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THE MEDICI PROJECT FIRST ANTHROPOLOGICAL AND PALEOPATHOLOGICAL RESULTS OF THE EXPLORATION OF THE MEDICI TOMBS IN FLORENCE

GINO FORNACIARI, ANGELICA VITIELLO, SARA GIUSIANI, VALENTINA GIUFFRA, ANTONIO FORNACIARI*, NATALE VILLARI**
Department of Oncology, Transplants and Advanced Technologies in Medicine
Division of Paleopathology, University of Pisa, I.
*Department of Archeology and History of Arts, Section of Medieval Archeology
University of Siena, I.
**Department of Clinical Physiopathology, Section of Clinical Radiology
University of Florence, I.

SUMMARY

Within the framework of the Medici Project, a paleopathological team of experts from the University of Pisa, the University of Florence and the Superintendence for Florentine Museums, is carrying out a study on 49 tombs of some of the Medici family members (16th-18th centuries) housed in the so-called Basilica of San Lorenzo in Florence. The project involves disciplines such as paleopathology, funerary archeology, physical anthropology, paleonutrition, parasitology, histology, histochemistry, immuno-histochemistry, electron microscopy, molecular biology, and identification of ancient pathogens. The most recent biomedical imaging technologies have been employed to obtain as much information as possible about the genetic make-up, eating habits, life styles and diseases of these important rulers of Renaissance Florence. The first anthropological and paleopathological results are presented here.

Introduction

Starting from the 14th century, the Medici gradually became one of the most powerful families of Italian Renaissance accumulating

Key Words: Medici – Florence – Anthropology - Paleopathology

vast wealth through banking, commerce and skilful political ventures. This brought them to the forefront of social and political power in Tuscany and especially in Florence, which was the intellectual centre of the Western world. Lovers of literature and science, the Medici were patrons of several of the great artists of that period, such as Michelangelo, Leonardo da Vinci, Botticelli, Galileo, and Benvenuto Cellini.

The senior branch of the Medici family was that of Lorenzo the Magnificent (1446-1492), while the junior branch - that of the Grand Dukes of Tuscany - began with John of the Black Bands (1498-1526) and ended with Gian Gastone (1671-1737), the last Grand Duke. The most important members of this latter branch, less famous than the former, were buried under the vaults of the Basilica of San Lorenzo in Florence[1]. In 2002, dr. Antonio Paolucci, Superintendent for the Florentine Museums, granted permission to examine 49 of the Medici family members buried in the church.

The Medici Project involves collaboration among scientists from the University of Pisa, the University of Florence and the Superintendence for Florentine Museums. The research programme includes paleopathology, funerary archeology, anthropology, paleonutrition, parasitology, pathology, histology, histochemistry, immunohistochemistry, electron microscopy, molecular biology, and identification of ancient pathogens. The most recent biomedical techniques have been employed to obtain as much information as possible about the life style, health, and environment of these mighty rulers of Renaissance Florence[2].

In order to conduct this study, a provisional laboratory was set up in the Lorena Chapel, which is the funerary crypt of the Grand Dukes of the Lorena dynasty, that ruled Florence and Tuscany after the Medici until 1859.

Some burials had already been explored during the Second World War[3], so we decided to begin our examination with the intact tomb of Gian Gastone, the last Medici Grand Duke (1671-1737). The removal of a plain dark marble disk, considered a simple floor decoration, displayed a secret opening, with a small stone stair leading to an

unknown hidden crypt. The small funerary crypt revealed a low raised plank supporting a large sarcophagus, and many small wooden coffins, which had collapsed to the floor, and were covered by a layer of dry mould, caused by the disastrous flood of 1966. Following the advice of the *Opificio delle Pietre Dure* in Florence, the famous Institute for the conservation of works of art, a special on-site climate-control chamber was built over the entrance of the crypt to face the problems of extreme dampness (90%) and high temperature (30°C) and to avoid additional damage to the coffins and bodies by the introduction of external air during the archaeologists' examination.

The outer wooden sarcophagus of the Grand Duke Gian Gastone, apparently well preserved, was in fact very fragile, because of the high levels of humidity. The lid of the sarcophagus was badly damaged and had fallen inwards, displaying the inner leaden coffin, with a large Christian cross and six iron handles on the lid. The funerary deposition of the Grand Duke was intact: he was still wearing his funerary crown in gold-plated copper and was covered by the silk Great Cape (*Cappa Magna*) of Grand Master of Knights of the Order of St. Stephen. He bore a small gold devotional medal in filigree at the neck and a silver crucifix on the chest; a large leaden tube, probably containing a parchment document celebrating his life, was near his right leg. On both sides of the Grand Duke's head were two large medallions, masterpieces of the royal engraver Louis Siries (1686-1757). The obverse design shows a bust of the Duke on top of a monument between two mountains. The figure of *Securitas* (Security) with two *genii* rejoicing in front of her can be seen below the monument. The Latin inscription reads *"IO(HANNIS) GASTO(NIS) I ETR(URIAE) MAG(NUS) DUX VII"* (Gian Gastone I, VII Grand Duke of Tuscany). The design on the reverse shows a ruined Temple, with seated figures representing the Arts mourning the death of the Grand Duke, and the Latin inscription *"AMPLIATORI ARTIUM"* (to the Patron of Arts)[4].

Other small coffins collapsed to the floor or randomly distributed on the raised plank and containing children's bodies were visible in the crypt. Contrary to all expectations, several of the burials in the small wooden coffins were considerably well-preserved. For exam-

ple, the elaborate clothes of a 5-year-old child, with shoes and silver crown, showed an excellent state of preservation. The red silk jacket with a thin collar and buttons was adorned with silver gallons and large plus-fours in the same flowery fabric. The costume is very similar to the one worn by Don Filippino (1577-1582), a young son of the Grand Duke Francesco I, portrayed by Bizzelli (1586), where he appears with his mother, the Arch Duchess Joanna of Austria.

Other burials including the remains of an unknown child, about one-year-old, wearing a precious silk vest with silver cuffs, was less well preserved.

Results

Study of the skeleton of Cosimo I (1519-1574), 1st Grand Duke of Tuscany, revealed that he was 1.74 m tall, with an athletic body, estimated skeletal age of 50-60 years, medium-sized skull and narrow nose[5]. His well-developed muscular insertions (deltoid, great pectoral, great dorsal, biceps, forearm and thigh muscles) confirm the historical descriptions reporting on his great physical strength and robusticity[6]. Skeletal markers left by habitual horseback riding (lumbo-sacral arthritis; exostoses ed ovalization of *acetabula*; hypertrophy of femoral rectum muscle; strong hypertrophy of the femoral biceps, great adductor, small gluteus, gluteal tuberosity, pectineus, lateral vastus and gastrocnemius; osteophyitosis of femoral head and *fovea* and trocantheric *fovea*; rotation and flattening of the small trochanter; very strong hypertrophy of the soleus muscle) are all present[7], confirming his reputation as a highly skilled horseman. The presence of some Schmorl's hernias reveals that, during adolescence, Cosimo carried heavy burdens on the thorax, probably the body armor of that period[8]. The clinical history of Cosimo I has been taken from the extremely rich archive data, which contain the reports of the ambassadors and court physicians. Cosimo I survived several illnesses, including smallpox, malarial fevers at age 24 and 25, 'gravel' (renal or bladder *calculi*) at age 41-43, and bronchitis. Contemporary descriptions indicate that he also experienced severe early arteriosclerosis with paralysis of the left

Fig. 1 - Column of Cosimo I (1519-1574): ossification of the anterior right vertebral ligament at the level of the 6th, 7th and 8th thoracic vertebral bodies (DISH).

arm at age 48, right hemi-paresis, dyslalia, psychological instability, urinary incontinence, as well as aphasia and agraphia at the age of 54. He also suffered from an acute articular disorder of the right knee, named "*gout*" by the court physicians, at the age of 49 and 52-53. Finally, death was caused by '*catarrhal fever*', probably bronchopneumonia, at the age of 55[9]. The paleopathological study of the skeleton reveals that Cosimo's vigorous physical activity was probably also responsible for his diffused arthritis in the lower thoracic/lumbar spine, sternum, shoulders, elbows, hips, knees and ankles[10].

Ossification of the anterior right vertebral ligament at the level of the 6th, 7th and 8th thoracic vertebral bodies (Fig. 1) and the diffused ossifications of the articular ligaments demonstrate that he was affected by DISH (Diffuse Idiopathic Skeletal Hyperostosis), an articular disease linked to diabetes and obesity[11]. Study of the teeth reveals a severe periodontal disease, with large abscess cavity and *ante mortem* loss of the first inferior right molar. At autopsy and embalming of the Grand Duke's body[12] the court surgeon tried twice but with no success to cut open the skull at the level of the right parietal bone; only in the third attempt was he able to make a rough horizontal cut. The surgeon then opened the skull by inserting a large chisel, which caused damage to three different points of the skullcap (Fig. 2).

The study of the skeleton of Eleonora of Toledo (1522-1562), wife of Cosimo I, revealed a woman aged 36-46 years, 1. 58 m tall, with a medium low skull, high orbits and narrow face and nose[13]. Her muscular insertions (deltoid, great dorsal, forearm muscles,

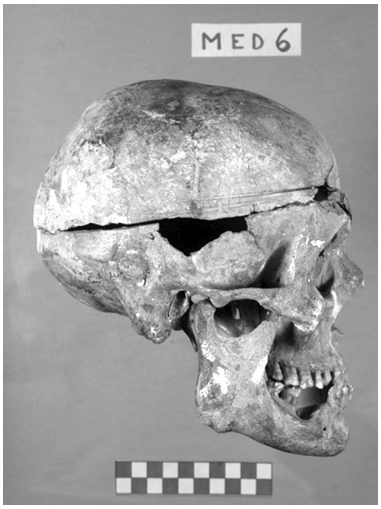

Fig. 2 - Rough horizontal craniotomy of the skull of Cosimo I, obtained with a bone saw and a large chisel (1574).

thigh muscles and soleus muscle of the right leg) show a fairly good muscular activity[14]. The clinical history of Eleonora is characterized by eleven births which took place between the ages of 18 and 32. As a result of her many deliveries, at about 29 years of age she developed pulmonary tuberculosis which, together with an attack of pernicious malaria, killed her at the age of 40[15]. A famous portrait by Agnolo Bronzino exhibited in the Uffizi Gallery depicts a very thin, emaciated and ailing Eleonora, affected by phthisis. The paleopathological study of Eleonora's skeleton revealed that she had experienced a mild form of rickets during childhood, made evident by the curvature of her *tibias*[16]. It is not surprising that she presents the pelvic skeletal markers of her numerous deliveries, in the form of large pre-auricular grooves and *retropubic foveae*[17]. At the time of death, Eleonora suffered from severe dental disease with destructive caries, and was affected by slight arthritis in her lower spine and shoulders, elbows, hips, knees and ankles[18].

The study of the skeleton of Cardinal Giovanni (1543-1562), second son of Cosimo I and Eleonora, revealed a young man with anthropological age of 19 years and stature of 1.75 m. The clinical history attests that he died from pernicious malaria after a visit to the swampy Maremma. The paleopathological study evidenced an advanced caries, with abscess of the left first upper molar and slight enamel hypoplasia, which suggests stress episodes at the age of 2 and 3 years. Some Schmorl's hernias, present on the thoracic and lumbar vertebral bodies reveal that, during adolescence, the column of Giovanni had carried very heavy loads[19].

The skeleton of Don Garzia (1547-1562), seventh son of Cosimo I and Eleonora, who died of pernicious malaria in the same way as his mother and brother, is that of a young 15/16 year-old-adolescent, 1. 67 m tall. The paleopathological study reveals a non-penetrating caries of the left first upper molar and enamel hypoplasia, which indicates many stress episodes, at the ages of 2, 3 and 4 years.

The study of the skeleton of Francesco I (1541-1587), 2nd Grand Duke of Tuscany, reveals that he was a vigorous man, with skeletal age of 40-50 years, a stature of 1.74 m, a medium-sized skull and a narrow nose[20]. The muscular insertions (deltoid, great pectoral, great dorsal, biceps, forearm muscles) indicate a man of great physical strength[21]. The skeletal markers associated with habitual horseback riding (lumbo-sacral arthritis; exostoses ed ovalisation of *acetabula*; hypertrophy of femoral rectum muscle; strong hypertrophy of the: femoral biceps, great adductor, small gluteus, gluteal tuberosity, pectineus, lateral vastus and gastrocnemius; osteophytosis of the femoral head and *fovea* and trocantheric *fovea*) already noticed for Cosimo I, are almost all present[22]. This new data changes completely the traditional view of Francesco I as an intellectual, sedentary scholar, nicknamed 'the prince of the *studiolo*' for his devotion to his humanistic and alchemic studies. On the contrary, Francesco evidently led a physically active life[23]. According to the archival records we know that Francesco I survived several episodes of non-severe illness such as acute bronchitis at the age of 20 and bronchopneumonia at the age of 38. After putting on quite a lot of weight around the age of 35, and suffering from 'gravel' with colics at 44 and 45 years of age, he died of pernicious malaria at 46[24]. The Grand Duke was fascinated with applied sciences and developed a deeply rooted interest in alchemy, which he practiced with great success. He was able to fuse the rock crystal and to manufacture, in his laboratory in the Pitti Palace, a ware with a translucent body called 'Medicean porcelain', very similar to the luxury wares imported from China[25]. As an alchemist, he certainly came into contact with chronic metallic poisons, and the toxicological study of his bone tissue will be important to establish to what extent

he was exposed to the different substances. The rumors according to which Francesco I and his second wife the Grand Duchess Bianca Capello were poisoned by arsenic compounds by the Grand Duke's brother Ferdinando - who succeeded him on the throne - are certainly false[26]. Owing to the wide use that the surgeons of that time made of arsenical mixtures in both embalming and visceral processing[27], it is probable that toxicology will be not able to verify this legend. The paleopathological study of the skeleton showed that Francesco I suffered from moderate vertebral and extra-vertebral arthritis[28]. Finally, the sectioning of the body of the sternum, clearly made in the course of autopsy[29], is worth mentioning.

The Grand Duchess Giovanna d'Austria (1548-1578), first wife of Francesco I, was a very religious woman, as confirmed by the discovery of her well-preserved rosary, made in simple wood. Joan appears in numerous portraits and was considered an ugly woman and described as '*hunchbacked*' by some contemporary reports. She survived six very difficult deliveries, but died in childbirth at the age of 30 after rupture of the uterus[30]. Study of the skeleton reveals that Giovanna was a woman with skeletal age of 25-35 years, a stature of 1. 57 m, medium-low skull and orbits and narrow face and nose[31]. Her weak muscular insertions suggest that her physical activity was very limited. Her sternum had been sectioned during autopsy. The paleopathological examination of the skeleton was able to detect a large number of disorders:

- prognathism: (anterior) projection of the mandible (the famous Habsburg jaw) (Fig. 3)
- marked congenital hyperostosis (about 1 cm) of the cranial vault
- *amelogenesis imperfecta*: congenital malformation of the dental crowns (Fig. 3, detail)[32]
- severe scoliosis of the lumbar column with impressive deformity of the pelvis (Fig. 4), which well explains her difficult deliveries and death following rupture of the uterus
- incomplete congenital dislocation of the hip[33]
- clear signs of numerous and difficult deliveries, such as enormous retro-pubic *foveae*, and deep pre-auricular *sulci*[34]

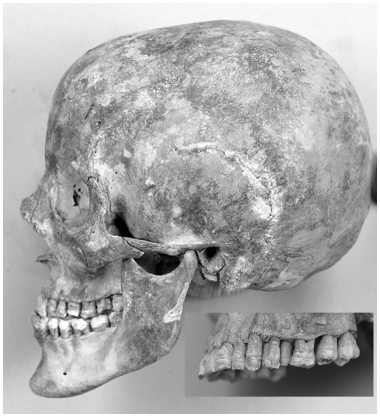

Fig. 3 - Skull of Giovanna d'Austria (1548-1578) with alveolar prognathism and amelogenesis imperfecta (detail).

What follows is the report of the death of Giovanna d'Austria and the results of her necropsy, as published by the obstetrician Resinelli in 1912 and cited by Pieraccini:

… la Ser. ma Gran Duchessa come hebbe desinato, che erano circa diciassette hore, si levò da tavola con certe dogl(i)e, le quali non furono molto grandi, et alle 20 hore et 1/2, gettò gran copia d'acqua ... et alle 4 hore in circa, apparve un braccio del putto vivo, et si battezzò, et poco di poi morse. La levatrice todesca, quale Sua Alt. Ser. ma haveva fatta venire dalla Magna con destrezza… cercò di rimettere dentro il braccio per dirizzare il parto…In questo mezzo che fu circa le 5 hore partorì la seconda, il che arrecò gran meraviglia a' medici, non parendo possibile che potesse passare, essendo di già apparito il putto… … alle 23 hore, cercando il cerusico con consenso di Sua Altezza Ser. ma con grandissima diligentia, et senza alcuna violenza, se poteva cavare il putto, prese il braccio, et appena toccollo, lo cavò fuora et cercando se poteva cavare il capo, per esser'alto non lo arrivava così facilmente, onde Sua Altezza Ser. ma non potendo star più a disagio volse si lasciassi stare con dire, che si mancava, et così era perché haveva di già perso il polso sinistro, et l'altro molto fiacco, che a gran fatica si trovava, onde i medici si confermorno più nella loro opinione che non fussi da tentar altro… et che fusse meglio lasciarla vivere quel poco di vita che gli restava, senza più travagliarla; alle 5 hore et mezzo passò all'altra vita…

Il giorno seguente, che fu il Venerdì, si aperse, et si trovò il putto fuora della matrice et il collo della matrice stracciato, cosa che come non più veduta fece maravigliare i medici, et insieme conoscer la cagione perché la seconda era passata. Nel resto del corpo era male disposta, perché 1'haveva la spina giù basso, torta a modo d'un esse maiuscola, il che era cagione che quando partoriva, i parti si gittassero da quella banda, come fece ancora questo, ma con maggiore impeto, poiché stracciò il collo della matrice; haveva il fegato duro bianco senza sangue, lo stomaco sottile come un velo, i polmoni appiccati al petto et infiammati, nel resto stava bene[35].

The skeleton of Ferdinando I (1549-1609), 4th Grand Duke of

Fig. 4 - Severe scoliosis of the lumbar column, with deformity of the pelvis of Giovanna d'Austria (1578).

Tuscany, revealed a vigorous man with skeletal age of 55-65 years and stature of 1.73 m[36]. The muscular insertions are those of a very strong man[37]; the skeletal markers associated with habitual horseback riding (lumbo-sacral arthritis; ovalisation of *acetabula*; hypertrophy of femoral rectum muscle; strong hypertrophy of the femoral biceps, great adductor, small gluteus, gluteal tuberosity, lateral vastus and gastrocnemius; osteophytosis of the femoral head and *fovea* and trocantheric *fovea*)[38] are almost all present, and confirm his reputation of a fine horseman. Ferdinando survived several illnesses, including a severe episode of pernicious malaria at the age of 14, and repeated episodes of bronchitis; after the age of 41 he gained a considerable amount of weight. From the age of 33 until death, he suffered from many acute attacks of gout, generally affecting the bones of the left foot, and typically positioned in the *hallux*. Finally, death was caused by heart failure accompanied by dropsy and intestinal blockage when he was 60 years old[39]. The paleopathological study of the skeleton revealed that Ferdinando I suffered from diffused arthritis of the spine, sternum, hips, knees and ankles, likely to depend on his strong physical activity[40]. Ossification of the anterior right vertebral ligament at the level of the 5th -11th thoracic vertebral bodies and the diffused ossifications of the ligaments demonstrate that Ferdinand, like his father Cosimo, was affected by DISH (Diffuse Idiopathic Skeletal Hyperostosis) (Fig. 5)[41]. His left foot shows a scoped-out defect located at the

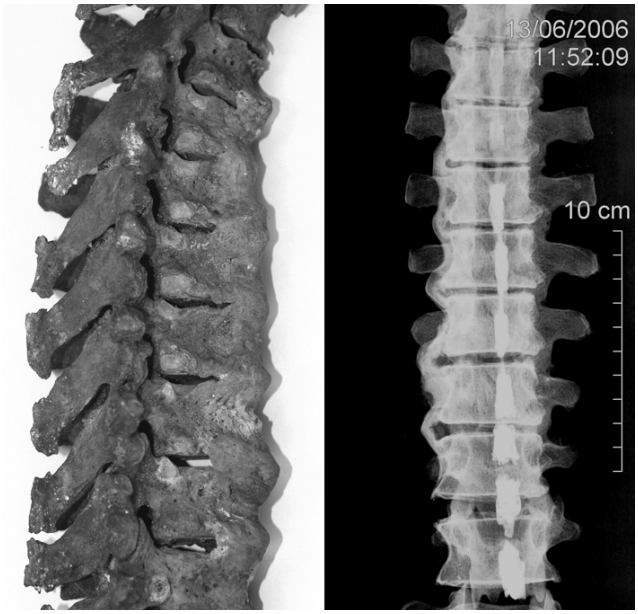

Fig. 5 - Ossification of the anterior right vertebral ligament, at the level of the 5th -11th thoracic vertebral bodies (DISH) of the column of Ferdinando I (1609).

peri-articular and articular surface of the interphalangeal joint of the *hallux dorsum*, with partial destruction of the sub-chondral plate; the lesion, revealing at X-ray an evident sclerotic margin, involved both the bones of the joint and is typical of chronic gout (Fig. 6)[42]. Archival records contain an accurate description of a typical gout attack, as reported by the court physician Giulio Angeli:

> *yesterday the gout started to pinch the big toe of the Grand Duke's left foot and then continued to advance rapidly! Overnight the toe has become swollen, inflamed and painful* (2nd April 1591)[43].

The teeth show a serious periodontal disease and severe penetrating and destructive caries with peri-apical abscesses. At the moment of death, a large abscessual cavity, with loss of the first and second inferior right molars, was in course of recovery[44]. The

Fig. 6 - Scoped-out defect at the interphalangeal joint of the hallux dorsum, with evident sclerotic margin (detail), by chronic gout, in the left foot of Ferdinando I (1609).

ambassador of the Lucca Republic Bartolomeo Cenami refers that (The Grand Duke) "*frequently, at present and in past times, suffered from toothache*" (23th June 1606)[45]. At autopsy of the Grand Duke's body, the court surgeon cut the soft tissues with a very subtle sharp blade, as proven by some horizontal and oblique thin incisions of the parietal and temporal bones; he then opened the skull with an accurate horizontal cut, obtained by a bone saw.

The skeleton of the Grand Duchess Cristina di Lorena (1565-1636), wife of Ferdinando I, indicated a 1.63-metre-tall woman who was between 60 and 70 years old[46]. Her sternum had also been sectioned during autopsy. The 'clinical history' of Cristina reports a large number of deliveries: between the ages of 25 and 39, she gave birth to as many as 9 babies and had an abortion. After surviving several episodes of non-severe illnesses such as acute bronchitis at the age of 28, smallpox at 29, intestinal fever at 31, malarial fevers

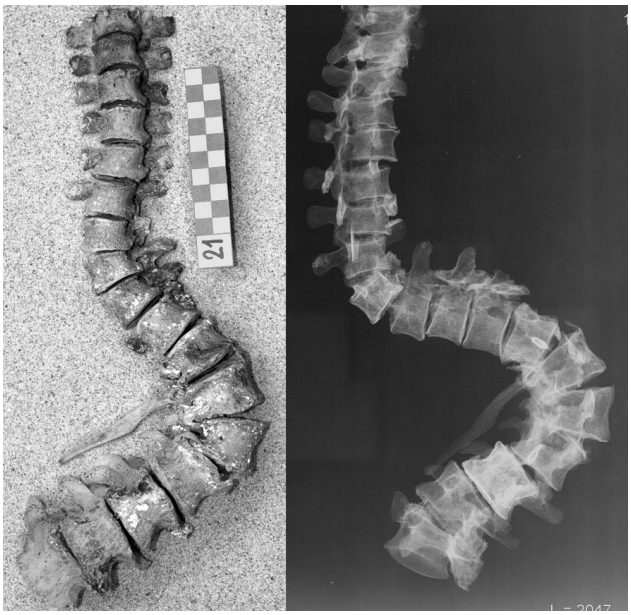

Fig. 7 - Severe scoliosis of the lower thoracic and lumbar column of Cristina di Lorena (1565-1636).

at 36-37 and cataract problems at 69, she died of cerebral arteriosclerosis and stroke when she was 72[47]. The paleopathological study of Cristina's skeleton revealed congenital hyperostosis (ca 1 cm) of the cranial vault, moderate vertebral and extra-vertebral arthritis, and total *intra vitam* tooth loss with a well-recovered large abscess cavity corresponding to the left wisdom tooth of the mandible. The severe left scoliosis of the lower thoracic and lumbar column, forming an angle of about 90°, was caused by lateral wedge-shaped collapse of the bodies of the twelfth thoracic and first lumbar *vertebrae*, with partial fusion on the concavity (Fig. 7). The absence of body fractures and osteoporosis strongly supports a static or juvenile etiology of this impressive column deformity[48].

Carlo (1595-1666), younger son of Ferdinando I, became Cardinal in 1615 and Dean of the Sacred College of Cardinals in 1652. His skeleton is that of a senile man aged more than 60 years,

1.70 m tall[49], with severe osteoporosis, especially of the lower limbs. There are two transversal cuts on the upper part of the sternum; the sternal extremities of the 4th, 5th, 6th and 8th right ribs, and the 5th of the left, appear completely sectioned, probably with scissors. We know that, at 8 years of age, he was affected by tuberculosis of the column (Pott's disease), upper thoracic or cervical. From 24 years of age he suffered from an acute articular disorder of the feet, hands and knees, diagnosed as 'gout' by the physicians; the documents report on 18 severe attacks from the ages of 35 to 59, with worsening between 60 and 65. From the ages of 50 to 70 he was affected by recurrent bronchitis and finally died of bronchopneumonia[50]. The facial skeleton shows a marked hypoplasia of the right mandibular corpus, with right deviation of the face and probable chronic *torticollis* (Fig. 8). There is congenital fusion of the atlas with the occipital bone. The articular facets, pillars and posterior bodies of the 1 st-5th cervical vertebrae are also fused, with narrow disc spaces, forming a C1-C5 block. This cervical anomaly, known as Klippel-Feil's syndrome, is frequently associated with *torticollis*[51]. A second block, involving the vertebral bodies with wedge-shaped collapse, fusion, and formation of an angular kyphosis, is at the level of C6-C7 (Fig. 9). There is also diffused periostitis of the internal surface of the ribs. These are the results of the cervical spine tuberculosis (Pott's disease), characterized by neck *fistula* and *gibbus*[52], well described in the archival records, at 8 years of age. Ferdinando I called one of the most famous physicians of that period, Girolamo di Fabrizio d'Acquapendente, professor of anatomy and surgery at the University of Padua and pioneer in orthopedics, to cure his son. The doctor applied to Carlo, who was starting to become hunchbacked:

> *… an iron tool pushing and bringing the vertebrae in opposite position… to this purpose I have prepared a hauberk, or light body armour in iron, with particular screws pushing the vertebrae which are out of place, gradually restoring them to their original position*[53].

The post-cranial skeleton shows an ankylosing disease, symmet-

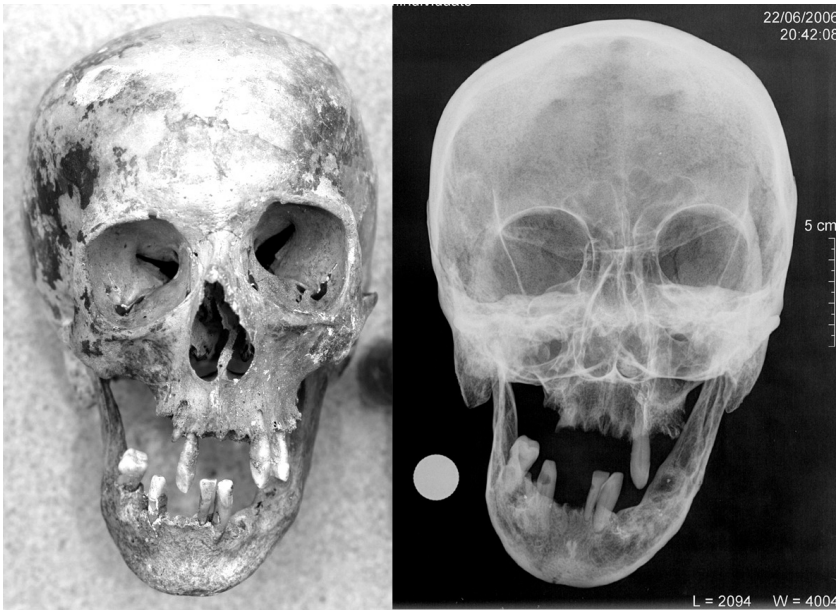

Fig. 8 - Marked hypoplasia of the right mandibular corpus, with right deviation of the face, of the Cardinal Carlo (1595-1666).

rical and extremely severe, of the great and small articulations, characterized by:

- fusion of the left elbow (in flexion at 55°);
- bilateral fusion of wrists, carpal bones, and some fingers (Fig. 10);
- fusion of the right sacroiliac joint
- fusion of knees and *rotulae* (in flexion at 90°)
- fusion of tarsal and metatarsal bones

This data, together with the very severe osteoporosis, in particular of the lower limbs, demonstrates the cardinal's total disability, in the last years of life, as reported by the archival documents. Indeed, from 1658 (at the age of 63), the cardinal was no longer able to sign any letters or documents. In a letter to a nephew he writes:

"*Y*(our) *H*(ighness) *please excuse me for not being able to sign in my own hand (writing), because my hand does not function*" (4 December 1658)[54].

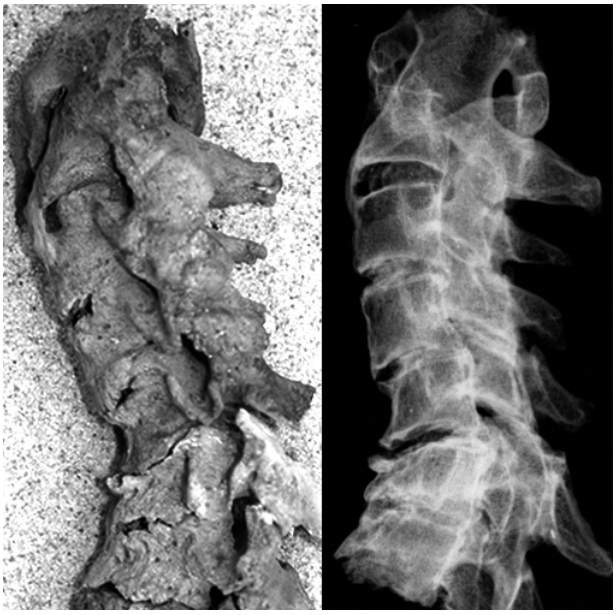

Fig. 9 - Vertebral block of the C6-C7 bodies with wedge-shaped collapse, fusion, and formation of an angular kyphosis (Pott's disease), of the Cardinal Carlo (1666).

The 'clinical' and pathological picture clearly shows severe symmetrical poly-arthritis. At present we can only speculate on a case of probable psoriatic arthritis. The molecular study is in course.

Prince Francesco (1594-1614) was one of the young sons of the Grand Duke Ferdinando I. The anthropological study of the skeleton revealed a young male of about 18-23 years, 1.80 m tall[55], with strong, but not particularly developed muscular insertions[56]. He died at 20 years of age of an acute intestinal disease, probably abdominal typhus[57]. At autopsy, the court surgeon opened the skull with an accurate, oblique cut, obtained with a bone saw. The sternal *manubrium* also reveals a deep, transverse incision. From the archival documents we know that Francesco entered the military career when he was 15, and in 1613, at only 19 years of age, he led the Tuscan army against the Duke of Savoy[58]. The paleopathological study of the skeleton showed, in addition to a slight arthritis of

Fig. 10 - Anchylosis of the left elbow and bilateral fusion of wrists, carpal bones and fingers of the Cardinal Carlo (1666).

the great joints (very rare in young individuals) two interesting and probably associated lesions: the presence of a right *os acromiale* and *osteochondritis dissecans* of the left knee. *Os acromiale* consists in the non-fusion of the acromion process of the *scapula* (Fig. 11), a very rare trait (0.5%) in contemporary populations. Instead, this is very frequent in two skeletal samples of ancient English archers of 15th and 16th centuries[59]. O*steochondritis dissecans* is a disorder that develops in response to repetitive traumas, especially in young, physically very active individuals[60]. In the case of prince Francesco these two lesions can be associated with the strenuous exercise in the use of weapons - in particular of the long bow - by a not very well trained individual. Indeed, many long bows are present in the Medici armory of that time.

Finally, a preliminary study of the skeletal remains of 8 young individuals between 0 and 5 years of age allowed us to diagnose three cases of rickets and three of porothic hyperostosis, of which two were quite severe. It is very likely that rickets was caused by the scarce exposure to light of the children in the environment of the Renaissance courts, while porothic hyperostosis was determined by prolonged nursing of the babies.

The anthropological study of individual n. 39 from the crypt of the Grand Duke Gian Gastone, nicknamed 'the child with the red jacket', revealed a little boy of about 5 years, with a stature of 1.15

Fig. 11 - Non-fusion of the acromion process (detail) of the right scapula (os acromiale) in the prince Francesco (1594-1614).

m. The child is almost certainly don Filippino (1577-1582), son of the Grand Duke Francesco I, who died in 1589 at the age of 5[61]. The paleopathological study showed evident hydrocephaly (Fig. 12)[62] and slight rickets, with curvature of the left *tibia* and *fibula*[63]. A portrait of don Filippino, painted in the same year of death (1582), shows a picture of non-severe hydrocephaly, with low implant of the orbits and auricles and evident expansion of the cranial vault. The archival documents contain the autopsy report of don Filippino, which provides an accurate description of a typical hydrocephalus:

> *On 29th March Filippo, great Prince of Florence, died... he was buried in* (the church of) *san Lorenzo. The doctors who had cured him - both physicians and surgeons - cut his head removing the cranial vault as if it were a bowl and found, underneath the first membrane of the brain,* (the

Fig. 12 - Skull of don Filippino (1577-1582), with non severe hydrocephaly.

equivalent of) *almost a glass of water, so that they all thought that this had been the real cause of his death*[64]… (The doctors) *opened the (body of the) Prince and found his head full of water*[65].

This paper reports only the first, very partial results of the investigations of 15 out of 49 tombs, including the burials of nine children. The laboratory studies are still in progress. Another 39 burials, the majority of which almost intact, will be explored in the next two years, and important results are expected. We can state that the global study of the Medici funerary depositions and bodies will increase considerably not only the current knowledge of the diseases and life habits, but also of the personality of the members of that dynasty, so important for the Italian Renaissance.

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26. PIERACCINI G., op. cit. nota 9, 154-159. Recently MARI *ET AL.* , "exhuming" this old legend, claimed that the Grand Duke Francesco I and his wife Bianca Cappello were poisoned with arsenic by the Grand Duke's brother, the Cardinal Ferdinand. (MARI F., POLETTINI A., LIPPI D., BERTOL E., *The mysterious death of Francesco I de' Medici and Bianca Cappello: an arsenic murder?* British Medical Journal 2006; 333: 1299-1301). We report a comment on this problem, published in the same journal (FORNACIARI G., *The mystery of beard hairs*, bmj.com 29 Dec 2006), which well reveals the weakness of this "romantic" hypothesis: *"In my quality of scientific director of the Medici Project (1,2) I feel bound to comment this article, which is important for various historical aspects. In brief, the key of the entire*

study seems to be "a few beard hairs with one small fragment of skin tissue still attached", which made it possible to establish a "high degree of similarity with the DNA" of three different pieces of "dry, thick, and crumbly material … collected within the broken terracotta jars" in the crypt of the church of Santa Maria a Bonistallo near Florence. On this basis, the Authors claim that it is "highly probable that these soft tissues were among those extracted from the body of Francesco I at autopsy". These results are by no means possible, simply because Francesco I appeared, at re-exhumation carried out in December 2004, totally skeletonised and disarticulated in the small zinc coffin used to re-bury the skeletal remains of the Grand Duke after exhumation in the 40's, and the skull showed no traces of soft tissues, skin or beard! Moreover, the Authors do not provide any information about the method adopted for identification of the ancient DNA (microsatellites, mithocondrial DNA?) or about the molecular size of the DNA fragments, nor do they explain whether the DNA extractions were performed in a laboratory designed for ancient DNA manipulation (where modern human samples are not processed!). On the contrary the published data is consistent with contamination by modern DNA and, consequently, the hypothesis of arsenic poisoning is also to be rejected. Furthermore, owing to the very frequent use of arsenical mixtures in embalming and visceral processing by the contemporary surgeons, it is impossible to establish whether the high arsenic concentrations in the specimens were obtained in vita or after death. Finally, some "minor" but not less important questions should be asked regarding the findings in the crypt of the church of Santa Maria a Bonistallo: is there an archaeological report on the excavations and on the stratigraphic position of the "broken terracotta jars"? Were the fragments examined – and dated – by a post-medieval archaeologist? This information is very important because the two small crucifixes, typical of 18th and 19th century, are clearly more recent than October 1587, date of the alleged murder. In conclusion, the article "The mysterious death of Francesco I de' Medici and Bianca Cappello: an arsenic murder?" quite appropriately finishes with a question mark!"

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Correspondence should be addressed to:
Fornaciari G., Dipartimento di Oncologia, dei Trapianti e delle Nuove Tecnologie in Medicina, Divisione di Paleopatologia, Via Roma 57-56126 Pisa, I.
g.fornaciari@med.unipi.it