grave 60 Quarto Cappello del Prete)

been recorded as "ND" (that stands for:. not detected). For the discrete markers, the presence/absence of traumas, fractures and arthropathies has been detected; for fractures and arthropathies also the site has been evaluated, recording the cases of politraumas.

1.2 History of Medicine in Rome

Valentina Gazzaniga and Silvia Marinozzi

Ancient Rome is, for the historian of medicine, an extremely rich reality due to the theoretical development, the available and highly intellectual, methodological and technical written sources, and the rich evidence provided by the archaeological findings and remains [53].

The chronological period, the anthropological and palaeopathological study dwells on in this book is one of the most representative of the whole ancient times: in Rome, a rich Italics heritage of herbal and therapeutic competence faces the medical knowledge acquired in Greece since the classical times, rising increasingly complex pharmacological theories, whose peak is Galen of Pergamon's "grades theory" but also the flourishing of encyclopaedic essays and manuals addressed to a wide and less refined public [55].

The worship of thaumaturgic gods, which only changes the name to the really wide number of Greek gods somehow involved in the treatment and in the promise of healing, is not only stifled by the importation of the rational medicine from Hippocrates, but, in a syncretistic way, it is enriched by the contributions from the Etruscan civilization first and then from the oriental esoteric religions; the survival of templar medical practices, which can be wholly superposable to the pre-classical and classical Greek ones, is well documented by Ovid's poetical tale on the importation of the worship of Asclepius and, in more recent ages and in a geographical and cultural Greek background, by the rhetorician Aelius Aristides' autobiographical *Sacred tales*, which tells his experience in healing.

As regards the rational medicine, the physicians claiming a medical training regularly gained in famous schools and teachers, have already learnt the lessons of the Hippocratic medicine suggesting a reworking which comes to an amazing complex degree (one of the most striking examples are Galen of Pergamon's writings) [54].

The heritage of the Alexandrian medicine, whose history is halfway the third century B.C. in a very short-term and extremely important period, is seen in Rome with a meaningfully increased anatomical awareness compared to the Greek experience: the human body, which was conceptualized as a hollow vessel intended to hold fluids in almost all the Hippocratic writings, is seen as an elaborate system of parts interacting to each other in the innovative Galenic medicine, completely able to exploit the Alexandrian Herophilus' and Erasistratus' medical experience on dissection and autopsy. Every part of the body has got its own function, which leads to health if successfully achieved; the change in the anatomical structure involves an impairment and so a disease [55].

The medical sects question the method as well as the epistemological nature of medicine [56]; the Empire opens up to imported cultural phenomena and faces with experiences, the therapeutic ones too, from the conquered countries and from the ones with an active trade, leading to wonderful opportunities of theoretical and practical enrichment particularly seen in pharmacopoeial works, as the *Compositiones*, dated around 47–48 A.D. and written by Scribonius Largus, a physician operating under emperor Claudius. In these works new substances of vegetable, animal and, in small percentage, mineral origin, spread by the maritime trade, meet the earliest pharmacological expertise, raising a really varied pharmacopoeia, where features of folk medicine merge, as well as the scientific ones. [57]

Moreover, in their preface letter sent to Callistus, Scribonius' *Compositiones* are an example of how the Roman medicine achieves original results as regards the moral and ethic thought; the suggestion to judge every patient equal and worth of treatment, even the enemies of the homeland, enriches a moral "inner" tradition coming from the Hippocratic Oath with new elements [58].

So, a very rich "medical marketplace" [59], characterized by different professional competences and by a progressive refinement of the medical knowledge comparing to the Greek origin, practised together by physicians from the Hippocratic tradition, traditional healers, specialist surgeons, obstetricians, priests of Asclepius and Gods and heroes skilled in the art of medicine, military doctors and slaves.

Consulting the several available historical sources, Roman Imperial medicine looks like a field of knowledge deeply related to the civil and social life, a field where different expectations and waitings join with an increasingly rising market demand [60]. The geographical borders expansion with the high variability of the socio-economic status of the inhabitants of the Empire, also followed by the change of the risk factors, of the onset conditions and spread of infectious diseases, in a word of the whole pathological background (called "pathocenosis" by Mirko D. Grmek, who coined a highly important neologism for the future study of the ancient Greek–Roman diseases) makes the Roman world a privileged place to investigate on the sanitary ancient history.

This work has favoured some of the available sources, because of their connection to the history of the treatment of orthopaedic injuries and trauma: first of all, the Hippocratic treatises, which directly or indirectly regard the healing of fractured and dislocated limbs, head trauma and wound's general treatment. As well-known, these works are not entirely attributable to the Kos master, although some of them were by the earlier reviewers, in particular Erotian, who lived under Nero, and author of a *Lexicon*, one of the first work trying to sort out the complex issue regarding the attribution of the works passed on under the name of Hippocrates. All these writings, however, share a rather early dating (end of the fifth – beginning of the fourth century A.D.) in unison with Hippocrates' real life span and are the basis of the "technical" reflection on a Roman "specialized" orthopaedic competence. In particular, operating from the medical and encyclopaedic point of view, Galen and Celsus regard them the starting point to process again bone, skeleton and limbs technology and intervention.

Celsus (1st cent. A.D.), as well known, has not got a medical background, but he is a highly brilliant data collector showing the best example of technical refinement ever reached in the Roman encyclopaedic field in his work *De Medicina*; in his survived book on surgery many pages regard the orthopaedic techniques and the description of the tools used for the treatment of bone injuries in Rome during the first Empire [61] .

Galen (130–200/210) is the well-known intellectual giant of medicine in antiquity; a versatile, very lucky and rich man, Marcus Aurelius' doctor first and then his son Commodus', he spends almost his whole life in Rome being on duty of the higher social classes. During his long Roman years, Galen collects books and makes up one of the most important medical library in the ancient times (destroyed by the Temple of Peace fire in 192 A.D. it was rebuilt by Galen himself, book by book, buying again what could be found on the market and writing "ex novo" his own works, when he didn't manage to find a copy among friends and acquaintances). His work, which survived almost entirely through the Syriac and Arabic translations, includes several essays on the treatment of fracture and dislocation, the instruments and technique [62].

The available written sources are very rich. We can also add the support of the material history, thanks to archaeology [63]: the healing temples, consecrated to Asclepius and to a huge number of principal and secondary deities, all involved in disease healing, which carry on their task during the Empire, a task confirmed by the richness of anatomical ex voto (Fig. 1.10a–c), a wide field of documents on diseases and deformity affecting the Romans and the Empire inhabitants, although unable to

Fig. 1.10 (**a**) Roman ex-voto: hand and foot, ca. I-II. Cent. A.D. (Museo di Storia della Medicina, "Sapienza" Università di Roma). (**b**) Roman ex-voto: harm, ca. I-II. Cent. A.D. (Museo di Storia della Medicina, "Sapienza" Università di Roma). (**c**) Roman ex-voto: foot, ca. I-II. Cent. A.D. (Museo di Storia della Medicina, "Sapienza" Università di Roma)

originally repeat the typologies already documented by the Greek and Etruscan clay production in forms and genres [64]; the treatment centres for slaves and soldiers (above all established at the borders of the Empire, the valetudinarian are complex buildings where wounded soldiers are admitted and where a military competence is practised, also extended to the orthopaedic treatments) [65]. We can add some most singular events: the ruins of private surgeries, as the Surgeon's House in Rimini, a second century A.D. building, where the Hellenic physician Eutyches lived and worked. When his house was destroyed by a fire, maybe in the third century after a barbarian raid, he left one of the richest surgical legacy of the ancient times; a hundred and fifty tools, of different material and dating, testifying their owner's high specialized level, and, maybe, the "military" origin of his medical knowledge [66].

Epigraphy helps to recreate the profile of the physicians working around the Empire, testifying the wandering features of the medical profession practised till the end of the Empire, excepting some cases concerning very famous physicians, settled for long periods in the same town. As regards, a slight difference between the practice of the Roman medical knowledge and its wandering organizational features in the Greek world, is the really wide dimension of the territories where doctors practice and the different cultures they meet: often coming from the eastern and Greek lands, not rare sepulchral statements testify their profession at the opposite edges of the great Empire.

A last notation goes to the "specialisms", characterizing the Roman medicine, unlike the classical Greek; the work of orthopaedists, eye specialists, doctors caring the women reproductive period and the first stages of the human life, surgeons of great technical competence, experts in difficult operations as trepanation, is documented by the equipment, by specific written works, as the case of Soranus of Ephesus' book on women diseases, and by important palaeopathological evidence [67]. In particular, a highly valuable example is the so-called Child of Fidene's skeleton (Fig. 1.11), belonging to the Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma and preserved in the Museum of the History of Medicine at the Sapienza-University of Rome. The outcomes of his trepanation testify a surgery performed only to relieve the pain caused by a cerebral tumour in a very young person, according to the technique described by Galen [68].

In the last years many valuable studies have regarded the different features of the intellectual and professional landscape of the art of medicine in Rome we have given a hint of; to mention the most meaningful contributions, the writings of V. Nutton, R. Jackson, D. Gourevitch, J. M. André, V. Boudon-Millot, V. Dasen, H. King, A. E. Hanson, M. Green, A. Krug, J. Scarborough, Ph. van der Eijke, L. Bliquez, I. Mazzini, S. Fortuna, S. Sconocchia, Ph. Mudry, F. Stok and A. Touwaide [69].

The study of these authors have demonstrated that the art of medicine in Rome is more than a simple reflection on the cultural background acquired from the classical Greece [70]; the new ideas, the outlook changes, the technological and methodological innovation make the Roman medicine a peculiar and highly complex competence, able to set again the "long terms" of its theoretical base unit adapting them to the sanitary and social needs of a very wide population, characterized by deep habits and customs differences.

Fig. 1.11 The child of Fidene, imperial age (Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma, at Museo di Storia della Medicina, "Sapienza" Università di Roma)

1.2.1 Orthopaedics, An Ancient "Specialty"?

Valentina Gazzaniga and Silvia Marinozzi

Generally speaking, ancient medicine is a non-specialized discipline. Hippocratic texts founding later medical rational tradition describe the image of a physician able to face fevers, cuts and traumas equally. Within this picture of generic medical competence, the surgical treatment of skin and skeletal lesions certainly fell into the category of the most successfully treatable medical practices [71]; in ancient times, traumatic lesions of varying origin must have been particularly frequent, due to wars, and accidental or occupational hazards (the type of lesions that wrestlers, gladiators or slaves employed for building or mining must have suffered): an empirical competence of their treatment had to be shared by the various health care "professionals". Hippocratic physicians, surgeons, medical practitioners and 'rhizotomoi' often dealt with traumas, assessed their outcome and gauged their potential complications from different perspectives, it being a chronic inflammation, a gangrene or an invalidating outcome [72] (Fig. 1.12a–c).

It is not surprising that in ancient Rome the competence of doctors who treated walking defects and limb problems in general rises to the level of specialistic discipline, capable of implementing some more practical features already belonging to the Greek Hippocratic medicine; the books of the *Corpus Hippocraticum* for general surgery and for the treatment of fractures and dislocations already had them, together with other scientific technical topics, such as obstetrics and pharmacology. Once again, it is not surprising

Fig. 1.12 (**a**) Roman surgical instruments, Imperial age (Museo di Storia della Medicina, "Sapienza" Università di Roma). (**b**) Roman surgical instruments, Imperial age (Museo di Storia della Medicina, "Sapienza" Università di Roma). (**c**) Roman surgical instruments, Imperial age (Museo di Storia della Medicina, "Sapienza" Università di Roma)

that orthopaedic competence has a high level of specialization in ancient Rome [73]; here, the highly educated Greek tradition (as transmitted by the Alexandrian sources) joins the empiric trait of the Italic and Roman tradition in a perfect balance.

1.2.2 "Noble" Origins

The theoretical lineage from the Greek Hippocratic knowledge is represented by the constant reference by Roman authors such as Celsus and Galen to a group of works belonging to the "Corpus"; these works document a rather high anatomical and osteologic competence: the essay "The Nature of Bones", which despite its title is a book on angiology, does contain a chapter on bones; the essays "Fractures and Joints", written by the same author between the end of the V and the beginning of the fourth century B.C. include directives on the treatment of arm and leg fractures, the reduction and treatment of dislocations of elbow and knee (Fig. 1.13), humerus and shoulder, collarbone, hip and fingers and correction techniques for backbone deviations; the essay "Mochlikos", already attributed to Hippocrates by Erotian, takes its name from the lever instrument used in the

COMMENT. II. 171

Non modò minùs molesta sunt, quàm quæ in primâ palmæ parte, sed multò magis, quàm quæ in pede. Sed quoniam de pede & manu communiter tractauit, ideò abundè existimat alterius partis duntaxat meminisse, quæ, quod ad molestiam pertinet, media est inter crus & pedem. quãto enim maiorẽ molestiam affert, quàm crus, tanto minorem, quàm pes, & præcipuè quàm calx, de quo paulo suprà egit.

NAm vel rotæ modiolũ defigere oportet, vel aliud quid simile: tum molli aliquâ re pedem obuoluere, bubulísque loris latis circumligare, & eorum capita, vel ad pistillum, vel ad aliud lignum deuincire, eiúsque imam partem, in modiolum demittere, summam recuruare: alios verò & ab humeri capite, & à poplite in contrariam partem extendere.

Lignum defigi iubet, quod recipere possit imam partem vectis, per quem membrum debet ab inferiori parte extendi. tibi verò ignotum esse non credo, rotæ modiolum [illegible] ab Ionibus appellari. cùm apud poëtam hoc quoque vocabulum legatur. Commonet autem Hippocrates, vt vbique ex ijs, quæ ad curationem conducunt, illis vtamur, quæ in promptu sunt: & nunc etiam meminit modioli rotæ, qui præsto nobis esse potest vbiuis gentium: similiter pistillo pro vecte nunc ad extendendum vtitur. Sed quâ viâ adhiberi hæc debeant, ipse suis verbis, si animaduertantur, apertè declarauit.

SEd à superiori quoque parte adhibere vim licet.
Vim, hoc est, valentem in vtramque partem intentionem [illegible] appellauit, vt vehementem eius potentiam indicaret.

Fig. 1.13 Repairing dislocated knee from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544 (Wellcome Library) reduction of fractures and dislocations; the essay *Head Injuries*, dating between the end of the V and the beginning of the fourth century, is a very technical text giving indications on the correct clinical approach towards a patient with head injury, who may need both specific diagnostic techniques, and specialized skills in the use of drilling tools. These essays all address a type of treatment which would be nowadays defined as "orthopaedic", and extracts from other works can also be added to them, for example "The doctor's workshop", with the description of mechanical tools for the reduction of dislocations and fractures, among which Hippocrates' s bench (Fig. 1.14); how to build this traction table was already found in the text *Joints*, and it will be discussed by future generations of doctors, from Rufus from Ephesus, to Galen, Oribasius and Paul from Aegina, thus becoming a very popular topic, and the reference point for corrections and constant modernizations that will occur in the history of orthopaedic surgery up until the modern era [74]. Most probably, some orthopaedic information must have been contained in a lost work by Hippocrates on war injuries, where working as an army physician was recommended as a way to acquire anatomical knowledge and rapidly effective therapeutic techniques [75]. Since its origins, a specific feature of the ancient orthopaedic competence is the self-perception of how spectacular the techniques of intervention on the bone are; the use of considerable tools, such as beams or ladders to hang the patient and bring the dislocated bone back to its anatomical site (Fig. 1.15), but also the immediate perception of the healing process and the external visibility of complex bandaging techniques, make orthopaedics an easy field to acquire fame and consensus, and to impress patients even without especially high medical qualities. A good doctor must regard orthopaedic tools – swings, levers, ladders and benches (Fig. 1.16) – as what they actually are tools that are often not designed for therapeutic goals, but directly borrowed from carpentry or other forms of craftsmanship, just like some other surgical tools for orthopaedic use, survived because they were made of metal, and difficult to identify today even by an archaeologist specialized in the history of ancient surgical instrumentation [76]. Tools cannot replace the doctor's professional skills, just like a planer, a saw, or a hammer cannot guarantee a good carpenter's work: "… the same is true for mechanical tools: they must be conceived correctly or not conceived at all: it is dishonourable and contrary to art when mechanical tools are designed to take the talent away from their designer" [77]. (Fig. 1.17). Orthopaedics, like any other branch of Hippocratic medicine, finds its ethical justification in its being correction "according to nature", a balanced technique which can bring things back to their natural course, where disease is its temporary discontinuation [78]. Its main goal is to limit a potential permanent damage caused by an error in the bone

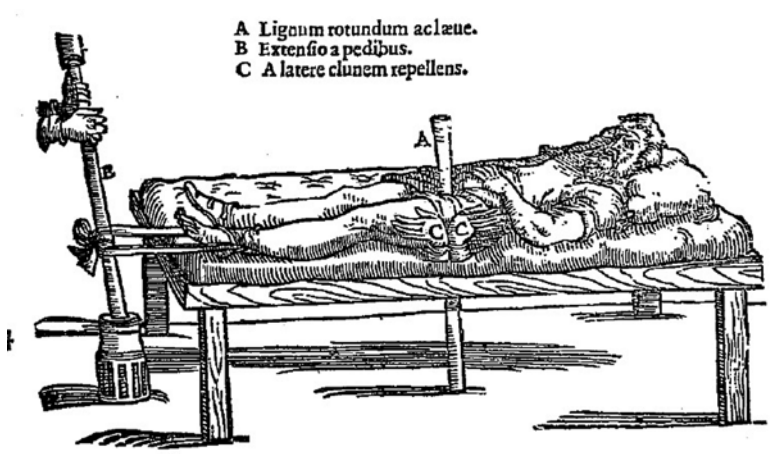


Fig. 1.14 Scamnum (Hippocratic bench), from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544

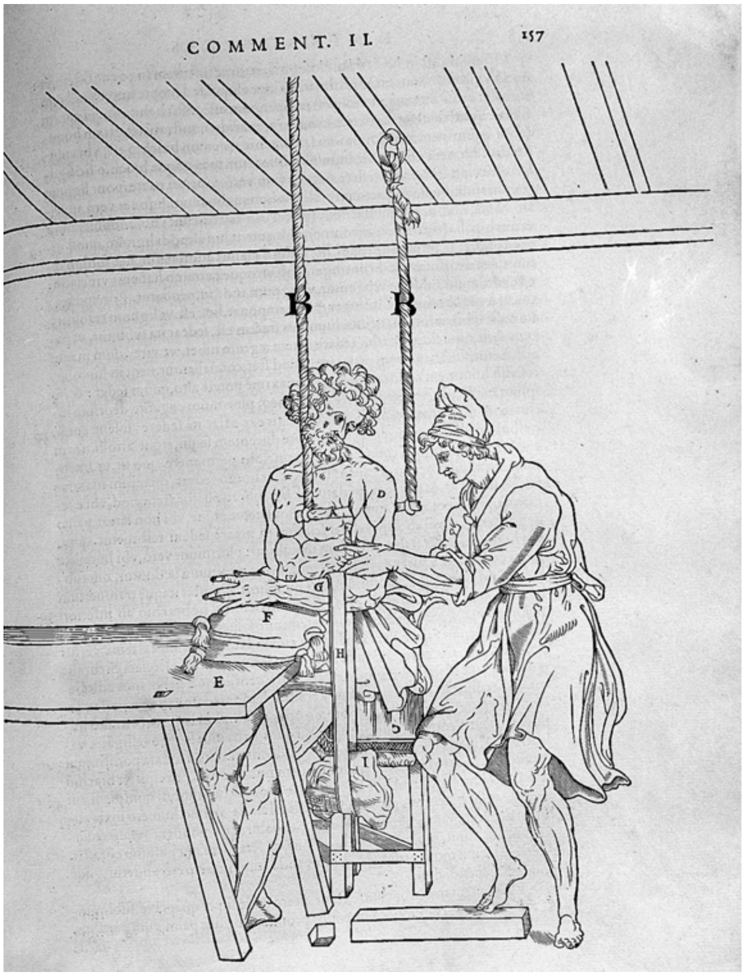


Fig. 1.15 Repairing a dislocation to the arm, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544 (Wellcome Library)

remodelling; the main interventions on fractures, for instance, include the removal of minute particles, the filing of the fracture's indented margins, the chiselling of overabundant or defective bone callus or the correction of congenital bone deformities [79] (Fig. 1.18a, b). All unnecessary pain must be limited, if not avoided; to this aim, an in-depth knowledge of the nature and arrangement of bones, together with the careful respect for the patient's needs are helpful; the faster the medical act, painful in itself, the more competent and morally correct. Medical texts and palaeopathology both offer the perception of the profound and impressive technical expertise required to bone surgeons: the high number of well-healed bone fractures on ancient human finds suggests good levels of treatment, even though a spontaneous healing can be hypothesized in most cases, also favoured by patients' long periods of immobilization and consequent care [80]. Immobility could also be guaranteed by specific items, such as wooden crates or cages made of flexible sticks tied together and bandaged to the broken limb; the use of long strips of bark and fresh soft branches is documented in pharaonic Egypt, in the Iron Age in Italy, and in the eruption of Mount Vesuvius in 79 by a young fugitive from Ercolano, who was forever immortalized by the lava together with the ferula blocking his fractured arm [81]. An increasing "orthopaedic" competence is also

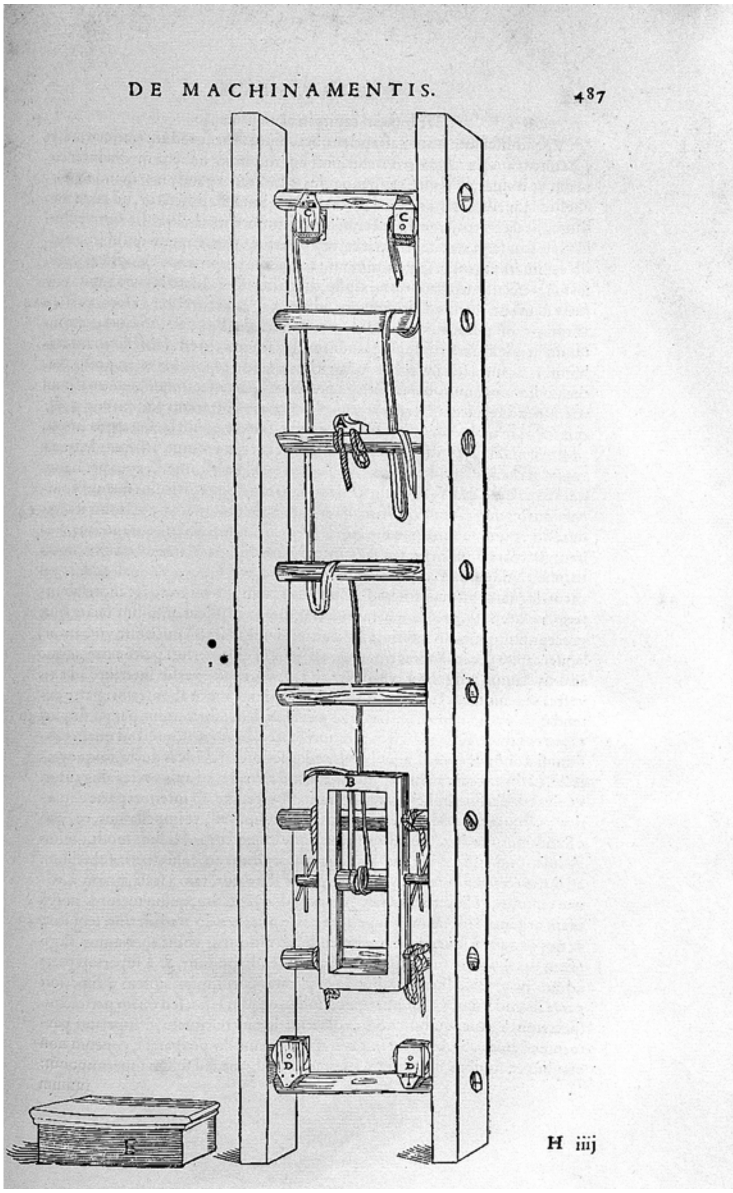


Fig. 1.16 Orthopaedics ladder, from Guido Guidi Chirurgia e Graeco in Latinum conversa, 1544 (Wellcome Library)

documented in the indirect tradition [82], which has passed on information about lost texts of medical authors, known as the inventors or renovators of tools for surgical correction of the bone: from Diocles of Carystus (fourth century B.C.), to Philotimus (IV B.C.), both specialized in the reduction of femur dislocation, to Nilaeus (III-I B.C.), the inventor of tools for the correction of out-of-site femur and humerus (Fig. 1.19), to Protarcus (II-I cent. B.C.) and Megetes (I B.C.), specialized in the knee; from Heliodorus (first century), with his technique of jaw reduction, to Archigenes (I-II cent.), an expert in amputation techniques, an increasing surgical specialization seems to have been established in the long series of centuries between the Hippocratic texts and their reinterpretation in Roman times, mainly by Celsus [83] and Galen.

Fig. 1.17 Roman Surgical Instruments, Imperial age (Museo di Storia della Medicina, "Sapienza" Università di Roma)

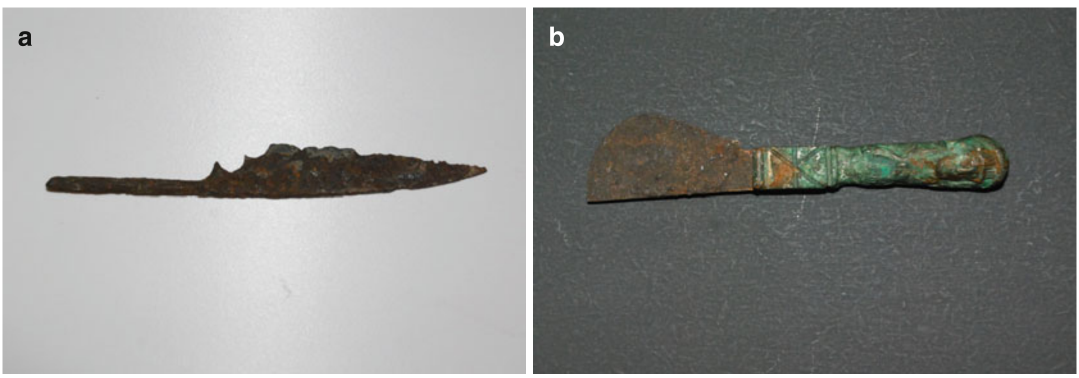
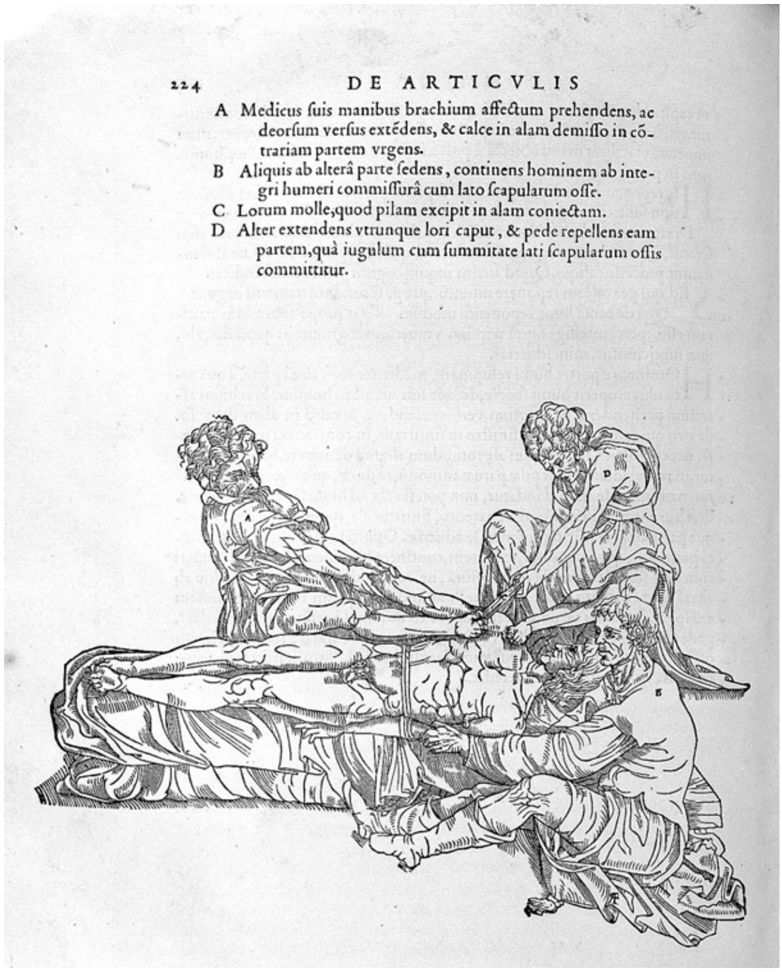


Fig. 1.18 (**a**) Roman surgical knife (Museo di Storia della Medicina, "Sapienza" Università di Roma). (**b**) Roman surgical knife (Museo di Storia della Medicina, "Sapienza" Università di Roma)

1.2.3 Orthopaedics in Rome

In Imperial Rome, the spectacular nature of some bone correction methods, already criticized in Hippocratic texts, seems to diminish; thus, the techniques are simpler than those described in Hippocratic texts, but the number of pathological situations where they can be used increases. Celsus and Galen, the main authors who provide indications on bone treatment in Rome, refine ancient techniques and propose innovative uses. In the *De Re Medica*, Celsus gives a more practical and realistic view of doctors' and surgeons' "modus operandi"; even with his pathological interpretations and some specific therapeutic treatments of Hippocratic tradition, Celsus is mainly interested in the praxis. On the other hand, Galen represents the Greek medical philosophical culture, and mirrors a Hippocratic approach also in the re-elaboration of orthopae-



224 DE ARTICVLIS

A Medicus ſuis manibus brachium affectum prehendens, ac deorſum verſus extẽdens, & calce in alam demiſſo in cõtrariam partem vrgens.

B Aliquis ab alterâ parte ſedens, continens hominem ab integri humeri commiſſurâ cum lato ſcapularum oſſe.

C Lorum molle, quod pilam excipit in alam conie&tam.

D Alter extendens vtrunque lori caput, & pede repellens eam partem, quà iugulum cum ſummitate lati ſcapularum oſſis committitur.

Fig. 1.19 Repairing broken arm, torn ligament or shoulder dislocation, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544 (Wellcome Library)

dic surgery through the Alexandrian tradition, which had enriched it with the design of new mechanical tools [84]. In his philosophical view, the animal body is formed from the matter of masculine and feminine seeds, which collect and hand down the most refined and vital part of the humours and generate the three primary organs, the heart, the liver and the brain; arteries, veins and nerves develop from each of these organs. They instil matter and life into the other parts of the body, and the bone structure forms around them (thanks to the action of the animal bodies' earthy component giving solidity and hardness, of air moving and giving vital wind, and of heat). In this perspective, the skeleton is given the role of protecting the vital organs, since the first part to be developed is the rib cage, and then, as in a process similar to the development and ramification of vegetables (Galen thinks of trees in particular), come the spine and the skull; after that, when the connective tissues and the muscles form around the bones, the skeleton becomes the basic structure, which enables us to be supported, move and stand [85]. In his *Commentaria* to Hippocratic works on orthopaedics, in particular the *De articulis* and the *De fracturis*, and in other less specific ones, such as the *De medici officina*, *De usu partium*, *De methodo Medendi*, *De fasciis*, Galen implements the original doctrine with the description of techniques and tools, refined and developed over time, and most of all with clinical cases observed by later authors and by himself. It is the case of humerus dislocation which Hippocrates believed occurring only inferiorly or anteriorly, because the head of the humerus can move forward while staying underneath the protrusion of the shoulder blade. Later Greek authors and Galen himself describe posterior and lateral (external) dislocations, mainly frequent in wrestlers because of the twisting movements they undergo; the same is true with the knee, which can dislocate laterally for the same reason. Celsus and Galen view the orthopaedic techniques differently: Celsus reflects the typical Roman encyclopaedic approach and the orthopaedical remedies and techniques he observes in Roman daily medical practice. On the other hand, both Celsus and Galen adopt a common method of explaining skeletal diseases of non-traumatic origins: they think an innate weakness or an inappropriate diet lead to heat deficiency and humoural imbalance. They both reclaim ancient indications in order to perfect them and propose some innovative uses. One example is the drilling of the skull, generally used to remove bone fragments, coming from compound fractures, that might damage the brain and induce humoural plethoras, accumulations of pathologic fluids, something very similar to our concept of infection; or, as is suggested in Galen, to allow the free flow of cerebral pneuma, which could be compromised by a depressed fracture, but also for the treatment of epilepsy or of persistent headaches [86] (Fig. 1.20).

Fig. 1.20 Drilled skull of the child of Fidene (Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologia di Roma, at Museo di Storia della Medicina, "Sapienza" Università di Roma)

Among the most spectacular techniques available to ancient doctors, the drilling with the use of circular or crown drills (modiolus), or with the combined use of chisels (Fig. 1.21) to bore the circular section of the skull to be removed, also represents the therapeutic model for the removal of bone fragments in compound fractures of other skeletal parts [87]. Other specialistic and visibly striking interventions are those performed with the Hippocratic bench, a dedicated orthopaedic bed equipped with levers, strings and tie-rods for the extension and the reduction of fractures and dislocations; however, both Celsus and Galen also report less complex, but more widely performed procedures used by surgeons to reduce humerus, femur and vertebral dislocations, but also spine incline, using a simple ladder (Fig. 1.22), either to lever on the rungs in rearrangement operations for humerus or femur dislocation, or for "succussions", performed tying the patient along the ladder and repeatedly moving it vertically to treat hunchback and vertebral inclinations [88]. A "retrospective diagnosis" is difficult and risky, given the theoretical adhesion to a strictly humoural model: with an analysis of the written sources only, it is difficult

Fig 1.21 Roman Chisel, ca I-II cent. A.D. (Museo di Storia della Medicina, "Sapienza" Università di Roma)

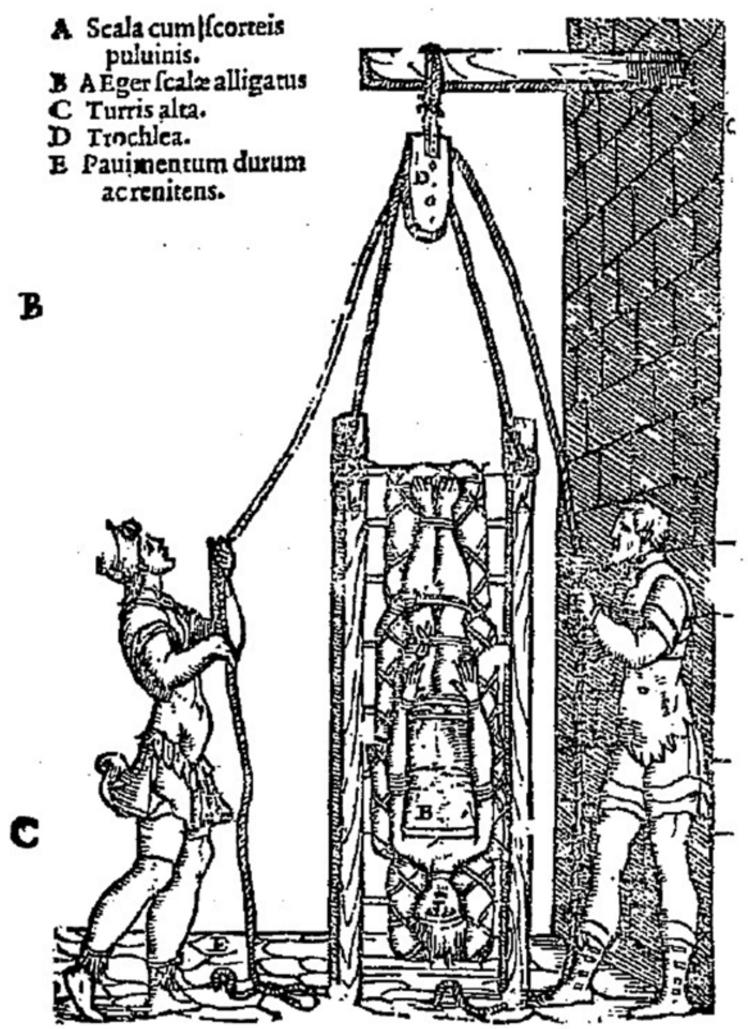


Fig. 1.22 Ladder for vertebral dislocation, from Guido Guidi Chirurgia e Graeco in Latinum conversa, 1544

to distinguish between rheumatic pathologies, pathologic arthritis or arthritis following excessive wear, load or strain from a simple description of symptoms. Pains in hands and feet, for instance, are often classified as podagra and chiragra, while the symptoms are nowadays attributable to a form of gout, which does not have a nosological classification in ancient times (Fig. 1.23a, b).

The same goes for the complex range of neoplastic diseases, whose description belongs to the ancient categories of "karkinos" or "phyma", but does not allow distinguishing a potentially malignant development from simple protrusions and swellings. Without a specific nosology to distinguish the various pathological processes, skeletal disabilities, including fractures and recurrent dislocations, are just a sign of innate weakness or inappropriate diet. This is why therapies are generally based on soothing compresses and local analgesics, diet, rest, laxatives, enemas and repeated bloodletting, so as to drain the corrupted humours clogging the lesioned part and leading to inflammation.

1.2.4 An Advanced Technique

The problems in the pathological interpretation are counterbalanced by the huge amount of data

FIG. 1.23 (**a**) Roman ex-voto: hand, ca. I-II. Cent. A.D. (Museo di Storia della Medicina, "Sapienza" Università di Roma). (**b**) Roman ex-voto: feet, ca. I-II. Cent. A.D. (Museo di Storia della Medicina, "Sapienza" Università di Roma)

about therapies coming from Roman sources: it is particularly important for the historian to work together with physical anthropology and palaeopathology, which approach skeletal diseases and dysfunctions objectively, and allow tracing a consistent therapeutic and *pathocenotic* picture [89]. In Celsus and Galen, the corrective treatment of fractures and dislocations confirms the high level of structural knowledge of the skeleton and the muscular system reached through animal dissections, but also the high level of technical specialization of Roman surgery in the Imperial time. A high level of technical expertise is documented in very interesting sources, such as the so-called Child of Fidene, a find from Imperial Rome, now owned by the Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'area archeologica di Roma and treasured at the Museum of Medical History of Sapienza-University of Rome. It documents a drilling technique which is very close to the Galenic model, and more complex than the techniques adopted for the simple removal of fractured segments from the skull [90]. The Child of Fidene actually shows the intracranial signs of a mass probably causing a considerable increase in endocranial pressure and, as a consequence, marked pain; there must have been the drilling and removal of a circular bone fragment to ease the symptom at least for some time [91]. Such a high surgical level is shown in the use of specific techniques of orthopaedic correction, of a specialized surgery and set of tools; and whereas Galen describes the various treatments and respective tools in detail, including their design, Celsus just mentions the more complex ones, and describes in detail the easier methods, the ones more commonly used by Roman surgeons. An example of such difference is the fastidiousness that Galen uses in his meticulous description of design, elements and uses of the Hippocratic bench for the reduction of fractures and dislocations of femur, vertebrae, long bones of lower limbs and ankle [92]; on the other hand, Celsus just mentions it as the tool of choice and of highest efficacy, without specifying its structure and functioning. In the absence of the Hippocratic bench, both Galen and Celsus provide precise indications on an alternative set of tools that can be used successfully: the extension can be performed with strings tied to the regions to be pulled, and connected to sticks (Fig. 1.24), so as to favour the traction in opposite directions; in case of fractures and dislocations of the lower limbs, two sticks can be set under the armpits to hold the body during the traction. The reduction and bandaging must be performed during the limb's extension, with manual replacement of the bone, and starting the bandaging from the protruding section of the dislocation; the use of more than one pad and one round of bandages allows the physician to make a greater pressure [93]. After this initial treatment, the affected part must be immobilized and positioned higher than the

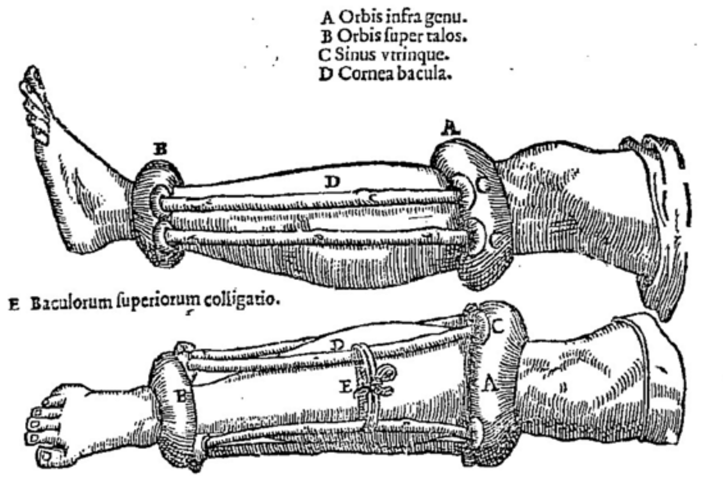


Fig. 1.24 Reduction of leg fracture, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544

Fig. 1.25 Roman ex-voto: leg, ca. I-II. Cent. A.D. (Museo di Storia della Medicina, "Sapienza" Università di Roma)

rest of the body. The foot and the leg can be supported by a soft pillow. As a last option, not completely aligned with Hippocrates's rules of conduct, surgeons can use a ladder. The indications to reduce diaphysial fractures of tibia, fibula, humerus, ulna and radius are also similar; both authors recommend methods of extension with the use of bandages and pulls and in site repositioning of the bone, holding it in the correct position with repeated wrappings at different degrees of pressure (Fig. 1.25). We already mentioned the technique with wooden sticks inside the bandaging that Celsus calls ferulae [94]. A few years ago, one of these ferulae was identified by Luigi Capasso and his team, in the form of partially burnt grapevine wood fragments, on the arm of a child from Ercolano (case E8) with a double fracture of the right forearm, probably occurred 6 or 7 weeks prior August 25th, 79 [95]. In case of jaw fractures, the dislocated teeth must be tied with a gold or silk thread (a dental technique documented on Etruscan bone samples and inherited and well documented in Roman medicine), and then the bone must be immobilized with bandages. Galen suggests a peculiar type of bandage [96]: a strip of Carthage leather is stuck under the chin with some rubber, while another strip is applied starting from the fractured section; the two laces will be tied together on the head; in this way, a permanent traction better guarantees the reduction of the fracture (Fig. 1.26). The indications for the treatment of humerus and ankle fractures, and of dislocations, especially of the humerus, the femur and the vertebrae, are particularly detailed due to two reasons: the importance of reduction and bandaging methods when restraining or immobilizing structures are impossible; the high risk of stiffness and the frequency of irreversible inflammatory processes, that lead to gangrene, sepsis and death of the patient.

D

Fig. 1.26 Jaw bandage, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544

1.2.5 A Rich Set of Tools

In different and complementary ways, both literature and archaeology offer evidence of the tools used for the therapy of orthopaedic lesions. The archaeological findings from the digs in Ercolano, Pompei, the Domus of the Surgeon in Rimini and other sites [97], have allowed to grasp the uses and orthopaedic applications of chisels, bone levers, ostagrae (forceps for bones) cauteries, osteotomes and drills (Fig. 1.27a, b); these tools have survived, at least in their metallic parts, well enough to be evidence of the organizational techniques of ancient surgical tool sets. Other tools, made of wood or of other perishable materials, have only been passed on through their descriptions: among these, the already mentioned orthopaedic bench. This is made up of a board, with side groovings deep enough to fit the levers used as extenders and brakes. The external end is equipped with supports for planks holding in place the ropes tying the patient; the median section has a hole to fit the pole used for counter-extension; two pestles are secured to the two ends of the board, to tie the ropes and achieve a balanced extension [98] (Fig. 1.28). In fractures of the lower limbs, Galen suggests the glossocome, a sort of lime wood crate – its name reminds us of the one of a jewellery box largely employed in the Greek region Attica – with a platform to put the foot on. Two holes at the sides of the board hold the laces used to tie the extremities of the bones to be reduced, and go through hoists, so as to impose a continuous pressure and keep the bones in place. The ropes are composed of two strips each; the ones belonging to the lower rope go through the holes in the board, while the ones used for the upper tying slide through wheels, and reach the pole at the end of the glossocome. The extension is performed by simply turning the wheels to pull in opposite directions. The small boards are only positioned in the middle section of the leg, and in the areas near the joints in general, and not at its extremity, so as to avoid compression, and consequent further inflammation and ulcers [99] (Fig. 1.29). A similar device is described by Celsus for fractures of the femur, the knee and the leg: the bandaged limb is positioned into a canal with two holes for any drainage, and a support blocking the foot from sliding; the sides have holes for the laces tying the tool to the leg. In fracture of the femur, the canal holds the whole limb, from foot to hip, but can also just reach the knee [100]. Another restraining tool is the shower, a wooden concave structure, modelled to hold the leg or parts of it, a sort of premanufactured cast to immobilize it. Specific tools are described, both by Celsus and by Galen, for surgery of exposed fractures, where dressing of the wound is essential, together with the removal of fragments and sharp sections of bone stumps, which might tear the flesh. Galen proceeds to the reduction of the fracture by repositioning the bones using levers to lift and lower the bone stumps during extension; he uses the wedge to remove fragments that might cause further lesions, and the axis wheel [101] (Fig. 1.30). For limb reduction, he uses a tool composed of two leather rings positioned at the ends of the bone to be extended. These rings may be concave or pierced, so they can fit sticks of varying

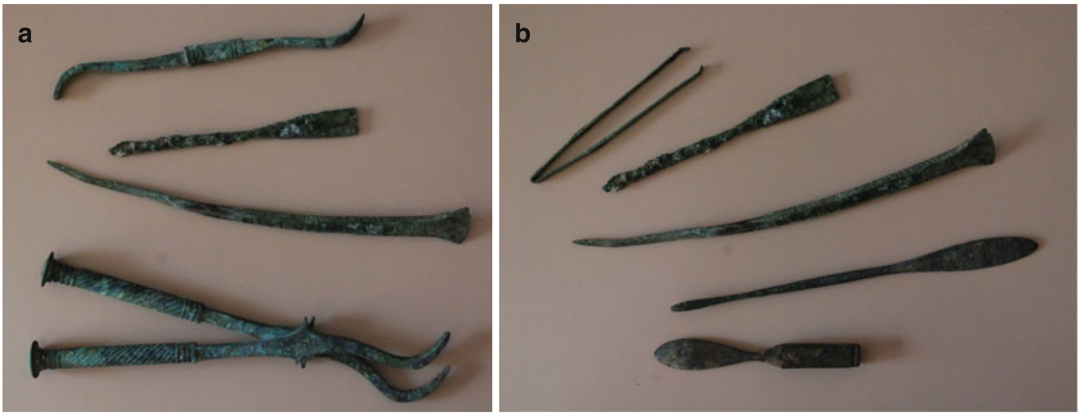


Fig. 1.27 (**a**–**b**) Roman Surgical Instruments, Imperial age (Museo di Storia della Medicina, "Sapienza" Università di Roma)

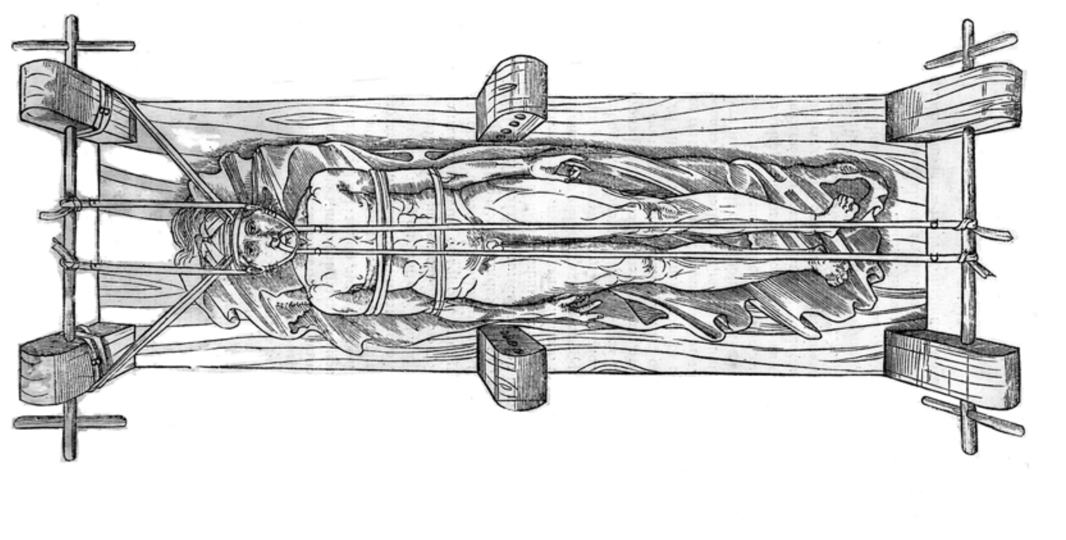
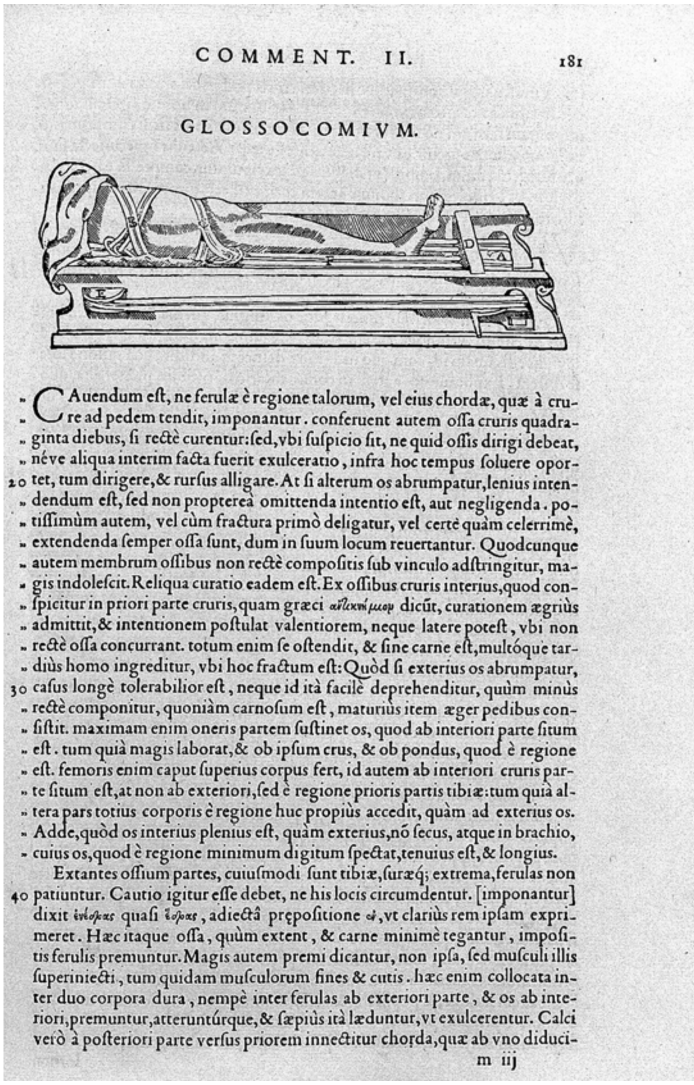


Fig. 1.28 The Hippocratic Scamnum (bench) for the correction of dislocation, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544 (Wellcome Library)

length made of a rather elastic wood, capable of a natural pressure inducing bone extension [102]. Celsus cuts and files the sharp points using chisel and pincers, and inserts a small smooth pole into the wound; the pole naturally pushes the two stumps to distance and align them, and avoid the formation of bone callus. If the bones have stabilized, cutting through the flesh or shortening or deforming the limb too much, the bone callus must be removed, the stumps must be taken out and repositioned, and a bandaging must be wrapped with a stick pressing on the protruding section of the bone to align it [103]. In the most severe compound fractures, even the bandaging might compress the parts too much and sharpen the inflammation, so doctors



COMMENT. II. 181

GLOSSOCOMIVM.

CAuendum eſt, ne ferulæ è regione talorum, vel eius chordæ, quæ à crure ad pedem tendit, imponantur. conferuent autem oſſa cruris quadraginta diebus, ſi rectè curentur: ſed, vbi ſuſpicio ſit, ne quid oſſis dirigi debeat, néve aliqua interim facta fuerit exulceratio, infra hoc tempus ſoluere oportet, tum dirigere, & rurſus alligare. At ſi alterum os abrumpatur, lenius intendendum eſt, ſed non propterea omittenda intentio eſt, aut negligenda. potiſſimùm autem, vel cùm fractura primò deligatur, vel certè quàm celerrimè, extendenda ſemper oſſa ſunt, dum in ſuum locum reuertantur. Quodcunque autem membrum oſſibus non rectè compoſitis ſub vinculo adſtringitur, magis indoleſcit. Reliqua curatio eadem eſt. Ex oſſibus cruris interius, quod conſpicitur in priori parte cruris, quam græci ἀντικνήμιον dicũt, curationem ægriùs admittit, & intentionem poſtulat valentiorem, neque latere poteſt, vbi non rectè oſſa concurrant. totum enim ſe oſtendit, & ſine carne eſt, multóque tardiùs homo ingreditur, vbi hoc fractum eſt: Quòd ſi exterius os abrumpatur, caſus longè tolerabilior eſt, neque id ità facilè deprehenditur, quùm minùs rectè componitur, quoniàm carnoſum eſt, maturiùs item æger pedibus conſiſtit. maximam enim oneris partem ſuſtinet os, quod ab interiori parte ſitum eſt. tum quià magis laborat, & ob ipſum crus, & ob pondus, quod è regione eſt. femoris enim caput ſuperius corpus fert, id autem ab interiori cruris parte ſitum eſt, at non ab exteriori, ſed è regione prioris partis tibiæ: tum quià altera pars totius corporis è regione huc propiùs accedit, quàm ad exterius os. Adde, quòd os interius plenius eſt, quàm exterius, nõ ſecus, atque in brachio, cuius os, quod è regione minimum digitum ſpectat, tenuius eſt, & longius.

Extantes oſſium partes, cuiuſmodi ſunt tibiæ, ſuræq; extrema, ferulas non patiuntur. Cautio igitur eſſe debet, ne his locis circumdentur. [imponantur] dixit [illegible] quaſi [illegible], adiectâ prępoſitione ἐν, vt clariùs rem ipſam exprimeret. Hæc itaque oſſa, quùm extent, & carne minimè tegantur, impoſitis ferulis premuntur. Magis autem premi dicantur, non ipſa, ſed muſculi illis ſuperiniecti, tum quidam muſculorum fines & cutis. hæc enim collocata inter duo corpora dura, nempè inter ferulas ab exteriori parte, & os ab interiori, premuntur, atteruntúrque, & ſæpiùs ità læduntur, vt exulcerentur. Calci verò à poſteriori parte verſus priorem innectitur chorda, quæ ab vno diduci-

m iij

Fig. 1.29 The Glossocomium, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544 (Wellcome Library)

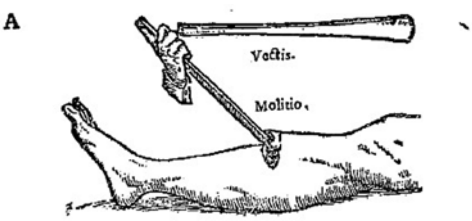


Fig. 1.30 Treating exposed fractures, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544

should only dress the wound, and prescribe fasting, rest and absolute immobilization of the limb. Celsus describes exostotic formations of the bones, which discolour or develop ulcers or fistulas, which can progress and eventually erode them; if this is the case, surgeons must use a cautery, and a tool to curette the bone, and drain the blood. By digging into the cavity as far as the hard part containing black matter, the tissue must be removed until the bone is completely white. For this intervention, Celsus uses the drill or the modiolus (Fig. 1.31); the latter is composed of a pierced stick, fitted with a second stick ending in a metal cylinder with a saw-toothed lower edge. The trephines are screwed into this edge; the handles of the bow are pierced and hold the

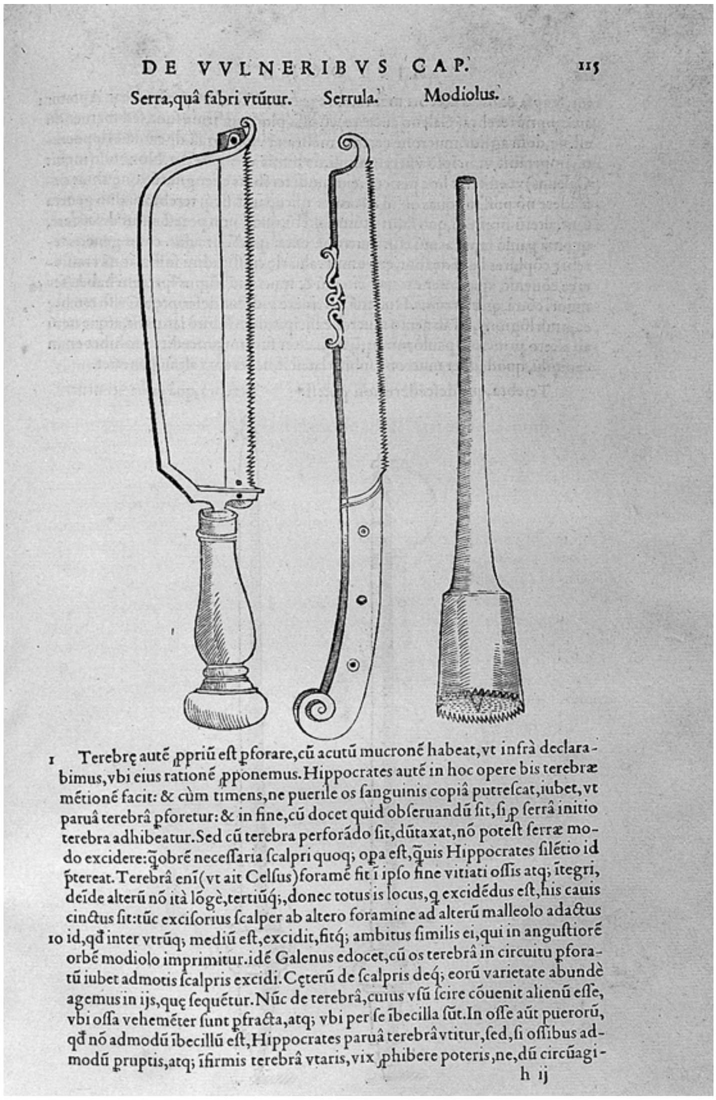


Fig. 1.31 Surgical instruments including Modiolus, from Guido Guidi, Chirurgia e Graeco in Latinum conversa, 1544 (Wellcome Library)

thread turning around the toothed crowns of the drill (it is pulled alternately from both sides to turn the trephines and bore a hole in the part to be removed). For wider and deeper lesions, surgeons use the drill, with a bit which enlarges itself and withdraws a larger amount of bone; some holes are bored around the affected area, so as to remove the whole affected area with a chisel [104]. In patients with recurrent joint dislocations of the humerus, especially if cartilage and bone tissue consumption is present, Galen cauterizes the armpit tissues to bore holes and insert a thin spatula to lift the skin and perform another eschar in the middle, with a thinner cautery, until he touches the shoulder blade. If necessary, some more cauterizations are performed anteriorly, to remove the tissues and directly handle the joint's cap [105].

Given the pain and crudeness involved, ancient medical competence must have been hard to bear, which goes to justify Galen's patients, whom he describes as willing to lie, in order to escape huge suffering [106].

This chapter is the product of collaboration of Valentina Gazzaniga and Silvia Marinozzi, Sapienza – University of Rome and is therefore attributable in equal measure to both the authors.

1.3 Basis of Palaeopathology

Carla Caldarini, Paola Catalano, and Federica Zavaroni

Palaeopathology is a branch of knowledge that studies the diseases of the ancient populations through the observation and examination of the pathological signs detected in the archaeological human remains, generally bone finds. The study of the pathological alterations is also relevant in the anthropological field, because it can indirectly give information on the ancient populations' lifestyle, environment and work and their main hazards.

The understanding and evaluation of palaeopathological data strictly depends on the differential diagnosis of the disease found in the human skeletal samples.

The palaeopathological analysis faces many limitations: first of all, the unavailability of soft tissues, organs, cells, blood and body fluids: the skeleton is only a part of the human body and may not show any trace of the disease affecting the subject during life. Secondly, many different pathologies can affect the bones similarly, which makes the identification of harmful evidence even more difficult. Joint modifications that may first appear as resulting from osteoarthritis, might have other causes instead: traumas, osteomyelitis, gout, haemophilia, psoriasis. A tibial lesion, showing a syphilis-like pattern may well be osteomyelitis due to *Staphylococcus Aureus*, Paget's disease or else [107].

Even a simple periodontal disease, with alveolar retraction, can be the consequence of diet deficiencies, as well as the direct result of poor hygiene [108]. Moreover, many bones can show hypostosis and/or hyperostosis variations (incomplete, failed or excessive ossification) or segment proportion variations: if the morphological differences are mild and do not alter the normal function of an organ, they belong to the wide category of the anatomical variants with little or no pathological relevance [109].

1.3.1 Methods Used in the Examination of the Skeletal Lesions

The first evidence of a disease is shown by a variation in the normal skeletal anatomy; this modification can be an abnormal density, size or shape of the bone, and/or an abnormal formation or destruction of the bone [107]. In human archaeological remains, some of these processes may be either the outcome of *post-mortem* changes (pseudo-pathologies) occurring in the sepulchral environment, or a consequence of problems during and after the excavation, and must not be confused with real pathological processes. Biotic (fungi, bacteria, insects, rodents, plants with their root system) and abiotic (water and sun exposure, ground pH) environmental factors, individual factors (different bone preservation in the same subject or in different subjects), and cultural factors (type of burial and funerary habits) can have significant effects on the state of preservation of human bones [110]. Water and soil can determine the development of concretions on the bone surface that might be confused with reactive modifications of the periosteum; erosive lesions due to fungi might resemble alterations due to osteoclastic activity, and the soil may also be responsible for bone deformation. Frequent *post-mortem* fractures are due to the soil's pressure above the deposition, or to an improper handling of the skeletal remains during and after the excavation. It is therefore of utter importance that experts distinguish between the *ante-* and *peri-mortem* fractures and the *post-mortem* damage. In *ante-mortem* destructive processes, the edges are paler and generally smooth and rounded, and signs of osteoblastic repairing may be present; on the other hand, *post-mortem* lesions are characterized by ragged and irregular edges, with no difference in colour with the other parts of the bone. Once the lesion has been identified as *ante-mortem*, the cause of the abnormality is retraced through the bones' macroscopic examination, the X-ray and electronic microscope examination, and, if possible, the chemical analysis.

The macroscopic observation is generally the first procedure used in the examination of skeletal remains. The first step is to give the most accurate description of the detected alteration, paying attention, as Ortner and Putschar advise [111], to use a clear terminology, to identify the correct location and distribution, and to give a descriptive summary of the abnormal bone morphology.

One example is the word "periostitis", commonly used in palaeopathological literature to define the presence of a bone fusiform hypertrophy [112] affecting the periosteum, which implies an inflammatory process. Since proliferative bone reactions can be caused by a variety of conditions different from inflammation, and the bone macroscopic analysis may not reveal changes in the cortex and/or in the endosteum, a more appropriate word is periostosis. This definition indicates a periosteum hypertrophy without specifying an unsubstantiated cause.

The essential steps of the diagnostic analysis are the cataloguing of the skeletal bones, the description, the location and distribution of the lesions of the subject presenting pathological alterations.

The descriptive analysis has to take into account: if there is only one abnormality with a single pathology focus, if it is bilateral and multifocal, if the alterations are randomly distributed in the skeleton. Moreover, an abnormal reduction of the bone mass in the whole skeleton (even if in different ways) and a local or general modification of the bone size may be present.

Another important consideration to bear in mind is that morbid processes preferentially affect specific bones, or groups of bones, with characteristic locations. Functionally speaking, the skeleton can be divided into axial skeleton (skull, mandible, rachis, ribs and sternum) and appendicular skeleton (pectoral girdles, upper limbs, pelvic girdle, lower limbs). From mid childhood onwards, the axial skeleton is the primary site of blood formation from the marrow, while the appendicular one is the site of fat storage; in skeletal diseases these physiological peculiarities are associated to different patterns of bone involvement and can help the differential diagnosis.

1.3.1.1 Radiological Study of Skeletal Lesions

The imaging techniques applied to bone remains (X-rays and CT) are useful tools in the examination of palaeopathological skeletals and should systematically be employed in the evaluation of the different cases. These techniques, based on differential X-ray absorption depending on tissue density, allow an extremely good analysis of the bone's shape and structure, as well as of the joints' surface. The view can be an orthogonal, oblique and axial view, depending on the need [113, 114]. In addition to the macroscopic evaluation, X-rays examine the bone appearance, its grade of calcification, and structure. If compared with the others, these procedures have an advantage: they are not destructive, and can be used before applying chemical or histological methods. The main information obtained from X examination is the bone tissue involvement and the bone density pattern in the affected area and in its immediate surroundings [115]. For instance, at the macroscopic observation a diaphysis can appear particularly thick with porous tissue and the presence of cloacae. On the contrary, visual examination only does not allow to determine if the medullary space is normal, enlarged or smaller, and the presence of alterations in the cortex. So the imaging techniques are essential to confirm the existence and specify the nature of a bone or joint lesion.

1.3.1.2 Molecular Analysis

There are several types of pathologies identified in the ancient material, and they often do not directly involve the human DNA, but rather the parasites' genetic material. The first pathogenic DNA identified in ancient samples was the *Mycobacterium tuberculosis* [116], soon followed by the *Mycobacterium leprae* [117]. This research has often involved documented epidemic cases, in which the pathogenic microorganisms could have had a crucial role in the pathogenesis [118]. If the preservation and persistence of an ancient bacterial DNA can appear controversial [119], different studies have demonstrated how microorganisms can set up a series of mechanisms which allow them to survive in sub-optimal living conditions, maintaining their genetic material's firmness. Several studies deal with this evidence, among them the analysis of an Israeli grave dated I century A. D.

[120] that represents the first burial, with a proved dating, of an individual suffering from tuberculosis and leprosy, identified at a molecular level. As for the ancient remains, the molecular study has also been useful for the pathogens' molecular identification in archaeological evidence with indefinite palaeopathological diagnosis. In Butrint, an Albanian little town (tenth to thirteenth century A.D.), the anthropological analysis had highlighted round osteolytic lesions on the thoracic and lumbar vertebrae consistent with various pathologies such as tuberculosis or brucellosis, a pathology from the *Brucella sp.* bacterium. The genetic screening on these etiologic agents has allowed identifying the genetic material of *Brucella sp.,* a bacterium easily transmitted with man–cattle contact. This observation has confirmed brucellosis as endemic in the area since the Middle Ages [121]. Finally the whole genome of the *Yersinia pestis* bacterium, isolated from skeletal remains belonging to subjects died during the Plague in 1300 [122], has been lately examined. This research has that there have not been any significant changes in the bacterial sequence if compared with the modern pathogen, which did not explain the reason why the Black Death was so aggressive and virulent in 1300. This epidemic had its onset in Europe in 1347, maybe coming from Asia, and quickly spread over the whole European continent, obliging the governments to set specific burial areas for the numerous deaths. It is from one of these burial areas that the dental elements have been taken as samples to draw the DNA. By a methodological selection of the bacterail genome we managed to ignore the human genetic material and of the environmental contaminants (such as other bacterial forms in the soil) to sequence the whole *Y. pestis* genome, through NGS methods. Without any significant differences among the bacterial strains, the genome analysis has therefore proved that the extreme severity of the Black Death could be ascribed to the epidemiological–environmental conditions of that period [123].

As well as bacteria, some parasites can also be identified through their genetic material preserved during time. Indeed, we are often not only interested in identifying the effects of some parasitic diseases on mummified bodies, but in recovering and analysing the genetic material pertinent to the parasitic agents. One of the pioneering article on the presence of pathologies caused by parasites described Chagas disease, caused by *Trypanosoma sp*., identified by the analysis of the cardiac lesions in mummies from Atacama desert [124]. Since the end of the 1990s a series of studies have begun to identify and isolate *Trypanosomacruzi* DNA, starting from 4000-year-old Peruvian mummies [125]. Further studies have led to various publications on the DNA isolation regarding the parasite even in 9000-year-old Chinchorr mummies [126], which have allowed to identify that Chagas disease was present in pre-Columbian societies and that maybe the prehistoric human groups were in touch with the parasite in different ways [127]. Finally another class of pathologies can be highlighted by the DNA study: tumours. The analysis of the mummified remains belonging to King Ferrante I of Aragon [128] is an example of this use. In this case the mummified body's dissection highlighted a pelvic neoplastic mass. The molecular analysis of ancient tumours gives the precious chance to evaluate the history of neoplasies and compare them to genetic alterations, to lifestyle and environmental risk factors. Because of the limited number of available samples for soft tissue tumours, the case of a King, with his life vivisected in detail by coeval chronicle, is an excellent sample to investigate the role of exogenous elements in the development of carcinogenesis. From a molecular point of view the development of a tumour is connected to the onset of mutations in genes called proto-oncogenes, often linked to the cellular cycle functions. In particular, the proto-oncogenes *K-ras*, especially related to colorectal tumours, if "activated" by mutations [129], and *BRAF* gene, mutated in a wide range of tumoural expressions [130] have been analysed. The achieved findings fitting a mutational pattern in *K-Ras* gene, also implies a mutual exclusion of the mutations in BRAF in colorectal tumours, representing independent elements in the colon carcinogenesis [131].

References

1. Lanciani R, Passeggiate nella Campagna Romana. Rome: Quasar; 1980 (ed. or. London: Wanderings in the Roman Campagna; 1909).
2. Musco S, Petrassi L, Pracchia S, Luoghi e paesaggi archeologici del suburbio orientale di Roma; Roma, 2001.
3. Catalano P, Amicucci G, Benassi V, Caldarini C, Caprara MC, Carboni L, Colonnelli G, De Angelis F, Di Giannantonio S, Minozzi S, Pantano W, Porreca F. Gli insiemi funerari d'epoca imperiale: l'indagine antropologica di campo. In: Tomei MA, editors. Memorie dal sottosuolo. Ritrovamenti archeologici 1980/2006. Ead. Electa, Milano, 2006. p. 560–63.
4. Catalano P, Caldarini C, Minozzi S, Pantano W. La popolazione di alcuni settori del suburbio orientale e meridionale di Roma in età imperiale: antropologia di campo, demografia e struttura sociale. Orizzonti: Rassegna di archeologia; 2003. p. 69–74.
5. Heinzelmann M. Culto dei morti e costumi funerari romani. Introduzione. In: Culto dei morti e costumi funerari romani. Roma, Italia settentrionale e province nord-occidentali. Internationales Kolloquium, Palilia 8, 2001.
6. Duday H. The archaelogy of the dead. Lecture in archeothanatology. Oxford: Oxbow Books; 2009.
7. Canci A, Minozzi S. Archeologia dei resti umani. Roma: Carocci; 2005.
8. Acsádi G, Nemeskéri J. History of human life span and mortality. Budapest: Akadémiai Kiadó; 1970.
9. Ferenbach D, Schwidetzky I, Stloukal M, Raccomandazioni per la determinazione dell'età alla morte e del sesso sullo scheletro. Rivista di Antropologia. 1977–1979; IX: 5–51.
10. Krogman WM, Iscan MY. The human skeleton in forensic medicine. Springfield: Charles C. Thomas; 1986.
11. Bruzek J. A method for visual determination of Sex, using the human Hip bone. Am J Phys Anthropol. 2002;117:157–68.
12. Lovejoy CO. Dental wear in the Libben population: its functional pattern and role in the determination of adult skeletal age at death. Am J Phys Anthropol. 1985;68:47–56.
13. Meindl RS, Lovejoy CO. Ectocranial suture closure: a revised method for the determination of age at death based on the lateral-anterior sutures. Am J Phys Anthropol. 1985;68:57–66.
14. Lovejoy CO, Meindl RS, Pryzbeck TR, Mensforth RP. Chronological metamorphosys of the auricolar surface of the ilium: a new method for the determination of adult skeletal age of death. Am J Phys Anthropol. 1985;68:15–28.
15. Burns KR. Forensic anthropology training manual. Upper Saddle River: Prentice Hall Englewood Cliffs; 1999.
16. Iscan M, Loth S, Wright R. Racial variation in the sternal extremity of the rib and its effect on age determination. J Forensic Sci. 1987;32:452–66.
17. Ubelaker DH. Reconstruction of demographic profiles from ossuary skeletal samples. A case study from the Tidewater Potomac. Smithson Contrib Anthropol. 1974;18:1–79.
18. Ubelaker DH. Human skeletal remains. Taraxacum: Washington, DC; 1989.
19. Krogman WM, Iscan MY. The human skeleton in forensic medicine. Springfield: Charles C; 1986.
20. France DL. Osteometry at muscle origin and insertion in sex determination. Am J Phys Anthropol. 1988;76:515–26.
21. Suchey JM. Skeletal age standards derived from an extensive multi-racial sample of modern Americans. Paper presented at the fifty-fifth A.A.RA. meeting, Albuquerque; 1986.
22. Iscan MY, Kennedy GE. Reconstruction of life from skeleton. New York: Alan R., Inc.; 1989.
23. Martin R, Saller K. Lehrbuch der antropologie. Stoccarda: Fisher-Verlag; 1957.
24. Trotter M, Gleser G. Estimation of stature from long limb bones of American whites and Negroes. Am J Phys Anthropol. 1952;10:469–514.
25. Trotter M, Gleser G. Corrigenda to "estimation of stature from long limb bones of american whites and negroes". Am J Phys Anthropol. 1977;47:355–6.
26. Hillson S. Teeth. Cambridge manuals in archaeology. Cambridge: Cambridge University Press; 1986.
27. Hengen OP. Cribra orbitalia: pathogenesis and probable etiology. Homo. 1971;22:57–75.
28. Manzi G, Sperduti A, Passarello P. Behaviour-induced auditory exostoses in imperial roman society: evidence from coeval urban and rural communities near Rome. Am J Phys Anthropol. 1991;85: 253–60.
29. Goodman AH, Rose JC. Dental enamel hypoplasias as indicators of nutritional status. Adv Dent Anthropol. 1991;5:225–40.
30. Ortner DJ. Identification of pathological conditions in human skeletal remains. San Diego: Academic; 2003.
31. Capasso L, Kennedy KAR, Wilczack CA. Atlas of occupation markers on Human Remains. Teramo: Edigrafital S.p.A; 1999.
32. Bard H, Cotton A, Rodineau J, Saillant G, Railhac JJ. Tendons et enthèses. Montpellier: Sauramps Medical; 2003.
33. Mann RW, Murphy SP. Regional atlas of bone disease. A guide to pathologic and normal variation in the human skeleton. Springfield: Thomas; 1990.
34. Wilczak CA, Kennedy KAR. Mostly MOS: technical aspects of the identification of skeletal markers of occupational stress. In: Reichs KJ, editor. Forensic Osteology II: the next generation. Springfield: Thomas; 1997.

35. Poirier P, Charpy A. Traité d'anatomie humaine, vol. 1. Paris: Masson; 1911.
36. Belcastro MG, Galletti L, Bosi A, Gualdi-Russo E. Before the advent of the ergonomy. The skeletal markers of activity. Atti del 3° International Congress on Science and Technology for the safeguard of Cultural Heritage in the Mediterranean Basin (Alcalà de Henares – Madrid, Spagna (9–14 luglio 2001)): 870–875, 2001.
37. Angel JL. Femoral neck markings and human gait. Anat Rec. 1959;133(2):244.
38. Angel JL. Human gait, hip joint and evolution. Am J Phys Anthropol. 1960;18(4):361.
39. Angel JL. The reaction area of the femoral neck. Clin Orthop Relat Res. 1964;32:130–42.
40. Stirland AJ. Possible correlation between acromiale and occupation in the Burials from the Mary Rose. Paper presented at the 5th European meeting of paleopathology association; Siena; 1985.
41. Messeri P. Note di paleopatologia sui neolitici della liguria. Arch per l'Antropologia e l'Etnologia. 1958;88: 101–19.
42. Messeri P. Morfologia della rotula nei neolitici della Liguria. Arch per l'Antropologia e l'Etnologia. 1961;91:1–11.
43. Fornaciari G, Giuffra V. Lezioni di paleopatologia. Genova: Edizioni Culturali Internazionali Genova; 2009.
44. Kennedy KAR. Skeletal markers of occupational stress. In: Reconstruction of life from the skeleton. New York: Alan R. Liss, Inc; 1989. p. 129–60.
45. Tainter JA. Behavior and status in a middle woodland mortuary population from the Illinois valley. Am Antiq. 1980;45:308–13.
46. Jurmain RD. Degenerative changes in peripheral joints as indicators of mechanical stress: opportunities and limitations. Int J Osteoarchaeol. 1991;5: 247–52.
47. Lovell NC, Dublenko AA. Further aspects of fur trade life depicted in the skeleton. Int J Osteoarchaeol. 1999;9:248–56.
48. Derevenski JRS. Sex differences in activity related osseous change in the spine and the gendered division of labor at Ensay and Wharram Percy, UK. Am J Phys Anthropol. 2000;111:333–52.
49. Slaus M. Biocultural analysis of sex differences in mortality profiles and stress levels in the late Medieval population from Nova Raca. Croatia. Am J Phys Anthropol. 2000;111:193–209.
50. Hawkey DE, Merbs CF. Activity-induced Muscoloskeletal Stress Markers(MSM)and subsistence strategy among ancient Hudson Boy Eskimos. Int J Phys Anth. 1995;5:324–38.
51. Mariotti V, Facchini F, Belcastro MG. Enthesopathies-proposal of a standardized scoring method and application. Coll Anthropol. 2004;28:145–59.
52. Mariotti V, Facchini F, Belcastro MG. The study of entheses: proposal of a standardized scoring method for 23 entheses of the postcranial skeleton. Coll Anthropol. 2007;31:191–313.
53. King H (2001) Greek and Roman medicine. Bristol, Bristol Classical Papers. Dasen V, King H. (2008) La médecine dans l'Antiquité grecque et romaine, BHMS, Lausanne. As regards a specialized set of the Roman medicine topics see at least Aufstieg und Niedergang der römischen Welt, vol. 37. p. 1–3, Wissenschaften (Medizin und Biologie), Hrsg. Wolfang Haase, Berlin-New York, Walter de Gruyter 1993–1996.
54. Maire B, editor. 'Greek' and 'Roman' in Latin medical texts: studies in cultural change and exchange in Ancient medicine. Brill: Leiden; 2014.
55. King H. Health in antiquity. Abington: Routledge; 2005.
56. Gourevitch D. La medicina nel mondo romano. In: Grmek MD, editor. Storia del pensiero medico occidentale. Antichità e Medievo. Roma-Bari: Laterza; 1993.
57. Scarborough J. Pharmacy and drug lore in antiquity: Greece, Rome, Byzantium. Farnham: Burlington Vt, Ashgate Publ; 2010.
58. Sconocchia S. Commento ad alcuni passi dell'Epistula dedicatoria di Scribonio Largo a Callisto. In: Ärzte und ihre Interpreten: Medizinische Fachtexte der Antike als Forschungsgegenstand der Klassischen Philologie. Fachkonferenz zu Ehren von Diethard Nickel. München, Leipzig, KG Saur; 2006. p. 101–16.
59. Nutton V. Healers in the medical market place: towards a social history of Graeco-Roman medicine. In: Medicine in society: historical essays. Cambridge: Cambridge University Press; 1992. p. 15–58. Id. (2004), Ancient medicine. London: Routledge.
60. van der Eijk PH, Horstmanshoff HFJ, Schrijvers PH, editors. Ancient medicine in its socio-cultural context: papers read at the Congress held at Leiden University 13–15 April 1992. Amsterdam-Atlanta: Rodopi; 1995.
61. Mazzini I. La medicina dei Greci e dei Romani, vol. I–II. Roma: Jouvence; 1997.
62. Manetti D, Roselli A. Galeno commentatore di Ippocrate. ANRW, II 37.2, 1994; p. 1531–5. Roselli A. Il commento di Galeno a Sulle fratture. Specimina per la nuova edizione. In: Manetti D, editor. Studi su Galeno. Scienza, filosofia, retorica e filologia, Firenze: Dipartimento di Scienze dell'Antichità «G. Pasquali». p. 93–117.
63. Krug A. La medicina nel mondo classico. Firenze: Giunti; 1990. Baker PA, Carr G. editors. Practitioners, practices and patients: new approaches to medical Archaeology and anthropology. Oxford: Oxbow Books; 2002.
64. Grmek MD, Gourevitch D. Le malattie nell'arte. Firenze: Giunti; 2000.

65. Horden P. Hospitals and healing from antiquity to the later middle ages. Aldershot: Ashgate; 2008.
66. Braccesi L Rimini salutifera. Magia, medicina e Domus del chirurgo. Bologna: Monduzzi; 2008. De Carolis S, Pesaresi V. (a cura di), Medici e pazienti nell'antica Roma. La Domus del chirurgo di Rimini. Rimini: Pazzini; 2009. De Carolis S. (a cura di), Ars medica. I ferri del mestiere. La Domus del Chirurgo di Rimini. Rimini: Guaraldi; 2009.
67. Bliquez l. Roman surgical instruments in the Johns Hopkins University Institute of the History of medicine. Bull Hist Med. 1982;56:195–217. Bliquez l. Roman surgical instruments and other minor objects in the National Archaelogical Museum of Naples. With a catalogue of the surgical instruments in the "Antiquarium" at Pompeii by Ralph Jackson. Mainz: Verlag Philip von Zabern; 1994. Bliquez l. Gynecology in Pompeii, in Ancient medicine in its socio-cultural context. Papers read at the Congress held at Leiden University (13–15 April 1992). Amsterdam: The Wellcome Institute; 1995.
68. Mariani Costantini R, Catalano P, di Gennaro F, di Tota G, Angeletti LR. New light on cranial surgery in ancient Rome. Lancet. 2000;355:305–7.
69. Jackson R. Doctors and diseases in the Roman Empire. London: British Museum; 1988. Gourevitch D. Le mal d'etre femmes. La femme et la médecine à Rome. Paris: Les Belles Lettres; 1984. Ead. Le triangle hippocratique dans le monde greco-romain: le malade, sa maladie et son medecin. Rome: Ecole francaise de Rome; 1984. André J.-M. La médecine à Rome. Paris: Tallandier; 2006. Gourevitch D., Pour une archéologie de la médecine romaine. Paris: De Boccard; 2011. Ead. Limos kai loimos. A study of the Galenic plague.Paris: De Boccard; 2013. Mudry PH. Medicina, soror philosophiae. Regards sur la littérature et les textes médicaux antiques (1975–2005). BHMS; 2006. p. 207–31.
70. Gazzaniga V. La medicina antica. Roma: Carocci; 2014.
71. Majno G. The healing hand. Cambridge: Harvard University Press; 1975. Pape HC, Webb LX, History of open wound and fracture treatment. J Orthop Trauma. 2008;22(10):S133–4.
72. Nutton V. Ancient medicine. London: Routledge; 2004.
73. Jackson R. Holding on to health? Bone surgery and instrumentation in the Roman Empire. In: King H, editor. Health in antiquity. Routledge: London; 2005. p. 97–120.
74. Jouanna J. Hippocrate. Paris: Fayard; 1995. Livingstone MC. Hippocratic principles in orthopedics. Orthop Rev. 1988;17(11):1122–27.
75. CH, Med. 14. See Jouanna J., op. cit., p. 96.
76. Jackson R. Holding on to health? Bone surgery and instrumentation in the roman Empire. In: King H, editor. Health in antiquity. London: Routledge; 2005. p. 97–119. Id. 'Lo strumentario chirurgico della domus riminese'/'The surgical instrumentation of the Rimini domus'. In: S. De Carolis, editors. Ars medica. I ferri del mestiere. La domus 'del chirurgo' di Rimini e la chirurgia nell'antica Roma. Rimini: Guaraldi; 2009. p. 73–91.
77. CH, Fr. 30. Cfr Jouanna J., op. cit. p. 98 sgg.
78. CH, Art. 70. Debru A., Scienza greco-romana. Pensiero medico e pratica della medicina nei trattati ippocratici. In: Storia della Scienza online, Treccani; 2001.
79. Milne JS. Surgical Instruments in Greek and Roman Times. Oxford: Clarendon; 1907. p. 122.
80. Capasso L, Angeletti LR. History of medicine and prehistoric orthopedics. Med Secoli. 1994;6(1):71–86.
81. Capasso L. I fuggiaschi di Ercolano. Paleobiologia delle vittime dell'eruzione vesuviana del 79. Roma: l'Erma di Bretschneider; 2001.
82. Mazzini I., La chirurgia celsiana nella storia della chirurgia greco-romana. In: Sabbah G, et Mudry Ph, editors. La médecine de Celse. Aspects historiques, scientifiques et littéraires. Centre Jean -Palerne, Mémoires XIII; 1994. p. 135–65, in part. p. 137.
83. Celsus, De medicina, L. VIII. As regards as the link between Celsus and his lost Alexandrian and Roman sources, see Marganne MH, La réduction des luxations de l'épaule dans le De medicina de Celse. In: Sabbah G. et Mudry Ph, éditors. La médecine de Celse, Centre Jean Palerne, Mèmoires XIII, Saint-Etienne; 1994. p. 123–27.
84. Marganne MH, op. cit., pp. 125 sgg.
85. Galen, De Semine, I, K. IV: 512–593
86. Celsus, De med. III, 513. See Rocca J., Galen and the uses of trepanation. In: Arnott R, Finger S, Smith C, editors. Trepanation: history, discovery, theory. Lisse, Swets and Zeitlinger; 2003. p. 253–71.
87. Tullo E. Trepanation and Roman medicine: a comparison of osteoarcheological remains, material culture and written texts. J R Coll Physicians Edinb. 2010;40:165–71.
88. Celsus, De med. XVIII, 15; Galen, De articulis, IV, 40–62 – K. XVIII/A: 731–754
89. The concept of pathocenosis has been firstly proposed by Mirko D. Grmek; it means the set of dominant diseases in a specific historical period and in a specific geographical area. Grmek M.D., Le malattie all'alba della civiltà occidentale. Bologna: Il Mulino, repr; 2011.
90. Rocca J. Galen and the uses of trepanation. In: Arnott R, Finger S, Smith C, editors. Trepanation: history, discovery, theory. Lisse: Swets and Zeitlinger; 2003. p. 253–71.
91. Mariani Costantini R, Catalano P, di Gennaro F, di Tota G, Angeletti LR. New light on cranial surgery in ancient Rome. Lancet. 2000;355:305–7.
92. Galen, De articulis, IV, 40–62 – K. XVIII/A: 746–754; De fracturis, II, 39–60 – K. XVIII/B: 476–495.
93. Celsus, XVIII, 15; Galen, De Articulis, I, 7–22 – K. XVIII/A: 313–345; IV, 40–62 – K. XVIII/A: 731–744; De fracturis, II, 39–60 – K. XVIII/B: 476–495.
94. Celsus, VIII, 10,2.
95. Capasso L., op. cit., ref. 81.
96. Galen, De articulis, II, 24–29 - K. XVIII/A: 453–459.

97. Bliquez L. Greek and roman medicine. Archaeology 1981;34(2):10–17. Kuenzl E. Medizinische instrumente aus Sepulkralfunden der roemischen Kaiserzeit. Cologne: Rheinland Verl; 1983. Jackson R. Doctors and diseases in the Roman Empire. Norman and London: University of Oklahoma Press; 1988. Id. Roman doctors and their instruments: recent research into ancient practice. J Roman Archaeology 1990;3: 5–27. Id. The surgical Instruments, Appliance and Equipment in Celsus' De medicina. In: Sabbah G., Mudry Ph, éditors, La médecine de Celse, op. cit. p. 167–209. Id. The composition of roman medical instrumentaria as an indicator of medical practice: a provisional assessment. In: van der Eijk Ph, Horstmannshoff HFJ, Schrijvers PH, (editors), Ancient medicine in its socio-cultural context. Rodopi: Amsterdam and Atlanta. p. 189–208. Baker P. Archaelogical remains as a source of evidence for roman medicine. UCL, 27 online http://www.ucl.ac.uk/~ucgajpd/medicina%20antiqua/sa_ArchaeologicalRemains.pdf. Id. Diagnosing some ills: the archaeology, literature and history of roman medicine. In: Baker P, Carr G, editors. Practitioners, practices and patients: new approaches to medical archaelogy and anthropology. Oxford: Oxbow Press; 2002. p. 16–29. Id. Roman medical instruments: archaeological interpretations of their possible 'nonfunctional' uses. Soc Hist Med 2004;17(1): 3–21. Kosmidis IA. et al. Orthopedic medical instruments: from antiquity to modern times. J Trauma and Acute Care Surg 2013;74(2): 692–98.
98. See ref. 88.
99. Galen, De fracturis, II, 62–66 – K. XVIII/B: 497–510; De usu partium, VII, 3 – K. III: 573–6; De Methodo Medendi, IV, 5 – K. X: 442–444
100. Celsus, VIII; 10, 5.
101. Galen, De Fracturis, III, 38–40 – K. XVIII/B: 590–594
102. Galen, De Fracturis, III, 27–32 – K. XVIII/B: 573–583; Celsus, VIII, 10,7; 25.
103. Celsus, VIII, 10,7.
104. Celsus, VIII, 2,1.
105. Galen, De Articulis, I, 40–53- K. XVIII/A: 374–390.
106. Gourevitch D. I giovani pazienti di Galeno. Roma-Bari: Laterza; 2001.
107. Ortner DJ. Identification of Pathological condition in human skeletal remains. New York: Smithsonians Institution Press; 2003.
108. Larsen CS. Bioarchaeology. Cambridge: Cambridge University Press; 1997.
109. Borgognini Tarli S, Pacciani E. I resti umani nello scavo archeologico. Metodiche di recupero e studio. Roma: Bulzoni; 1993.
110. Pinhasi R, Mays S. Advances in human paleopathology. Chichester: Wiley & Sons Ltd; 2008.
111. Ortner DJ, Putschar WGJ. Identification of pathological condition in human skeletal remains. New York: Smithsonians Institution Press; 1985.
112. Resnick D, Niwayama G. Diagnosis of bone and joint disorders, 3rd. Philadelphia: Saunders; 1995.
113. Ballinger P, Frank E. Merrill's atlas of radiographic positions and radiologic procedures. St. Louis: Mosby; 1999.
114. Bontrager K. Textbook of radiographic positioning and related anatomy. St. Louis: Mosby; 1997.
115. kÖhler A, Zimmer EA. Limiti del normale ed inizio del patologico nella diagnostica radiologica dello scheletro. Milano: Casa EditriceAmbrosiana; 1986.
116. Ricaut FX, Auriol V, von Cramon-Taubadel N, Keyser C, Murail P, Udes B, Crubézy E. Comparison between morphological and genetic data to estimate biological relationship: the case of the EgyinGol necropolis (Mongolia). Am J Phys Anthropol. 2010;143:355–64.
117. Spigelman M, Lemma E. The use of the polymerase chain reaction (PCR) to detect Mycobacterium tuberculosis in ancient skeletons. Int J Osteoarchaeol. 1993;3:137–43.
118. Rafi A, Spigelman M, Stanford J, Lemma E, Donoghue H, Zias J. Mycobacterium leprae DNA from ancient bone detected by PCR. Lancet. 1994;343:1360–1.
119. Willerslev E, Hansen Anders J, Rønn R, Brand TB, Barnes I, Wiuf C, Gilichinsky D, Mitchell D, Cooper A. A Long-term persistence of bacterial DNA. Curr Biol. 2004;14(1):R9–10.
120. Matheson CD, Vernon KK, Lahti A, Fratpietro R, Spigelman M, Gibson S, Greenblatt CL, Donoghue HD, Zissu B. Molecular Exploration of the First-Century Tomb of the Shroud in Akeldama. Jerusalem. PLoS One. 2009;4, e8319.
121. Mutolo MJ, Jenny LL, Buszek AR, Fenton TW, Foran DR. Osteological and molecular identification of brucellosis in ancient butrint. Albania. Am J Phys Anthropol. 2012;147:254–63.
122. Schuenemann VJ, Bos K, Dewitte S, Schmedes S, Jamieson J, Mittnik A, Forrest S, Coombes BK, Wood JW, Earn DJ, White W, Krause J, Poinar HN. Targeted enrichment of ancient pathogens yielding the pPCP1 plasmid of Yersinia pestis from victims of the Black Death. Proc Natl Acad Sci UA. 2011;108:746–52.
123. Bos KI, Schuenemann VJ, Golding GB, Burbano HA, Waglechner N, Coombes BK, Mcphee JB, Dewitte SN, Meyer M, Schmedes S, Wood J, Earn DJ, Herring DA, Bauer P, Poinar HN, Krause J. A draft genome of Yersinia pestis from victims of the Black Death. Nature. 2011;478:506–10.
124. Rothhammer F, Allison MJ, Nuñez L, Staden V, Arriza B. Chagas disease in pre-Columbian South America. Am J Phys Anthropol. 1985;68:495–8.
125. Guhl F, Jaramillo C, Vallejo GA, Yockteng R, Cardenas-Arroyo F, Fornaciari G, Arriaza B, Aufderheide AC. Isolation of T. cruzi DNA in 4.000-year-old mummified human tissue from northern Chile. Am J Phys Anthropol. 1999;108:401–7.
126. Aufderheide AC, Salo W, Madden M, Streitz J, Buikstra J, Guhl F, Arriaza B, Renier C, Wittmers LEJR, Fornaciari G, Allison M. A 9,000-year record

of Chagas' disease. Proc Natl Acad Sci U S A. 2004;101:2034–9.
127. Emperaire L, Romaña CA. Triatominae et Cactaceae: un risque pour la transmission de la trypanosomose Americainedans le peridomicile (Nord-Est duBresil). Parasite. 2006;13:171–8.
128. Ottini L, Falchetti M, Marinozzi S, Angeletti LR, Fornaciari G. Gene-environment interactions in the pre-Industrial Era: the cancer of King Ferrante I of Aragon (1431–1494). Hum Pathol. 2011;42:332–9.
129. Castagnola P, Giaretti W. Mutant Kras, chromosomal instability and prognosis in colorectal cancer. Biochim Biophys Acta. 1756;2005: 115–25.
130. Cho NY, Choi M, Kim BH, Cho YM, Moon KC, Kang GH. Braf and Kras mutations in prostatic adenocarcinoma. Int J Cancer. 2006;119:1858–62.
131. Ogino S, Goel A. Molecular classification and correlates in colorectal cancer. J Mol Diagn. 2008;10:13–27.

2 Study and Data Description

Carla Caldarini, Paola Catalano, Andrea Piccioli,
Maria Silvia Spinelli, and Federica Zavaroni

2.1 Data Description

Carla Caldarini, Paola Catalano and Federica Zavaroni

This study examines the inhumed individuals of ten Imperial Age Roman graveyards (Fig. 2.1), from several different areas of the Suburb, and concentrates on subjects affected by pathological phenomena of great scientific interest.

2.1.1 Castel Malnome

The necropolis of Castel Malnome [1, 2], dating back to between I and II century A.D., extends for about 3,000 m^2 on a sandy hill, near Ponte Galeria, close to the Via Portuense.

The graveyard excavation has unearthed 289 subjects, most of them inhumed, in a good state of preservation. The anthropological laboratory examination on 265 subjects, indicates a humble-class reference population, characterized by a sharp preponderance of male adults. The presence of clear stress markers due to hard work, has suggested the connection with the old Roman saltworks, found during the recent excavations in the nearby areas. One hundred and fifty-seven cases from the sample have been subjected to further palaeopathological examinations.

2.1.2 Collatina

The most numerically representative sample comes from the necropolis of Collatina [3–5], between Via della Serenissima and Via Basiliano, at about 3.5 km from the Aurelian Walls, having its northern border in the urban section of the A24 highway, and Via Prenestina as its southern border (Fig. 2.2). The necropolis, near the old Via Collatina, is composed of many pit graves and funeral monuments. The excavation of this graveyard, of likely urban fruition, has unearthed 2,164 subjects of both genders and of every age. The laboratory analysis has been currently carried out on a sample of 800 subjects, 19 of which re-examined from a palaeopathological point of view.

2.1.3 Casal Bertone

In the area of Casal Bertone, in an eastern Roman suburb delimited by the Via Tiburtina to the north and the Via Prenestina to the south, an extensive archaeological research, prior to the implementation of the High Speed Train Railway, has unearthed several archaeological finds most likely related to one another [6, 7]: to the north, five funeral structures standing aligned

A. Piccioli et al., *Bones: Orthopaedic Pathologies in Roman Imperial Age*,
DOI 10.1007/978-3-319-19485-1_2

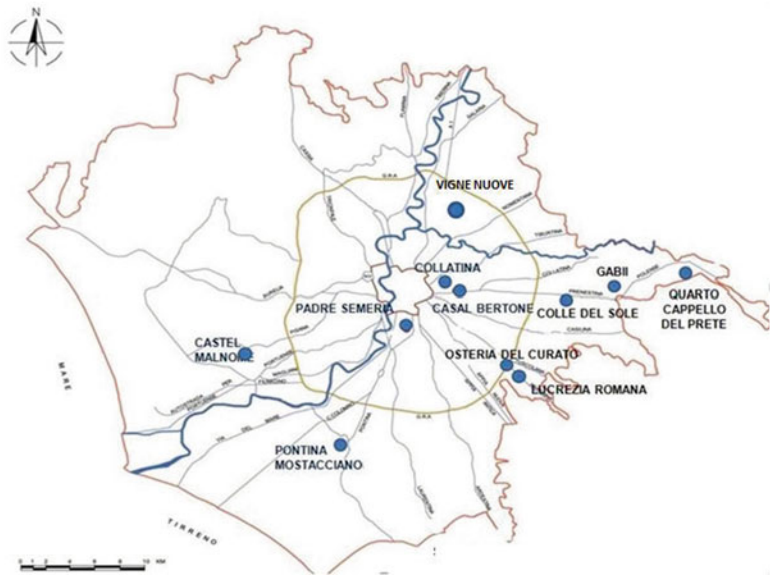


Fig. 2.1 Location of the examined graveyards

Fig. 2.2 Aerial view of the Collatina necropolis

next to a wide production plan, identified as a *fullonica*, and lying close to a road track (Fig. 2.3); to the east, the plan of a big villa, composed of a residential area and a monumental nymphaeum; to the south, a funerary area with a "sub divo" necropolis and a mausoleum; finally, to the west, a group of structures of uncertain identification. Overall, 221 subjects have been found, 190 of which are analysed in the laboratory. Among these, 28 have been re-examined from a palaeopathological point of view.

Fig. 2.3 Hot-air balloon view of the Casal Bertone site

The incidence of enthesopathic lesions and traumas, found in both sexes, as in the sub-adult section of the sample, suggests a reference population employed in hard work jobs, thus hypothesizing a link between the funerary complex and the nearby *fullonica*.

2.1.4 Padre Semeria

The necropolis in Via Padre Semeria [7], a side street off Via Cristoforo Colombo, is in the south of the Urbs, just outside the Aurelian Walls. The archaeological investigation has unearthed a total of 114 *sub divo* monuments and sepulchral sections, chronologically dating back to II and III century A.D. The laboratory anthropological analysis has been performed on 107 inhumed, 15 of which show noteworthy pathologies.

2.1.5 Osteria del Curato and Lucrezia Romana

This area is in the south-east quadrant of the Suburb, along the Via Tuscolana, close to the Grande Raccordo Anulare. The excavations have identified various sepulchral units, unearthing 410 subjects (Figs. 2.4 and 2.5). The uncovered sepultures are likely related to the agricultural buildings of the nearby villas Lucrezia Romana and Sette Bassi and so linked to the slave and wage worker units employed in the *praedium*, as the archaeological evidence seems to suggest [8–10]. The laboratory

Fig. 2.4 Panoramic view of the Osteria del Curato site

anthropological study has involved 223 subjects, 124 of which are re-examined from palaeopathological point of view.

2.1.6 Gabii

The archaeological park of the ancient Latin town of Gabii, is situated 20 km far from Rome, at the 12th mile of the ancient Via Prenestina. The ancient built up area stood on the southern ridge of the volcano of Castiglione, off-centred from the Alban Hills volcanic complex, containing a volcanic lake dried up in the nineteenth century. The 53 examined subjects from the Imperial Age (18 of which have been selected for the palaeopathological examination), come from the so-called Eastern Sanctuary, just east of the ancient town walls, clearly connected to a road track going to Tibur [11].

2.1.7 Quarto Cappello del Prete

The area known as Piano di Castiglione-Quarto Cappello del Prete [11] lies at about 1.5 km east of the town of Gabii, along the Via Prenestina Polense (Figs. 2.6 and 2.7). The necropolis lies in the furthermost south-west quadrant of the site and extends to the west of a monumental rectangular structure. The site, which covers a 40,000 m^2 area, is composed of a series of north to south oriented buildings, most of which related to water management. Seventy per cent of the 120 examined subjects are children and young-age burials, most of which died under the age of 6.

2.1.8 Pontina – Mostacciano

The area, lying between the Via di Decima to the south/south-west and the Via Pontina to the north/north-east, is characterized by the presence of a long section of the ancient Via Laurentina and of 49 burials lying near the road. The graves are chronologically dated back to I–II century A.D. (Fig. 2.8).

2.1.9 Colle Del Sole

The site is near the Via Prenestina, at about 4 km from the Grande Raccordo Anulare. After an initial phase of agricultural exploitation of the area, characterized by the presence of plantation trenches and drainage canals, the burial period produced a small unit with 11 graves, chronologically dated back to the full Imperial Age (Fig. 2.9).

2.1.10 Via Delle Vigne Nuove

The sepulchral unit, in the north-east area of the Roman Suburb and near the Grande Raccordo Anulare, has unearthed 13 inhumation burials dating back to the full Imperial Age.

The graves lie close to the ancient Via *Patinaria*, now called Via delle Vigne Nuove, between the Via Nomentana and the Via Salaria.

Fig. 2.5 Hot-air balloon view of one of the graveyards, Lucrezia Romana

Fig. 2.6 Hot-air balloon view of one of the burial sites, Quarto Cappello del Prete

Fig. 2.7 Hot-air balloon view of one of the burial sites, Quarto Cappello del Prete

Fig. 2.8 Grave 46 Pontina Mostacciano, tibio-talar ankilosis left limb

Fig. 2.9 Grave 1 Colle del Sole, fracture with left radius and ulna fusion

2.2 Inclusion Criteria

Andrea Piccioli and Maria Silvia Spinelli

The challenging aim of palaeopathology is to detect pathologies in bone remains, in order to assess a diagnosis or look for an aetiology. Several palaeopathological studies have focused on the Roman Imperial Age, but what makes this study unique and innovative is that the investigation on the human remains is shared by anthropologists and orthopaedists.

Both these experts have intruded into a different area of expertise from their own, in order to add new elements, and draw new cultural stimuli and a new interpretation of the pathology from the other branch, which is similar and distinct at the same time.

The aim of this work is not to write a masterful book on palaeopathology, as the well-known ones by Donald J. Ortner [12] or Aufderheide and Rodriguez-Martin [13], whose contribution to this scientific discipline is still the cornerstone of the experts' work; its aim is to allow the two sciences of anthropology and orthopaedics to talk to each other, with no time distance between the bone remains and the living, in an attempt to evaluate the pathologies of the bones, or those that left their signs in the bones, due to the functional or quality of life alteration on the subject.

The orthopaedic contribution to the palaeopathological study of the ancient bone remains has introduced the interpretation of some "signs" also due to the latest understanding in the orthopaedic field, as for the diagnosis of femoroacetabular impingement (Castel Malnome, T. 250), which is also new to contemporary orthopaedists [14]. The strictly palaeopathological study has shown today's orthopaedists some incredibly interesting images, and healing processes, dating back to an era with very limited therapeutic and surgical possibilities.

Orthopaedics itself did not exist, because it was born in 1741 thanks to Nicolas Andry; however, many recovery cases shown in this book, above all of fractures, imply the knowledge of the basic principles of bone reduction and healing.

The study has brought out the different points of view on the investigation of bone remains when the two sciences, anthropology and orthopaedics, have faced each other. Even though the many different bone alterations had undergone a palaeopathological examination, they did not have an equivalent word or meaning in the orthopaedic field. One example is "enthesitis", a word referring to the alterations left on the bone by the tendinous insertions, either in a proliferative (calcification of the entheses), or a destructive, way (osteolysis, as in the rhomboid fossa on the clavicle). Finding these signs on the bone segment provides a valuable tool to retrace, for example, working, life style, and motor habits; from an orthopaedic point of view, however, they are of little importance, and do not represent a diagnostic clue in the definition of a pathology with a functional impact on daily life.

The population sample studied in this project belongs to a selection from excavations led by several teams of anthropologists, in particular since the late 1990s under the aegis of the Antropological Service of Soprintendenza Speciale per il Colosseo, il Museo Nazionale Romano e l'Area Archeologica di Roma. We examined ten Roman graveyards, and unearthed 3,448 subjects from the Imperial Age (I–III century).

The anthropologists have carried out a macroscopic examination on the remains of 1,774 subjects taken from this wide population sample, in order to detect ortho-traumatological, or other origin, bone pathologies (such as metabolic or neoplastic diseases), which have left their signs on the bone segment.

The selection has been performed following some criteria of morphometric and morphological macroscopic examination.

This chapter will describe the inclusion criteria and the selection's limitations with reference to the cases presented in the following chapters.

The first narrowing of the final population has been based on the sample's state of preservation. The subjects with at least 1/3 of the skeleton in a good state of preservation have been included. A good state of preservation means the presence of at least 2/3 of the whole segment of long bones, and the possibility to identify the segment itself.

Inclusion criteria	
Historical	I–III century
Topographic	Rome Suburbium
State of preservation	1/3 of the entire skeleton in a good state of preservation
	2/3 of the whole segment
Palaeopathological criteria	Morphological and morphometric alterations
Orthopaedic criteria	Lesion suggesting a functional impairment and a reduction of quality of life

The subjects with less than 1/3 of the whole skeleton have been included in the study only if one or more of its segments showed signs of undoubted bone alteration, for example of traumatological origin (fracture, consequence of fracture, pseudoarthritis, dislocation, etc.). The reason for this selection criterion is that the distribution of the bone alteration, and its site on a segment or another, are indispensable to diagnose many systemic bone diseases (haematological tumours, infections, metabolic diseases, carcinoma metastases). In the absence of this type of evaluation, there is a completely uncertain and confounding diagnosis.

Our analysis originated from Donald J. Ortner's words: "The variations in the regular anatomy of a bone are the initial evidence of the disease"; however, not all bone alterations are a sign of pathology, and they are not always sufficient to reach a diagnosis.

The first screening was carried out through a macroscopic examination, following Donald J. Ortner' s criteria [12]:

1. Abnormal bone formation
2. Abnormal bone destruction
3. Abnormal bone density
4. Abnormal bone size
5. Abnormal bone shape

The last criterion has been redefined with the following items:

- Alteration in length, rotation, and angular deformity of the sample on the segment's sagittal and coronal plane
- Alterations of the periosteum
- Alteration in the normal anatomical profile of the segment
- Variations in vertebral height

This screening clearly rules out all those intramedullary pathologies, which do not involve a macroscopic modification of the bone, such as all the intramedullary new and etero-formations (enchondromas, angiomas, etc.) and also all those fractures which healed with no consequences or complications.

One example can be found in a subject's pelvis (Lucrezia Romana II, T. 98), where the morphological study suggested a diagnosis of fracture of the iliac wing also affecting the acetabular roof. CT scan on the anatomical section, however, has shown the presence of a calcific lesion at the ischial tuberosity (Fig. 3.21).

Another example can be found in the subject with periacebular calcific tissue affecting the proximal section of the femur, and with fusion of the femoral head with the acetabulum (Castel Malnome, T. 277), where the imaging analyses have also suggested the presence of an intramedullary chondroid calcified lesion at the distal third of the femur, most common site of enchondromas or low-degree chondrosarcomas (Fig. 6.37).

Some bone segments, such as the fibula, often show alterations of the periosteum or of the cortex, which make the diagnosis very difficult. The same is true for many superficial osteolyses, which meet the above-mentioned inclusion criteria, but do not identify a specific pathology, or alteration in the quality of life (e.g. the osteolytic lesion of the middle third of the clavicle, known as rhomboid fossa).

Following these criteria, the anthropological analysis of the population selected 563 subjects, who subsequently underwent the orthopaedic study for a confirmation or refutation of the diagnosis.

All those cases where the detected sign could be related to an impairment of functional activity or to a decreased quality of life have been included in the orthopaedic examination. According to us, the definition of choice for the term "disease" is the following: "A morbid condition impairing a function or the quality of life of a subject with different degrees of severity".

The orthopaedic investigation involved in this work requires a peculiar reasoning, which is different from what experts normally do. Rather than starting from a clinical picture, assuming first, and then confirming, the signs of the bone pathology with clinical and imaging studies, the orthopaedic examination on these remains has been carried out interpreting the signs left by the pathology (in many cases signs of its structural consequences, as in healed fractures) and assuming, and reconstructing, the degree of limitation that justified the definition of the morbid state.

The orthopaedic examination has been supported by X-rays and CT scans, in the most complex and unclear cases. CT examination has been essential for new-formation lesions (suspected primary bone tumours) or traumatic pathologies affecting the joint, to allow a better study of the anatomical endangerment. It has also been of great support for intramedullary lesions, some of which would have easily eluded the macroscopic examination, as they represented a random find. Among these, the most common ones are the calcific lesions. On the other hand, Nuclear Magnetic Resonance (NMR) studies have been impossible, because of the dehydration of the bone remains.

The case records show a selection of cases, which have been grouped according to category of pathology (traumatic, degenerative, oncological, metabolic), and the most significant ones from a macroscopic and imaging point of view have been further selected for this work. The oncological cases are particularly interesting due to the presence of pathologies, which are still very rare nowadays, such as parosteal osteosarcoma of the distal tibia (see Sect. 5.3). The cases with the biggest diagnostic uncertainty have needed an additional evaluation by consultant radiologists and data both from the palaeopathological and the orthopaedic current literature.

References

1. Catalano P, Benassi V, Caldarini C, Cianfriglia L, Mosticone R, Nava A, Pantano W, Porreca F. Attività lavorative e condizioni di vita della comunità di Castel Malnome (Roma, I-II sec. d.C.). Med Secoli. 2010;22(1–3):111–28.
2. Catalano P, Caldarini C, Mosticone R, Zavaroni F. Il contributo dell'analisi traumatologica nella ricostruzione dello stile di vita della comunità di Castel Malnome (Roma, I-II sec. dC). Med Secoli. 2013; 25(1):101–18.
3. Buccellato A, Musco S, Catalano P, Caldarini C, Pantano W, Torri C, Zabotti F. La nécropole de Collatina. Les Dossiers d'Archéologie. 2008;330: 22–31.
4. Buccellato A, Catalano P, Musco S, Alcuni aspetti rituali evidenziati nel corso dello scavo della necropoli Collatina (Roma). In: Scheid J, editor. Pour une archéologie du rite: nouvelles perspectives de l'archéologie funéraire, vol. 407. Collection de l'École Française de Rome; 2008. p. 59–88.
5. Catalano P, Caldarini C, Pantano W. Necropoli Collatina, Via Basiliano, Il Mausoleo, Appendice antropologica. In: Tomei MA, editor, Memorie dal sottosuolo. Ritrovamenti archeologici 1980/2006. Milano: Electa; 2006. p. 341
6. Musco S, Catalano P, Caspio A, Pantano W, Killgrove K. Le complèxe archéologique de Casal Bertone. Les Dossiers d'Archéologie. 2008;330:32–9.
7. Benassi V, Buccellato A, Caldarini C, Catalano P, DE Angelis F, Egidi R, Minozzi S, Musco S, Nava A, Pantano W, Paris R, Pescucci L. La donna come forza lavoro nella Roma imperiale: nuove prospettive da recenti scavi nel Suburbio. Med Secoli. 2011;23(1):291–305.
8. Egidi R. Un'area suburbana alle pendici dei colli albani. In: Tomei MA, editor. Memorie dal sottosuolo. Ritrovamenti archeologici 1980/2006. Milano: Electa; 2006. p. 360–403.
9. Catalano P, Arrighetti B, Caldarini C, Colonnelli G, Di Bernardini M, Di Giannantonio S, Pantano W. L'antropologia di campo nella zona di Osteria del Curato. In: Egidi R, Catalano P, Spadoni D, editors. Aspetti di vita quotidiana dalle necropoli della via Latina – Località Osteria del Curato. Roma: Electa; 2003. p. 65–7.
10. Catalano P, Minozzi S. Studio antropologico del materiale rinvenuto negli scavi di Osteria del Curato (I e II). In: Egidi R, Catalano P, Spadoni D, editors. Aspetti di vita quotidiana dalle necropoli della via Latina – Località Osteria del Curato. Roma: Electa; 2003. p. 57–64.
11. Musco S, Tra la Via Tiburtina e l'autostrada Roma-Napoli, L'attività della Soprintendenza Archeologica di Roma. In: Tomei MA, editor. Memorie dal sottosuolo. Ritrovamenti archeologici 1980/2006. Milano: Electa; 2006. p. 278–328.
12. Donald OJ. Identification of pathological conditions in human skeletal remains. 2nd ed. Academic: Elsevier; 2003. Hardcover use pre formatted date that complies with legal requirement from media matrix.
13. Aufderheide AC, Rodriguez Martin C. The Cambridge encyclopedia of human paleopathology. Cambridge: Cambridge University Press; 1998.
14. Ganz R, Leunig M, Leunig-Ganz K, Harris WH. The etiology of osteoarthritis of the hip: an integrated mechanical concept. Clin Orthop Relat Res. 2008;466(2):264–72.

Part II

Clinical Cases

3 Traumatic Pathologies

Carla Caldarini, Paola Catalano, Andrea Piccioli,
Maria Silvia Spinelli, and Federica Zavaroni

3.1 Introduction

Carla Caldarini, Paola Catalano, Andrea Piccioli,
Maria Silvia Spinelli and Federica Zavaroni

3.1.1 Historical Development of Osteosynthesis Techniques

For years, the most important principle in the treatment of fractures has been to create appropriate conditions for recovery, which in most cases followed alignment and immobilization. The first techniques in the surgical treatment of fractures were developed at the end of the eighteenth and the beginning of the nineteenth century, and the first fracture osteosynthesis using an iron wire was described in 1827 by Rodgers. The use of cerclage wires to fix fractures has remained popular over time: Malgaigne treated Flaubert for his fracture of the humeral diaphysis using a metallic suture in 1839 [1]. Later on, Lister started using metallic wires to fix fractures in 1870, then Trendelenburg adopted this technique in Germany, and Lucas Championnière in France [2–4]. In all of these cases, "osteosynthesis" meant an open reduction of the fracture followed by a very unstable fixation with cerclage wires. This method involved the combination of the disadvantages associated with conservative treatment, and the risks associated to surgery.

History of Medicine: Fracture Care
Valentina Gazzaniga and Silvia Marinozzi

Displacements, due to dislocations or bone fracture, are firstly treated with extension trying to set the limb in the right position, that is the most physiologically correspondent, considering the muscle retracted tension and contraction which could impair the right repositioning of the bony stumps, and the tendon and muscle lesions which could develop after twistings or changes of place, so severe to tear them and not to allow the right bone repositioning.

According to ancient sources, the right technique is to lay the muscular fibres in a straight line, to check the contraction and get an adequate reduction. Then the part is immobilized, in different ways depending on type and affected region, and broad-spectrum therapies are prescribed, considering the humoural theory of the ancient medicine disease. Diet, phebotomy, laxatives and diuretics draw corrupted humours away from the wounded area but lead to inflammation and can impair the healing to degenerate in gangrene.

Both Celsus and Galen prescribe a diet rich in light foods, infusions and drinkings with laxative and diuretic properties to draw corrupted humours away from the lesion area, leading to inflammation.

The fracture is treated with ointments and waxed to ease the suppurative process and exsiccative to fight inflammation. According the

A. Piccioli et al., *Bones: Orthopaedic Pathologies in Roman Imperial Age*,
DOI 10.1007/978-3-319-19485-1_3

Hippocratic tradition, wine and oil based ointment and base waxed preparations, or wax, oil, rose water and other anti inflammatory substances (dry, astringent and hot are often used). Galen is particularly concerned about bandaging technique, carried out to hold but not compress a fracture, to avoid flesh inflammation and lesion (*De Off*. Med. II, 6–12 – K. XVIII/B: 738–758; *De Medendi methodo*, VI,4 – K. X: 423–444)

Open Fractures

In open fractures, a high risk of inflammation and necrosis is due to the resulting wounds and inflammation process. To medicate the lesions, greasy wool compresses are recommended, which have soothing properties as oil, soaked in red and row wine, less penetrating than the white one, and so less irritating, but exsiccative and purgative in the same way. Galen uses cooked or raw virdigris too, for its exsiccative, restraining and antiseptic property; with clear inflammation, a pitch-based wax, less penetrating and detergent, but soothing and palliative. A piece of leather is put under the limb to let the absorption of the humours and of the pharmacological liqueurs used.

For the limbs reduction, Galen uses a tool made of two leather rings to extend the bone far ends, concave or perforated to insert different length sticks depending on the anatomical structures and made of wood elastic enough to be put in the slightly curved rings, to make a natural pressure which, alone, can lead to the bones extension (Galen, *De Fracturis*, III, 27–32 – K. XVIII/B: 573–583; Celsus, VIII, 10,7; 25). Some physicians treat the wounds only with wood and soothing wax-based preparations, extend the bones only after 3 days, when needed. On the other hand, Galen immediately reduces the fracture, repositioning the bones with appropriate orthopaedic tools: levers to raise or lower the bone stumps during the extension; a wedge, to remove bony fragments and splinters which can lead to further flesh lesions, the wheel with the axle (Galen, *De Fracturis*, III, 38–40 – K. XVIII/B: 590–594).

Celsus cuts and smooths the sharp ends with the scalpel and, if the hand cannot get them, he holds the bones with pincers, which, in the convex part, are also used to raise and reposition the bony stumps. The wound is continuously washed to move the spoiled parts away, when there are rotting fragments; if the stumps do not come out but the inner bony splinters injure flesh and muscles, fomentations are carried out with cold water in the summer and cool water in the winter, applying a myrtle oil and wax based preparation and in the most severe cases the skin is cut and the splinters are resect. When the wound outcome involves a shortening of the limb because of dislocation or resection of the bones splinters, a little smooth stake is pushed deeper and deeper in the wound every day, to separate and align the two stumps; every day the wound is treated with myrtle, ivy and other verbenaceae dissolution as long as a bony callus develops. When a simple mechanical bone reduction is unsuccessfull, the extension is carried out manually detaching the consolidated parts of the bones and curetting the greasy part (callus) developed to disconnect and reposition them; then the wound is treated with albumen and pomegranate peel solution boiled in wine; dressed with the canonical bandage, from the third day, during the treatment fomentations are carried out with warm water, where verbenaceae have been boiled in and ferulas are put on the fifth day. If the bones are obliquely consolidated and tear the flesh, after the application of fomentations and liquid waxed packs, they are detached by the hands breaking the bony callus and during the extension they are handled to reposition them; if needed, the limb is dressed with a splint which presses on the protruding bone to align it. To treat or prevent an over growth of the bony callus, oil, salt and nitre frictions, salted water fomentations, pharmacological doughs medications are carried out together with a tight bandage, following a vegetable-rich diet and taking vomitives to drain plethoras away (overabundance of humours) localized on the fracture (Celsus, VIII, 10,7)

The bandage is similar to the one carried out for simple fractures, but with less pressure to avoid muscular and flesh lacerations and too severe inflammation; moreover, a greater number of bandage is used because wooden rods cannot be put on the wound (Galen *De Fracturis*, III 1–2 – K. XVIII/B: 532-–35). For more severe compound fractures, with spread and deep flesh lesions, Galen does not carry out any reduction operation, which could lead to "spasm", a muscular contraction so severe to tear the vessels and flesh and cause acute inflammation which can degenerate in gangrene. In these cases, also bandage can be dangerous, because of its flesh compression against the splintered bones with the failure of the humours to draw away, with severe and damaging plethoric phenomena. So the leg is only lain straight on the bed, the patient is only put on a fast and the wounds are treated with ointment, tepid waxed, greasy wool soaked in oil and wine. Galen uses pitch-based ointments, compresses soaked in wine, chard and coltsfoot (tussilago farfara) and advices perfusion remedies, to penetrate to the recent sores, and not too much exsiccative, to avoid spasmodic outcomes. So, he uses the "barbaric" one, bitumen based but emollient (Galen *De Fracturis*, III 3–26 – K. XVIII/B: 535–573; Galen, *De Articulis*, IV, 15–30 K. XVIII/A: 683–712; Celsus, VIII, 25).

3.1.2 Intramedullary Nailing

Intramedullary fixation methods were developed at the end of the nineteenth century. In 1883, Stimson was the first person who described a synthesis method with ivory hinges fixed into the medullary cavity [5], but it was Ernest Hey-Groves who first used metal nails in 1912 [6]. The "true" intramedullary fixation technique, with the use of an intramedullary nail, was developed in the 1930s independently by the Rush brothers in Minnesota and by Gerhard Küntscher in Hamburg [7, 8], and this method was used and experimented on a large scale during World War II. The method became popular thanks to Klemm and Shelman, and Gross and Kemf in the 1970s [9, 10].

3.1.3 The External Fixator

Many surgeons were perplexed about the use of intramedullary nails in subjects with exposed fracture focus. In the first few years of the 1950s, Gavrijl Abramovich Ilizarov developed a circular fixator, which allowed to stabilize bone fragments, but also allowed three-dimensional reconstructions. In 1980, the technique was introduced to Europe thanks to the Italian surgeon Carlo Mauri, who had been treated successfully after a pseudo-arthritis of Ilizarov tibia. During the 1970s, De Bastiani developed the "dynamic axial fixator", and Gotzen the "Monofixator" [11]. Nowadays the external fixator is still used in the treatment of fractures associated to a large range of soft tissue damages, and in the fixation of hip and long bones in poli-traumatized patients.

3.1.4 Plaques and Screws

Arbuthnot and Lambotte (1905) are considered the founders of synthesis with plaques and screws [12]. Later on, the principle of inter-fragmentary compression, described by Danis, became extremely popular thanks to the scientific work of the AO team at the end of the 1950s [13]. In 1967, Schenk and Willenegger demonstrated that, in anatomical reduction and with inter-fragmentary compression, bone necrosis and retraction are reduced, and the bone tissue growth occurs fast, thus leading to primary bone recovery without callus formation [14].

3.1.5 Conclusion

The healing of fractures needs some optimal conditions, which include stabilization, fragment juxtaposition, and a correct biology. Since the pioneers of traumatology, further synthesis means and more and more sophisticated and minimally invasive fixation techniques have been developed. Thanks to their contribution, in the last few years the development of new osteosynthesis techniques has allowed to achieve better and better immobilizations, and juxtaposition between the fracture heads, thus allowing the immediate load and a fast functional recovery.

3.2 Fracture of the Nasal Septum

Subject: Gabii SO/99 T.6

Sex: male

Age: 35–40 years

Finding site: Gabii, Eastern Sanctuary

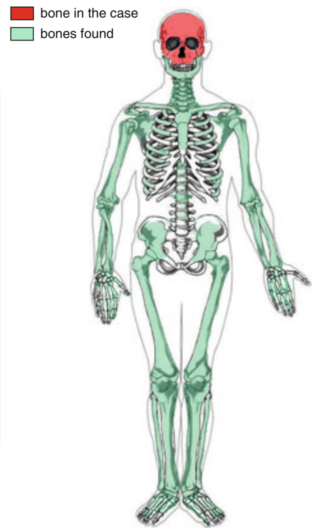
Type of grave: pit in the tuff with “cappuccina” cover

Type of burial: primary

Deposition: supine, with extended upper and lower limbs

State of preservation: good

Stature: ~159 cm



3.2.1 Morphological and Palaeopathological Description of the Subject

The subject is male, and has a strong skeleton, even though the muscular insertions are generally poorly developed. On the inferior surface of the right clavicle, the rhomboid fossa lies as a deep depression with jagged margins and a rough surface, while the contra-lateral area is slightly porous and defined by irregular margins. These lesions [15] indicate generalized stress on the pectoral muscle, particularly when the shoulders are hunched forward while carrying heavy weights [16, 17]. Among the muscles involved in plantar flexion, the only one showing mild variations is the *soleus* muscle; the rest of the appendicular skeleton – both superior and inferior – does not show any enthesopatic alterations. Even though most somas of the thoraco-lumbar vertebrae were destroyed *post-mortem,* three Schmörl hernias have been detected, and these can probably be associated to the ponderal overload, in particular to the strain of carrying heavy weight on the back [18]. A massive periosteal reaction with new bone production is observable on the diaphyses of tibias and fibulas: there is a thick layer of bone tissue, characterized by irregular surfaces and thin spicules, lying perpendicularly to the cortical. Periostitis is more commonly found on the anterior surface of the tibial diaphysis.

Among the anatomical variants, the morphology of the first left rib is peculiar, as it shows a fork, with rounded corner at the sternal extremity (Luschka rib) [19]; since the body of the bifurcated rib (Fig. 3.1) is as tall as the contralateral, it is not a case of complete fusion of two consecutive ribs. The cranial and transverse fronto-parietal indices of the skull have intermediate values, which indicate mesocrany and metriometopy respectively, while the height index suggests a high skull (hypsicranic). The frontal crests diverge, the orbits are large, and the *piriformis* aperture is long and narrow (leptorrhine). A fracture can be seen on the nasal bone, with a deviation of the septum to the left (Fig. 3.2).

3.2.2 Description of the Fracture

The clinical case shows a deviation of the nasal pyramid on the left. The likely presence of bone callous on the surface suggests the hypothesis of a post-traumatic deviation as a consequence of the fracture of the pyramid, rather than a

Fig. 3.1 Bifurcated rib

Fig. 3.2 Nose fracture

congenital deviation of the nose (Fig. 3.2). The most common dynamics is a direct trauma in the direction of the deviation (e.g. a punch on the nose). Among the fractures involving this region, the fracture with a deviation of the pyramid is the most common one, and it involves both nasal bones, the septum, and sometimes the frontal process of the maxillary sinus. The acute clinical case shows swelling, bruising and bleeding from laceration of the nasal mucosa and can hide the deformity, thus delaying a manual correction and resulting into deformity after swelling resolution. On top of the aesthetic damage, this type of fracture determines an obstruction of varying degree of one or both nasal cavities. The deviation can be clearly seen macroscopically, and from a radiology (Figs. 3.3 and 3.4), which only shows lateral deviation and does not allow further assessments due to the overlapping of several bone structures.

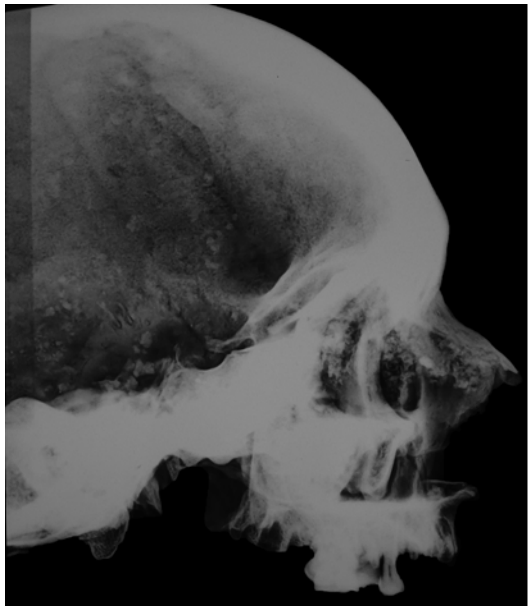


Fig. 3.3 X-rays (lateral view) of the nose

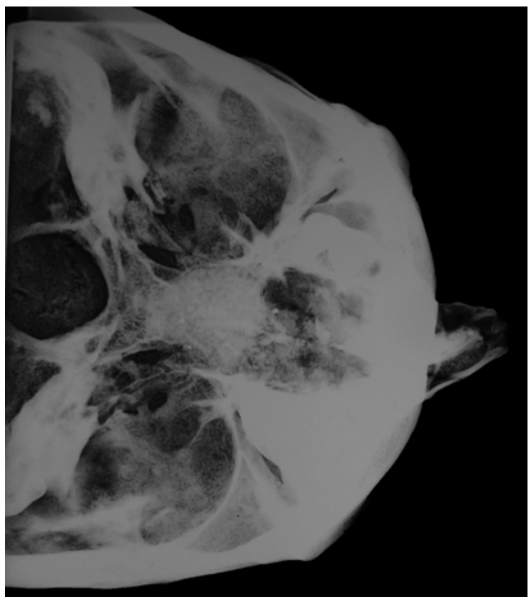


Fig. 3.4 X-rays (axial view) of the nose showing its lateral deviation on the left

3.3 Fracture of the Humerus

Subject: CBQ T.95

Sex: male

Age: 35–45 years

Finding site: Casal Bertone area Q

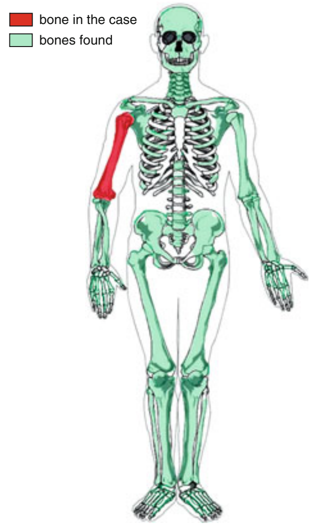
Type of grave: pit in the ground with flat cover

Type of burial: primary

Deposition: supine, with extended upper and lower limbs

State of preservation: good

Stature: ~170 cm



3.3.1 Morphological and Palaeopathological Description of the Subject

The subject is averagely built, with round-shaped humeri (euribrachy), and flattened femurs antero-posteriorly (platimery). The skull is high (hypsicranic) and elongated (dolichocranic), with averagely diverging frontal crests, the orbits are large (hypsiconchic) and the nose shows a long and narrow *piriformis* aperture (leptorrhine). The hypoplasia of the enamel and the simultaneous presence of *cribra cranii* and *orbitalia* suggest episodes of generalized suffering occurred during early childhood. The subject's health is characterized by the presence of a few dental caries, the likely cause of the loss of several teeth *intra-vitam.* A large cavity affected the first left maxillary premolar, and its alveolus shows osteolisis, probably caused by an odontogenic abscess (Fig. 3.5) [20]. The deltoid tuberosity of the clavicles is irregular, with small enthesopathic bone spicules associated to erosions, and the insertion area of the *pectoralis major* muscle shows a strong, flattened surface. The infraglenoid tubercle of the right scapula highlights a wide, marked ruggedness at the insertion of the long head of the *triceps brachii*. The insertion area of the *pectoralis major* on the humerus is marked and rough bilaterally, the surfaces of the lesser and greater right tuberosities, where the muscles of the rotator cuff are attached, show alterations with erosions and ruggedness. The left ulna shows a mild enthesopatic ossification, implanted on the upper margin of the posterior facet of the olecranon (*woodcutter's lesion*) [21]. The enthesopaties detected on the upper limbs affect the muscles promoting adduction and anteversion movements of the arm and extension of the forearm on the arm. The lower limbs do not show signs of any relevant muscular stress,

Fig. 3.5 Odontogenic abscess

Fig. 3.6 Bipartite patellae

even though the antero-posterior flattening of the superior third of the femoral diaphysis is generally associated to a strong development of the trochanters due to biomechanical stress. A pathological anomaly involves both patellas, where the superior lateral ossified nucleus is not welded to the rest of the bone (bipartite patella) (Fig. 3.6): in that area the margin is rough and eroded [22]. A small sessile ossification, 22 mm long and 8 mm wide, is situated on the cortical of the left femur's posterior face (myositis ossificans) (Fig. 3.7): a traumatic episode, probably limited to the soft tissues, may have caused a haematoma, with the production of a calcification of the torn muscular tissue [23]. The subject has some mild arthritic degenerations, which are confined to a few skeletal regions. A widespread porosity on the sternal and acromial extremities of the clavicles, on the glenoid cavity of the scapulas and on the humeral heads are all signs of suffering of the shoulders' joint cartilage. There are mild degenerations on the hip joints, with erosion and reshaping of the femoral heads and of the acetabulum. The bodies' ventral margins and the articular facet of some cervical and lumbar vertebrae show small osteophytes. The thoracic vertebrae do not show any somatic alterations, except for the three small imprints of intraspongeous hernias and small laminal spurs on the superior border, in the insertion points of the inferior *ligamenta flava*.

3.3.2 Description of the Fracture

The fractures of the distal humerus account for 2 % of all fractures and 1/3 of the humeral fractures [24]. The direct trauma mechanism is the most common, while less frequently the indirect one, due to rotation traumas, leads to spiral or oblique fractures.

The clinical case shows the consequence of a fracture of the distal third of the right humeral diaphysis (Fig. 3.8). This site represents the least common one if compared with the fractures of the other two segments of the humeral diaphysis, the middle third (most common) and the proximal third (second most common). The fracture looks well healed, with bone callous formation, thus suggesting a secondary bone healing. The bone callous progress, though partly reshaped, looks like the type of fracture that could have been oblique or spiroid, meaning an indirect rotational trauma. There might have been a third fragment on the medial profile, where the callous is most overabundant. This hypothesis can be supported also by the slight varus deviation of the distal part of the segment. The remaining axes of the segment look well preserved, and the healing of the fracture clears (Fig. 3.9). This recovery picture does not show any alterations in the limb's function.

Fig. 3.7 Consequence of potential myositis ossificans

Fig. 3.8 Fracture of the right humerus

Fig. 3.9 X-rays of the humerus antero-posterior view shows consequences of a fracture of the distal third of the bone segment with a mild varus deviation

3.4 Fracture of the Radius and Ulna

3.4.1 Fracture of the Medial Third of the Radius and Ulna

Subject: CDS T.1

Sex: female

Age: 45–50 years

Finding site: Colle del Sole

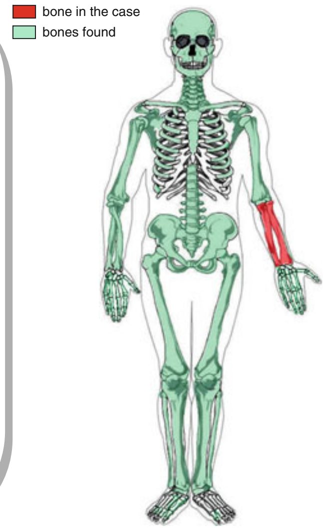
Type of grave: pit in the ground with "cappuccina" cover

Type of burial: primary

Deposition: supine with flexed upper limbs and extended lower limbs

State of preservation: good

Stature: ~158 cm



3.4.1.1 Morphological and Palaeopathological Description of the Subject

The subject is of average build, with particularly marked muscular imprints only at the pectoral girdle and at the upper arms. The clavicles and humeri show enthesopaties at the origin and insertion of the deltoid and *subscapularis* muscles, which are used respectively, for abduction and rotation of the arm. The inferior appendicular skeleton does not show any enthesopathic alterations, even though the femurs reveal an antero-posterior flattening of the diaphyseal superior third (platimery).

The presence of only two Schmörl's nodes at the thoracic tract of the spine, together with a mild degree of arthritis, suggests a low ponderal and functional load of the column. The extra-vertebral arthritis, limited to the shoulders joint, may be linked to the subject's advanced age.

The marked preauricolar grooves of the ileum, the hypertrophy of the pubic tubercle and the depressions of the hind symphysis area may be the signs of birth giving; tooth cavities and the loss *intra-vitam* of several teeth, may result from a calcium deficiency due to pregnancies [25–27].

The examination of the maxillary dento-alveolar complex, shows two abscesses, on the right first and second molar and the agenesis of the left second incisor and first molar. The height and horizontal cranial indices have average values (mesocranic and orthocranic) and the frontal crests are averagely diverging.

In addition to the fracture of the left radius and ulna, the palaeopathological study shows a likely muscular trauma of the diaphyseal distal third of the right fibula, three right rib fractures and one left rib fracture.

3.4.1.2 Description of the Fracture

This case shows a biosseous fracture of the diaphyseal medium third of the radius and ulna with synostosis and calcification of the interosseous membrane (Fig. 3.10 a, b). Radius and ulna fractures may lead to several complications, including Volkmann Syndrome, which is the most severe one, and post-traumatic radio-ulna synostosis, which is rather infrequent, since its incidence accounts for 3–9 % [28].

The most common risk factors associated with this complication are as follows:

- Fracture of both segments at the same level (11 %, that is the most common risk factor)
- Delay in fracture consolidation
- Closed cranial trauma, which increases the rate of formation of heterotopic ossifications
- "Crush syndrome", with severe damage to the soft tissues, and pluri-fragmented fracture
- Lesion to the interosseous membrane
- Infections

X-ray examination (Fig. 3.11) shows well-healed and consolidated fractures, with recovery of the cortical continuity and presence of ossification of the interosseous membrane. The redundant ossification could lead to an impairment or hampering in the forearm pronation and the radius and ulna rotation. The length of the two osseous segments is well preserved and mild angular deviation can be observed. This picture suggests a deficit or impossibility in prono-supination movements.

Fig. 3.10 (**a**) Consequence of radio-ulna diaphyses fracture with synostosis (**b**) Detail

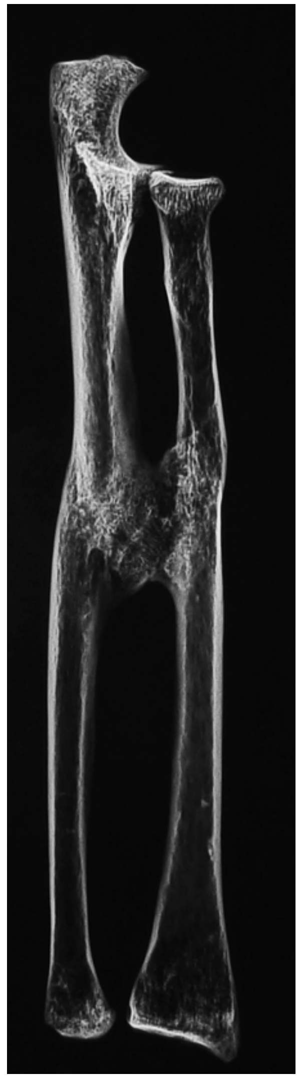


Fig. 3.11 Radio and ulna X-rays showing the synostosis of the diaphyseal middle third of the radio and the ulna

3.4.2 Fracture of the Distal Third of the Radius and Ulna

Subject: QCP T.26 b

Sex: male

Age: 45–55 years

Finding site: Quarto Cappello del Prete

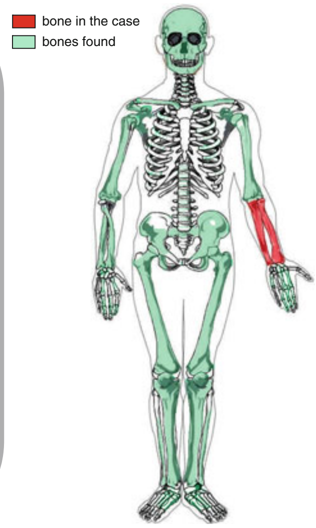
Type of grave: pit in the tuff with flat cover

Type of burial: primary

Deposition: supine with non deductible limbs position

State of preservation: mediocre

Stature: ~162 cm



3.4.2.1 Morphological and Palaeopathological Description of the Subject

The skeleton, in a mediocre state of preservation, pertains to a robust subject. The skull, elongated (dolichocranic) and flat (chamaecranic), shows a mild prognathism; the frontal crests are averagely diverging, the orbits are low (hypsiconchic) and the *piriformis* aperture of the nose is long and narrow (leptorrhine).

A Wormian sutural ossicle can be observed along the skull's coronal suture, at the bregma [29]. The dento-alveolar complex shows some major pathologies affecting both the maxillary and the jaw bones: the right first superior premolar and second inferior molar show two apical abscesses.

The jaw's second premolars are affected by caries: the left lesion is superficial, while the right one has led to tooth uncrowning. The alveolar processes of several teeth are completely resorpted: the right upper first premolar and three molars, the left lower first molar, the right lower incisors and the right first molars were lost *intra-vitam*.

The most widely spread enthesopaties on the upper limbs have been detected at the insertions of the muscles used for the extensions and flexions of the forearm on the arm: in particular, the left forearm shows modifications of the entheses of the *biceps*, *triceps brachii* and *brachii* muscles.

A hypertrophy of the *linea aspera*, the high and narrow pilaster and the flattening of the small trochanter of the femurs, together with the presence of a protruding crest on the popliteal line of the tibias, may suggest a long distance strenuous habitual locomotion, carrying heavy loads.

The skeleton does not show any signs of severe arthritis, with the exception of the articular surfaces of the glenoid fossa of the scapulas and of the sternal extremities of the clavicles, which are finely eroded. Moreover, a mild cribriform area can be observed on the subchondral bony surfaces of the acetabuli, whose superior *cilii*, bilaterally fringed by a thin new bone formation, are affected by *acetabular flange lesion:* this is an alteration characterized by *pitting* and fringed edge, at the origin of the reflex tendon of the *rectus femoris* muscle [30].

The whole vertebral column shows mild signs of articular degeneration, both intersomatic and posterior intervertebral.

The lower limbs have an abnormal morphology: the femurs show an antero-posterior curved diaphysis, while the tibias and the fibulas are bow-shaped with medial convexity. The detected modifications may result from a metabolic dis-

Fig. 3.12 Fracture of the left radius and ulna

Fig. 3.13 X-rays of radio and ulna: deviation of the axis of both segments and repairing bone callus at the diaphyseal distal third. The X-rays show the consequence of the fracture with stump overlap and shortening of both segments

ease (osteomalacia?[1]). An infrequent exposition to the sunlight, malabsorption, renal or intestinal diseases are some of the causes underlying an altered metabolism of vitamin D, calcium or phosphorus [31]. This pathology affects mainly women, and leads to a widespread bone frailty, which may have been responsible for the fracture of left radius and ulna (Fig. 3.12).

3.4.2.2 Description of the Fracture

The clinical case shows the consequence of a biosseous fracture of the distal third of the forearm. The bone callous looks good on both segments and the fracture is well healed, but some minor angular deformities and, above all, a major reduction in length can be observed. The mechanism of the trauma may have been direct or indirect, which explains the oblique course of the fracture on both segments. This oblique area has been the site of the complication of the fracture's healing process, which is its telescopic shortening, as shown by X-rays (Fig. 3.13). The conservative treatment has led to a good healing of the fracture, but hasn't preserved the length of the limb.

This picture could have led to varying impairment of the functional outcomes on the elbow and wrist joints.

[1] Osteomalacia, a skeletal disease caused by a defect in vitamin D metabolism or by its deficiency in the diet, is characterized by defects mineralization, with a non mineralized matrix (osteoid) buildup in the bone. The bone is weaker and softer than normal and suffers deformations under load (for instance bowed legs). This type of lesions is referred to as rickets in children and osteomalacia in adults.

3.5 Fracture of the Pelvis

Subject: LR II T.98

Sex: male

Age: 40–50 years

Finding site: Lucrezia Romana II

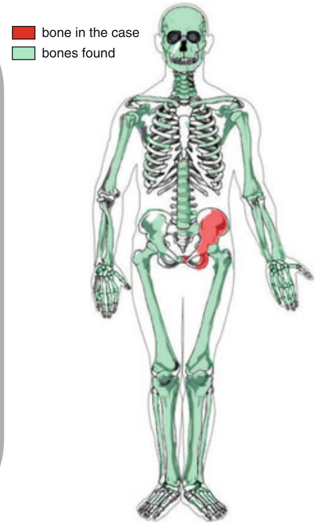
Type of grave: pit in the ground with “cappuccina” cover

Type of burial: primary

Deposition: supine with flexed right upper limb and extended left upper limb, extended lower limbs

State of preservation: mediocre

Stature: ~169 cm



3.5.1 Morfological and Palaeopathological Description of the Subject

The subject is a robust male, despite the poorly marked ruggedness due to the tendon and ligament insertions.

The cranial index shows a roundish skull (brachycranic), while the fronto-parietal and the fronto-transverse indices suggest an eurymetopic skull, with medially diverging frontal crests; the orbits are very low (hypsiconchic).

Two big carious cavities have destroyed the distal and mesial half of the mandibular right first molar and second premolar (Fig. 3.14); the latter shows osteolysis, externalized on the buccal surface (odontogenic abscess) (Fig. 3.15). The left hemi mandible shows alveolar resorption process of the second molar, due to its loss *intra-vitam*. Superiorly the left lateral incisor and second premolar were lost *ante-mortem*, and three caries, wide but not very deep, affect the central incisor, the canine and the right first premolar.

The insertion of the costo-clavicular ligament shows some osteolytic enthesopathies bilaterally, while the attachment area of the deltoid muscle is a small wrinkled protrusion on the left. The only alteration observed on the lower limbs is an irregular crest at the enthesis of the *soleus* muscle.

Fig. 3.14 Severe caries of the right mandibular second premolar and first molar

Fig. 3.15 Abscess associated with lower right second premolar

Fig. 3.16 Fracture of the left emipelvis

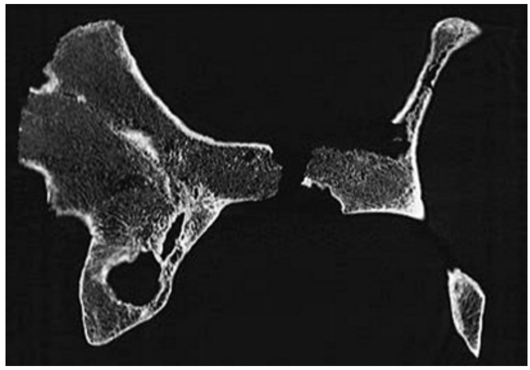


Fig. 3.17 CT scan coronal plane multiplanar reconstruction

The post-cranial skeleton does not show any signs of arthritic degeneration, except for the last cervical tract of the rachis (C5-C6-C7), which manifests osteophytosis of the ventral margins of the bodies. Signs of intraspongious hernias on the thoraco-lumbar tract indicate a moderate discal distress, which might result from prolonged axial overload stress along the vertebral column. The body of the sternum shows a fissure along the medial line, suggesting a defect in the development and ossification [32, 33].

3.5.2 Description of the Fracture

The examined case is an example of consolidated fracture of the left pelvis (Fig. 3.16). These fractures are the most uncommon traumatic lesions in palaeopathology. The trauma mechanism is a high-energy trauma (fall from a height). Compared with traumas in other areas, this one may lead to severe, even life-threatening, short-term complications, such as hemorrhagic shock and major disability.

The description of this fracture refers to Judet e Letournel's concept of two structural columns around the acetabulum [34]:

- Anterior column: from the iliac crest to the pubic symphysis, including the anterior acetabular wall
- Posterior column: from the greater sciatic foramen to the ischial tuberosity, including the posterior acetabular wall

This subject's fracture is very likely a mixed fracture of both columns with a medial opening of the acetabular wall (Figs. 3.17, 3.18, 3.19, and 3.20). In some cases this fracture leads to an endopelvis sub-dislocation of the femoral head.

When no surgery or traction of the ipsilateral femur are performed, the muscular forces involved in these fractures make the resolution complex even for today's orthopaedists; however, the bone callous is firm and the acetabular morphology is sufficiently preserved even with a discontinuity at its bottom. The subject's clinical picture could have varied due to antalgic ambulation deficit, with limping and severe limitations in autonomous ambulation.

The CT scans performed for the evaluation of the fracture has shown the presence of a small calcific enchondroma in the contra-lateral ischial tuberosity (Fig. 3.21).

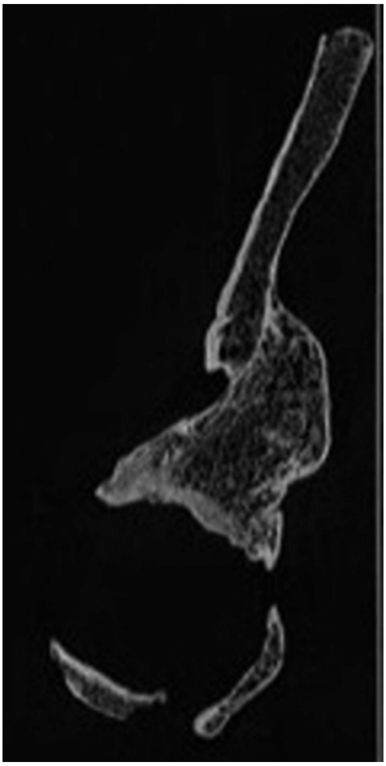


Fig. 3.18 CT scan sagittal plane multiplanar reconstruction

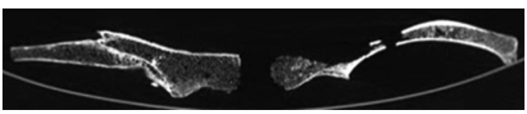


Fig. 3.19 CT scan axial plane multiplanar reconstruction

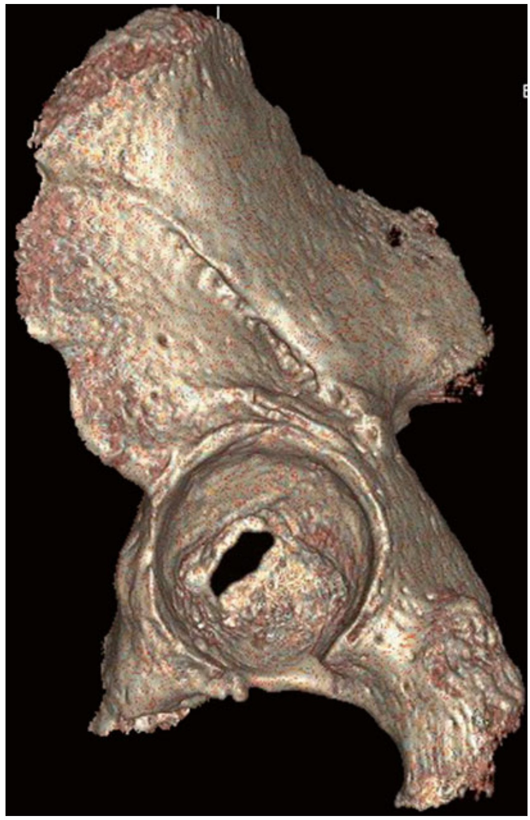


Fig. 3.20 CT scan 3D reconstruction

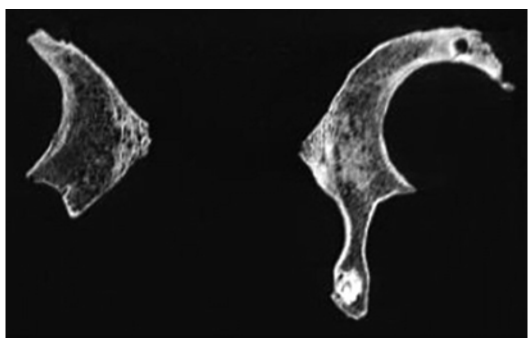


Fig. 3.21 CT scan coronal plane multiplanar reconstruction shows a calcified lesion in the ischial tuberosity

3.6 Fracture of the Femur

3.6.1 Proximal Femur Fracture Secondary to Paget's Disease

Subject: LR I T.107

Sex: male

Age: 35–45 years

Finding site: Lucrezia Romana I

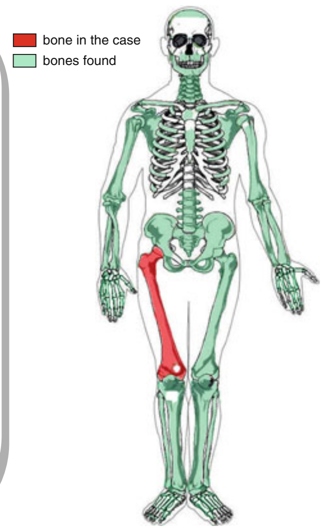
Type of grave: pit in the ground with "cappuccina" cover

Type of burial: primary

Deposition: supine with extended upper and lower limbs

State of preservation: good

Stature: ~163 cm



3.6.1.1 Morphological and Palaeopathological Description of the Subject

The subject is an adult male of average build. A mild ruggedness affects the point of insertion of the deltoid muscle on the anterior margin of the left clavicle's lateral portion, while the surface of the costo-clavicular ligament's imprint is characterized by a poor porosity. The proximal portions of the ulnae show a mild enthesopathic ossification, at the point of oleocranon insertion of the *triceps brachii* muscle (olecranon spur). These alterations suggest biomechanical stress of the shoulder and repeated extension of the forearm on the arm.

The femurs are strong and platymeric and the crest *vastus medialis* muscle on the left femur is marked, with enthesophytes, that suggest frequent extensions movements of the leg on the thigh.

Signs of bone involvement with progressing arthritic degeneration, affect the articular surfaces of the appendicular skeleton, both superior and inferior, and in particular the coxofemoral joint is the most severely affected: the acetabuli and the femoral heads are bilaterally fringed by a thin new bone formation and the endo-articular surfaces are eroded.

Angular osteophytes can be observed on the cervical metamers, while the vertebral endplates and the articular intervertebral facets are affected by superficial erosions.

The subject shows lumbarization: a congenital condition characterized by the modification of the first sacral vertebra, which takes morphological characteristics of the fifth lumbar vertebra, due to the lack of fusion with the second sacral vertebra [31].

Finally, the bodies of the sacral vertebrae, with the exception of the first vertebra, are not fused together and so the sacral canal is open (spina bifida occulta) [35, 36].

3.6.1.2 Description of the Fracture

The subject's right femur macroscopically shows a varus deformity of the proximal portion, with gross formation of reparative bone callous around the great trochanter (Fig. 3.22a, b). The ossified formation protrudes antero-laterally. There are no alterations of the periosteum,

Fig. 3.22 (**a**) Fracture of the right femur, anterior view. (**b**) Fracture of the right femur, lateral view

erosions or new formations on the cortical surface of the femur. The picture is suggestive of the healing of a fracture of the proximal femur, but the characteristics shown by the X-ray examination do not completely match those of a femoral fracture on a normal bone. The corticals appear restored in their continuity but the marrow looks different if compared to the other parts of the segment. The radiographic picture shows a "mosaic" pattern of osteolytic areas and new bone appositions. At the angle of greater deformity, the middle medullary area looks almost completely affected by repairing bone deposition.

The described radiological picture suggests the consequence of a pathological fracture of the proximal femur in Paget's disease.

Paget's disease is a metabolic disease of the bone, mainly affecting subjects older than 40 years of age and rarely younger. The disease was named after Sir James Paget, who firstly described it in 1877 [37]. He observed that long bones, especially the weight bearing segments, were affected focally by softening, flaring, and bending under stress. Assuming it was a bone inflammation, he called it *osteitis deformans*. Since then, the understanding of this disease has been progressing. The most commonly affected segments are the femur, the pelvis, the vertebral column, the tibia and the skull. Only one third of the affected subjects show symptoms of deformity, pain, heat and local swelling, and one third can be affected by complications, given mainly by the pathological fractures.

The radiological features of Paget's disease are rather peculiar, showing a lytic wedge in the early stages, and alternating lytic and bone apposition areas as the disease progresses (Fig. 3.23). The bone apposition appears disorganized, forming the characteristic "mosaic" pattern. The examined case lacks the characteristic flaring of the cortical and of the periosteum, because of the superimposition of repairing images of the pathological fracture.

Fig. 3.23 X-rays antero-posterior view show a sub trochanteric varus deviation of the segment. The examination shows restoration of the cortical bone's thickness, but also "mosaic" medullary alterations at the metadiaphysis and at the greater trochanter, which suggest Paget's Disease

3.6.2 Fracture of the Femoral Diaphysis

Subject: CM T.141

Sex: male

Age: 30–40 years

Finding site: Castel Malnome

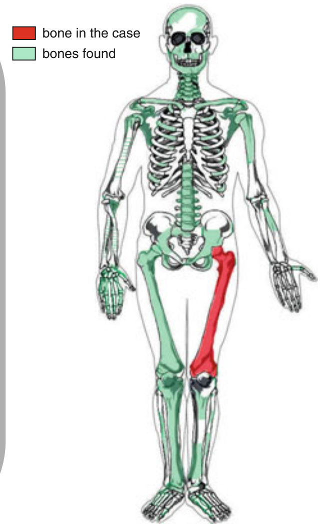
Type of grave: pit in the ground with no cover

Type of burial: disturbed primary by clandestine digging

Deposition: supine, with slightly flexed right upper limb, non-deductible upper left limb and lower limbs

State of preservation: poor

Stature: ~152 cm



3.6.2.1 Morphological and Palaeopathological Description of the Subject

The skeleton, poorly preserved, pertains to a short,[2] well-built subject. The skull, rather roundish (brachycranic), shows five Wormian sutural ossicles (Fig. 3.24), irregular in shape, along the lambdoid suture [29]. The presence of porotic hyperostosis on the outer table of the skull and hypoplasia of the tooth enamel suggest episodes of stress during the subject's growth.

The incompleteness of the upper appendicular skeleton has not allowed to detect most metric characters and skeletal stress markers.

The imprint for the insertion of the costo-clavicular ligament is bilaterally made up by a cortical erosion area (rhomboid fossa), while the imprint for the insertion of the conoid ligament shows a left hypertrophy. These ligaments, along with other muscles, are involved in the elevation of the humerus and in scapular stability [38]. The type of morphology of the acromial extremity of the right clavicle, characterized by osseous remodelling and by a clear strength, is due to the outcomes of a well-healed fracture.

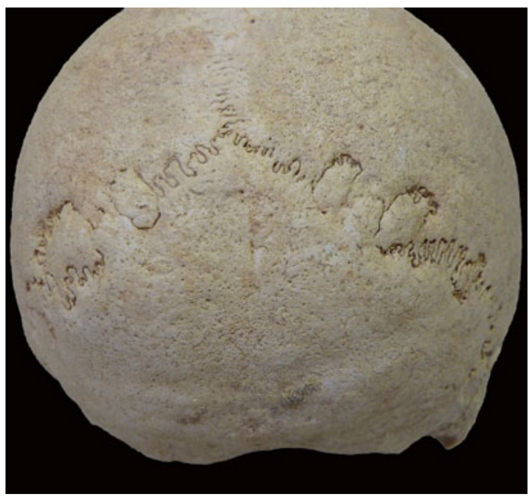


Fig. 3.24 Small Wormian sutural bones

Enthesopaties at the origin of the *semitendinosus* muscle and at the insertions of the *gluteus minimus* and *maximus* muscles, detect continuous and repeated extensions of the thigh on the pelvis and internal and external rotation of the femur [39, 40]; the presence of these alterations only on the right side could suggest overload

[2] The stature is clearly inferior to the average of coeval sample [43].

Fig. 3.25 (**a**) Fracture of the left femur anterior view. (**b**) Fracture of the left femur lateral view

events of compensatory origin, due to the consolidation of the contra-lateral femur fracture (Fig. 3.25a, b), in a faulty posture. A usual and prolonged *squatting* position could have lead to an incisure of the supero-lateral corner of the right patella (*vastus* notch) and to the formation of an accessory facet on the tibia, at the level of the joint with the talus [21, 41, 42].

The rachis shows, on the dorso-lumbar tract, wide and deep imprints of Schmörl's node (Fig. 3.26) on the superior and inferior vertebral endplates. Poor angular osteophytes are spread along the edges of the disks and also the posterior vertebral joints are affected by arthritic degeneration.

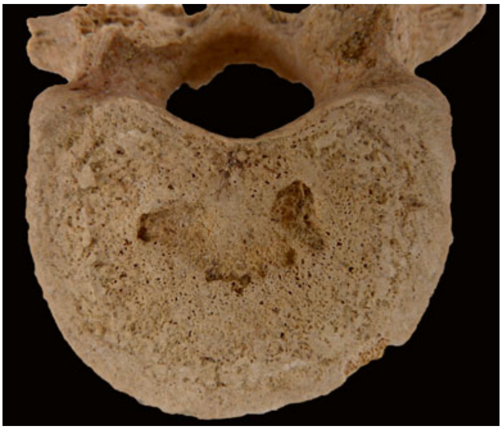


Fig. 3.26 Schmörl's depression in a lumbar vertebra

3.6.2.2 Description of the Fracture

The fracture examined in this medical case is a really rare and interesting remain because it shows the healing of a severe displaced fracture of the femur healed in a very complex way. The fracture regards the middle third of the diaphysis of the left femur with major deformity and shortening of the diaphysis due to a loss of contact of the stumps (Fig. 3.27). A high-energy trauma has lead to this fracture. Despite the gap between the fragments and their failed contact, the fracture haematoma with the conservative treatment has lead to the formation of a good and stable bony callus (Fig. 3.28). The deformity, in which the fracture has hesitated, even showing a pro curve mark, has preserved the mechanical axis of the segment on the sagittal and coronal plane. The most severe functional alteration is due to the length reduction of the whole segment with at least a 3 cm shortening. The clinical picture of this outcome has lead, because of a firm callus, to an autonomous ambulation, but with lameness due to a severe aetherometry of the lower left limb.

Fig. 3.27 CT scan coronal plane multiplanar reconstruction shows fracture with severe segment misalignment and shortening

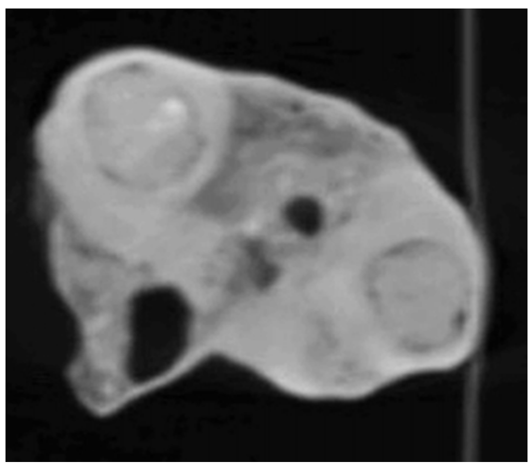


Fig. 3.28 CT scan axial plane multiplanar reconstruction shows the distance between fracture stumps and their lack of contact. However, the bone callus envelops both stumps into calcified repairing tissue

3.7 Fracture of the Ankle

Subject: CM T.159

Sex: male

Age: 45–55 years

Finding site: Castel Malnome

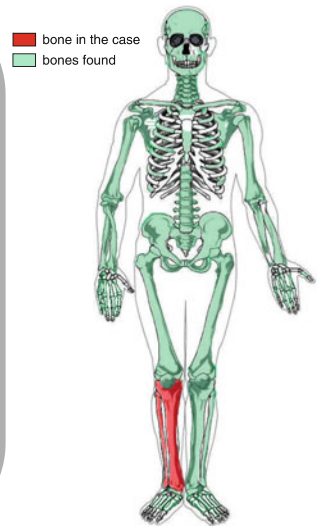
Type of grave: pit in the ground with no cover

Type of burial: primary

Deposition: supine with flexed upper limbs and extended lower limbs

State of preservation: good

Stature: ~178 cm



3.7.1 Morphological and Palaeopathological Description of the Subject

The skeleton is attributable to a subject of advanced age and high stature, if compared to the group of his finding site [44].

The skull is elongated, according to the cranial index, and shows a completely closed interparietal suture and a sutural ossicle at the lambdoid fontanelle. Among the anatomical variants, the absence of the left parietal foramen can be observed. The imprint of the *obliquus capitis* inferior muscle, that is involved in the head's rotation, is bilaterally marked. The dento-alveolar complex is affected by a destructive caries, with alveolar pocket, on the left inferior first molar, and by of the loss *ante-mortem* of some posterior teeth, both maxillary and mandibular.

From a pathological point of view, arthritis is definitely this subject's primary disease: the glenoid cavities of the scapulae are surrounded by an osteophytic edge, and the inferior surfaces of the acromion show remodelling with new bone formations (Fig. 3.29). The sternal processes of the clavicles are severely eroded and the sterno-costal joints show osteophytic reactions, with bilateral hyperthrophy. Four ribs, two on the left and two on the right, show the consequences of fractures near the sternal extremities, with bone callus.

Fig. 3.29 Osteoarthritis of the right scapula and clavicle

The joints of the limbs also show all the characteristic signs of arthritis: in the medial part of the olecranon fossa and frontally, at the coronoid fossa of the humeri, there is a globular bone growth; moreover, the surfaces of the heads and epicondyles show protruding and jagged margins, as do the ulnar olecranon and the radial capitulum ones.

The ilium shows a wide rugged surface in the area above the acetabulum bilaterally; the roughness areas are larger and more obvious on the right, with sindesmophatic new bone formations at the insertion area of the *rectus femoris* muscle.

The joint surface of the simphyseal region is completely remodelled, and the horizontal grooves, due to the interpubic cartilage, are filled; the cotyloid cilium, above all in the lateral area of the acetabulum, is altered.

Some bone spurs of about 11 mm can be observed at the insertion points of the coxal and femoral obturator muscles.

The articular surfaces of the femoral condyles are asymmetrically edged with a thin marginal bone ring and, only on the left, an erosion of the subchondral bone, with an eburnated area on the medial epicondyle, can be detected. The same type of lesion affects the lateral part of the patella's articular face, with osteophytic new depositions on the edges, making the area irregular and expanded.

The condylar surfaces of the tibiae are edged with new marginal formations, the lateral intercondylar tubercle is hypertrophic, and the distal end of the left fibula is spicular and rough.

Severe intra and extra-articular arthritic degenerations are widespread on the tarsal bones and on the distal ends of the first metatarsals, which show mild eburnation of the plantar surfaces; the dorsal margins of the naviculars show edges with ossifications that extend upwards. Enthesophytosis can be detected at the insertion of the Achilles tendon, and only on the left calcaneus, at the insertion of the long plantar ligament.

The spine shows signs of disc and interapophyseal degeneration, with a greater involvement of the inferior cervical and dorsal tracts.

The superior and inferior facets of some cervical and thoracic vertebrae show enlargements with porosities and jagged margins, and the surfaces are sometimes eburnated.

Syndesmopathic ossifications can be observed at the insertion of the *ligamenta flava*, and irregular osteophytic cribriform beaks branch out from the anterior margin of the dorsal vertebral bodies;

Fig. 3.30 Hypertrophy of the soleus insertion

T9 and T10 show, mainly on the right, bulky syndesmophytes that show internal friction surfaces with the body below. The first coccigeal and the last sacral vertebrae are fused together.

Marked enthesopathies can be observed mainly on the lower limbs, especially on the dorsal surfaces of the femurs and tibiae; a furrow with a hypertrophic crest can be clearly seen at the insertion of the *gluteus maximus* muscle, while an irregular and rugged spur can be observed at the insertion of the *soleus* muscle on the tibia (Fig. 3.30). These muscles can be highly developed, because of long and frequent climbs, or of repeated plantar hyperflexion, during a march on a hard or rough ground [16, 45, 46].

3.7.2 Description of the Fracture

Bimalleolar fractures have the second highest incidence rate among ankle traumas, followed by trimalleolar fractures, and second only to isolated fractures of one of the two malleoli. The

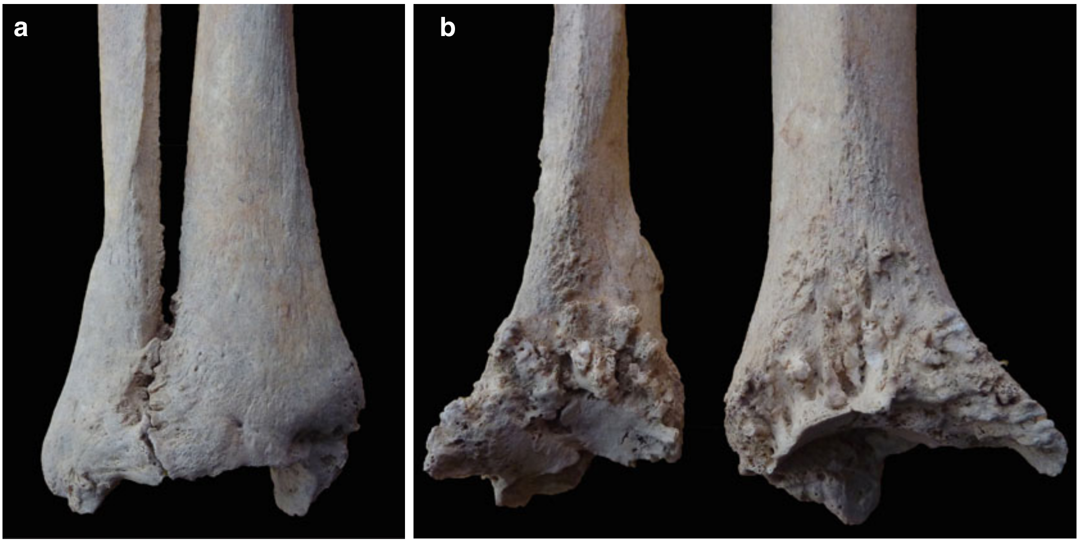


Fig. 3.31 (**a**) Fracture of the right ankle anterior profile. (**b**) Fracture of the right ankle medial profile

Fig. 3.32 X-rays antero-posterior view of the ankle show consequences of a fracture of the peroneal malleolus and medial malleolus with mild diastasis on the medial cortical profile. Subchondral sclerosis and an alteration of the joint profile assigns of post-traumatic ankle arthritis

trauma mechanism of this fracture is usually ankle inversion.

The macroscopic examination (Fig. 3.31a, b), and later the X-ray investigation (Fig. 3.32), show an oblique fracture line on the right fibula at the supra-sindesmotic level, and on the medial malleolus, which is displaced inside the malleolar joint profile. In Danis-Weber's classification of ankle fractures, they are divided into A-B-C according to the height of the fracture on the fibula, which indicates the degree of stability and of damage of the tibio-peroneal syndesmosis [28]. This fracture is classified as C.

Weber's C fractures involve the fibula with a fracture line above the syndesmosis, and lead almost always to its interruption especially when there is a fracture of the medial malleolus, so they are the most unstable ones.

The fracture's healing shows this instability. The alteration of the articular profiles and of the calcifications or osteophytic formations clearly shows a secondary arthritis due to joint instability from widening of the mortise. X-ray examination reveals subchondral sclerosis at the insertion of the syndesmosis (Fig. 3.32), which is the area of greatest overload in an unstable ankle.

Nevertheless, the fracture shows a good healing, and the ankle's axis looks partly restored; the conservative treatment has been effective.

The clinical picture is characterized by persistent pain of varying degrees of intensity, and a major impairment of ankle movement.

3.8 Fracture of the Rib

Subject: CBQ T.98

Sex: male

Age: 35–45 years

Finding site: Casal Bertone area Q

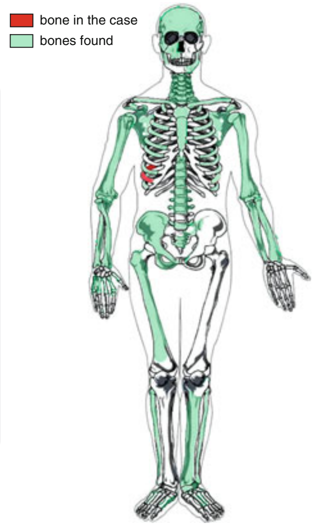
Type of grave: pit in the ground with no cover

Type of burial: disturbed primary by clandestine digging

Deposition: supine, with flexed right upper limb and left lower limb, non-deductible left upper limb and right lower limb

State of preservation: mediocre

Stature: ~164 cm



3.8.1 Morphological and Palaeopathological Description of the Subject

The skeleton, attributable to a mature male individual, is incomplete, totally lacking the femur and the left hand, the right tibia, and the patellae; some elements of the skeleton, even if present, are incomplete. In the media-lambdoid region, the ectocranial surface shows a mild depression, not associated to any bone remodelling, while at the obelion level there is a small exostosis, probably of traumatic origin. The outer surface of the skull shows a diffused micro-porosity, due to porotic hyperostosis. The hypertrophy of the external occipital protuberance, with a smooth surface and regular edges facing downward posteriorly, suggests the morphology called tubercle of Hasebe, or *calcar occipitalis* posterior of Balabbio (Fig. 3.33). Such ossification, 10.4 mm long, can be associated to the syndesmopathy of the occipital intersection of the nuchal ligament [47]. The muscular attachments are very strong at the shoulder girdles, especially the deltoid one, the *pectoralis major*, and the *triceps brachii* and the costo-clavicular also turns out to be bilaterally modified. The biomechanical stress detected on such muscles, together with Schmörl's hernias on the thoraco-lumbar region of the rachis, might indicate repeated heavy load lifting, accompanied by flexion and lateral torsion of the column. Such hyper-stress might have contributed to the development of arthritic degenerations detected on the joints of the shoulders. The marked insertion observed on the ischial tuberosity of the right coxo-femoral joint, at the *semitendinosus* origin and on the ipsilateral femur, at the insertion of the *gluteus maximus*, would testify recurrent exten-

Fig. 3.33 Tubercle of Hasebe

Fig. 3.34 Fracture of the left fibula

sion movements of the thigh on the pelvis, suggesting walking on uneven grounds carrying heavy weights. The third distal portion of the diaphysis of the left fibula, right above the tibia-fibular joint, shows a compound fracture, with enlargement of the affected segment and new bone production (Fig. 3.34). The distal joint surface of the tibia shows marked margins and the beginning of partial subchondral bone necrosis, characterized by an oval-shaped imprinted area finely eroded [36].

Fig. 3.35 Rib fracture

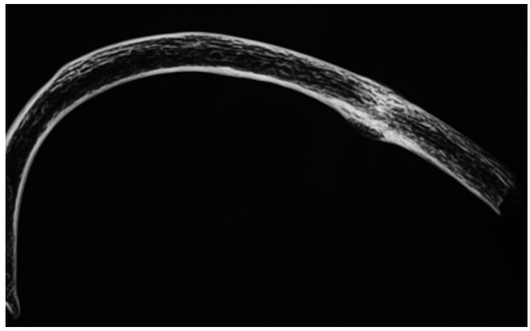


Fig. 3.36 X-rays of the rib showing repairing bone callus at the rib fracture

3.8.2 Description of the Fracture (Ninth Right Rib)

The lesion shown in this clinical case is a cribrose, irregular alteration of the bone surface of the antero-lateral profile of the rib (Fig. 3.35). The radiography of the segment shows a radiopacity for the entire costal diameter (Fig. 3.36). These finds are attributable to a costal fracture on the mend. When costal fractures are not compound, they do not require surgical treatment, and there are virtually no risks of a pleural lesion or of pneumothorax. The only treatment required addresses pain, so as to allow correct breathing, and avoid complications following hypo-mobility of the rib cage (such as pneumonia in the most severe cases).

History of Medicine: Rib Fractures Care
Valentina Gazzaniga and Silvia Marinozzi

Simple rib fractures, without tissue or internal organ damage, are treated by simply applying oilcloths, compresses or bandages; the patient is advised to eat a lot, because abdominal extension helps to support the ribs; the bone stabilizes in approximately 20 days. If the surrounding flesh or even organs are involved or injured, there is a superadded inflammation process, which is initially localized, but then spreads to the whole body and reaches the brain, with fever, empyema, bleeding from the mouth. The diet must be strict, mainly based on fluids and with no fats or stinging foods, which would lead to a further production of pituous humours; the patient has to lie still as much as possible, avoid swallowing efforts, hiccupping, cough and breathing acceleration, which all stress the chest muscles. Bloodletting from the arm corresponding to the region of the rib cage with the fracture helps to drain blood and humours clotting in the rib cage, and the bandaging has to be performed applying many oak ums and compresses on the damaged area and with many loose bandages so as to avoid pressing on the rib stumps inward and cause more damage to the organs (Galen, Comm. to *De Articulis*, III, 57–64 – K. XVIII/A. 569–578).

3.9 Fracture of the Vertebra

Subject: LR I T.118

Sex: male

Age: 30–40 years

Finding site: Lucrezia Romana I

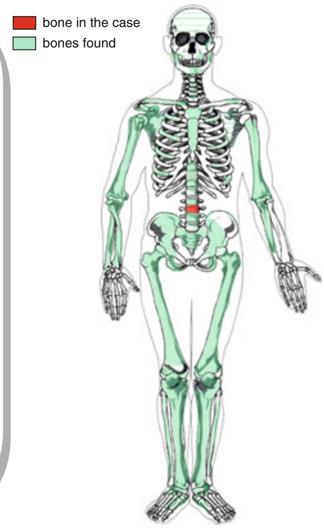
Type of grave: brick grave with flat cover

Lying Type of burial: primary

Deposition: supine, with flexed right upper limb, extended left upper limb, and extended lower limbs

State of preservation: mediocre

Stature: ~175 cm



3.9.1 Morphological and Palaeopathological Description of the Subject

The skeleton is consistent with a rather tall, adult, male individual. The conditions of the dento-alveolar complex are relatively good: there are only three small cavities inferiorly and the loss of the first left molar *ante-mortem*. The mediocre conservation status and the absence of some epiphyses of the limbs did not allow the detection of several indices of the craniofacial block and of the post-cranial skeleton. The diaphyseal and robustness indices of the right humerus express a rounded shape and average robustness of the segment, while the diaphyseal index of the radius has a non-protruding crest. These values, together with the absence of enthesopathic lesions, suggest a poor muscle use of the upper limbs. On the other hand, although the shaft of the femur is weak, the flattening of the superior thirds of the femurs (platimery) and the tibias (platycnemia) suggests a prolonged and intense use of the legs. The right femur (contra-lateral non-observable) shows a Poirier's facet, which looks like the consequence of a extreme flexure and abduction of the thigh. The anterior margin of the distal part of the left tibia (right one non-observable) is interrupted by a facet which can be attributed to the squatting position. The joint of the elbows, the sterno-clavicular joint, and the joint of the feet show a mild marginal lipping, with less than 3 mm long osteophytes attributable to the beginning of arthritis. The joint of the right hip and that of the knees show a more severe form. Also the rachis is moderately affected by arthritic degenerations, in the form of osteophytosis of the ventral margins of the bodies and of the posterior apophyses; three thoracic vertebrae and a lumbar one show intraspongious hernias, which can be connected to physical stress, such as carrying heavy weights.

3.9.2 Description of the Fracture

The subject shows an anterior cuneiform deformity of a lumbar vertebra (most likely L3) (Fig. 3.37). Ninety per cent of fractures involving the spine involve the thoracolumbar tract, and about 60 % affect the segments between T11 and L2 [28]. The thoracic tract of the rachis is much more rigid than the lumbar one in flexion and extension, and lateral bending movements. The highest number of fractures in the area between the thoracic and the lumbar tracts is due to the

Fig. 3.37 Fracture of a lumbar vertebra (L3)

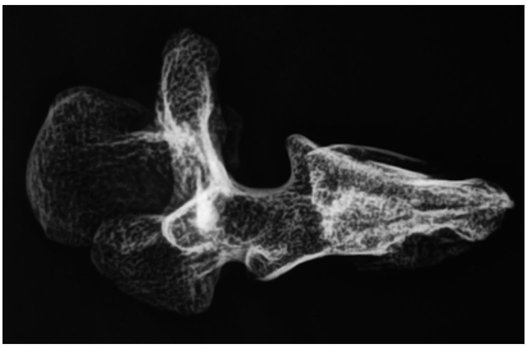


Fig. 3.38 X-rays lateral view of the vertebra: severe cuneal deformity of the vertebral body as a consequence of a fracture

bigger susceptibility of this transition area from a more rigid to a more mobile one. The trauma mechanism can be high energy (precipitated from above) or low energy, in the presence of bone weakness. Isolated fractures of older subjects with an image of cuneiform deformity are more commonly associated to osteoporosis, and do not need high entity traumas to occur. Such fractures are called "compression fractures" in some classifications (Denis), a definition which describes the dynamics of the trauma. Eighty-nine per cent of compression fractures involve the anterior wall, and they are rarely associated to neurological damage. They are mostly considered stable, and the criteria of instability are loss of height in the vertebral body >50 %, angular deformity >20–30 %, multiple compression fractures of adjacent vertebral bodies. In the present fracture, the anterior wall is reduced of less than 50 % if compared to the posterior one, which does not look interrupted (Fig. 3.38), thus ruling out bigger neurological involvement. This medical case is of severe low back pain in the acute phase, which may be reduced over time and reach a recovery status, but leave a loss of physiological lumbar lordosis as its consequence.

References

1. Broos PLO, Sermon A. From unstable internal fixation to biological osteosynthesis a historical overview of operative fracture treatment. Acta Chir Belg. 2004;104:396–400.
2. Lister J. An address on the treatment of fracture of the patella. Br Med J. 1883;2:855.
3. Lucas-Championniere J. Chirurgie antiseptique. Paris: JB Baillière; 1876. Malgaigne JF. Traité des fractures et des luxations. Paris: JB Baillière; 1847.
4. Hoffmann R. Rotules à os pour la reduction dirigée non sanglante des fractures (osteotaxis). Helv Med Acta. 1938;5:844.
5. Stimson LA. A treatise on fractures and dislocations. Philadelphia: Henry C. Lea's Son and Co; 1883.
6. Hey-Groves E. Some clinical and experimental observations on the operative treatment of fractures with special reference to the use of intramedullary pegs. Br Med J. 1912;2:102.
7. Küntscher G. Die Marknagelung von Knochenbruchen. Klin Wschr. 1940;19:6.
8. Rush LV, Rush HL. A reconstructive operation for comminuted fractures op the upper third of the ulna. Am J Surg. 1937;38:332.
9. Klemme K. Begrundete Indikationen für den Verriegelungsnagel. Hefte Unfallheilkd. 1977;129:84.
10. Kempf I, Grosse A, Beck G. Closed locked intramedullary nailing. J Bone Joint Surg. 1985;67A:709.
11. Gotzen L, Haas N, Schlenzka R. Forschritte in der externen stabilisierung. Chirurg. 1985;56(11):705.
12. Lambotte A. L'intervention opératoire dans les fractures récentes et anciennes envisagées particulièrement au point de vue de l'ostéo-synthèse. Lambertin: Bruxelles; 1907.
13. Müller ME, Allgöwer M, Schneider R, Willenegger H. Manual of internal fixation. Techniques recommended by the AOASIF group. Berlin: Springer; 1991.
14. Schenk R, Willenegger H. Morphological findings in primary fracture healing: callus formation. Simp Biol Hung. 1967;7:75.
15. Mariotti V, Facchini F, Belcastro MG. The study of entheses: proposal of a standardized scoring method for 23 entheses of the postcranial skeleton. Coll Anthropol. 2007;31(1):191–313.
16. Galera V, Garralda MD. Enthesopaties in a Spanish medieval population: anthropological,

epidemiological, and ethnohistorical aspects. Int J Anthropol. 1993;8:247–58.
17. Stirland AJ. Possible correlation between Os acromiale and occupation in the burials from the Mary Rose. Paper presented at the 5th European meeting of paleopathology association; Siena; 1984.
18. Fornaciari G, Giuffra V. Lezioni di paleopatologia. Genova: Edizioni Culturali Internazionali Genova; 2009.
19. Schedtler O. Röntgenpraxis. 1936;8:1–12.
20. Hillson S. Dental pathology In: Katzenberg AM, Saunders RS. Biological anthropology of the human skeleton. Ed. New York: Wiley-liss; 2000.
21. Capasso L, Kennedy KAR, Wilczak CA. Atlas of occupational markers on human remains. Teramo: Edigraphital; 1999.
22. Mann RW, Hunt DR. Photographic regional atlas of bone disease. A guide to pathologic and normal variation in the human skeleton. 3rd ed. Springfield: Thomas; 2012.
23. Buikstra JE, Ubelaker DH. Standards for data collection from human skeletal remains, 44 Archeological survey research series. Arkansas; 1994.
24. Bucholz RW, Heckman JD, Court-Brown C, Tornetta P, Koval KJ. Rockwood and Green's – fractures in adult, vol. 2, 6th ed. Philadelphia: Lippincott Williams and Wilkins; 2006.
25. Kelley MA. Parturition and pelvic changes. Am J Phys Anthropol. 1979;51:541–6.
26. Suchey JM, Wiseley DV, Green RF, Noguchi TT. Analysis of dorsal pitting in the os pubis in an extensive sample of modern American females. Am J Phys Anthropol. 1979;51:517–40.
27. Ullrich H. Estimation of fertility by means of pregnancy and childbirth alterations at the pubis the ilium and the sacrum. OSSA. 1975;2:23–39.
28. Egol KA, Koval KJ, Zuckerman JD. Handbook of fractures. 5th ed. Philadelphia: Walters Kluwer/ Lippincott Williams and Wilkins; 2014.
29. Hauser G, De Stefano GF. Epigenetic variants of the human skull. Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller); 1989.
30. Mann RW, Hunt DR. Photographic regional atlas of bone disease. A guide to pathologic and normal variation in the human skeleton. 3rd ed. Springfield: Thomas; 2012.
31. Aufderheide AC, Rodriguez Martin C. The Cambridge encyclopedia of human paleopathology. Cambridge: Cambridge University Press; 1998.
32. Barnes E. Congenital anomalies. In: Pinhasi R, Mays S, editors. Advances in human paleopathology. Chichester/Hoboken: Wiley; 2008.
33. Brothwell DR. Digging up bones. 3rd ed. Ithaca: New York: Cornell University Press; 1981.
34. Saterbak AM, Marsh JL, Turbett T, Brandser E. Acetabular fractures classification of Letournel and Judet – a systematic approach. Iowa Orthop J. 1995; 15:184–96.
35. Roberts C, Manchester K. The archaeology of disease. 3rd ed. Ithaca: New York: Cornell University Press; 2005.
36. Waldron T. Palaeopathology. Cambridge: Cambridge University Press; 2009.
37. Paget J. On a form of chronic inflammation of bones. Med Chir Trans. 1877;65:37–63.
38. Stirland AJ. The men of the Mary Rose raising the dead. Stroud: Sutton; London: 2005.
39. Hawkey DE. Use of upper extremity enthesopathies to indicate habitual activity patterns. M.A. thesis, Department of Anthropology, Arizona State University, Tempe; 1988.
40. Hawkey DE, Merbs CF. Activity-induced musculoskeletal stress markers (MSM) and subsistence strategy changes among ancient Hudson Bay Eskimos. Int J Phys Anthropol. 1995;5:324–38.
41. Dlamini N, Morris AG. An investigation of the frequency of squatting facets in later stone age foragers from South Africa. Int J Osteoarchaeol. 2005;15:371–6. Wiley Inter Science.
42. Trinkaus E. Squatting among the Neanderthals. A problem in the behavioral interpretation of skeletal morphology. Am J Archaeol Sci. 1975;2:327–51.
43. Catalano P, Amicucci G, Benassi V, Caldarini C, Caprara MC, Carboni L, Colonnelli G, De Angelis F, Di Giannantonio S, Minozzi S, Pantano W, Porreca F. Gli insiemi funerari d'epoca imperiale: l'indagine antropologica di campo. In: Tomei MA, editor. Memorie dal sottosuolo. Ritrovamenti archeologici 1980/2006. ead. Electa, Milano: 2006. p. 560–3.
44. Catalano P, Benassi V, Caldarini C, Cianfriglia L, Mosticone R, Nava A, Pantano W, Porreca F. Attività lavorative e condizioni di vita della comunità di Castel Malnome (Roma, I-II sec. d.C.), Medicina nei Secoli, Arte e Scienza. J Hist Med. 2010;22(1–3):111–28.
45. Dutour O. Enthesopaties (lesions of muscular insertions) as indicators of activities of Neolithic Saharan populations. Am J Phys Anthropol. 1986;71: 221–4.
46. Lai P, Lovell NC. Skeletal markers of occupational stress in the Fur trade: a case from Hudson' Bay company fur trade post. Int J Osteoarchaeol. 1992;2:221–34.
47. Hasebe K. Knochenerhebungen in der schchäfer-und nachengegend der Schädel der Mikronesier. Arbeiten aus dem Anatomische Institut des Kaiserlische-Japanischen Universitat zu Sendai, Heft; 1935. p. 17.

4 Joint Degenerative Pathologies

Carla Caldarini, Paola Catalano, Andrea Piccioli,
Maria Silvia Spinelli, and Federica Zavaroni

4.1 Introduction

Carla Caldarini, Paola Catalano, Andrea Piccioli,
Maria Silvia Spinelli and Federica Zavaroni

4.1.1 Evolution of Orthopaedic Surgery in the Treatment of Degenerative Conditions

During the twentieth century, the development of orthopaedic surgery led to a more solid definition of the orthopaedist's boundaries and competences. It started at the beginning of the 1900 from Alessandro Codivilla's intuition, and his stating that the orthopaedist had to deal with the diseases of the musculoskeletal system [1]. However, the main pathologies involving orthopaedists in the first few years of last century were the congenital and childhood ones, those resulting from poliomyelitis, and the bone complications of tuberculosis. Later on, the treatment of degenerative diseases focused mainly on the treatment of coxoarthritis, among which the worth mentioning are consequences of congenital dysplasias, and knee arthritis. Up until the 1960s, arthritis surgery mainly consisted of osteotomies, with the aim of modifying the axes and the load areas of the joint cartilage, and arthrodeses, which inevitably led to poor functional results in large joints, even though it acted directly upon the cause of the arthritic pain. In 1962, Sir John Charnley described his hip prosthesis, thus changing the approach to degenerative surgery for ever [2]. In parallel, only after several attempts, John Insall improved the knee prosthesis with a condylar design in the 1970s [3]. Interestingly, in about a decade the approach to the treatment of coxoarthritis changed completely in the records of the national congress of the Italian Society of Orthopaedics and Traumatology (SIOT). In the 49th Congress in 1964 on the surgical treatment of coxoarthritis, osteotomies, arthrodeses, and many interventions on the soft parts were the pillars of the orthopaedist's cultural background, while more modern therapies such as acetabuloplasties and arthroplasties were only beginning to develop. In 1969, many orthopaedists already reported on their experience in prosthetic implants, and the scientific community was split between "conservatives and prosthesisizers". Since then, the development of more and more sophisticated prosthetic implants has characterized orthopaedic surgery, which nowadays faces the issue of revision surgery and complication management [4]. Another innovation in the treatment of degenerative conditions has certainly been the implementation of arthroscopic techniques of the large joints, which has been widely considered as a technological innovation of the

A. Piccioli et al., *Bones: Orthopaedic Pathologies in Roman Imperial Age*,
DOI 10.1007/978-3-319-19485-1_4

last few years, even though a 1912 contribution from Severin Nordentoft has just been found: at the 41st congress of the German Surgery Society in Berlin he presented his contribution on laparoscopy, cystoscopy, and knee endoscopy, followed after a few years by Takagi (from Japan), and Bircher (from Switzerland), who mainly concentrated on joint endoscopy [5]. Finally, the last few years have seen a growing interest in new treatment approaches towards degenerative arthritis, through the implementation of bioengineering in surgery, in particular with studies on osteocartilage transplants, mesenchymal cells, biomaterials, and growth factors.

History of Medicine: Arthritis Care

Valentina Gazzaniga and Silvia Marinozzi

When there is no damage or evidence of trauma or tumour, joint pain is generally explained as a sign of weakness induced by other diseases, or ageing, or inappropriate life styles, and leads to the accumulation of cold and corrupt matter in the peripheral parts of the body. In arthrosis and arthritis, of pathological origin, or deriving from wear, load or stress, the procedure is the same as in case of inflammation. According to the Hippocratic theories pathological processes are a sign of imbalance among the fundamental elements of the body, fluids, qualities, and solid parts, which compromises the health of the whole body. Without any apostemas, swelling, or localized clotting, the corrupt humours are drained, in particular the cold ones (such as phlegm and black bile), with drainage and calefaction treatments to re-establish normal body heat and bring the body back to balance. The therapy involves enemas, emetic medications, cupping, diets and localized treatments, such as warm compresses, and in the most complex cases, where the pain is very sharp, and there is motor difficulty and a chronic condition, the cauterization of the areas where there is visible or hypothetic clotting of pus (Celsus, *De re medica*, lib. IV, 33–35;). Galen mainly relates about chronic pain and inflammation of the femoral joint. There is a nosological overlap between low back pain and skeletal pathologies, so everything is attributed to an inflammatory process involving the whole limb due to plethoric processes to be treated with warm compresses, baths, rest, appropriate exercise, and drainage treatments, both pharmacological and surgical, which is phlebotomy. The disease is not caused by the pituous humour per se, but by the fact that it stays raw: the treatment varies according to the patient's temper, age and physical strength. First palliative medications, which do not cool or warm too much, to ease the pain, then bloodletting from the popliteus muscle or from the heel. According to Galen, acrid medications, largely widespread in his time, have to be avoided, because they cause excessive dryness, which would solidify the dense pituous humours, that undissolved continue to cause illness; he prescribes palliative medications and composite oilcloths, providing several recipes for oilcloths and mixtures, mainly based on turpentine, tar, sulphur, and "spices" such as cardamom, colocynthis, ruta, and other "warming" substances (Galen, *De Compositione medicamentorum*, X,2-3 – K.XIII: 331–341; XIV: 756).

4.2 Femoro-acetabular Impingement

Subject: CM T.250

Sex: male

Age: 40–45 years

Finding site: Castel Malnome

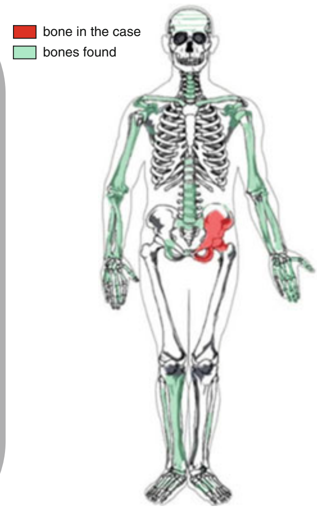
Type of grave: pit in the ground with no cover

Type of burial: disturbed primary

Deposition: supine with flexed upper right limb and extended left limb; extended lower right limb and absent lower left limb

State of preservation: poor

Stature: ~ 158 cm



4.2.1 Morphological and Paleopathological Description of the Subject

The skeleton pertaining to a mature male, it is in a poor state of preservation: only a few fragments of the skull are preserved and regarding the inferior appendicular skeleton, only the proximal epiphysis of the left femur, a portion of the left fibula, the right tibia and fibula, and part of the feet bones are left. The examination of the dental disease shows a big abscessual cavity at the alveoli of the maxillary right lateral incisor and canine. The right first premolar and contra-lateral canine and second premolar are affected by destructive decays; moreover, many maxillary and mandibular teeth were lost *intra-vitam*. On the clavicles, at the origin of the deltoid and at the insertion of the *pectoralis major* muscle, enthesopathic modifications, of osteophytic type, due to repeated movements of the shoulder, are bilaterally detected. Strong insertions at the origin of the *brachii* muscle are observed on the humeri, especially on the right, because of a repeated flexion of the forearm on the arm. In reference to the lower limbs, the right tibia is medio-laterally flattened (platycnemia); the flattening is probably due to a strong and prolonged exertion of the calf muscle. The only remaining small diaphyseal portion of the left fibula shows a severe periostitis with scabrous surface and exuberant reactive bone production. The shoulder joints show some mild arthritic degenerations: on the acromial and sternal facets of the clavicles and on the humeri heads, a mild porosity is spread, with poor marginal ostheophytes. The enthesopathy examined at the insertion of the *supraspinatus* muscle of the right humerus, would confirm a frequent rotation of the humerus on the scapula. The column shows poor lipping on the ventral margins of the vertebral bodies; a posteriorly expelled hernia is also detected on the inferior endplate of a thoracic vertebra.

4.2.1.1 Description of the Lesion

The present case shows a deformity of the head-neck compartment of the left femur now known as "cam" type (Figs. 4.1 and 4.2) that suggests femoro-acetabular impingement.

Femoro-acetabular impingement (FAI) is a condition that is more and more frequently treated and detected nowadays in adult active patients complaining of hip pain. The Medical Subject Headings thesaurus of the US National Library defines FAI as a "condition where a pathological mechanical process causes hip pain when morphological anomalies of the acetabulum and/or the femur, combined with vigorous hip motion (above all at the extreme degrees), lead to repeated collisions that damage the soft tissue structure within the joint itself".

The essential features of this definition are as follows:

- Morphological anomalies of the femur or acetabulum
- Anomalous contact between the two structures
- Supra-physiological movements leading to this contact
- Recurrence of these movements and the mechanical insult
- Damage of the soft tissue

Fig. 4.1 Femoro-acetabular impingement posterior view

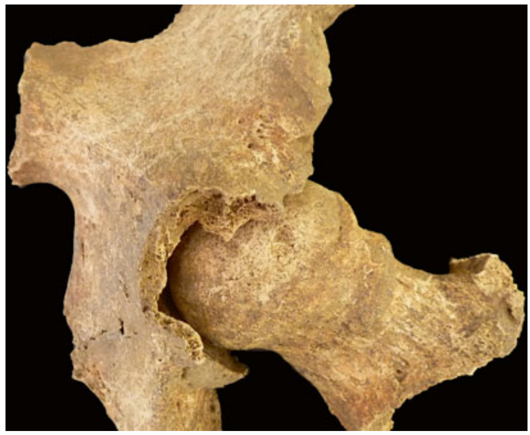


Fig. 4.2 Femoro-acetabular impingement anterior view

FAI can be further subdivided into two categories, depending on whether the deformity concerns the acetabulum or the femur, called respectively "pincer" and "cam deformity", or both. The typical clinical picture is a progressive hip pain in a young active patient, which can irradiate laterally to the trochanteric region, medially to the adductor muscles region and, more rarely, to the gluteal region or to the knee. In the past some authors [6] hypothesized that only 10 % of hip arthritis could be accounted as purely primary and that in more than 90 % of cases the pathogenesis was due to other causes (mechanical, inflammatory, metabolic, biological). Ganz et al. [7] stated that more than 90 % of hip arthritis was due to mechanical pre-existing conditions such as an acetabular dysplasia and FAI.

4.3 Primary Arthritis

4.3.1 Primary Arthritis of the Hip in Coxa Vara

Subject: Coll.T.603

Sex: male

Age: 50–60 years

Finding site: Collatina

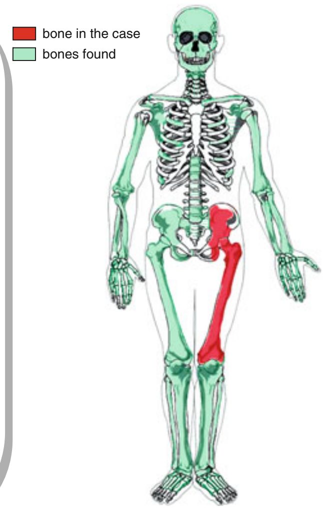
Type of grave: pit in the ground with no cover

Type of burial: primary

Deposition: supine with extended upper right limb, flexed upper left limb, and extended lower limbs

State of preservation: mediocre

Stature: ~ 174 cm



4.3.1.1 Morphological and Palaeopathological Description of the Subject

The subject, averagely built, has humeral euribrachy and strong platymeric femurs. The skull is elongated (dolichocranic) and flat (chamaecranic); the frontal crests are very diverging, the orbits are wide (hypsiconchic), and the nose is long and narrow (leptorrhine). The porosity of the outer table of the skull (*cribra cranii*) and of the roof of the orbits (*cribra orbitalia*), together with hypoplastic lines on the enamel of some mandibular teeth, suggests stress episodes that may have impaired the normal development of the subject. The maxillary bones show alveolar resorption processes due to the loss of all dental components (edentulism) *intra-vitam*; the central incisors and the lateral left one of the mandibular bone were also lost *ante mortem,* and an abscess can be observed on the buccal side of the left mandibular second molar. The carious lesions on the remaining teeth are widespread, but moderately severe, with the exception of a destructive decay detected on the right second incisor. The limited presence of alterations in the muscle-ligament insertions and the moderate degree of degenerative phenomena observed on the whole skeleton, suggest that the subject was not involved in hard work. The only enthesopathy observed on the upper limbs regards the insertion of the *brachii* muscle of the ulnas; this muscle is used for flexion of the forearm on the arm. Even though the

Fig. 4.3 Poirier's facet

Fig. 4.5 Pelvis and femur with varus deformity

Fig. 4.4 A protruding plica of the left tibia

rachis is incomplete, the fusion of two thoracic low vertebrae can be observed. The trochanteric fossae of the femurs, on the insertion surface of the *obturator externus* muscle, are affected by exostoses; the *gluteous* insertions are marked, bilaterally. An extension of the articular surface of the head of the right femur, which can be seen on the anterior surface of the neck (Poirier's facet) (Fig. 4.3) [8], may be the result of a contact between the *caput femoris* and the margin of the acetabular fossa during flexion and extension movements of the limb [9]. A further etiological factor can be the acute and repeated muscular stress of the *iliopsoas* muscle, which presses on the medial margin of the cervical eminence. The anterior surface of the patellae is affected by ossifications of the *quadriceps* tendon, mainly on the right side. The diaphyses of the lower limbs, in particular of the tibiae and fibulae, show osseous remodeling due to acute or chronic inflammatory processes, and this affects the cortical bone, as well. The surfaces are irregular and rugged, due to the deposition of a new bone in the form of striae and plaques. The anterior crest of the left tibia is particularly well developed, forming a protruding plica (Fig. 4.4), compared with the 4.6 mm cortical bone underneath.

4.3.1.2 Description of the Lesion

Macroscopically, the subject's left coxo-femoral joint does not show any alterations of the periosteum or asperities, thus suggesting a fracture, even if the cervico-diaphyseal angle of the proximal femur is narrower than 120°, indicating coxa vara (Fig. 4.5). The aetiology of this pathology can be innate or acquired. The latter can be secondary to several metabolic (i.e. type IV mucopolysaccharidosis or Morquio's disease), neoplastic (as in fibrous dysplasia), or traumatologic diseases. Monolateral coxa vara is clinically associated to lower limb heterometry, but this case has been selected because it shows the arthritic alteration which is more evident at the level of the superior profile of the head of the femur, where the osteophytosic collar is well shown. The acetabulum alterations are less evident, and X-rays examination (Fig. 4.6) shows subchondral sclerosis.

Fig. 4.6 X-rays antero-posterior view of the hip confirm varus deformity of the cervico-diaphyseal femoral angle and subchondral sclerosis at the acetabulum. The absence of osteostructural alterations rules out the potential secondary origin of the deformity

4.3.2 Osteoarthritis of the Knees

Subject: CBM F.3 Liv. 4 Ind. E

Sex: female

Age: 45–50 years

Finding site: Casal Bertone Mausoleo

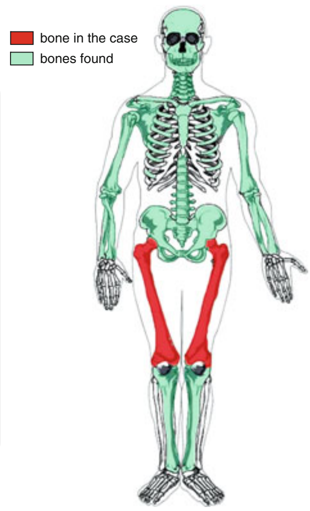
Type of grave: forma with flat cover

Type of burial: primary

Deposition: supine with extended upper limbs and non deductible lower limbs

State of preservation: good

Stature: ~ 156 cm



4.3.2.1 Morphological and Palaeopathological Description of the Subject

The skeleton belongs to a mature female and is of average build. The values of the main cranial indices are average, with the exception of the height index which denotes a flat skull (chamaecranic) and the nasal index which reveals a long and narrow *piriformis* aperture (leptorrhine).

The dento-alveolar complex is compromised: a dental caries, with destructive lesion penetrating the pulp cavity, can be observed on the upper right second premolar and several teeth have been lost *ante-mortem*.

On the anterior surface of the left clavicle, at the origin of the deltoid muscle, the regular curved margin is interrupted by a rough protrusion; the costo-sternal joints are affected by erosions, particularly on the left. The gleno-humeral joints are bilaterally modified by arthritic degenerations: the surfaces and the contours of the lesser and greater tubercle of the humerus, (where, respectively, the *subscapularis* and the *supraspinatus* muscles are inserted), are eroded and sclerotic, suggesting a joint pathology of the rotator cuff (Fig. 4.7). A major degeneration can be detected at the right elbow joint: the surface of the humeral epicondyles is hemmed by a bony ring, the capitulum of the right humerus is eburneated, and posteriorly the olecranon fossa is irregularly rough. The cartilage loss and the bone destruction due to the contact with the humerus can be seen on the radial capitulum, whose lateral edge is expanded and eroded. The superior margin of the olecranon posterior face is affected by a protruding enthesopathic ossification at the insertion of the *triceps brachii*,

Fig. 4.7 Signs due to a pathology of the rotator cuff

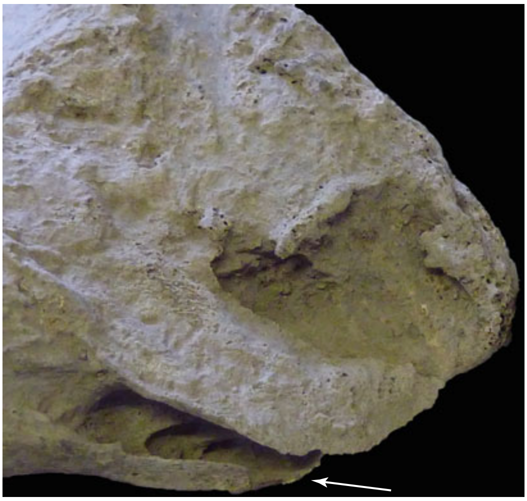


Fig. 4.8 Preauricular groove (*arrow*)

Fig. 4.9 Sacralization

due to repeated extension of the elbow (*woodcutter's lesion*); moreover, the contours of the olecranon and of the coronoid process are jagged and irregular. A compound fracture can be observed on the distal third of the right ulna diaphysis. The cotyloid cilium is bilaterally altered, with mild new bone production, and the acetabular fossa is mildly porous. The margin of the dorsal symphyseal face of the pubis, at the insertion of the inguinal ligament, shows a large pit, the pubic tubercle is hypertrophic and the preauricular groove (Fig. 4.8) has very deep depressions; these modifications are related to the mechanical solicitations of birth delivery. Severe lesions can be observed at the knee: bilaterally a marginal osseous ring hems both femoral condyles, but it is especially developed on the superior edge of the lateral condyle's anterior face, with a worn area with eburnation affecting the whole patella articular surface. The alterations of the tibial plateau are minor, the intercondylar eminences are marked, and some osteophytes hem the posterior portions of the joint's edges. The vertebral bodies referring to C3-C6 tract are enlarged, surrounded by limited osteophytes and with erosions especially on the imprint area of the *nuclei polposi*. The costo-transverse facets, both on the ribs and on the transverse apophysis, at T10 and T11 metameres, are irregularly expanded and cribrous, and show clear osteophytes. The last three lumbar vertebrae show an expansion of the inferior facets, latero-posteriorly, characterized by macroporosities and irregular margins. The fifth lumbar vertebra is fused with the sacrum (sacralization) (Fig. 4.9). There are no Schmörl's intraspongious hernias.

4.3.2.2 Description of the Lesion

The subject's macroscopic picture is compatible with severe arthritis of the patello-femoral joint of the right knee. The profiles of both femoral condyles are irregular due to marginal osteophytosis, but even in a picture of tricompartmental degenerative arthropathy, the severe signs of patello-femoral overuse are more evident and significant (Fig. 4.10). This pathology can be the consequence of an alteration of the normal profile of the femoral trochlea and/or of the patella, or of repeated chronic overload on the patello-femoral joint. In most cases the contact is between the lateral facet of the patella and the lateral profile of the trochlea. In the case examined, the trochlea shows "traintrack-like" grooves, with eburnation of the subchondral bone (Fig. 4.11) at the sliding area of the kneecap, due to its severe and repeated contact with the trochlea. The clinical and symptomatological picture is extremely variable. Standing up from a sitting position, climbing up or down some stairs, or kneeling can start or worsen the pain.

Fig. 4.10 Osteoarthritis of the knees

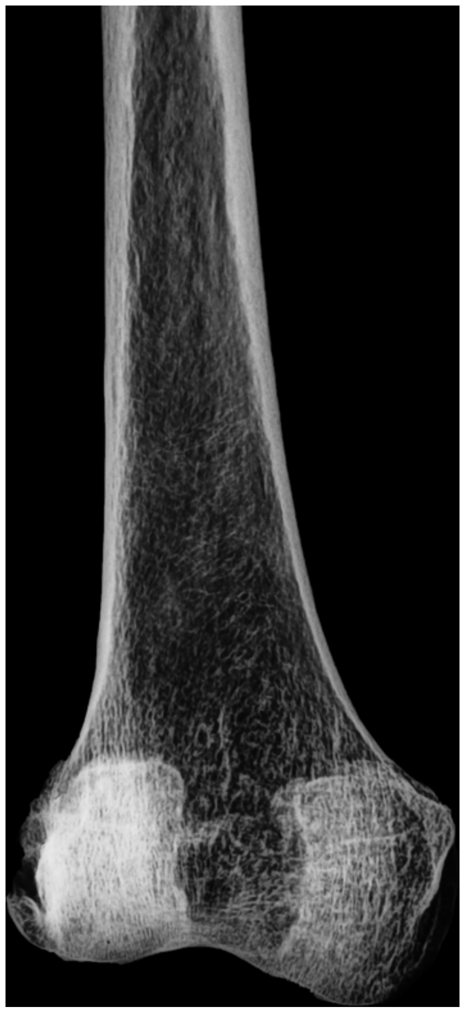


Fig. 4.11 X-rays antero posterior view of the distal femur shows an area of hyper-opacity at the lateral condyle, due to subchondral sclerosis, a sign of arthritis of the knee joint

4.3.3 Spine Arthritis

Subject: CM T.18

Sex: male

Age: 40–50 years

Finding site: Castel Malnome

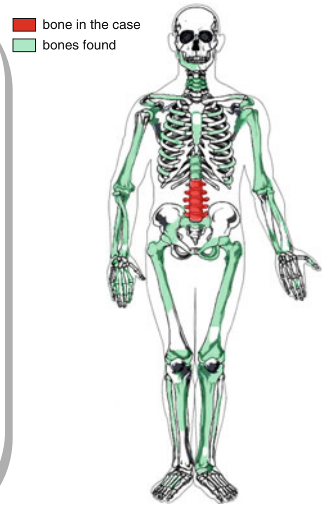
Type of grave: pit in the ground with "cappuccina" cover

Type of burial: disturbed primary by clandestine digging

Deposition: supine with non deductible upper and lower limbs

State of preservation: mediocre

Stature: ~ 183 cm



4.3.3.1 Morphological and Palaeopathological Description of the Subject

The skeleton, pertaining to a mature and very tall subject, shows strong muscular insertions only in the lower limbs; the anthropometric indices of the postcranial skeleton denote roundish sections, only slightly modified by biomechanical stress. The skull, preserved only in the occipital portion, shows some Wormian ossicles along the lambdoid suture and a small bone at the lambda. Mild osteolytic degenerative alterations can be detected bilaterally at the acromio-clavicular joint. The whole superior appendicular skeleton shows no relevant ergonomic alterations. The presence of little cribrosities inside the acetabular fossa and the raised cotyloid cilium, indicate an early stage coxoarthritis, while a bone rarefaction on the right ischial tuberosity, at the origin of the *semitendinosus* muscle, would indicate an enthesopathy, related to the flexion of the knee and to the extension of the hip. The surface of the head of the left femur shows a bony ring along the inferior perimeter, and a wide and deep fovea. The presence of a facet, called anterior cervical imprint, on the neck of the right femur, suggests hyperflexion and/or extension movements of the femur [9]. Repeated plantar flexion and foot inversion movements may have caused the strong development of the *soleus* muscle entheses on the tibiae's dorsal surfaces, and the formation of the marked furrow of the left *tibialis* posterior tendon.

The tibial and fibular diaphyses are affected by periostitis, with striated deposition of new bone.

The rachis shows osteophytic and osteolytic arthritic degenerations and the presence of four thoracic hernias.

4.3.3.2 Description of the Lesion

The macroscopic examination of this tract of the vertebral column shows a severe spondyarthritis of the lumbar tract, from L1 to L5 (Fig. 4.12). The fairly good state of preservation allows the observation of the calcification of the ligaments along the marginal profiles of the superior and inferior somatic limitants of the vertebral

Fig. 4.12 Spondyarthritis of the lumbar tract (L1–L5)

bodies, which are very irregular with wide osteophytosic flarings. This picture refers to a severe pre-existing discopathy and major overload compatible with the subject estimated age and with the location at the last segments of the rachis, where the load forces are mostly concentrated. The clinical picture is characterized by pain and severe movement rigidity and by a varying degree of functional limitation. This severe presentation and the “bone casting” complete fusion between the contiguous vertebral segments may be differentially diagnosed as ankylosing spondylitis, a chronic autoimmune inflammatory rheumatic pathology. This diagnostic hypothesis cannot be verified because of the few elements we have.

4.4 Secondary Arthritis

4.4.1 Post-traumatic Arthritis of the Elbow

Subject: CM T.152

Sex: male

Age: 45–55 years

Finding site: Castel Malnome

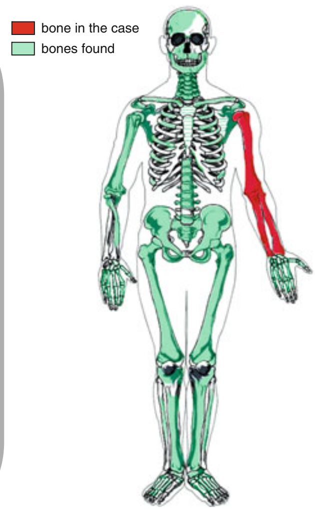
Type of grave: pit in the ground with no cover

Type of burial: primary

Deposition: supine with flexed upper limbs and extended lower limbs

State of preservation: mediocre

Stature: ~ 169 cm



4.4.1.1 Morphological and Palaeopathological Description of the Subject

The skeleton belongs to a senile, well-built man.

The examination of dental disease reveals periapical abscess associated with the upper second molars.

From an enthesopatic point of view, the subject shows alterations due to repeated and strained use of the muscles involved in the shoulder and the forearm flexo-extension movements. On the right, a mild area of cortical erosion (rhomboid fossa) replaces the rough imprint for the costo-clavicular ligament; the distal extremity, at the origin of the deltoid muscle, shows a marked imprint bilaterally; on the lesser tubercle of the humerus, the surface is rough and irregular. On the infraglenoid tubercle of the scapulae, a furrow with a protruding crest can be detected at the origin of the *triceps brachii* muscle; the insertion area of the *pectoralis major* muscle on the humeri is strong and marked, and the bicipital tuberosities of the radial bones are extended and fringed by a bony hem. The surface of the ischium, at the origin of the *semitendinosus* muscle, is bilaterally eroded, suggesting flexions of the movements of the knee and extensions of the hip. Small enthesophytes at the insertion of the *gluteus minimus* muscle of the right femur indicate abduction movements of the thigh [10]. Signs of arthritic degeneration can be seen on the appendicular skeleton. The alterations of the vertebral column suggest spondyloarthritis likely due to the subject's age, with clear signs of macroporosity on C6 and C7 and of angular osteophytosis on the last thoracic and lumbar vertebrae. Moreover, ankylosis of T6-T7 and of the left seventh rib (Fig. 4.13a, b) can be observed, with the formation of a bony bridge between the superior and inferior margins of the vertebral bodies. The rib joint facet is fused in the costal fovea and surrounded by a bone callus formation. The imprint of a posteriorly exteriorized intraspongious hernia can be seen on T7 inferior face. Several fractures with axis deviation can be detected on ten ribs, seven on the right and three on the left. In addition, the subject shows a comminuted fracture of the left tibial lateral plateau (Fig. 4.14), even though the incomplete preservation of the proximal portion does not rule out the hypothesis that the traumatic event involved both condyles.

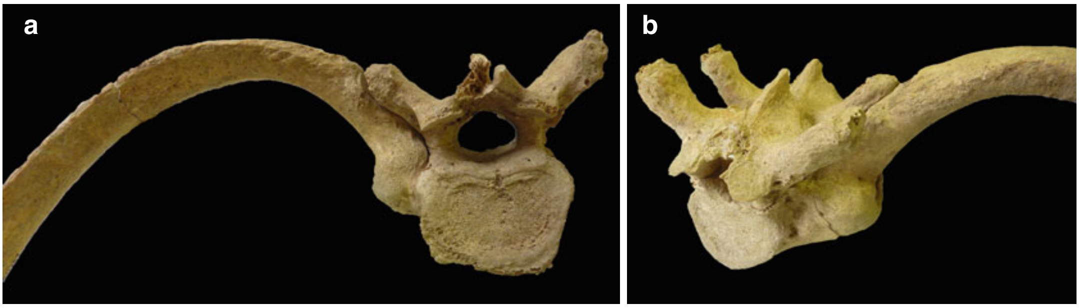


Fig. 4.13 (**a**) Anchylosis of T6-T7 and of the left seventh rib inferior view. (**b**) Anchylosis of T6-T7 and of the left seventh rib supero-lateral view

Fig. 4.14 Fracture of the left tibia's lateral plateau

The fracture is related to a subchondral spongious depression, with a resulting lack of levelling of the joint's surface.

4.4.1.2 Description of the Lesion

The degenerative pathology of arthritis almost always affects load stressed joints. The joints of the upper limbs, except for those found in the hand, where deforming arthritis of the distal and proximal interphalangeal joints primarily sets in, are usually affected only by post-traumatic arthritis. The subject shows a marked alteration of the joint profiles (Fig. 4.15). The left capitellum shows the potential consequence of a fracture with crushing and angulation of the neck (Fig. 4.16). The periarticular calcifications and the eburnation of the articular surfaces are signs of a likely primitive arthritis of the elbow, due to the subject's hard work.

Fig. 4.15 Arthritis of the upper limb

Fig. 4.16 Fracture of the left capitulum of the radius

The clinical picture regards a painful swelling, with restriction of the movement, on inflammatory and mechanical basis, due to the alteration of the articular profile.

History of Medicine: Elbow Dislocation and Fractures

Valentina Gazzaniga and Silvia Marinozzi

According to Celsus, the elbow can dislocate in every direction and the reduction is performed pulling the arm in opposite directions, and then pushing in the direction that the humerus or radius has come out (Celsus, XVIII, 16).

On the other hand, Galen states that the elbow can dislocate inwardly and outwardly: the ulna and radius dislocations are reduced with an extension in line with the humerus, performed pulling the wrist in the opposite direction to the pulling arm held from the axilla, while a third assistant presses on the joint's head (Galen, *De Fracturis*, III, 51–61 - K. XVIII/B: 611–624)

4.4.1.3 Fracture of the Tibial Plateau

Associated to the above-described arthritic picture, the examined subject also showed a fracture of the left tibial plateau (Fig. 4.14). The macroscopic find confirmed the diagnosis, which might have been mistaken for some post-mortem signs, except for the presence of healing bone callus on the depression area. However, the medical report has been the following after X-ray examination.

Radiologist's Evaluation

Silvana Giannini

Irregular radiolucency line of discontinuity of the articular surface on the external tibial plateau. Distrectual radiopacity on the lateral side of the proximal metaphysis, likely due to a collapse of the subchondral trabecular, and depression of the articular surface. Major radiopacity in the posterolateral aspect of the proximal tibia showing a pattern of bone healing (Fig. 4.17).

Moderate flaring diaphyseal–metaphyseal proximal feature.

Intra bone marrow nubecular hardening.

The CT scan's coronal and sagittal plane better shows the depression of the articular surface with collapse of the hyperdensity trabeculae (Figs. 4.18 and 4.19).

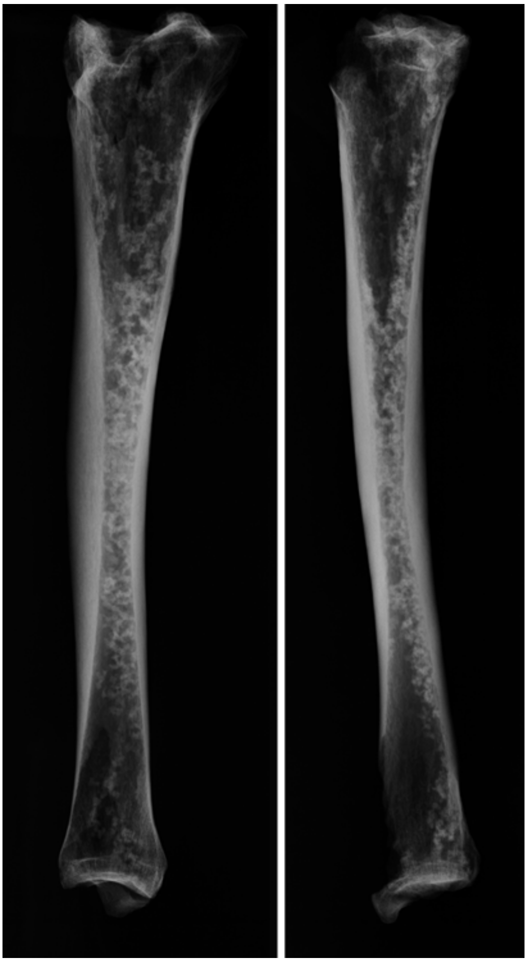


Fig. 4.17 X-rays antero-posterior and lateral view: fracture of the tibial plateau. On the side is interesting to note diffuse hypodensity of the central part of the metaphysis is caused

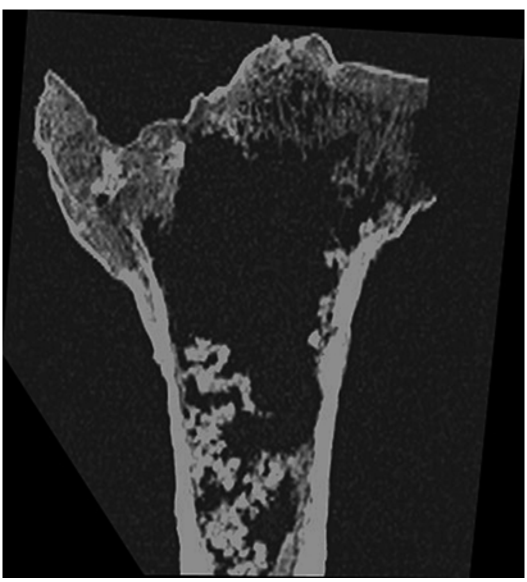


Fig. 4.18 CT scan coronal plane multiplanar reconstruction

History of Medicine: Tibia Fracture Care

Valentina Gazzaniga and Silvia Marinozzi

In tibia and fibula fractures doctors do not need complex equipment: an extension performed by two assistants pulling in opposite directions is enough. Dressings are wrapped to apply pressure on the protruding part of the stump, and after the first bandage, rods can be put to immobilize the area. Galen advices to use doctors' specific devices only if needed, for movements due to linen changing or to go to the toilet. One of these instruments is the glossocomion, a little box used by Atticans to preserve precious things, which is a wooden box where the fractured limb is placed; another tool is the shower, a wooden and concave frame, a sort of prefabricated cast, hollowed out to hold the leg or their parts. Axles tied with strings are also used to immobilize the leg.

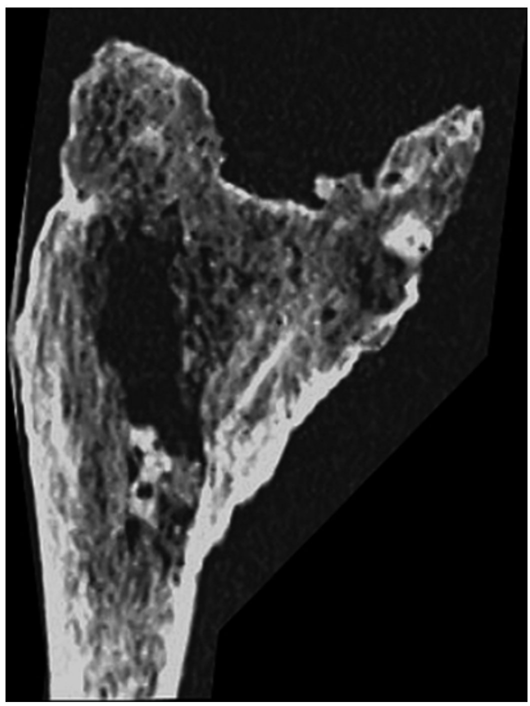


Fig. 4.19 CT scan sagittal plane multiplanar reconstruction

4.4.2 Post-traumatic Hip Arthritis

Subject: VN T.6 ind.2

Sex: male

Age: 25–35 years

Finding site: Via delleVigne Nuove

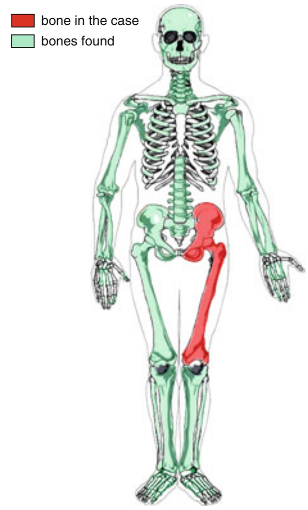
Type of grave: brick grave with flat cover

Type of burial: primary

Deposition: extended upper left limb, slightly flexed upper right limb, extended lower limbs

State of preservation: good

Stature: ~ 176 cm



4.4.2.1 Morphological and Palaeopathological Description of the Subject

The skeleton refers to a tall, average built male subject. The skull is elongated (dolichocranic), with a narrow forehead (stenometopic), very diverging frontal crests and large orbits (hypsiconchic). A fine erosion affects the table of the skull, in particular in the area of the bregma, where more and bigger holes can be observed (*cribra cranii*); the roof of the orbits also shows a mild bilateral porosity (*cribra orbitalia*); these lesions suggest spread porotic hyperostosis. One of the anatomical variants that can be observed is the bilateral mendosa suture. From an entheso and syndesmopathic point of view, there are many different sites, with a mixture of erosive phenomena at the bone insertion, with several expressions of bone metaplasiae of the tendons and ligaments. The points of insertion of the deltoid muscle, both on the clavicles and the humeri, show ossifications, maybe due to the repeated action of carrying heavy loads on the shoulders. Alterations at the origin and insertion of the *triceps brachii* muscle, respectively on the infraglenoid tubercle of the scapula and on the posterior part of the olecranon of the ulna are maybe due to frequent extension and flexion movements of the forearm on the arm; the origin of the *brachioradial* muscle of the humeri and the insertion of the *brachialis* muscle of the ulna, which are involved in the same movement, are also highly developed. The origins of the superficial flexor muscles of the fingers show wrinkled protrusions. On the whole, all the above-described movements suggest a type of work involving repeated flexion and extension movements of the forearm and of the fingers. The insertion area of the *soleus*, on the posterior face of the right tibia, is characterized by a depression which traces the direction of the oblique line while some spicules can be observed on the left heel bone tuberosity, at the insertion of the Achilles tendon. These stresses may suggest repeated extensions movements of the foot. The posterior face of the left ischial tuberosity shows limited oval erosion, with well-defined and slightly raised margins, with a maximum diameter of 16 mm at the area in contact with the ischial mucous bursa. Ischial bursitis ("weaver's buttock") is an inflammation affecting the bursa (the small cavity full of fluid surrounding joints) which separates the *gluteus medius* muscle from the ischial tuberosity and its onset occurs after prolonged periods in a sitting position on a hard surface [9]. This

Fig. 4.20 Periostitis of the tibial diaphysis

pathology can also be a consequence of a direct trauma, such as fall onto a hard surface; in the examined subject, the fracture on the left iliopubic eminence might have caused this condition. The presence of some parrot's beak osteophytes on the lateral margin of the auricular surface and the formation of an additional facet at the right sacroiliac joint, may be related to the complex condition of the hip [11]. Abnormal fusiform swellings, observed on the diaphyses of the tibias and the fibulas, could be ossifications of subperiosteal haematomas, of potential post-traumatic origin. In case of a vascular subperiosteal lesion, caused by contusive trauma, the periosteal detachment, produced by a haematic extravasation, stimulates the periosteum itself in an osteoblastic way, thus originating a reactive periosteal (Fig. 4.20) bone formation [12].

The shoulder and wrist joints, and the thoracolumbar vertebral bodies show mild signs of arthritis.

4.4.2.2 Description of the Lesion

The most evident macroscopic sign of this subject's coxofemoral joint is an arthritic degeneration of the head of the left femur (Fig. 4.21). A widespread marginal osteophytic rim can be observed without severe alterations of the head's spherical shape, as in the most severe cases of arthritic degeneration. The X-ray examination (Fig. 4.22) shows the presence of formations of geodic type at the level of the subchondral bone, a sign of chronic distress and arthritic degeneration. However, after a more thorough examination the acetabulum, at the quadrilateral layer, shows a solution of continuity with linear alterations of the bone surface resulting from the fracture of the acetabulum. Without any treatment, such as traction, this type of fracture may have medialized the femoral head, thus resulting in coxa profunda. The clinical picture is the same as that of primary arthritis, characterized by pain, stiffness and reduction of the articular excursion.

Fig. 4.21 Arthritis of the left hip joint

Fig. 4.22 X-rays: antero-posterior view of the hip

References

1. Putti V, Istituto Ortopedico Rizzoli (Bologna). Alessandro Codivilla's medical essays. Ed. Bologna, Italy: Cappelli; 1911.
2. Berry DJ, Lieberman JR. Surgery of the hip, vol. 2. Elsevier, 2011, Canada.
3. Pal S. Design of artificial human joints and organs. New York: Springer; 2014.
4. Misasi M. The S.I.O.T. congresses of the last 40 years (1963–2002) in the history of Italian orthopaedics. GIOT. 2004;30:198–214.
5. Strobel MJ. Manual of arthroscopic surgery. Berlin/Heidelberg: Springer; 1998.
6. Solomon L. Patterns of osteoarthritis of the hip. J Bone Joint Surg Br. 1976;58(2):176–83.
7. Ganz R, Leunig M, Leunig-Ganz K, Harris WH. The etiology of osteoarthritis of the hip: an integrated mechanical concept. Clin Orthop Relat Res. 2008; 466(2):264–72.
8. Poirier P, Charpy A. Traité d'anatomie humaine, vol. 1. 3rd ed. Paris: Masson; 1911.
9. Capasso L, Kennedy KAR, Wilczak CA. Atlas of occupational markers on human remains. Teramo: Edigraphital; 1999.
10. Dutour O. Enthesopaties (lesions of muscular insertions) as indicators of activities of neolithic Saharan populations. Am J Phys Anthropol. 1986;71:221–4.
11. Mann RW, Hunt DR. Photographic regional atlas of bone disease. A guide to pathologic and normal variation in the human skeleton. 3rd ed. Springfield: Thomas; 2012.
12. Ortner DJ. Identification of pathological condition in human skeletal remains. 2nd ed. San Diego: Academic Press; 2003.

5 Oncologic Pathologies

Carla Caldarini, Paola Catalano, Andrea Piccioli,
Maria Silvia Spinelli, and Federica Zavaroni

5.1 Introduction

Carla Caldarini, Paola Catalano, Andrea Piccioli,
Maria Silvia Spinelli, and Federica Zavaroni

5.1.1 Historical Developments in Musculoskeletal Oncology: From Amputation to Limb Conservation

Current musculoskeletal surgery is based on studies from the beginning of 1900 and the incorporation of metal implants (into the human body) that are subjected to corrosion when in contact with bodily fluids, thus reacting as a foreign body. In 1932, the development of Vitallium, an alloy of chromium and cobalt, first used in dental implants, opened the way to the employment of chromium-cobalt alloy syntheses in orthopaedics [1, 2]. The use of Vitallium in musculoskeletal oncology dates back to 1943, when a proximal femur endoprosthesis was implanted [3] after resection due to giant-cell tumour, with signs of evident integration at autopsy and radiography 1 year later. This led to the creation of new implants using different materials, such as steel, polyethylene, and others, both in the treatment of resections and in long bone defects [4]. However, amputation represented the main treatment option in patients affected by musculoskeletal neoplasias. The actual spread of prosthetic implants (still personalized) came thanks to the progress in radiology, pathology, chemotherapy, and radiotherapy, which allowed a better staging and assessment of the tumour's size, and a higher survival rate in patients with musculoskeletal tumours. In particular, adjuvant chemotherapy was used in the 1970s as additional therapy in surgery to reduce local relapses and treat any residual cancer cells with encouraging results in terms of survival rates [5, 6]. Moreover, thanks to the progress in integrated treatments, the number of candidate patients for prosthetic treatments and conserving surgery increased, and this was a major improvement compared to amputation. This context led to a growing effort towards the improvement of prosthetic systems and the birth of standard modular endoprostheses [7], first for the proximal and distal femur, for the proximal tibia, and for the proximal humerus [8–11]. With the development of more and more sophisticated prostheses for the reconstruction of bone defects after resection, a major contribution to the systematization of the treatment approach of musculoskeletal tumours was given by Prof. Campanacci and Prof. Enneking [12] who set the ground rules for staging, reconstruction, and integrated treatment of musculoskeletal tumours. In conclusion, musculoskeletal oncologic surgery was actually born about half a century ago and has evolved since then. In particular, the new material technologies, the development of adjuvant therapies, and the systematization of the approach have led us to the present context, where we are able to save most patients' limbs, thus increasing their quality of life, and the prognosis in case of musculoskeletal tumours [13].

A. Piccioli et al., *Bones: Orthopaedic Pathologies in Roman Imperial Age*,
DOI 10.1007/978-3-319-19485-1_5

History of Medicine: Tumours Care

Valentina Gazzaniga and Silvia Marinozzi

In Ancient medical texts, the term tumour is not always used as our term neoplasm, generally referring only to swellings, skin lesions, inflammatory status. Palaeontology and palaeopathology studies have highlighted how cancer seems to be characteristic of terrestrial vertebrates, even though some neoplastic forms have also been found on fossils of water animals and reptiles, and have demonstrated the philogenetic relationships between focal hyperostosis in fish and osteoma in man. Neoplastic lesions have been found on animal fossils from the Palaeolithic and Mesozoic periods, but the finds dating back to the Jurassic and the Cretaceus periods, that is the time of the development of terrestrian animals and reptiles, certainly show a higher rate of neoplasms than the water species. The difficulty in reaching a diagnostic certainty on biological and human ancient material is clearly shown in an article by Luigi Capasso (Antiquity of Cancer. *International Journal of Cancer*. 113(1):1–12). The diagnoses of tumours on palaeolithical human skeletal finds are still unreliable, and the small number of finds does not allow a realistic hypothesis of the incidence of these diseases in prehistoric and ancient populations. In Hippocrates's works, the terms karkinos and karkinoma recall, metaphorically and literally, a "wear and tear" of the areas attributable to animals' bites and scratches, and they are used by the Hippocratic doctor to explain the appearance of ulcers and internal and far-between new formations, as a consequence of a pathological process recalling a live entity moving within the body, and eating and corroding its organs and limbs. The semantic and conceptual continuity of some forms of neoplasms is found in the use of the Latin terms cancer and carcinoma to identify some pathological conditions. Celsus describes carcinoma as an abnormal hard new growth, forming mainly in the high areas of the body, in particular on the face (skin, nostrils, ears, and lips) and on women's breasts; first it develops as a swelling, and later involves the blood vessels thus producing red, rugged ulcers. It is difficult to remove after the very first growth phase, and almost always incurable, because the disease relapses even when removed. Similarly, Celsus attributes the ability to relapse also to "goitre", a disease characterized by hard and resilient nodules growing underneath a corrupt and purulent part of the body, particularly in the armpit, groin, and breast areas, that can be interpreted as a scirrhous swelling of the glands (*De medicina* V, XXVIII, 7). In Galen (129–210), the choice of terms is based on what the lesions and pathological new growths look like, and on the assonance of signs and symptoms with a specific animal: "…we often see a tumour in the breasts that totally looks like a crab", because it has legs on both sides, as the veins that branch out from the tumour mass (*Ad Glauconem de Methodo Medendi*. II, K. XI, 140–141). Sometimes, due to black bile build-up, some blackish, non-purulent swellings grow and cause some malignant ulcers corroding the flesh (*De atra bile*, K. V, 122). The diseases called after an animal's name due to the morphologic similarity of the physical alterations to a given animal species often have a similar aetiologic interpretation: in Galen, cancer and elephantiasis both derive from a black bile build-up, which causes preternatural growths (*De alimento* K XV, 331). The same is found in the choice of therapies, which involves, based on the principle of similia similibus curantur, the pharmaceutical use of crab (Plinius N.H.XXXII, 46, 134). Celsus provides information of lesions likely associated to bone tumours when he refers to forms where the bone grows big, then becomes black, and decays, developing ulcers or fistulas that can progress and erode it; the intervention involves the removal of the rotten flesh so as to uncover the bone and cauterize it, and in case of larger lesions the bone has to be scraped to allow some blood to come out. If there are caries, the bone has to be scraped until the harder part of it is reached, while in the presence of black matter the tissue is removed until the bone is completely white. For this operation, Celsus also uses the drill, which the Hippocratic tradition had indicated for the removal of bone segments and splinters which could be harmful in fractures of the skull. The modiolus is composed of two wooden sticks, a thread, and a series of removable metallic tips; one stick is bow-shaped, with handles at its extremities, and pierced in the middle so as to allow the second stick to slide through it; this one ends in a metal cylinder with a saw-toothed lower edge to screw the trephines on; the grips of the bow are pierced to allow the thread to turn around the upper part of the toothed crowns of the drill (and to pull it alternately in one or the other direction to turn the trephines and pierce the area to be removed). This tool is used in case of small lesions, because it acts with one only perforation able to insert the catheters and dry the bone, so as to remove the corrupt areas, then scrape and remove the rotten ones. In the presence of larger and deeper lesions, a drill is used, with a tip that widens and lifts a bigger amount of bone; some holes are pierced around the corrupt area, thus allowing the removal of the whole diseased region with a chisel. Non-oily medications are then placed on the area, such as raw wool soaked in oil and vinegar (*De medicina* VIII, 2, 1).

5.2 Benign Bone Tumours

5.2.1 Osteochondroma of the Proximal Humerus

Subject: CM T.108

Sex: male

Age: 35–45 years

Finding site: Castel Malnome

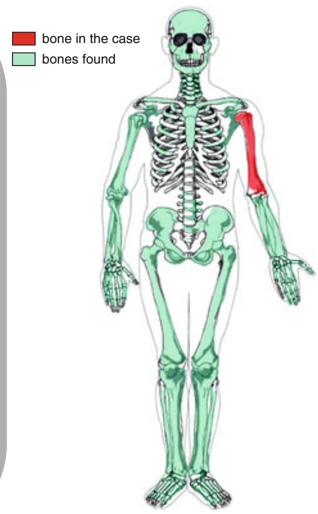
Type of grave: pit in the ground with "cappuccina" cover

Type of burial: primary

Deposition: supine with slightly flexed upper and lower limbs

State of preservation: good

Stature: ~ 161cm



5.2.1.1 Morphological and Palaeopathological Description of the Subject

The skeleton, pertaining to a mature male subject, is whole and in a good state of preservation. The cranial indices denote a roundish shape (brachycranic), with averagely diverging frontal crests; the orbits are large (hypsiconchic), while the nasal index has intermediate values (mesorrhine). The right portion of the frontal bone shows a subcircular depression, presumably due to a trauma (Fig. 5.1). Two Wormian sutural ossicles can be observed bilaterally along the lambdoid suture. The oral pathologies consist of moderate calculus build-ups on all the teeth and resorption of the alveolar margins, both on the maxillary and mandibular bones. Moreover, some cavities can be observed only on the left emi-maxillary: a destructive one on the second molar, a mild one at the mesial neck of the first premolar, and a superficial one mesially on the third molar. The right superior second incisor and right inferior canine present rotated if compared with proper alignment. The section indices of the limbs suggest a robust subject with well-developed muscular insertions. The shoulders seem particularly under stress, with the presence of enthesopathies at the insertion of the costo-clavicular and conoid ligaments of the right clavicle and at the insertion of the *pectoralis major* muscle of the right humerus. The femurs are platymeric, and the attachment tubercle of the adductors, on the medial condyle of the right femur is hypertrophic and defined by bone spicules. The third trochanter can also be detected on the right femur, and is considered as a variant of the post-cranial skeleton [14] by some authors, while others consider it as an occupational marker, because it is a part of the insertion of the *gluteus major* muscle [15]. The lateral epicondyle of the right tibia shows the outcomes of a likely depression fracture, with remodelling of the antero-medial margin and new bone apposition (Fig. 5.2). A concave depression of the supero-lateral margin of the right patella may have resulted from a prolonged contraction of the *quadriceps* (*vastus* notch). A severe and localized periostitis can be observed on the proximal third of the right fibula diaphysis. Only the joint of the left elbow shows some arthritic signs: the trochlea articular margins are raised and irregular and the coronoid fossa is enlarged, with well-defined margins; a small area of subchondral

Fig. 5.1 Depression on the frontal bone

Fig. 5.2 Fracture of the lateral epicondyle of the right tibia

necrosis can be detected on the lateral epicondyle (*osteochondritis dissecans*) [16]. In addition, the surfaces of the olecranon and of the coronoid process are expanded, with new spicular bone formations. The vertebral column is affected by mild degenerative, erosive, and productive phenomena, and four thoracic vertebrae, on the eight that can be observed, show Schmörl's hernias. Bilaterally the ischiatic tuberosity, at the origin point of the *semitendinous* muscle, is extended and eroded, the potential manifestation of a chronic inflammation.

5.2.1.2 Description of the Lesion

Osteochondroma (also called exostosis or osteocartilaginous exostosis) is the most common

Fig. 5.3 Left humerus osteochondroma

benign lesion affecting the bone and accounts for 10–15 % of all bone lesions, both in women and in men [17]. The location is typically metaphyseal or metadiaphyseal. In this case, the metadiaphyseal location, the large implant base, and the continuity of the medullary from the host bone into the exostosis with no periosteal reaction is highly suggestive of sessile osteochondroma of the proximal left humerus (Fig. 5.3).

Fig. 5.4 X-rays antero-posterior view of the proximal humerus. Exostotic lesion with no osteostructural alterations

The macroscopic examination shows the top of the extostosis as a spongious marrow, resulting from the loss of the cartilaginous cap. The absence of intramedullary and periosteal reactions (Fig. 5.4) of the contiguous bone rules out malignancies. In this type of lesion, the area more prone to a malignant transformation is the cartilage cap (chondrosarcoma) with a percentage <1 % in single cases and from 3 to 5 % in cases of multiple exostoses [17]. Symptoms depend on the site of the lesion and on the adjacent structures, because the clinical picture depends on the compression "ab extrinseco" of the exostosis.

5.2.2 Osteochondroma of the Proximal Tibia

Subject: CM T.137

Sex: female

Age: 16–20 years

Finding site: Castel Malnome

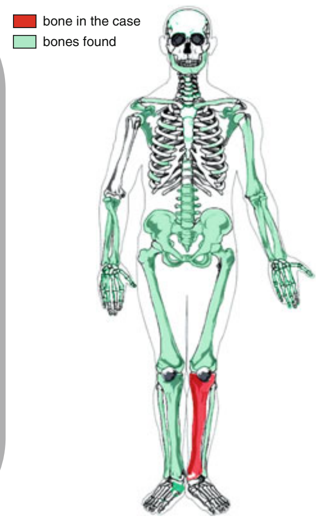
Type of grave: pit in the ground with no cover

Type of burial: primary

Deposition: supine with slightly extended upper left limb and extended upper right limb, extended lower limbs

State of preservation: good

Stature: ~155 cm



5.2.2.1 Morphological and Palaeopathological Description of the Subject

The skeleton belongs to a young subject; even though the state of preservation is good, the right humerus is missing completely, and only a few fragments of the skull's right parietal and occipital bone are left. The examination of the mandibular dento-alveolar complex shows the presence of a decay at the mesial position of the dentine, of the left second molar and one on the occlusal surface of the left third molar; the right third molar is typically peg-shaped (Fig. 5.5): it is a small-size tooth, without the normal crown morphology (diameter b-l: 3.9 mm) [18].

The skeleton is in the growth phase and shows some metaphyseal lines still partially active when the subject died. The right radius, ulna (the humerus is missing) and lower limb are about 8 mm longer than their contra-laterals. The ligament and tendon insertions are generally weak: only two enthesopathic alterations can be detected at the insertions of the *brachii* muscle of the left ulna and *iliopsoas* of the right femur. The fifth lumbar vertebra shows an early sacralization with osteophytic reaction and remodelling of the articular facets. The anteversion of the right femoral neck (Fig. 5.6) is noteworthy, that is the angular difference between the axis of the neck of the femur and the transcondylar axis of the knee. The anteversion of the femoral neck, which is an important feature for hip stability and normal ambulation, is a multifactorial outcome of heredity, fetal development, intrauterine position, and mechanical forces [19]. The anteversion of the femoral neck draws an angle of about 55°. The right clavicle exhibits a well-healed fracture in the diaphyseal portion, with overlapping of the two bone stumps and robustness of the lateral extremity. Only a few vertebral fragments of the cervical column and of the superior tract of the dorsal one are left. On the contrary, the

Fig. 5.5 Peg-shaped right third molar

Fig. 5.6 The anteversion of the right femoral neck

Fig. 5.7 Osteochondroma of the left tibia

tract between T9 and L5 is well preserved; five thoracic vertebrae show osteophytic interapophyseal degenerations and two Schmörl's hernias. Because of the subject's young age, the alterations on the axial skeleton may be due to biomechanical stress.

5.2.2.2 Description of the Lesion

A pedunculated osteochondroma can be observed on the medial profile of the left tibia's proximal part (Fig. 5.7). When exostoses are so small, a differential diagnosis with the insertional calcifications of the tendons is needed. However, the present case shows a "centrifugal" attitude of the knee joint that is characteristic of osteochondroma. Even in this case, X-ray examination (Fig. 5.8) shows the lack of periosteal and endosteal reaction of the host bone and the continuity of the exostosis' cortical and medullary with that of the tibia. In some cases, such small lesions in areas with a reduced representation of the adjacent soft tissue make the exostoses a potential site for its own fractures, and this would explain the remodelling of the end edge of this subject's exostosis. The clinical picture shows a condition that ranges from silent to localized pain, mainly in case of fracture of the exostosis, with local swelling and jerk sensation during exercise due to conflict with the adjacent soft tissues.

Fig. 5.8 X-rays antero-posterior view of the proximal tibia show the exostotic formation (*arrow*) with a centrifugal trend with respect to the joint and a narrow implant base on the host bone

5.2.3 Osteochondroma of the Distal Tibia and Fibula

Subject: CM T.80

Sex: male

Age: 35–45 years

Finding site: Castel Malnome

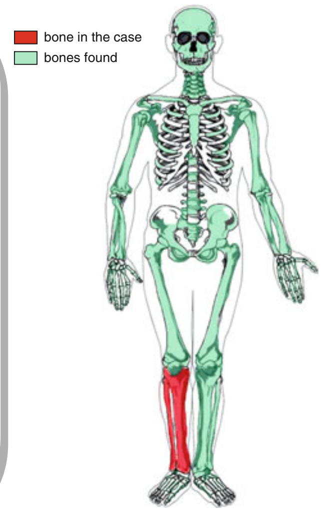
Type of grave: pit in the ground with “cappuccina” cover

Type of burial: disturbed primary

Deposition: supine with flexed upper limbs and extended lower limbs

State of preservation: good

Stature: ~162 cm



5.2.3.1 Morphological and Palaeopathological Description of the Subject

The subject shows a roundish skull (brachycranic), with diverging frontal crests, long and narrow *piriformis* aperture (leptorrhine) and hypsiconchic orbits (not roundish). Tooth decay lesions on the left mandibular first and second molar and on the right second and third molar, with the presence of odontogenic abscesses on the lower first molars, indicate some fairly severe dento-alveolar diseases. Moreover, the *intra-vitam* loss of the second and third molars can be observed on the maxillary bone. The asymmetry of the clavicles and humeri (both as enthesopathic alterations and as length asymmetry of these segments) can be related to a higher and more frequent use of the right shoulder and upper limb than of the left. The erosions at the insertion point of the costo-clavicular ligament and of the humeral *pectoralis major* muscle, more marked on the right, confirm that the subject stressed the scapular girdle musculature differently. Small enthesopathic ossifications on the left humerus only at the insertion points of the *brachioradialis* and *subscapularis* muscles, and on the right radial tuberosity, at the *biceps brachii,* show repeated stress on the elbows. As for the lower limbs, the femurs are hyperplatymeric, suggesting a severe flattening of the superior third of the diaphysis, and the muscular imprints of the *gluteus major* and *iliopsoas* muscles, especially on the right, show a significant stress on the hip, confirmed by the enlargement of the acetabulum's *facies lunata*, and by an increase of the articular surface of the femoral head. The presence of Schmörl's hernias, on five thoracic and two lumbar vertebrae, suggests that the subject stressed the vertebral column with a ponderal overload, especially with lateral flexions of the trunk; because these lesions are not linked to signs of degenerative alteration, they do not seem to be related to arthritic disease. In addition, the fifth lumbar vertebra shows a partial sacralization of the left transverse process and no fusion of the spinous process, which can be considered as hereditary dysplasia.

5.2.3.2 Description of the Lesion

This last case of osteochondroma affects the distal metaphysis of right tibia and fibula in their medial profile, which is rather atypical (Fig. 5.9a, b).

Fig. 5.9 (**a**) Distal tibia and fibula with osteochondroma. (**b**) Distal tibia and fibula medial profile with osteochondroma

The peculiarity of this site is that the exostosing lesion has fused with the facing bone during its growth. Even in this case, the medullary continuity with no fractures or periosteal reaction with a benign deformity of the inner profile of the two segments suggests a diagnosis of osteochondroma (Fig. 5.10). The clinical picture is represented by distal leg pain due to the lack of elastic mobility of the syndesmosis with any ankle movement.

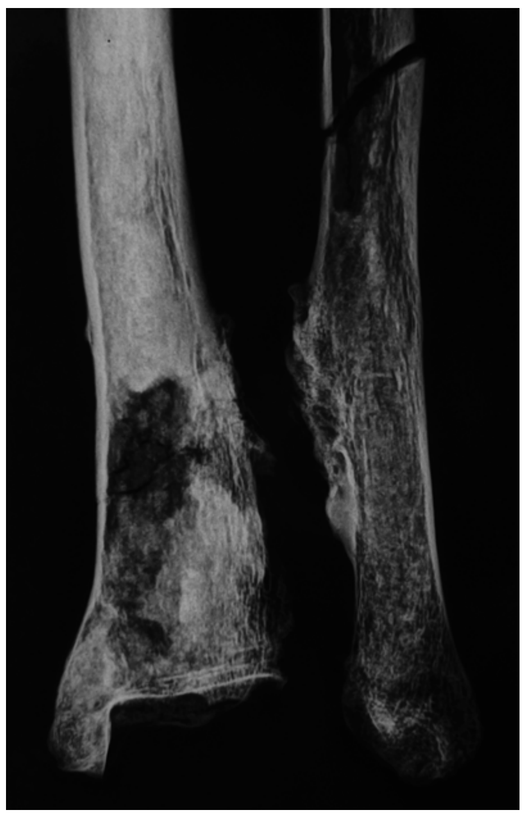


Fig. 5.10 X-rays antero-posterior view of the ankle

5.2.4 Supra-acetabular Cyst

Subject: CM T. 69

Sex: male

Age: 45–55 years

Finding site: Castel Malnome

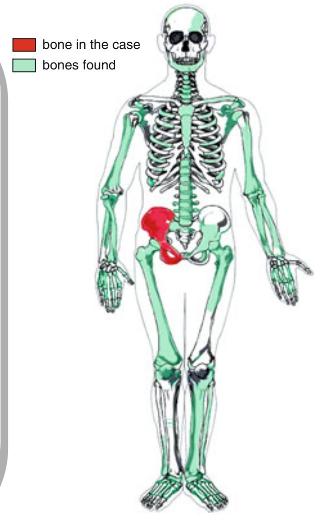
Type of grave: pit in the ground with “cappuccina” cover

Type of burial: primary

Deposition: supine with extended upper and lower limbs

State of preservation: poor

Stature: ~159 cm



5.2.4.1 Morphological and Palaeopathological Description of the Subject

The incomplete skeleton pertains to a mature, fairly robust, male subject. The splanchnic region of the skull is missing almost completely; the right clavicle is absent and the homolateral scapula is represented only by a fragment of the glena and of the acromial portion; the left coxal bone and the right tibia are fragmented. A mild depression, associated to a slight bone reaction, can be observed on the left parietal of the skull, at the lambdoid suture. Bilaterally, the imprint of the *obliquus capitis* inferior muscle, which is involved in the rotation of the head, is well defined. The imprint of the costo-clavicular ligament is characterized by porosities and by a moderate oval-shaped depression (rhomboid fossa), with regular margins, associated to a smooth tubercle enlarging towards the posterior margin. The insertion of the deltoid muscle, on the anterior margin of the clavicle’s lateral portion, is affected by a mild furrow of enthesopathic origin; the margin of the medial portion, at the insertion of the *pectoralis major* muscle, is flattened dorsoventrally.

The lack of the right clavicle does not allow to determine if the lesions are bilateral. The bicipital tuberosities of the radii are symmetrically marked, with raised margins and rough surfaces. The *semitendinosus*, at its origin on the ischiatic tuberosity, shows a mild osteophitic enthesopathy only on the right. Moreover, the cotyloid cilium is affected by *acetabular flange lesion* (Fig. 5.11): the attachment area of the reflex tendon of the *rectus femoris* muscle shows a frayed edge, with pitting. The femurs, strong and with an average pilaster, show a severe flattening of the diaphyseal superior third (hyperplatymery) and the anterior part of the neck is characterized by the extension of the head’s joint surface (Poirier’s facet).

The anterior face of the right patella (the left is missing) shows a mild ossification on the superior margin, and a concave depression (Messeri’s patella) [20] on the supero-lateral margin, due to a repeated contraction of the *quadriceps*. A lesion can also be detected on the medial articular surfaces of the left calcaneus and of the talus (the right ones are not observable), characterized by a subchondral bone necrosis (Fig. 5.12) and an oval-shaped area of trabecular tissue (*osteochondritis dissecans*).

The column shows signs of arthritic degeneration, above all at the level of the apophyseal joints and at the insertion points of the *ligamenta flava*, affected by laminar ossifications with frayed edges. Lytic lesions, with a mild osteophytic edge, can be observed on the inferior surface of the seventh cervical vertebra, whose body shows a supero-inferior crushing; angular osteophytes of moderate sizes affect the bodies of the last few thoracic vertebrae. Finally, the superior face of the first sacral vertebra is affected by ostheophytosis on the lateral edges, with no involvement of the central tract of the *annulus*. There are no signs of intraspongious hernias. The subject is characterized by moderate bone remodelling limited to some insertion areas. The joint of the shoulder seems to have been more under stress, and its alterations may be associated to heavy load lifting over the head, while the ones at the insertion of the *biceps brachii* of the radius to loads carried with flexed or extended elbows. The modifications of the lower limbs suggest extension movements of the thigh on the pelvis and flexion of the leg; the formation of Poirier's facet could be related to ambulation on steep grounds, because the *iliopsoas* opposes to the forces determining the extension of the limb.

Fig. 5.11 *Acetabular flange lesion* of the right cotyloid cilium

5.2.4.2 Description of the Lesion

The macroscopic examination of this find shows a lesion at the right supra-acetabular roof, with a regular circular shape (Fig. 5.13a, b). The bottom of the cyst is corticalized and does not show any trabeculae of the hemipelvis medullary. There are no periosteal reactions or alterations showing any malignancy of the lesion (Fig. 5.14). The first differential diagnosis has to be initially related to the so-called pseudo-pathological

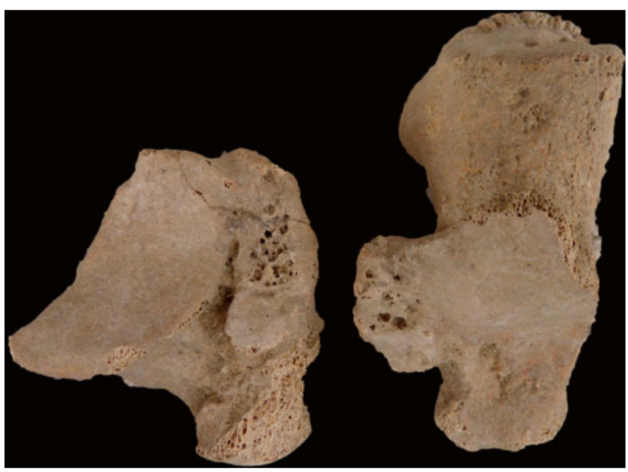


Fig. 5.12 A subchondral bone necrosis of the left calcaneus and talus

Fig. 5.13 (**a**) Right supra-acetabular cyst. (**b**) Supra-acetabular cyst in detail

Fig. 5.14 X-rays antero-posterior view shows a regular size cyst with sclerotic margins and no alterations of the surrounding bone

situations, due to post-mortem modifications. Pseudo-pathological alterations result from two main causes: the burial environment and events occurred during and after the excavation. Several agents can alter the bone after the burial, including microorganisms (fungi), insects (larvas), animals (rodents), chemical and physical agents (Ph, water, pressure, ground changes, temperature) [21]. However, the regularity of the lesion and the presence of the inner corticalization, sign of "in vivo" response of the bone suggest a diagnosis of cystic lesion of the bone. The supra-acetabular site would be typical of the geodic lesions of coxo-femoral arthritis, which, however, come on at a subchondral level and do not show discontinuity of the outer cortical, so a mucous cyst is a more likely diagnosis.

5.2.5 Femoral Cyst

Subject: LR II T.49

Sex: male

Age: 20–24 years

Finding site: Lucrezia Romana II

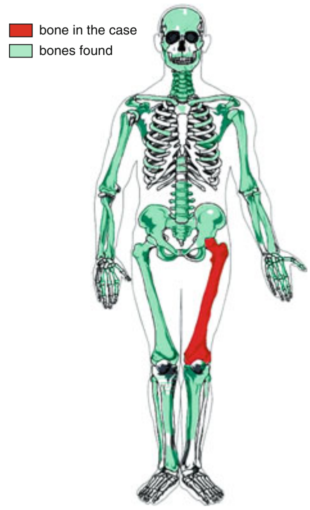
Type of grave: pit in the ground with no cover

Type of burial: primary

Deposition: supine with flexed upper limbs and extended lower limbs

State of preservation: mediocre

Stature: ~160 cm



5.2.5.1 Morphological and Palaeopathological Description of the Subject

The subject is a young adult who has not completed his somatic growth yet. The skull is characterized by a very elongated shape (dolichocranic), a wide forehead (eurymetopic), and medially diverging frontal crests. Several cavities affect both the maxillary and the mandibular bone, some reaching the pulpar cavity. The skeletal signs show a major continuous muscular activity of the shoulders and arms, above all on the right side, as indicated by a wide syndesmopathic lesion at the insertion area of the costo-clavicular ligament, and the presence of small bone spicules, with erosions, on the deltoid tuberosity of the clavicles. The metaphyseal activity, bilaterally in this area, had not finished when the subject died: the medial clavicular epiphysis is only partially fused to the diaphysis. Enthesopathies at the points of insertion of the *pectoralis major*, *latissimus dursi*, and *teres major* muscles can be detected on the humeri. The morphology of the muscular insertions, on the bones of the forearm, shows a marked development of the interosseous tubercles of the radius and a moderate enthesopathy at the insertion of the *brachii* muscle of the right ulna, probably related to flexions and pronation movements of the forearm. The femurs are robust and platymeric; the insertion area of the *gluteus maximus* muscle of the femurs and the oblique line of the tibias show a moderate remodelling, due to repeated extension movements of the thigh and foot. A mild osteophytic edge can be observed on the lesser trochanter of the left femur, and a moderate ossification is implanted at the insertion area of the *rectus femuris* muscle, right above the acetabulum; these muscles are involved in the flexion movements of the thigh on the pelvis. There is lumbarization of the first sacral vertebra, which has become similar to the last lumbar one moving away from the sacrum. This anomaly did not lead to a functional defect thus being probably asymptomatic. The perforation of the *olecranon fossa* of the left humerus represents the only anatomical modification detected on the appendicular skeleton [22]. Along the parietomastoid suture, above the right mastoid bone on the skull, there is a small oval-shaped perforation, with a diameter of about 5 mm, with a retracted inferior margin. The endocranial surface shows alterations with sclerosis and apposition of new bone tissue.

Fig. 5.15 Cyst of the left distal femur (*arrow*)

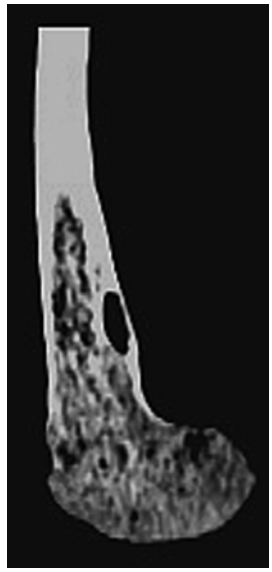


Fig. 5.16 CT scan sagittal view

Expert orthopaedic oncologist's evaluation (*Rodolfo Capanna*): "The lesion shown an intracortical osteolysis, probable non-ossifying fibroma".

5.2.5.2 Description of the Lesion

The macroscopic examination of the distal femur shows an interruption of the cortical at the posteromedial profile of the left distal femur (Fig. 5.15). The margins of the lesion are smooth and with no periosteum alterations. Notwithstanding its benign nature, a CT scan has been performed on the lesion which showed an intracortical cystic cavity with sclerotic margins that did not infiltrate the surrounding bone (Fig. 5.16), which preserves its trabecular structure. The diagnosis of this formation is certainly benign.

5.3 Malignant Bone Tumour

5.3.1 Parosteal Osteosarcoma of the Distal Tibia

Subject: PS T.72

Sex: female

Age: 20–30 years

Finding site: Padre Semeria

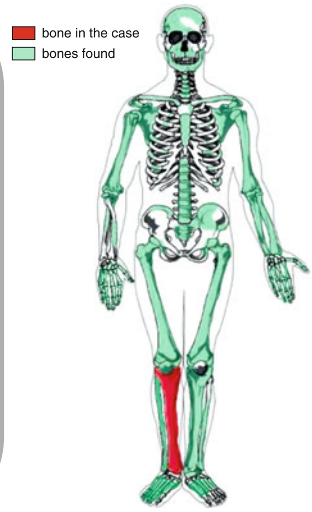
Type of grave: pit in the ground with "cappuccina" cover

Type of burial: primary

Deposition: supine with extended upper and lower limbs

State of preservation: mediocre

Stature: ~156 cm



5.3.2 Morphological and Palaeopathological Description of the Subject

The cranial and the skull height indices have median values (mesocranic – orthocranic); the masticatory apparatus shows six superficial decays on the molars occlusal surface, the retention of the deciduous inferior second molar, and the loss of the left superior canine *ante-mortem*. The subject shows strength median values in all of the skeletal segments; on the clavicles, a marked roughness of the lateral portion of the anterior margin is observed at the deltoid muscle insertion.

The right humerus is 6 mm longer than the contralateral; however, the dimensional differences do not involve other parameters: there are no valuable differences both in the transverse diameters and in the circumferences.

At the origins of the *triceps brachii* muscle of the left scapula (the right one is not detectable) and of the *pronatur quadratus* of the homolateral ulna, small enthesopatic ossifications are observed. These lesions are due respectively to the forearm continuous extensions and pronations.

The long flexor muscles of the thumb seem particularly stressed, maybe due to a repeated flexion of the distal phalanx on the proximal one.

The dorsal surfaces of the femurs show wrinkled areas at the insertion of the *gluteus maximus* muscle, the tibias ones at the origin of the *soleus* muscle.

The signs of a previous trauma are detected on the ventral surface of the proximal third portion of the right femur showing an osseous remodelling with a marked dorso-ventral curvature.

An articular lesion is observed on the distal surface of the left first metatarsal, with a fragment detachment of the cartilage and bone subchondral necrosis (*osteochondritis dissecans*).

Fig. 5.17 (**a**) Parosteal osteosarcoma of the right distal tibia. (**b**) Detail of the parosteal osteosarcoma of the right distal tibia

5.3.3 Description of the Lesion

The tibial distal third shows a bone lesion on its medial profile. The base is large and shows the features of a slow erosion due to remodelling of the periosteum (Fig. 5.17a, b). Macroscopically, it seems to have the same density as the bone and shows no invasiveness to the whole segment. The surface of the new formation looks blurred and disorganized. This type of mass growing on the periosteum, indistinguishable from the bone, is highly suggestive of parosteal osteosarcoma of the distal tibia.

X-ray examination (Fig. 5.18a, b) confirms the higher density of the neoformation if compared to the rest of the tibia and its partial intramedullary involvement, more significant at CT scan (Figs. 5.19 and 5.20).

Parosteal osteosarcoma is a malignant primary tumour with osteoformative features (malignant osteoid). It accounts for 5 % of all osteosarcomas [23]. The standard location is on the posterior profile of the distal femur, and has its highest incidence rate around the third decade. In addition to the distal femur, the other most frequent sites are at the proximal humerus and proximal tibia. The distal tibia localization is very rare, about 2 % [23]. Histologically, it is a low-grade tumour with a slow and subtle progression. Because of its poor aggressiveness, the tumour reached such a large size in the present subject. However, in addition to the pain, the lesion has likely crossed the soft tissue layer, poorly represented on the medial profile of the distal tibia, leading the subject to a severe disability.

Comparing these images with those found in literature [23], they are extremely suggestive of a diagnosis of parosteal osteosarcoma.

Fig. 5.18 (**a**, **b**) X-rays antero-posterior view: a large, dense, and homogeneous lobular mass starting from the surface of the bone. The mass is more dense than normal adjacent bone. Normal appearance of the medullary space of the bone

Expert Orthopaedic Oncologist's Evaluation

Rodolfo Capanna

In my opinion macroscopical and radiological aspects of the lesion are suggestive for Parosteal Osteosarcoma of the right distal tibia.

Fig. 5.19 CT scan coronal plane multiplanar reconstruction

Fig. 5.20 CT scan 3D reconstruction

5.4 Secondary Bone Tumours

5.4.1 Skull Osteolysis

Subject: LR I T.175

Sex: male?

Age: adult

Finding site: Lucrezia Romana I

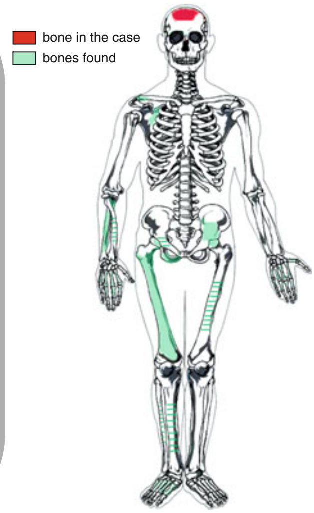
Type of grave: pit in the ground with no cover

Type of burial: disturbed primary

Deposition: supine with extended right upper limb, absent left and extended lower limbs

State of preservation: poor

Stature: undetectable



5.4.1.1 Morphological and Palaeopathological Description of the Subject

The skeleton, in a poor state of preservation, is composed of the skull, extremely fragmented, the pectoral girdle and the right forearm, fragments of the pelvic girdle and of the lower limbs. Despite the incompleteness, the platymery (platymeric femur) and pilastric indices (null pilaster) of the right femur have been calculated. The occipital bone and the parietal bones, the only parts of the skull suitable for the examination, show the presence of some subcircular lesions, sometimes confluent. The sex diagnosis has been rather difficult, because the only detectable dimorphic character is the morphology of the ischiatic incisure of the left coxal bone, which is narrow. Moreover, we had to put the subject into a generic range of adult age, due to the lack of skeletal regions assessing a precise age at death. Finally, the incompleteness of the bones has not allowed to detect most metrical features, the musculoskeletal markers, and the main pathological alterations of the post-cranial skeleton.

Fig. 5.21 Lytic lesions of the cranial vault

5.4.1.2 Description of the Lesion

The lesions showed in this clinical case are lytic lesions of the cranial vault variably set around the bregmatic suture (Fig. 5.21). The find only regards this part of the neurocranium and the whole skull was not found. Multiple myeloma (MM) is the most malignant tumour affecting the skeleton. It is a haematopoietic disorder regarding the plasma-cellular line. MM characteristic lesions are roundish and multiple, with a diameter ranging from 5 mm to 2 cm and well-defined margins. The malignant plasma cells locally inhibit the osteoblastic activity, thus differentiating these lesions from the metastatic ones, which often show marked margins and osteoblastic activity at the edges of the lesions. A differential diagnosis with the diffused metastatic pathology must be used in case of multifocal skeletal involvement. MM onset sites in the skeleton are on the axial skeleton, which contains most bone marrow, while the locations of long bone involvement are the metaphyses, mainly of femur and humerus. On the cranial vault skeletal sites, the lesions are more prone to affect both tables, like carcinoma metastases. The differential diagnosis of MM lesions with the metastatic ones from breast carcinoma is really difficult, and gender can help, even if uncertain, since MM is more frequent in males and breast cancer in females. The presence of varying size of lesions could favour a diagnosis of carcinoma metastasis, but the lack of marginal osteoblastic reactions (Fig. 5.22) weakens the diagnostic certainty. The bad state of preservation of the whole skeleton and the lack of further bone segments make the differential diagnosis extremely difficult, but could also be the reason for the widespread bone pathology. Further hypotheses on the diagnosis would be arbitrary because there are no certainty signs.

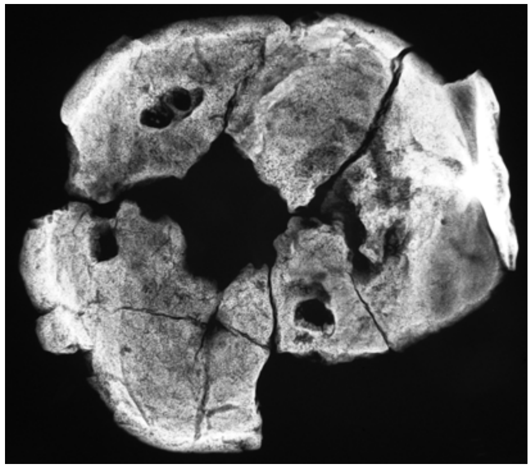


Fig. 5.22 X-rays of the skull show grossly rounded osteolytic lesions showing size variability and minimal marginal osteoblastic reaction

5.4.2 Vertebral Metastasis

Subject: CM T.194

Sex: male

Age: 30–40 years

Finding site: Castel Malnome

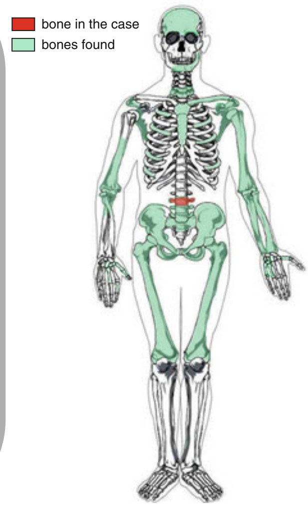
Type of grave: pit in the ground with “cappuccina” cover

Type of burial: disturbed primary

Deposition: supine, with extended upper limbs, non deductible lower limbs

State of preservation: mediocre

Stature: ~166 cm



5.4.2.1 Morphological and Palaeopathological Description of the Subject

The skeleton, belonging to an adult individual, is completely lacking of the tibias, the fibulas, and the feet. The skull is elongated (dolichocranic), the transverse fronto-parietal and the fronto-transverse indices show eurymetopy and average diverging frontal crests, respectively. A fine erosion involves the outer table (*cribra cranii*) and the roof of the orbits (*cribra orbitalia*). Among the anatomical variants, there is lack of the right parietal *foramen*, and presence of an occipital segmentation which starts from the *asterion* and goes towards the occipital protuberance for a short tract without reaching it (sutura mendosa) [24]. Moreover, three small depressions can be seen, probably of traumatic origin: on the occiput, above the superior nuchal line, on the mid-frontal, and on the left parietal. The humeri are flattened dorsoventrally (platybrachia) as a probable consequence of *biceps* and *deltoideus* work; the radial tuberosities have enhanced margins and porous surfaces, as a result of forearm flexion stress on the insertion area of the *biceps brachii*. The robust femurs, with strong pilaster, show marked muscular imprints at the insertion of the *gluteus maximus* and the *iliopsoas* muscles, which are a sign of repeated femoral movements of extension and external rotation, and of flexion of the thigh on the hip [25]. The rachis, well preserved only in the dorsolumbar tract, shows imprints of small intraspongious hernias on two thoracic and one lumbar bodies. An upper thoracic vertebra shows a large developmental asymmetry of the vertebral soma: the height of the body at the right anterior corner is 14.7 mm, while on the left it is 18.6 mm. One left rib shows morphological anomaly and reduced size, which are typical characteristics of the rudimental or extralumbar ribs [26]. Two lumbar vertebrae (L4-L5) show epiphysitis, which leads to new spicular bone formations and erosions in the antero-superior marginal part of the body; the lesions, limited to the imprint area of the *anulus fibrosus,* both suggest a spondylitis (Fig. 5.23) [27].

Fig. 5.23 Spondylitis of a lumbar vertebra

Description of the Lesion: Radiologist's Evaluation

Silvana Giannini

X-Rays (Fig. 5.24)

The image of the left peduncle shows homogeneous radiopacity extended to the lamina, posteriorly and on the somatic area. This radiopaque region has sclerotic borders.

The right peduncle shows slight radiopacity, and no bone erosions or somatic reductions can be detected. The upper vertebral end plate shows a nick as a marginal anomaly of the district.

CT Scan (Figs. 5.25 and 5.26)

CT scan shows a densitometric bilateral peduncular alteration, in particular, a right peduncular widening with a densitometric alteration, and peripheral hyperdensity and hypodensity of the central portion. No discontinuity or double outline of the cortical can be seen. On the left side, the lesion affects lamina and peduncle, which appears deformed and open. The hyperdensity also involves the left half of the vertebral end plate with an anomalous distribution of density, which is dishomogeneous and extended in the bone trabeculae. A homogeneous hyperdensity reaches the subchondral region of the upper vertebral end plate with mild erosions of the surface.

Conclusions: Sclerotic bone metastases with a low degree of aggressiveness, considering their slow extension from the left peduncle to the vertebra.

5.4.2.2 Description of the Fracture

The same case shows also a fracture of the middle third of the left clavicle (Fig. 5.27), which has a frequency rate of about 80 % of all clavicle fractures, where the middle third and the lateral third represent 5 and 15 %, respectively [28]. The most frequent trauma mechanism is the fall on the shoulder, and less frequently, the direct trauma on the clavicle and the fall with a raised arm. The consolidation is very good, even though it shows shortening of the segment (Fig. 5.28), probably due to incorrect tension of the shoulders "during the opening". There is no major decomposition in any of the planes, and this rules out severe functional deficits of the shoulder in active movements.

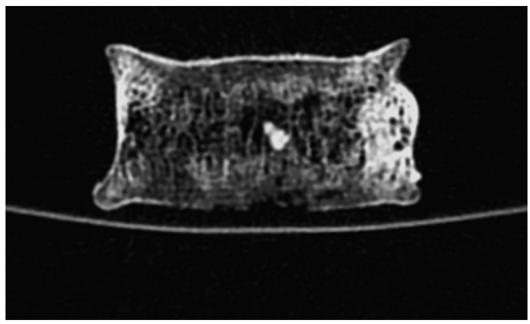


Fig. 5.25 CT scan coronal plane multiplanar reconstruction of the vertebra shows densitometric bilateral peduncular alteration with deformation of the peduncle on the left side

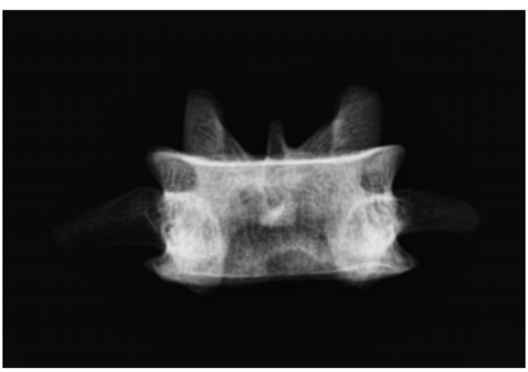


Fig. 5.24 X-rays antero-posterior view of the vertebra show homogeneous radiopacity of the left peduncle

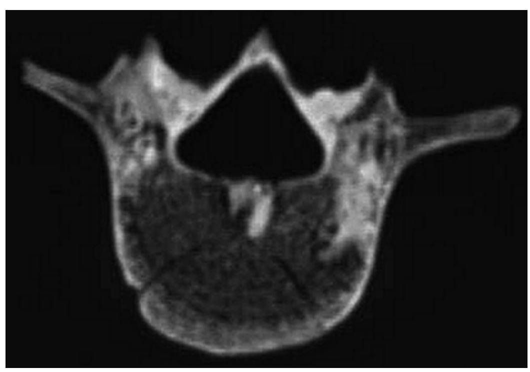


Fig. 5.26 CT scan axial plane multiplanar reconstruction

Fig. 5.27 Fracture of the left clavicle

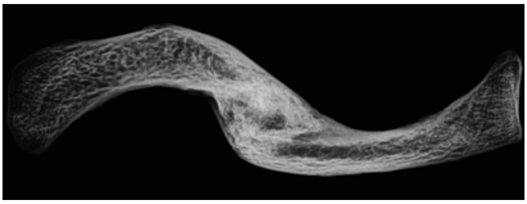


Fig. 5.28 X-rays of the clavicle show shortening of the segment but good healing after fracture

References

1. Venable CS, Stuck WG. Results of recent studies and experiments concerning metals used in the internal fixation of fractures. J Bone Joint Surg Am. 1948;30A(1):247–50.
2. Venable CS, Stuck WG. Clinical uses of vitallium. Ann Surg. 1943;117(5):772–82.
3. Moore AT, Bohlman HR. Metal hip joint: a case report. J Bone Joint Surg Am. 1943;25(3):688–92.
4. Hwang JS, et al. From amputation to limb salvage reconstruction: evolution and role of the endoprosthesis in musculoskeletal oncology. J Orthop Traumatol. 2014;15:81–6.
5. Rosen G, Caparros B, Nirenberg A, et al. Ewing's sarcoma: ten-year experience with adjuvant chemotherapy. Cancer. 1981;47(9):2204–13.
6. Bleyer WA, Haas JE, Feigl P, et al. Improved three-year disease-free survival in osteogenic sarcoma. J Bone Joint Surg Br. 1982;64(2):233–8.
7. Chao EY, Sim FH. Modular prosthetic system for segmental bone and joint replacement after tumor resection. Orthopedics. 1985;8(5):641–51.
8. Sim FH, Frassica FJ, Chao EY. Orthopaedic management using new devices and prostheses. Clin Orthop Relat Res. 1995;312:160–72.
9. Ritschl P, Braun O, Pongracz N, Eyb R, Ramach W. Modular reconstruction system for lower exteremity. In: Enneking WF, editor. Limb salvage in musculoskeletal oncology. New York: Churchill Livingstone; 1987.
10. Johnston J. A modular prosthetic knee system for tumor surgeons. In: Enneking WF, editor. Limb salvage in musculoskeletal oncology. New York: Churchill Livingstone; 1987. p. 234–6.
11. Chao EY, Sim FH. Modular types of tumor endoprostheses for limb salvage. In: Enneking WF, editor. Limb salvage in musculoskeletal oncology. New York: Churchill Livingstone; 1987. p. 198–206.
12. Campanacci M, Enneking. Bone and soft tissue tumors. Springer, Heidelberg; Germany: 1990.
13. Malawar M, Sugarbaker PH. Musculoskeletal cancer surgery: treatment of sarcomas and allied diseases. 1st ed. Kluwer Academic Publishers, Dordrecht; The Netherlands: 2001.
14. Brothwell DR. Digging up bones. 3rd ed. Ithaca: Cornell University Press; 1981.
15. White TD, Folkens PA. Human osteology. San Diego: Academic Press; 1991.
16. Aufderheide AC, Rodriguez Martin C. The cambridge encyclopedia of human paleopathology. Cambridge: Cambridge University Press; 1998.
17. Wu JS, Hochman MG. Bone tumors. Springer; New York: 2012.
18. Coppa A, Rubini M. Per la conoscenza del patrimonio biologico umano. Scheletro e Denti, Atlante di caratteri discontinui. Rassegna, Schermaglie e Noterelle. Ministero per i Beni Culturali e Ambientali, Soprintendenza Archeologica per il Lazio; Roma: 1996.
19. Gulan G, Matovinoc D, Nemec B, Rubinic D, Ravlic-Gulan J. Femoral neck anteversion: values, development, measurement. Common problems. Coll Antropol. 2000;24(2):521–7.
20. Messeri P. Morfologia della rotula nei neolitici della Liguria. Archivio per Antropologia e l'Etnologia. 1961;91:1–11.
21. Ortner DJ. Identification of pathological condition in human skeletal remains. 2nd ed. San Diego: Academic; 2003.
22. Mays S. Septal aperture of the humerus in a mediaeval human skeletal population. Am J Phys Anthropol. 2008;136:432–40.
23. Schwab JH, Antonescu CR, Athanasian EA, Boland PJ, Healey JH, Morris CD. A comparison of intramedullary and juxtacortical low-grade osteogenic sarcoma. Clin Orthop Relat Res. 2008;466(6): 1318–22.
24. Hauser G, De Stefano GF. Epigenetic variants of the human skull. Stuttgart: E. Schweizerbart'sche Verlagsbuchhandlung (Nägele u. Obermiller); 1989.
25. Mariotti V, Facchini F, Belcastro MG. The study of entheses: proposal of a standardized scoring method for 23 entheses of the postcranial skeleton. Coll Anthropol. 2007;31(1):191–313.
26. Barnes E. Congenital anomalies. In: Pinhasi R, Mays S, editors. Advances in human paleopathology. Chichester/Hoboken: Wiley; 2008.
27. Capasso L, Kennedy KAR, Wilczak CA. Atlas of occupational markers on human remains. Teramo: Edigraphital; 1999.
28. Egol KA, Koval KJ, Zuckerman JD. Handbook of fractures. 5th ed. Philadelphia: Walters Kluwer/ Lippincott Williams and Wilkins; 2014.

6 Infective and Metabolic Disease

Carla Caldarini, Paola Catalano,
Andrea Piccioli, Maria Silvia Spinelli,
and Federica Zavaroni

6.1 Gout

Subject: CM T. 213

Sex: male

Age: >50 years

Finding site: Castel Malnome

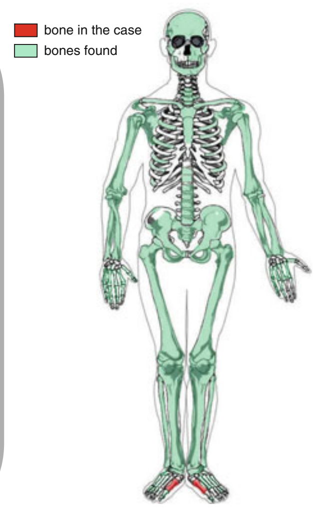
Type of grave: pit in the ground with "cappuccina" cover

Type of burial: disturbed primary by clandestine digging

Deposition: non deductible

State of preservation: mediocre

Stature: ~ 175 cm



6.1.1 Morphological and Palaeopathological Description of the Subject

The skeleton, attributable to a senile male subject, is well built, but the bone sections have not been particularly modified by bio-mechanical stress. The horizontal cranial index suggests mesocrania (not particularly elongated shape of the skull), the frontal crests are averagely diverging, and the forehead is broad (eurymetopic). Two Wormian bones can be seen on the skull along the lambdoid suture, and some sessile exostoses are at the external auditory meatus (Fig. 6.1); these ossifications seem to be connected to a prolonged, frequent soak in cold water [1], even though many authors are inclined to think of a multifactorial aetiology [2]. As for the dento-alveolar complex, there is a large abscess cavity in correspondence with the alveoli of the first mandibular incisors (Fig. 6.2), which were lost *intra-vitam*; the first left molar and the second right molar are characterized, respectively, by a cavity in the tooth pulp and one in the dentine, and they both show

A. Piccioli et al., *Bones: Orthopaedic Pathologies in Roman Imperial Age*,
DOI 10.1007/978-3-319-19485-1_6

Fig. 6.1 Auditory exostosis

Fig. 6.2 Abscess associated with first mandibular incisors

Fig. 6.3 Dislocation of the left temporo-mandibular joint

Fig. 6.4 Ankylosis of T9-T10

the consequence of odontogenic abscesses on the alveolar processes. The left maxilla shows the loss of the three molars *intra-vitam* (the right one cannot be seen). A probable dislocation can be seen at the left temporo-mandibular joint (Fig. 6.3), with reshaping of the edge of the glenoid fossa and formation of a bone ring on the antero-superior margin of the mandibular condyle. At the insertion of the conoid and trapezoid ligaments and at the origin of the deltoid muscle on the clavicles, there are some evident enthesopatic modifications of ostheophytic nature, likely resulting from repeated shoulder movements; moreover, the enthesopathy at the insertion of the *infraspinatus* muscle of the right humerus confirms a frequent rotation of the humerus on the scapula. The diaphyseal index, and the enthesopathies on the interosseous tubercles of the radial bones, denotes a protruding interosseous crest, which suggest habitual forearm movements of pronation and supination; this hypothesis is also corroborated by the marked development of the attachment area of the *pronator quadratus* muscle of the ulnas. The flattening of the lesser trochanter, where the *iliopsoas* muscle is inserted, and the presence of the facet of Poirier on the femurs suggest a major flexion and abduction of the thigh; on the other hand, the enthesopathies at the origin of the tibial *soleus* muscle, at the insertion of the Achilles tendon and at the insertion of the plantar ligament would suggest habitual extension movements of the foot and prolonged marching on broken ground. The surfaces and the articular outline of most bone epiphyses of the appendicular skeleton are well worn, with diffused porosities and formation of bone rings. In particular, the right elbow joint is characterized by the formation of sclerotic bone plaques, at the humerus olecranon fossa and of the ulnar semilunar incisure; on the humerus condyle, an area of smooth compact bone can be seen, similar to ivory (eburnation), and the ulnar coronoid process is deformed, with expanded and jagged margins. These variations suggest diffused suffering of the joint cartilages, and their aetiology probably results from gout. The outer face of the ilium shows a new bone formation in the insertion area of the abdominal external oblique muscle (*calcar crest*) [3], while the attachment area of the reflexed tendon of the *rectus femoris* muscle is hypertrophic. A defect in the acetabulum fusion can be seen as a U-shaped notch, on the superior part of the acetabular fossa; this anomaly can be considered as a non-metric trait of almost no pathological value. As for the rachis, exuberant sindesmophytes are localized on the superior and inferior margins of the vertebral bodies; in T9-T10, the bone protuberances are linked and form a bony bridge between the two vertebrae, with a resulting ankylosis (Fig. 6.4). The fifth lumbar vertebra shows the imprint of an intraspongious hernia on the superior endplate. The costo-sternal cartilages are completely ossified, with a considerable deformity of the sternal margin.

6.1.2 Description of the Disease

Gout is an acute inflammatory arthropathy resulting from a deposition of micro crystals. It is characterized by the deposition of monosodium urate monohydrate crystals, and this is what distinguishes it from pseudo-gout, which is characterized by the deposition of calcium pyrophosphate dihydrate. Its aetiology is often connected to a diet rich in meat and alcohol, which is the reason why it manifested in wealthy individuals. However, some other factors, such as kidney failure, can raise the plasma levels of uric acid and produce pseudo-gout signs. Males have twice as high incidence as females, while pseudo-gout is equally distributed between males and females. The clinical manifestation of gout usually follows a long period (up to a decade) of asymptomatic hyperuricemia. The typical anatomical site, almost pathognomonic, of the first gout onset is the first metacarpo-phalangeal joint, also known as podagra. The other joints, rarely the ones near the trunk such as shoulders and hips, can be affected by the following attacks. The pain of the first attack is very sharp, and resolves spontaneously, if untreated, in 5–14 days. The gout attack appears again in 90 % of cases [4]. A prolonged condition of untreated hyperuricemia or of its causes leads to tophaceous gout, with a deposition of monosodium urate monohydrate microcrystals in the soft tissues. Gout tophi do not usually calcify, but they apply pressure on the adjacent bone structures, thus causing marginal erosion and the shape of a “mouse’s bite” on the articular bone surface (Fig. 6.5a, b). In the present case, the erosions around the head (distal meta-epiphysis) of the first metatarsus show the picture just described, and must undergo a differential diagnosis with the pseudo-pathologies (rodents’ bite) (Fig. 6.6). However, the typical site and the absence of identical lesions in other bone regions lead to an almost certain diagnosis of gout lesion on the first MT.

6.1.3 Vertebra with Angioma

The patient showed an interesting additional pathological findings.

The macroscopic and imaging study shows an intriguing, large lesion, probably an angioma, on the lumbar vertebra in the picture (Figs. 6.7 and 6.8).

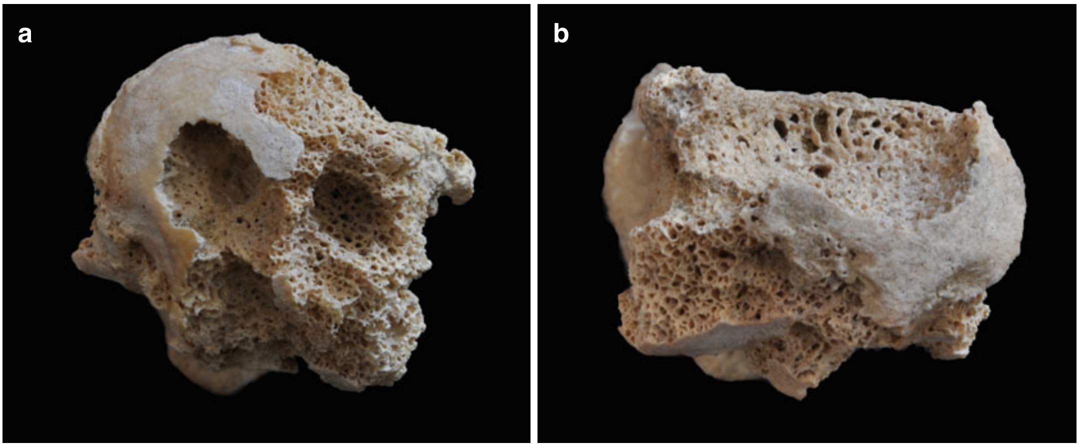


Fig. 6.5 Case of gout in the *right* (**a**) and *left* (**b**) medial first metatarsal

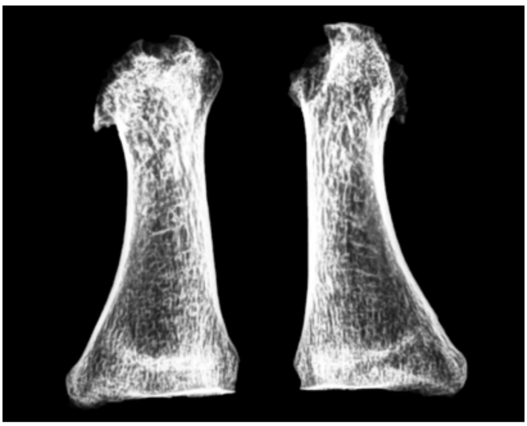


Fig. 6.6 Lateral and antero-posterior projection X-rays of the first metatarsus. The joint profile of the distal epiphysis is irregular, with higher erosion at the dorsal profile

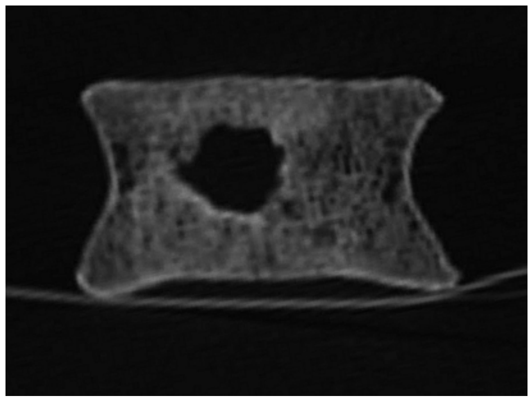


Fig. 6.8 CT scan coronal view multiplanar reconstruction: distrectual central hypodensity area with peripheral hyperdensity ring

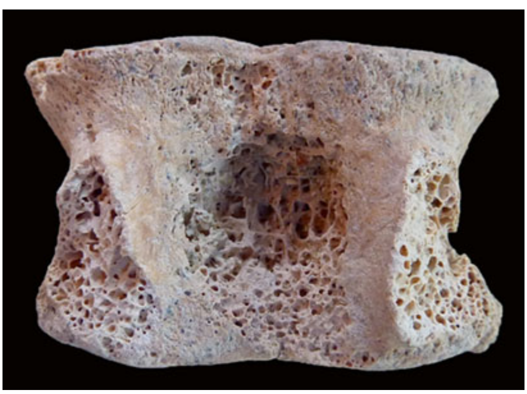


Fig. 6.7 Vertebral body showing an osteolytic lesion in the bone marrow context

6.1.4 Radiologist's Evaluation

Silvana Giannini,
CT Scans
Densitometric alteration with a well-defined central hypodensity and regular margins, placed in the central part of the soma with a clear hyperdensity peripheral border (Fig. 6.8). *Regular densitometric representation of the adjacent bone trabeculae and absence of deformities in the opposing vertebral plates. The clear line of demarcation and the site of the lesion suggest a benign angiomatous formation, especially considering the centrifugal development typical of angiomas.*

6.2 Pott's Disease

Subject: LR I T.173

Sex: male

Age: 25–30 years

Finding site: Lucrezia Romana I

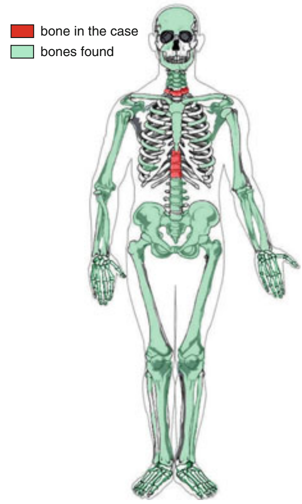
Type of grave: pit in the ground with no cover

Type of burial: primary

Deposition: supine with extended upper and lower limbs

State of preservation: good

Stature: ~ 182 cm



6.2.1 Morphological and Palaeopathological Description of the Subject

The subject, longilineal with slender upper and lower limbs, and does not seen to have undergone any severe biomechanical stress in life.

The skull is elongated (dolichocranic), with convex and not very large forehead (metriometopic).

There is a porotic hyperostosis both on the roof of the right orbit (*cribra orbitalia*), and on the outer table of the skull (*cribra cranii*). The dento-alveolar complex is compromised, in particular on the upper part, where destructive decay lesions can be seen on the first molars, three milder ones on the second premolar and on the second and third molar on the left, and a severe one on the right third molar. The alveolar process of the left first molar is affected by an odontogenic abscess. On the mandibular bone, the second and third molars are affected by mild cavities, on the buccal and occlusal surfaces, respectively.

Even though there is a medium-strong development of the muscular imprints, the enthesopathic alterations have been detected only at the origin of the *triceps brachii* muscle of the scapulae and at the insertion of the *biceps brachii* muscle of the left radius; these muscles are all involved in the forearm extension and flexion movements.

The presence of Poirier's facets on the femoral heads and the flattening of the lesser trochanter, at the insertion of the *iliopsoas* muscle, both suggest flexion movements of the thigh on the pelvis, while the facets of squatting on the anterior margin of the tibio-talar joint, may have resulted from a prolonged squatting position.

The palaeopathological study has highlighted a fracture on the distal third portion of the radius and the presence of *osteochondritis dissecans* on the right radial capitulum (Fig. 6.9) and on the glenoid cavity of the right scapula (Fig. 6.10).

The fusion of the body of the sternum with the xiphoid process can be observed.

6.2.2 Description of the Disease

Spine tuberculosis is one of the oldest diseases of mankind, but although the first cases were documented in Egyptian mummies about 5,000 years ago, in modern times Sir Percival Pott described the first case of this disease in 1779 [5]. In subjects with tuberculosis (TB), the manifestation of the

Fig. 6.9 Osteochondritis dissecans on the right radial capitulum

Fig. 6.10 Osteochondritis dissecans on the glenoid cavity of the right scapula

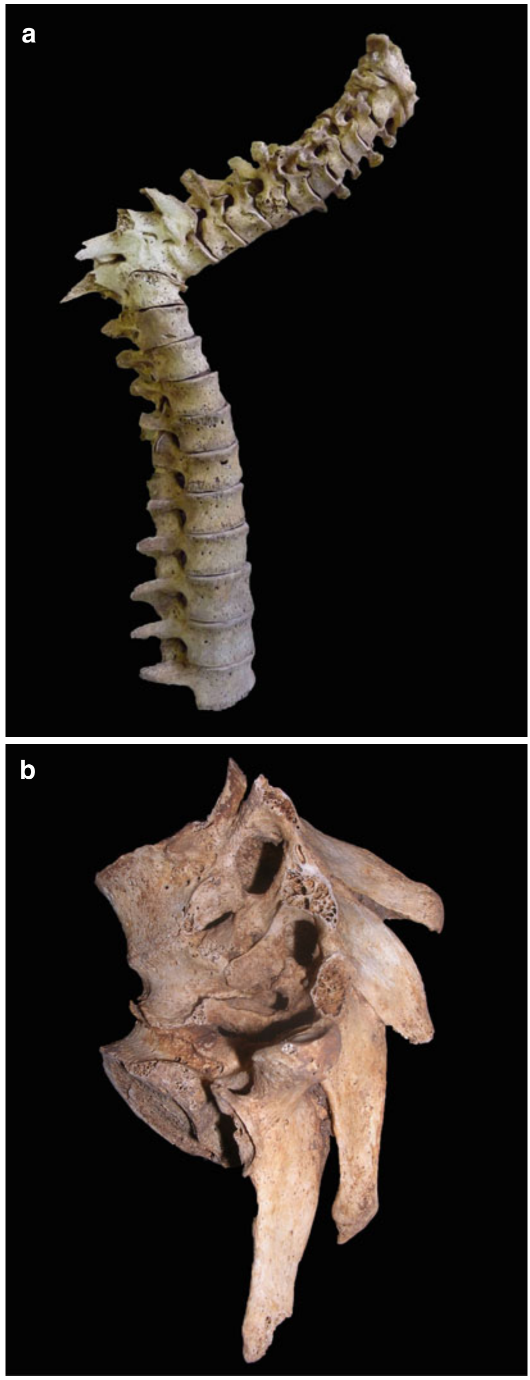


Fig. 6.11 Pott's disease with collapse and kyphosis of the spine (**a**) and detail (**b**)

disease at the rachis (Pott's disease) is rather rare (about 2 %), nevertheless it is a common site of extrapulmonary tuberculosis, accounting for about 50 % of all skeletal locations [6].

Tubercular rachis infection, compared with other infectious diseases, is connected to a greater morbidity and mortality rate, with severe complications ranging from neurological deficit to severe malformations. Risk factors for this infection are deprivation, overpopulation, malnutrition, immunodeficiency or immune suppression. The spinal location is generally secondary to the pulmonary or abdominal one, but it can also be the primary site of disease onset. The most frequent location is the short thoracic and the first lumbar segments, followed by the higher thoracic segments and by the cervical tract. The typical manifestation of the disease affects two adjacent vertebrae, less often only one vertebra, multiple vertebrae or skip-lesion (4–10 %). At first the disease affects the anterior inferior portion of the vertebral body, then it spreads to the central area of the disc. The typical sites of the disease are paradiscal, anterior, central and of the neural arch.

The central infection of the vertebral body, when the disc is not affected, spreads through the Batson venous plexus and produces a progressive shock, reaching vertebra plana. In paravertebral lesions, the disease spreads through the arteries. Young patients show a primary involvement of the disc.

The finds which are characteristic of Pott's disease are as follows:

1. Destruction of the inter-vertebral disc and of the adjacent vertebral bodies
2. Collapse of the spinal elements and wedging of the anterior elements, leading to kyphosis (Fig. 6.11)

The neurological complications of Pott's disease vary from 10 to 43 % [7]. Paraplegia is the most devastating complication. Its clinical presentation can be early or late.

The early presentation refers to a paraplegia onset during the active phases of the disease, and needs an acute treatment; its prognosis is better. The cause of paraplegia in this manifestation is the formation of pus, detritus, granulation tissue, unsteadiness due to lesion of the vertebral anterior columns, which leads to sub dislocation and dislocation.

Fig. 6.12 X-rays: lateral view shows the typical kyphosic deformity

The late presentation of paraplegia can occur after a very long period, varying from 20 to 30 years after the healing from TB active phase. It is commonly associated to a marked spinal deformity. Since bio-molecular studies are complicated and sometimes impossible on palaeopathological finds, the first line of diagnostic auxiliary tools has been the evaluation of the radiographic characteristics.

In the late stages, traditional radiography shows the typical kyphosic deformity (Fig. 6.12) of the column with several degrees, according to the collapse and wedging severity. The first signs are a reduction of the articular space, and paradiscal blurred margins of the vertebrae. In the thoracic regions, the formation of paravertebral abscesses, with necrotic tissue and granulation, is called "bird nest" and is fusiform and radio-opaque. Long lasting abscess leads to concave and excavating lesions of the anterior aspects of the vertebra, similar to aneurismatic phenomena [8].

CT scan allows a higher definition of bone alterations and their location inside the vertebral body (sclerosis, osteolysis), but also a collapsed disc and an abscess calcification inside a soft tissue. Moreover, it is useful for the definition of abscess calcifications inside the soft tissues. In vivo, it does not allow a better visualization of nervous structures than MRI, but it can be diagnostic in the analysis of skeletal findings.

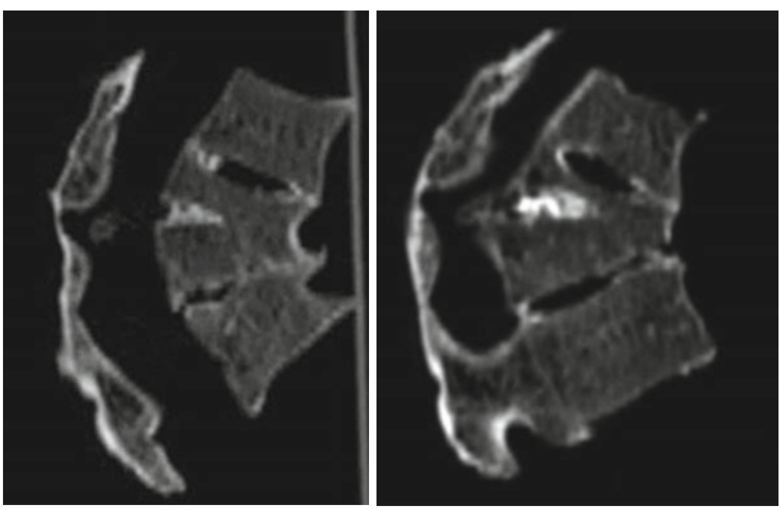
The presence of calcifications inside an abscess is almost always diagnostic of spinal tuberculosis [9].

6.2.3 Radiologist's Evaluation

Silvana Giannini

CT scans in axial, sagittal and coronal planes multiplanar reconstruction.

Metameric anterior fusion with intradiscal calcifying material, severe collapse of two vertebrae, fulcrum of the wedging (Fig. 6.13). *Irregular density of the somatic limitants opposed to multiple fissures and cerebral feature with marginal erosions. In conjunction with trabecular areas of hypodensity and intrametameric ones of hyperdensity, showing the reduction to load resistance and resulting vertebral collapse. The disc spaces show hyperdense nebular precipitates, the result of phlogistic damage due to the spread of the cold abscess into the intradiscal space, which is reduced in height* (Fig. 6.14). *This is a valuable radiologic sign of Pott's* [10]. *Anteriorly, in the site of granulomatous development, which determines the anterior vertebral collapse, small hyperdensity plates can be observed, which are remains of the calcification of the anterior longitudinal ligament. This aspect suggests an extension of the granulomatous process from the vertebral bodies and from the intradiscal area to the anterior area beneath the anterior longitudinal ligament and later in the paravertebral periosteal area* [11]. *The coronal level of the CT scan reconstruction shows a reduced thickness of the bone cortex with marginal encoche from modelling and some cribrate areas, compatible with excavation from organized collection. Finally, regarding the somas preserved in height, some hypodensity areas due to trabecular rarefaction can be observed, with hypodensity areas due to trabecular bundle pattern resulting from reduced osseous resistance due to altered load determined by the vertebral collapse of the metamers above.*



Figs. 6.13 and 6.14 Sagittal plane multiplanar reconstruction CT scan: severe collapse of two vertebrae, fulcrum of the wedging and Metameric anterior fusion with intradiscal calcifying material

6.3 Gaucher's Disease

Subject: CF T.1

Sex: male

Age: 40–50 years

Finding site: Osteria del Curato - Casal Ferranti

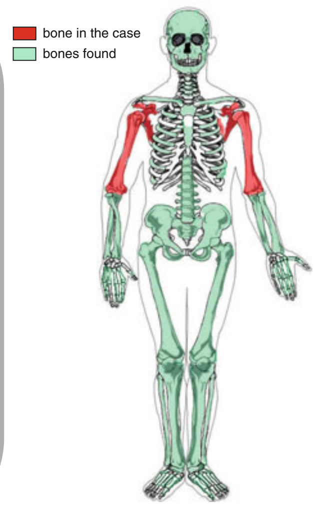
Type of grave: pit in the tuff, with inclined tiles cover

Type of burial: primary

Deposition: supine with extended upper and lower limbs

State of preservation: good

Stature: ~ 167 cm



6.3.1 Morphological and Palaeopathological Description of the Subject

The skeleton, pertaining to an adult male subject, shows a high skull (hypsicranic), with very diverging frontal crests, large orbits (hypsiconchic) and a long and narrow nose (leptorrhine); the cranial index denotes mesocrany. Small bony formations (4 and 5 mm) can be observed on the anterior edge of the *foramen magnum*, at the *basion*. A pair of button osteomas can be seen on the outer table of the right emifrontal bone; moreover, a widespread porotic hyperostosis can be observed on the cranial theca (*cribra cranii*) (Fig. 6.15) and on the roof of the orbits (*cribra orbitalia*). The *ante-mortem* loss of some dental elements can be observed both on the maxillary and the jaw bones, in particular, the alveolar processes of the superior left first molar and inferior second premolars and first molars are completely resorpted.

The subject is robust, but both upper and lower limbs sections are not particularly modified by biomechanical stress.

The upper right limb is longer than its contralateral, even though the differences in size do not apply the other parameters: as a matter of fact, there are no meaningful differences either between the transverse diameters, or between the circumferences and the muscular insertions are more marked on the left. A biomechanical stress of the *pectoralis major* muscle on the humerus and of the deltoid muscle is detected, both at the clavicular origin and at the humeral insertion. Repeated adduction and abduction movements of the arm may have lead to the detected lesions. The lower limbs show some enthesopathies at the insertion of the *vastus medialis* and *soleus* muscles, which may suggest repeated extension movements of the leg on the thigh and of the foot. The axial skeleton is the area which is most frequently affected by degenerative phenomena, above all in the dorsal portion of the rachis;

Fig. 6.15 *Cribra cranii*

signs of discal distress, in the shape of wide and deep intraspongious hernias (Fig. 6.16), can be observed on the vertebral bodies of the thoracic and lumbar tracts; superiorly L3 and L4 show two oval depressions affecting the posterior right quadrant of the disc and in both cases cross the *annulus* imprint. A widespread presence of Schmörl hernias suggests intense and prolonged compression on the vertebral axis. The appendicular skeleton shows mild degenerative phenomena that can only be seen at the level of the acetabular fossae of the coxal bones and of the superior margin of the first sacral vertebra. Small articular lesions, with a local detachment of the cartilage and local subchondral bone necrosis (*osteochondritis dissecans*), can be observed on the lateral condyles of both femurs and on the distal articular surface of the right tibia. Three right ribs show macroscopic signs of previous fractures, with the complete ossification of the bone callus.

Fig. 6.16 Schmörl's node in a lumbar vertebra

Fig. 6.17 Heterometry of the humeri and abnormal development of the humeral heads

6.3.2 Description of the Disease

The lesions examined in this subject are very peculiar. They affect both shoulder joints and show a marked heterometry of the humeri (Fig. 6.17), with the left one longer (294 mm) than the contra-lateral (272 mm). The epiphyses of both humeri have lost their roundness and the congruence with the glenoid fossa, which also lacks its physiological concavity (Fig. 6.18). The macroscopic find suggests a bilateral necrosis of the heads of the humeri. Moreover, the X-ray examination shows a structural alteration of the diaphysis with alternating demineralized and osteosclerosis areas (Fig. 6.19). The systemic signs, such as the alterations in the alveolar processes, lead towards a systemic picture of Gaucher's disease. The eponym takes its name from Philippe Charles Earnest Gaucher, who discovered it in 1882 [12], even if the orthopaedic signs were first described by Amstutz [13], and enzyme deficiency was only identified in 1965. This autosomal recessive pathology is characterized by an enzymatic deficiency in the sphingolipid metabolism. The lack or deficiency of hydrolase, a glucocerebrosidase enzyme, determines a build-up of this in the

Fig. 6.18 Lack of physiological concavity of the right glenoid fossa

Fig. 6.19 X-rays antero-posterior view shows bilateral deformity and necrosis of the humeral head with flat surface of both epiphyses (humerus and glenoid fossa)

reticulo-endothelial system, thus affecting the spleen, the liver, the bones and the nervous system.

There are three types of Gaucher's disease [14]:

- Type I is the most common and interesting form, from an orthopaedic point of view and does not involve the central nervous system.
- Type II prematurely and severely affects the nervous system. Affected children die by the age of one.
- Type III, in addition to type I characteristics, involves the central nervous system slowly and progressively.

The main clinical sign of Gaucher's disease regarding the bones is a non-specific and dull bone pain, generally periodic and chronic [15]. Typical characteristics are the bone crises, similar to the sickle-cell ones, affecting the joints, especially hips, knees, shoulders and the rachis, resulting in osteonecrosis. The crisis can be accompanied by fever, joint tumefaction and, in absence of treatment, rest is the only relief, thus limiting the disease duration to about 2–3 weeks. Bone pain can also derive from complications such as pathological fractures and osteomyelitis. In case of the latter, crises are diagnosed differentially. Among the build-up metabolic diseases, mucopolysaccharidosis is one where an enzymatic deficiency in the metabolism of complex carbohydrates leads to their decomposition. The clinical picture of mucopolysaccharidosis is very similar to that of Gaucher's disease, with osteonecrotic epiphyseal changes, mainly in the hips, short height and sometimes valgus knee due to incomplete ossification of the lateral margin of the proximal metaphysis of the tibia. The differential diagnosis between the two build-up diseases is impossible, due to the lack of discriminating diagnostic features, but type I Gaucher's disease is more likely [16].

Fig. 6.20 Axial plane multiplanar reconstruction CT scan: glena deformity with flat pattern and subchondral hyperdensity. Multiple hypodensity areas at the humeral head suggesting necrosis

Fig. 6.21 Coronal plane multiplanar reconstruction CT scan: deformity of the lower part of the right humeral epiphysis with pseudo-exostosis. Narrowing of the joint space and remodelling of both articular surfaces as the cause of neoarthrosis

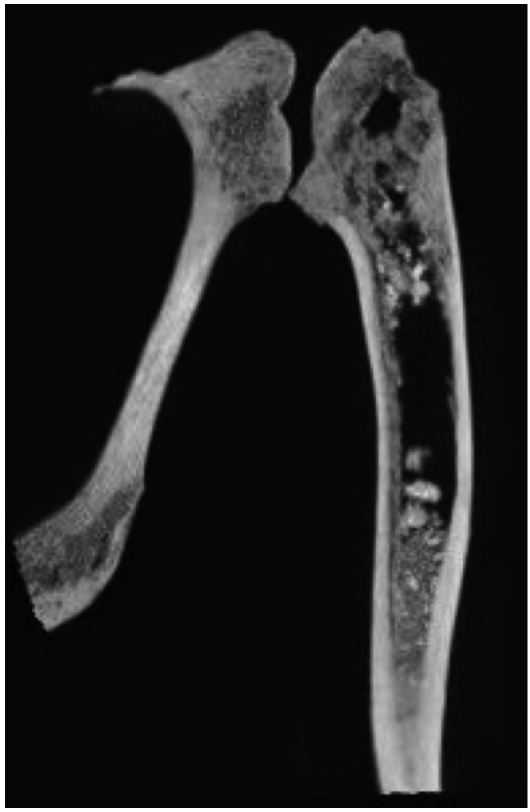


Fig. 6.22 (Left side detail): coronal plane multiplanar reconstruction CT scan: presence of structured hyperdensity precipitates with a "cobblestones" feature in the bone marrow and thinner adjacent cortex

6.3.3 Radiologist's Evaluation

Silvana Giannini

The humeral metaphyseal bone deformity suggests the presence of fracture and vascular necrosis of the humeral head compatible with Gaucher's disease bone evolution (Figs. 6.19 and 6.20) [17]. *Bone deformity of the heads, which are oval-shaped and with a lower pseudo-exostosis caused by neoarthrosis by functional remodelling suggests a post-fracture collapse restoration. Bone frailty is well shown by a reduced representation of the bone reticular pattern because of a reduced calcium component. A densitometric alteration with structural capsizing of the entire segment can be observed, with internal structured precipitates* (Fig. 6.21). *The sample can be compared to an aggregation of* "*cobblestone*" *structured polysaccharides occupying the bone marrow while the cortical appears thinner* (Fig. 6.22).

In conclusion, the absence of growth lines is suggestive of an adult subject. The peculiar bone deformity and the typical aspect ("*cobblestone*" *feature*) *of the bone marrow are highly suggestive of a storage disease* (*probably type I Gaucher's disease*).

6.4 Ankle Infection

Subject: PM T.46

Sex: male

Age: 30–40 years

Finding site: Pontina Mostacciano

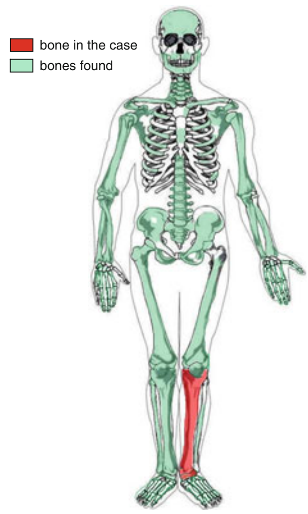
Type of grave: pit in the ground with no cover

Type of burial: primary

Deposition: prone and curled, with flexed upper and lower limbs

State of preservation: good

Stature: ~173 cm



6.4.1 Morphological and Palaeopathological Description of the Subject

The metric analysis and the appendicular skeleton's musculo-skeletal markers both define a well-built individual, with no major biomechanical stress in life. The cranial and the height indices describe a large and high skull (brachycranic and hypsicranic); the transverse fronto-parietal and frontal indices suggest a wide forehead, with averagely diverging crests (eurymetopic). As for the dento-alveolar diseases, there are two superficial cavities, both on the left upper jaw third molar: one mesial, and one occlusal. Quite a lot of calculus can be seen on most teeth, both of the upper and of the lower jaw, and some resorption can be seen on the alveolar margins. There are signs of a major muscle stress only on the right shoulder, as expressed by the presence of enthesopathic alterations at the origin of the deltoid muscle and at the insertion of the costo-clavicular ligament. Moreover, the values of the right radio and ulna diaphyseal indices denote a protruding interosseous crest, the result of repeated forearm movements of supination and pronation. These indicators suggest a dimensional and functional asymmetry, which indicates a prevalence of the right upper limb and of its overload. As for the lower limbs, the femurs are strong and platymeric, while the cnemic indices of the tibia are eurycnemic, revealing scarce activity of the calf muscle. There are no signs of arthritic degenerations on the axial and appendicular skeleton, other than a mild marginal lipping, lower than 3 mm., on the incisure of the first left rib. Severe and diffused periostitis has been observed on the right tibia, on the left fibula, and on the lateral surface of the right calcaneus, on the fibular tubercle. The remodelling is due to inflammatory processes at the cortical portion of the diaphyses, with deposition of new streaked bone and plaques.

A circular osteolytic area can be observed on the proximal surface of the right navicular.

6.4.2 Description of the Disease

The subject shows a left tibio-talar-calcaneal sinostosis, a complete bone fusion of the tibio-talar and astragalo-calcaneal joint (Fig. 6.23a, b). The three hind-foot bones appear arranged regularly in the fusion, with a normal hind-foot axis on the coronal and sagittal plane. There is a probable heightened dorsal flexion, and an increase in

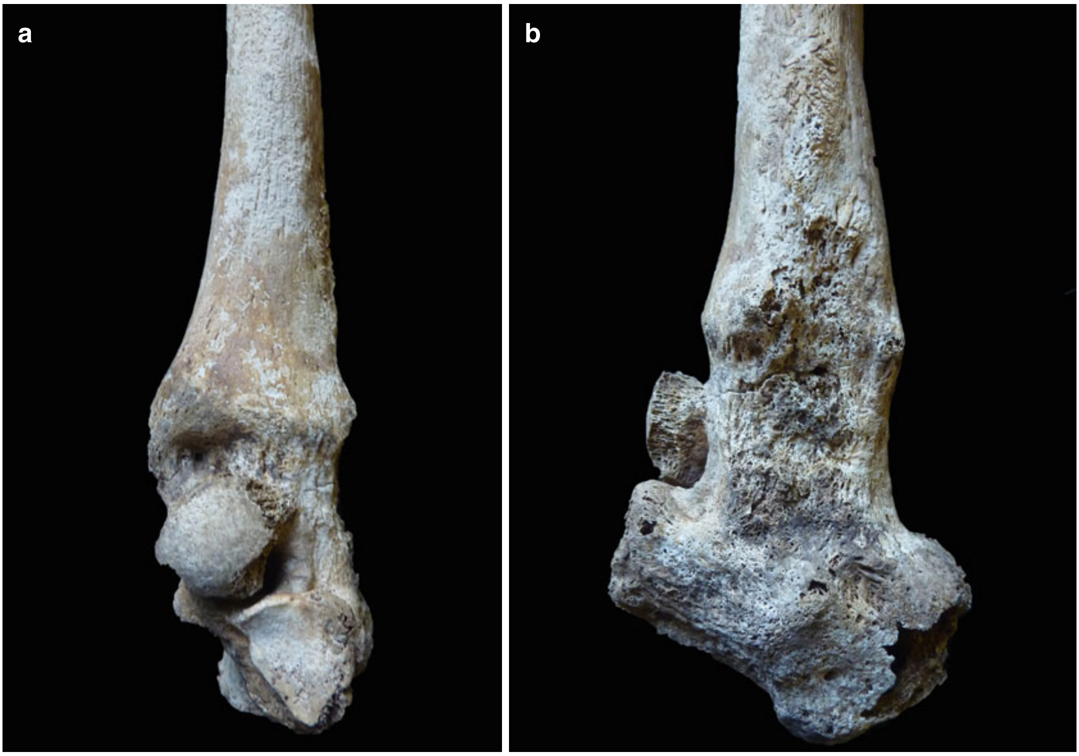


Fig. 6.23 Tibio-talar-calcaneal sinostosis (**a**) Anterior view (**b**) lateral view

the height of the plantar vault. This can suggest potential neurological pathologies (M. di Charcot-Marie-Tooth). The radiology examination (Fig. 6.24) shows the three bones to be normal, with well-preserved articular lines: this feature rules out a potential congenital malformation. The bone fusion seems limited to the periskeletal soft tissues, leading to a circumferential calcification of the joints involved, without altering the bone and articular profiles. The bone profiles, with a regular anatomical shape, rule out the presence of a more severe traumatic pathogenesis. The radiographic investigation, and the CT scan (Figs. 6.25 and 6.26), show an osteostructural alteration of the talar vault, with a likely infective aetiology (tuberculosis?, brucellosis?, pyogenic arthritis?). The periskeletal ossification would be secondary to a prolonged immobilization of the limb, and recovery process of arthritis. The issue of a spontaneous healing of the ankle from septic arthritis is still suspicious, since it is not a major medical problem today, but could certainly become lethal in the pre-antibiotics era. Arthritis can reasonably be hypothesized, with a not too aggressive aetiologic agent, responsible for a chronic infection, and confined to the subject's response in a bone sarcophagus. The above described features seem to resemble those of sub-acute tuberculosis become chronic.

6.4.3 Radiologist's Evaluation

Silvana Giannini

Cortical integrity, with absence of deformity, and the tibio-talar-calcaneal functional unit. Hardening caused by homogeneous hyperdensity distributed on joint surfaces with an incomplete talar-calcaneal synostosis (Fig. 6.25).

Fig. 6.24 X-rays lateral view: Peripheral osseous fusion of the tibio-talus-calcanear joint. Integrity of the bone shapes with focal irregularity of the chondral surface of the talus and the tibia (kissing lesion)

The diagnosis of a fracture can be ruled out due to cortical integrity, absence of marginal deformity and integrity of tibio-talar-calcaneal functional unit.

Loss of the cleavage plane with subtotal joint fusion (Fig. 6.26) *and deformity of the talus dome.*

The preservation of part of the joint line and the uniformity of the joint surface rule out the hypothesis of osteomyelitis [18, 19].

The sample suggests the fusion of a non-post-traumatic arthritis process, likely resulting from tuberculosis, also considering the areas of radiopacity adjacent to the bone rarefaction, as in bone exuding-caseous TBC with pseudo-seizure [20].

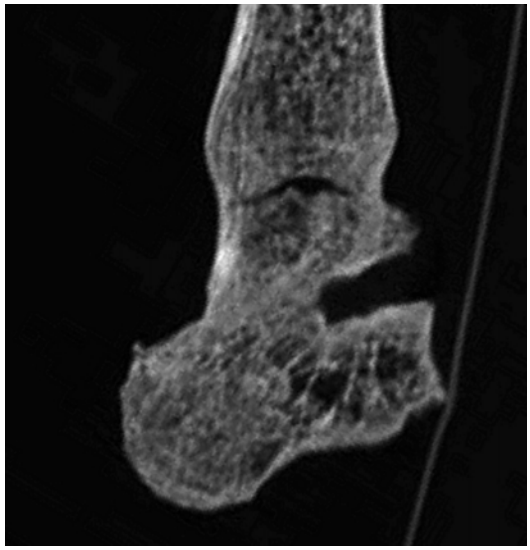


Fig. 6.25 CT scan sagittal plane multiplanar reconstruction: peripheral trabecular fusion of the tibio-talar joint, with hyperdensity area. Sub-total posterior fusion with compact aspect of the trabeculae (focal hyperdensity area) around the sub-talar joint

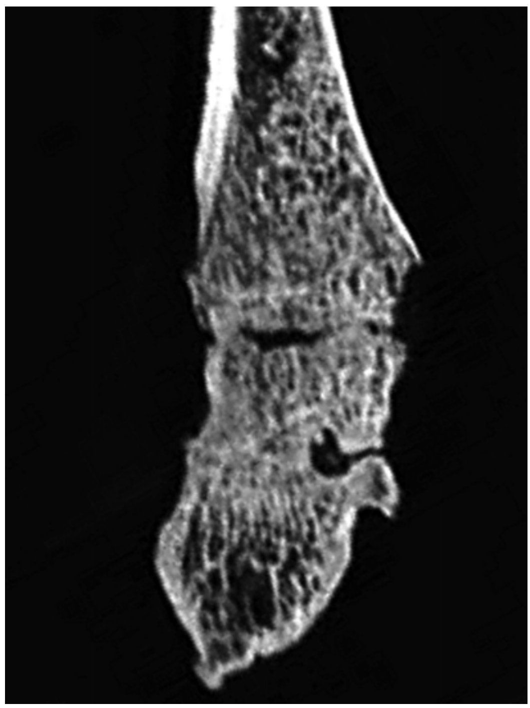


Fig. 6.26 CT scan coronal plane multiplanar reconstruction: central hypodensity area, suggesting Brodie abscess with surrounding hyperdensity area

6.5 Osteochondritis Dissecans of the Knees

Subject: CBQ T.51

Sex: male

Age: 25–35 years

Finding site: Casal Bertone area Q

Type of grave: pit in the ground in "Recinto" with inclined cover

Type of burial: primary

Deposition: supine, with flexed upper limbs and extended lower limbs

State of preservation: good

Stature: ~165 cm

6.5.1 Morphological and Palaeopathological Description of the Subject

The skeleton, pertaining to an adult male individual, is strong, with eurybrachic humeri and platymeric femurs. The skull is elongated (dolichocranic), with slightly diverging frontal crests, large orbits (hypsiconchic) and long, narrow nose (leptorrhine); the height index shows intermediate values (orthocranic), while the gnathic one expresses a vertical facial skeleton (orthognathism). There is a slight deviation of the nose towards the right; there is also a diffused porosity on all the cranial theca, more evident on the supercilliary arches (*cribra cranii*). The tendon and ligament insertions are generally weak: only the deltoid tuberosity and the pectoral crest of the humerus are large and rugged; the right humerus is stronger and longer than the contra-lateral (322 mm versus 313 mm). The insertion area of the *pronator quadratus* muscle on the ulnas has a longitudinal furrow, and the interosseous crests of the radii are protruding, thus suggesting frequent pronation and supination movements of the forearm. The lower limbs only show mild ruggedness at the insertion of the *gluteus maximus* on the femurs and at the origin of the *soleus* muscle on the tibias. There are several intraspongious hernias (Fig. 6.27) on the vertebral column: these lesions are wide and involve both the superior and the inferior face of the bodies. Since they are not associated to any more signs of joint degenerations (such as ostheophytosis and/or inter-somatic or interapophyseal porosity), a

Fig. 6.27 Schmörl's node in a thoracic vertebra

Fig. 6.28 *Osteochondritis dissecans* in the distal femurs (**a**) *left side* with detachment of a fragment (**b**) *right side* with bone fragment in place

traumatic aetiology with ponderal overload of the rachis can be hypothesized. The sixth cervical vertebra shows a bipartite left transverse foramen due to the presence of a complete bone partition.

6.5.2 Description of the Disease

Macroscopically, two symmetrical lesions can be seen on both joint surfaces of the distal femurs in correspondence to the femoral trochlea on the lateral eminence (Fig. 6.28). The lesion on the right is roughly circular, with a furrow surrounding an area which continues with the articular surface of the trochlea. The lesion on the left is similar in size and shape, but seems to miss the defined fragment of the lesion, as if it had dropped off. The described finds seem to be compatible with a diagnosis of osteochondritis dissecans (OCD) of the femoral trochlea. This site is the rarest one in OCDs of the knee, accounting for just 6 % of cases. In the latest review of this pathology, Wall et al. [21] count a total of just 50 cases in literature. This case represents an utter rarity. The first description of OCD belongs to Paret and Paget, but the first one to give it a name was Konig in 1888 [22]; with this term, he indicated an inflammatory process, a theory that he later gave up, which caused the presence of mobile bodies within the joint. The aetiology of the disease is still unclear, and no theory is universally acknowledged. The features underlying the development of the lesion, which are crucial for its aetiology are repeated micro-traumas, vascular insufficiency of the fragment, growth imbalance between the fast cartilage growth and the ossification of the distal femur's growth cartilage. The position on the femoral trochlea seems to be more likely correlated to traumatic factors, as there is a high incidence in young athletes who undergo repeated chronic traumas on this joint. The distribution ratio between males and females is 2:1, respectively, with a bilaterality from 15 to 30 % of cases, and a peak of incidence between 10 and 15 years [23]. However, Smillie [24] recognizes two forms, one juvenile, due to a development disturbance in the femur's distal epiphysis with the development of areas of subchondral bone separated from the main nucleus where repeated micro-traumas trigger a hypoxia area and are the cause of the detachment. Smillie also describes an adult form which is more directly linked to a traumatic pathogenesis. The typical site for knee OCD is the lateral profile of the medial condyle, but it can also be somewhere else in the body as this case shows. The acute phase of this pathology is represented by pain, generally anterior, and swelling, but the prognosis depends mainly on the detachment of the fragment due to its stability or instability. Another precious feature of this case is that it seems to show both evolutions of OCD: the re-ossification of the fragment, initially detached, with a furrow in one knee, and in the other one the space left by the fragment which is detached as a free body in the knee.

6.6 Distal Femur Osteomyelitis

Subject: Gabii SO/99 T.18

Sex: female

Age: 35–40 years

Finding site: Gabii Eastern Sanctuary

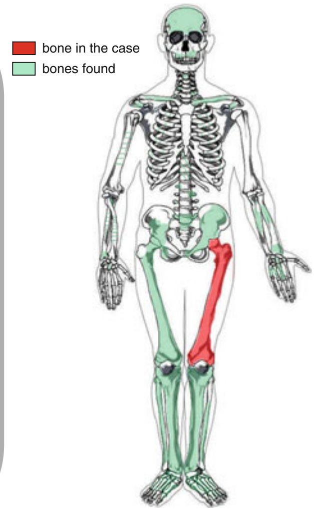
Type of grave: pit in the ground with tile fragments

Type of grave: primary

Deposition: supine, with flexed upper and lower limbs

State of preservation: poor

Stature: ~151 cm



6.6.1 Morphological and Palaeopathological Description of the Subject

The skeleton, pertaining to a minute and gracilis individual, shows fragmented bones, especially in the areas of the trunk and of the upper limbs; the skull, which has been reconstructed only partially, is elongated (dolichocranic), with averagely diverging frontal crests. The conditions of the dento-alveolar complex are relatively good: there is only a cavity at the mesial side of the first left maxillary molar, and a fair amount of calculus on all the teeth. The poor state of preservation of the post-cranial skeleton has strongly limited the detection of the musculo-skeletal markers and of the articular alterations; however, the imprint of the right costo-clavicular ligament shows a mild osteophytic alteration, the femurs are platymeric, and the gluteal tuberosity area is more marked on the left side. The first metatarsal bones show an osteolytic enthesopathy at the insertion of the *peroneus longus*, involved in the plantar flexion of the foot. The ileum's pre-auricular sulcus has small foveas, and the left pubic symphyseal margin shows a marked depression (the right one cannot be seen); these features are probably due to postpartum sub-ligamentous haematomas.

6.6.2 Description of the Disease

In this clinical case, the macroscopic lesion of the femur shows a central cortical alteration at the left femur's mid-distal third (Fig. 6.29a). This superficial alteration of the cortex and of the periosteum is accompanied by a distal diaphyseal enlargement (Fig. 6.29b). There are no visible interruptions in the cortex, and the periosteal reaction seems to involve circumferentially the most highly interested posterior profile. Without a traumatic and metabolic aetiology, the suspected diagnosis is of an oncology infectious origin, which seems to be supported by the imaging.

Fig. 6.29 Osteomyelitis of the left distal femur (**a**) posterior view (**b**) detail

6.6.3 Radiologist's Evaluation

Silvana Giannini

Deformity of the femur with a flared distal diaphysis, affected by a peripheral, bone trabecolar rarefaction, periosteal layering with multiple appositions (Fig. 6.30a). *The external area shows an "onion-skin" type periosteal delamination* (Fig. 6.30b), *and district discontinuity with pseudo Codman due to potential fistulas. The central, oblong, oval radiopaque hardening in the centre of the bone marrow in the context of flaring femoral is consistent with Brodie*'*s abscess caused by bone seizure with cloaks of the fistula tracts* (Fig. 6.31).

The turnover of areas of bone impoverishment (*rarefying osteomyelitis*) *and bone hardening due to prevalent processes of neo-apposition by hyperactivity of osteoblasts processes suggests a mixed form of condensing and peripheral rarefying osteomyelitis. Moreover, the presence of a double outline from external cortical delamination confirms the diagnosis of osteomyelitis* (Fig. 6.32).

6.6.4 Expert Orthopaedic Oncologist's Evaluation

Rodolfo Capanna

In my opinion macroscopical and radiological aspects of the lesion are suggestive for Chronic osteomyelitic process.

Fig. 6.30 (**a**) X-rays antero-posterior of the femur showing the distal deformity with enlargement of the diaphysis with dishomogeneous radiopacity in the centre of the bone marrow. (**b**) X-rays (detail): "Onion-skin" type periosteal reaction and discontinuity of the cortical bone

Fig. 6.31 CT scan coronal plane multiplanar reconstruction: central hypodensity area, suggesting Brodie abscess with surrounding hyperdensity area

Fig. 6.32 CT scan sagittal plane multiplanar reconstruction: the posterior aspect of the cortical bone is enlarged with sub-cortical hyperdensity area

6.7 Septic Hip Arthritis with Distal Femur Enchondroma

Subject: CM T.277

Sex: male

Age: 30–40 years

Finding site: Castel Malnome

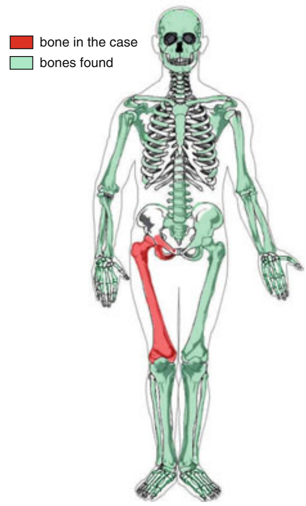
Type of grave: pit in the ground with cover of tiles

Type of burial: disturbed primary

Deposition: supine, non deductible upper limbs and extended lower limbs

State of preservation: poor

Stature: ~ 158 cm



6.7.1 Morphological and Palaeopathological Description of the Subject

The subject is an adult male of short height, characterized by a strong skeleton. Phenotypically, the skull is elongated (dolichocranic), with averagely diverging frontal crests, large orbits (hypsiconchic), and long and narrow apertura piriformis (lepthorrine). The height, transverse fronto-parietal, and gnatic indices express intermediate values (orthocranic, eurymetopic, orthognatic). The skull shows a series of anatomical variants of limited pathological value: total persistence of the metopic suture (Fig. 6.33), presence of the suture mendosa (Fig. 6.34) and of two Wormian sutural ossicles, along the lambdoid suture (Fig. 6.35). Moreover, a small sutural bone, symmetrically bipartite, can be seen at the level of the lambdoid suture. There is a 3 mm diastema between the two upper central incisors. The health of the dento-alveolar complex is compromised: there are large calculus deposits on the vestibular and lingual sides of the dental crowns. On the maxilla, the second right premolar has a cavity at the mesial margin and the alveolar processes are resorpted at the right molars. The crowns of the lateral incisors are strongly

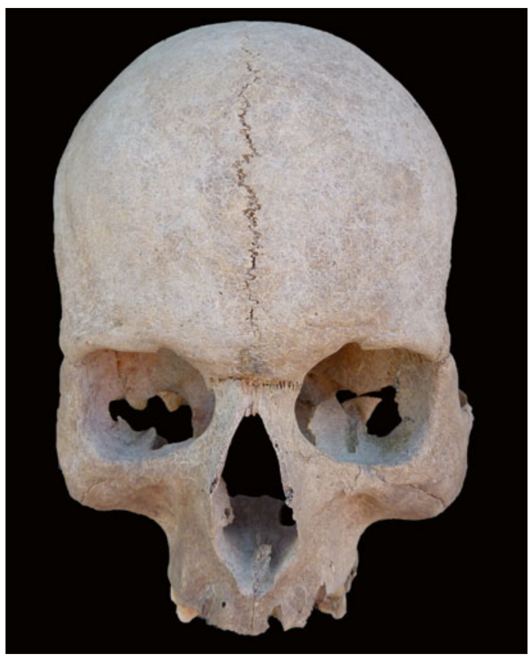


Fig. 6.33 Metopic suture

worn, with total enamel and dentin demolition, and pulp cavity exposure. Both incisors are reduced to small radicular stumps, probably due to destructive caries; there is also a small cavity on the vestibular side of the right lateral incisor's

Fig. 6.34 Mendosa suture (*arrow*)

Fig. 6.35 Ossicles along the lambdoid suture

alveolar process, secondary to a prior odontogenic abscess, with the tooth's root at its centre. A larger bone fistula opens on the apex of the second lower left molar. As for the appendicular skeleton, the muscular insertion areas show an intensive activity of the pectoral girdle muscles, with enthesopathies at the origin of the *triceps brachii* muscle and of the scapular *teres minor* muscle. The insertion area of the costo-clavicular ligament is marked on the sternal extremities of the clavicles; the surface is irregular, slightly depressed and outlined by discontinuous margins. The surface of the lesser humeral tubercles shows thick and deep porosity at the insertion of the *subscapularis* muscle; there are some enthesopathic alterations, only on the right side, at the insertions of the radius's *biceps brachii* and *interosseous* tubercle muscles and the ulna's *brachial* muscle. On the anterior inferior iliac spine, at the origin of the *rectus femoris* muscle, the surface is altered, with a crest formation of about 18.4 mm from the irregular margins. The marked imprints on the lower limbs are of interest: in particular, the anterior surfaces of the femurs' trochanter major are irregular, with enthesophytes and bone apposition; only on the left side, the *linea aspera* appears prominent and rough, while bilaterally above the medial condyle, there is hypertrophy of the *gastrocnemius* muscle's origin area. A mild ossification of the tendons of the *quadriceps femoris* muscle, with new bone formations, can be seen on the tibial tuberosities, at the level of the posterior cruciate ligament and on the anterior surface of both patellas. Overall, the alterations detected suggest diversified movements: stress of the shoulder with arm adduction and intrarotation, forearm extension and flexion on the arm, and partially, also forearm supination and pronation. As for the lower limbs, there must have been frequent abduction, adduction, flexion and rotation movements of the thigh, leg extension on the thigh and foot extension. The presence of encrustations limited the observation of the axial skeleton: the segments that could be analysed did not show any disc degenerations, but there are a mild osteophytes on the ventral margins of the vertebral bodies. Among the congenital anomalies, there is fusion of the fifth lumbar vertebra with the first sacral vertebra (sacralization); the sacrum has kept its morphological aspect, but with one more sacral foramen. A fracture can be seen on the distal third of the diaphysis of the second right metatarsal, with bone callus formation and mild axis deviation.

6.7.2 Description of the Disease

The lesion shown in this case is extremely complex to interpret. There is an ossifying component that seems to affect the right coxo-femoral joint, with greater effort of the periacetabular

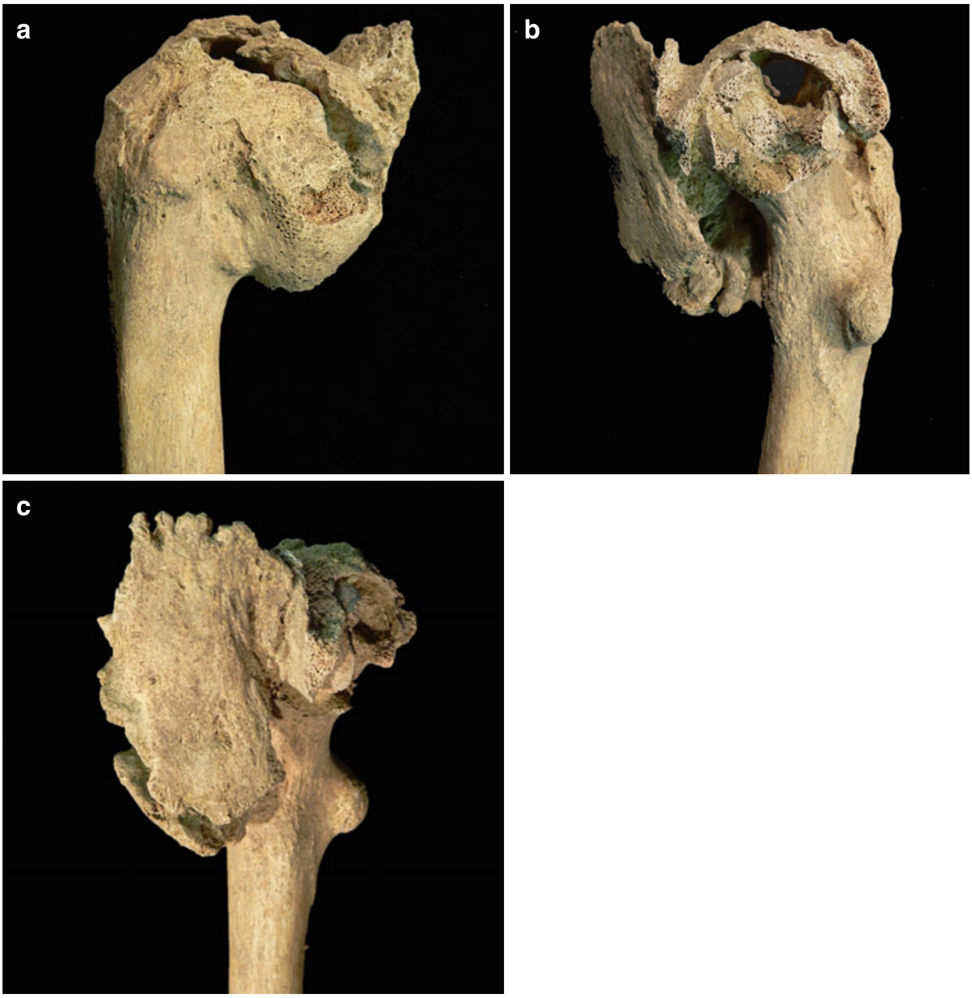


Fig. 6.36 Fusion of coxo-femoral joint (**a**) medial view (**b**) posterior view (**c**) anterior view

area, and joint fusion presenting no relevant deformity of the femur's head (Fig. 6.36). The ossifying new formation seems to include the proximal femur's anterior portion without any signs of periosteum alterations (Figs. 6.37 and 6.38). The lesion seems to be too large and too compact to be a heterotopic ossification of the soft tissues. A malignant neoplastic aetiology seems to be ruled out by the absence of periosteal reactions, but suggested by the macroscopic picture.

There is also an osteolysis at the femoral head, as resulting from colliquative collection. The most likely diagnostic hypothesis is osteomyelitis with peripheral sarcophagus, colliquation and presence of abscesses at the femoral head.

6.7.3 Radiologist's Evaluation

Silvana Giannini

Iliac wing: *densitometric alteration with hyperdense image and well-structured, hypodense areas associated to hyperdense nubecular areas. The CT scan shows a peripheral hyperdensity* (Fig. 6.39), *together with a central hyperdensity presenting a hypodense peripheral area.*

Femur: Cribrate

Cribrate hyperdensity of the joint surface with subtotal fusion at the level of an extensive and dishomogeneous bone defor-

Fig. 6.37 CT scan sagittal plane – multiplanar reconstruction showing the dishomogeneous area of hyperdensity involving the femoro-acetabular joint. A nubecular hyperdensity is shown distally (*arrow*), suggesting a possible enchondroma

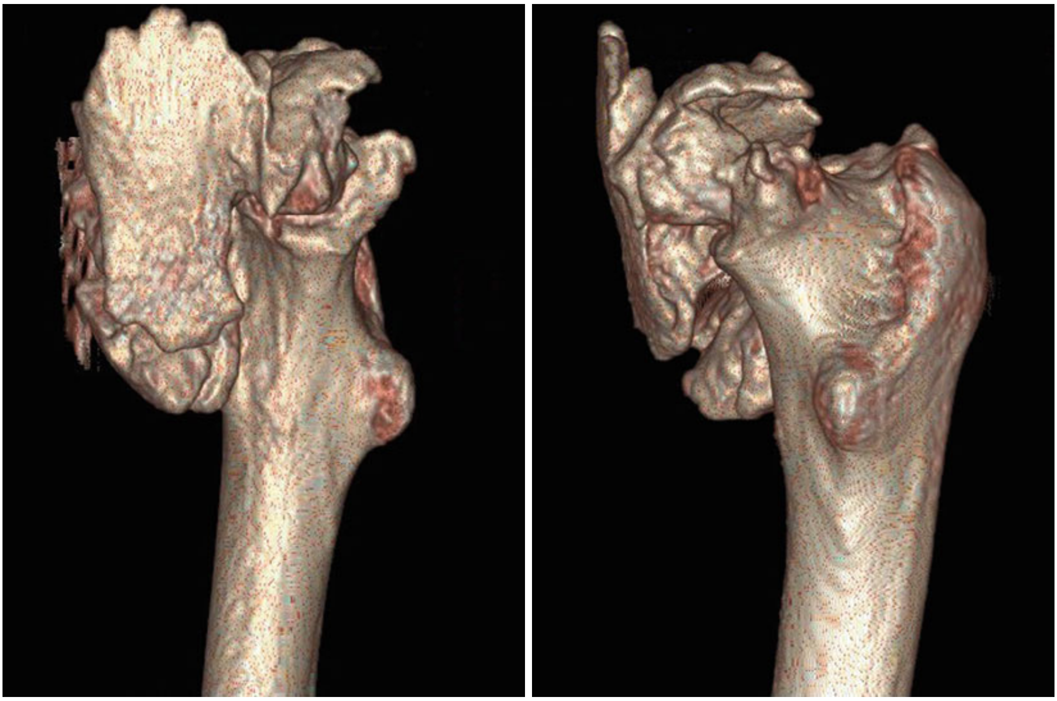
Fig. 6.38 CT scan sagittal plane of the proximal part of the femur: deformity of the femoral head and bone marrow dishomogeneity

mity of the femoral head (Fig. 6.40). *It also shows an irregular deformity with cribrate areas of medium hyperdensity*, *and loss of regular trabecular distribution. Focal discontinuity of the femoral head caused by erosion with trabecular circinate hypodensity and peripheral hyperdensity. There are also external concave areas at the femoral neck*, *with some sections of circinate hyperdensity* (Fig. 6.40). *The find shows an abnormal structured capital and sub-capital density*, *and cleavage plane with the bone marrow diaphysis area. Partial femoral-acetabular synostosis*.

The irregular discontinuity of the femoral head, *similar to erosion*, *suggests a partial femoro-acetabular fusion with possible extension of the inflammation to the surrounding soft tissue*.

Distally focal, *34 mm moriform densitometric alteration*, *with nubecular hyperdensity*, *a large implant area inside the diaphyseal supracondylar*, *probably caused by enchondroma*, *with hyperdensity of the adjacent lateral cortex* (Fig. 6.39).

Conclusions: *possible inflammation process*, *like osteomyelitis of the meta-epiphyseal femoral region with an extension to the acetabulum*, *partial fusion on the joint*, *and possible extension to the surrounding soft tissues given the erosion of the femoral head*.



Figs. 6.39 and 6.40 3D reconstruction CT scan shows the erosion of the femoral head and the spreading to the surrounding soft tissue

6.7.4 Expert Orthopaedic Oncologist's Evaluation

Rodolfo Capanna

The finds suggest a destructive osteoarthritis (TBC?). Unlikely oncological aetiology.

References

1. Manzi G, Sperduti A, Passarello P. Behavior induced auditory exostoses in Imperial Roman society: evidence from coeval urban and rural communities near Rome. Am J Phys Anthropol. 1991;85:253–60.
2. Hutchinson DL, Denise CB, Daniel HJ, Kalmus GW. A revalutation of the cold water etiology of external auditory exostoses. Am J Phys Anthropol. 1997;103(3):417–22.
3. Capasso L. I Fuggiaschi di Ercolano: Paleobiologia delle vittime dell'eruzione vesuviana del 79 d.C. Roma: L'Erma di Bretschneider; 2001.
4. Fitzgerald RH, Kaufer H, Malkani AL. Ortopedia e Traumatologia, vol. 3. Rome: Verduci ed.; 2004.
5. Pott P. Fartherremarks on the useless state of the lowerlimbs, in consequence of a curvature of the spine: being a supplement to a formertreatise on thatsubject. 1782. Clin Orthop Relat Res. 2007;460:4–9.
6. Moorthy S, Prabhu NK. Spectrum of MR imaging findings in spinal tuberculosis. AJR Am J Roentgenol. 2002;179(4):979–83.
7. Sai Kiran NA, Vaishya S, Kale SS, Sharma BS, Mahapatra AK. Surgical results in patients with tuberculosis of the spine and severe lower-extremity motor deficits: a retrospective study of 48 patients. J Neurosurg Spine. 2007;6(4):320–6.
8. Ansari S, Amanullah MF, Ahmad K, Rauniyar RK. Pott's spine: diagnostic imaging modalities and technology advancements. N Am J Med Sci. 2013;5(7):404–11.
9. Chauhan A, Gupta BB. Spinal tubercolosis. Indian Acad Clin Med. 2007;8:110–4.
10. Ascenzi A, Mottura G. Anatomia Patologica. 5th ed. Torino: UTET; 1997.
11. Resnick DL, Kransdorf MJ. Bone and joint imaging. 3rd ed. Philadelphia: Elsevier-Saunders; 2004.
12. Zimran A, Kay A, Gelbart T, Garver P, Thurston D, Saven A, Beutler E. Gaucher disease. Clinical, laboratory, radiologic, and genetic features of 53 patients. Medicine (Baltimore). 1992;71(6):337–53.
13. Amstutz HC, Carey EJ. Skeletal manifestations and treatment of Gaucher's disease. Review of twenty cases. J Bone Joint Surg Am. 1966;48(4):670–701.

14. Grabowski GA, Dinur T, Osiecki KM, Kruse JR, Legler G, Gatt S. Gaucher disease types 1, 2, and 3: differential mutations of the acid beta-glucosidase active site identified with conduritol B epoxide derivatives and sphingosine. Am J Hum Genet. 1985;37(3):499–510.
15. Javier RM, Hachulla E. Osteoarticular manifestations of Gaucher disease in adults: pathophysiology and treatment. Presse Med. 2007;36(12 Pt 3):1971–84. Epub 2007 May 10.
16. Charrow J, Esplin JA, Gribble TJ, Kaplan P, Kolodny EH, Pastores GM, Scott CR, Wappner RS, Weinreb NJ, Wisch JS. Gaucher disease: recommendations on diagnosis, evaluation, and monitoring. Arch Intern Med. 1998;158(16):1754–60.
17. Khan A, Hangartner T, Weinreb NJ, Taylor JS. Risk factors for fractures and avascular osteonecrosis in type 1 Gaucher disease: a study from the International Collaborative Gaucher Group (ICGG) Gaucher Registry. J Bone Miner Res. 2012;27(8):1839–48. doi:10.1002/jbmr.1680.
18. Berquist TH. Radiology of the foot and ankle. New York: Raven; 1989.
19. Forrester DM, Brown JD, Nesson JW. The radiology of joint disease. 2nd ed. Philadelphia: W.B.Saunders CO; 1978.
20. Forrester DM, Kirkpatrick J. Periostitis and psuedoperiostitis. Radiology. 1976;118(3):597–601.
21. Wall EJ, Heyworth BE, Shea KG, Edmonds EW, Wright RW, Anderson AF, Eismann EA, Myer GD. Trochlear groove osteochondritis dissecans of the knee patellofemoral joint. J Pediatr Orthop. 2014;34(6):625–30.
22. Konig F. Uber freie Korper in den Glenken. Zeiteschr Chir. 1888;17:90–109.
23. Dennis CC, Safran MR. Osteochondritis dissecans of the knee. J Am Acad Orthop Surg. 2006;14:90–100.
24. Smillie IS. Osteochondritis dissecans: loose body in the joints. Edinburgh: Churchill Livingstone; 1960.