7. Discussion and conclusion

In this chapter a general view of different pathologies recovered in TB samples of T.O.C. will be reported. The aim is to outline the global health status of the sample concerning all skeletal pathologies analyzed per anatomical sites with a particular focus for TB.

7.1 Introduction

The recovered collection is constituted of 59 individuals, versus 80 quoted in Tedeschi's register (22 females and 37 males, versus 27 females and 53 males). Tab. 7.1 shows the general descriptive statistics, concerning age and job per genders, while the following Tab. 7.2 presents all recovered skeletal sites.

Tab. 7.1 Statistical descriptive of TB sample.

	Age±SD	Older	Younger	Job mostly diffused
M	31,73±12,41	65	20	Farmer
F	30,44±11,28	53	18	Housewife

Only Zimmermann and Kelly (1982) report female sex slightly more predisposed to TB, while it is generally accepted that skeletal tuberculosis can affect individuals of all ages and both genders. For this reason we will lead our analysis considering the whole sample, while gender frequency will be considered only for specific diseases.
The same order of skeletal elements used for each form will be preserved.

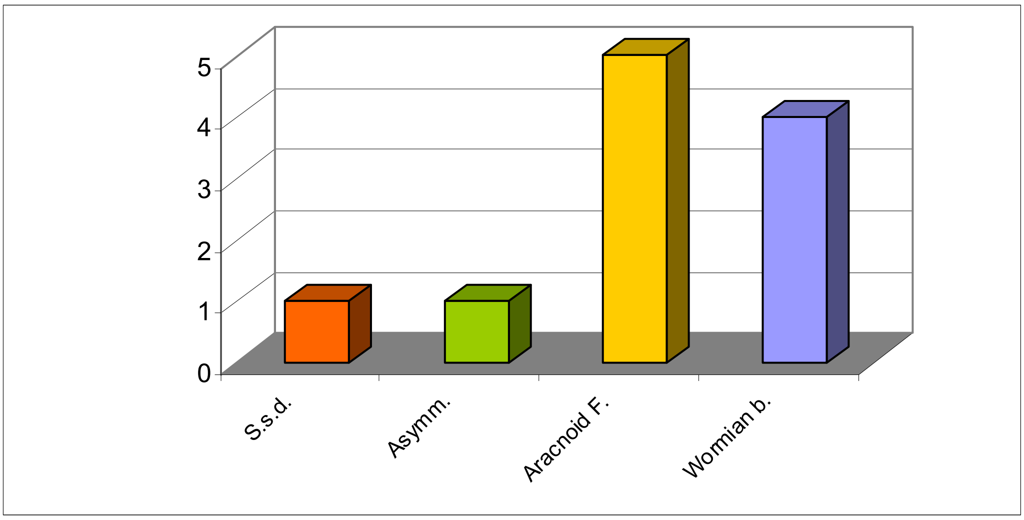
7.2 Skeletal pathologies in T.O.C.

Skull and teeth

In total, 29 crania were recovered, 8 of which were found with their skullcaps apart and surely determinable. Only 1 skullcap (Individual 1588, F, 21yrs) has no correspondent remaining cranium. 33 mandibles are found: 21 connected with crania and 1 with skullcap (Individual 1588).

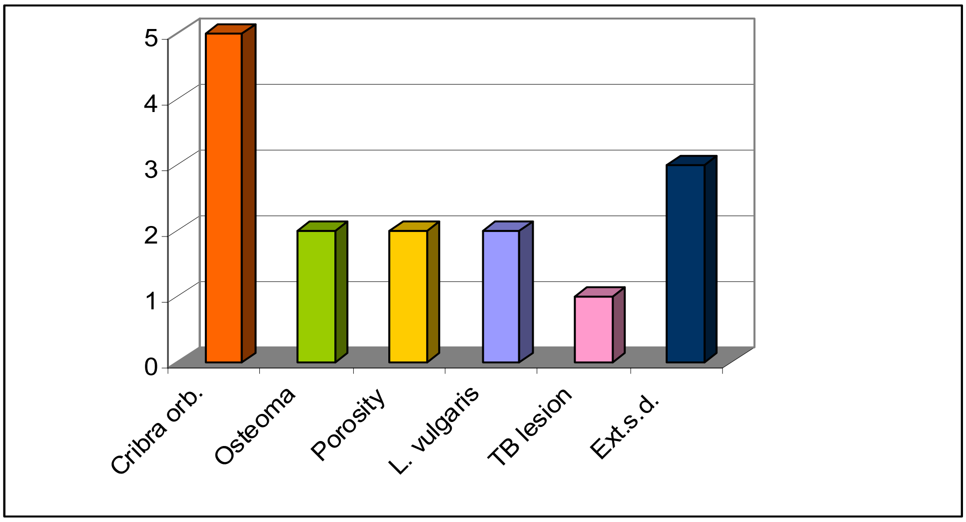
Fig. 7.1 gives a general view of the different non-pathological characteristics of all crania recovered, while Fig. 7.2 shows the pathological signs recovered.

Fig. 7.1 Cranial non-pathological features



Sagittal suture depressed; Asymmetrical shape; Aracnoid Fovea; Wormian bones.

Fig. 7.2 Cranial pathological features



Cribra orbitalia; Osteomata; Porosity; Lupus vulgaris; TB lesion; External surface damaged.

Only one case of particular cranial suture is found (Individual 397, M, 64yrs) with a sagittal suture depressed. In general, there are 3 different types of sutures: depressed, flat, and raised (Capasso, 2001). No particular pathology is associated to these features, such as on cranial asymmetrical shape, on aracnoid foveae, and on wormian bones. Generally also the two reported osteomata (Individual 462, M, 20yrs; Individual 1457, M, 69yrs) are considered benign tumours.

Cribra orbitalia are detectable in 5 individuals: the following table (Tab. 7.2) shows the type of classification according to Knip (1971, cited by Campillo, 1994*a*).

Tab. 7.2 *Cribra orbitalia*

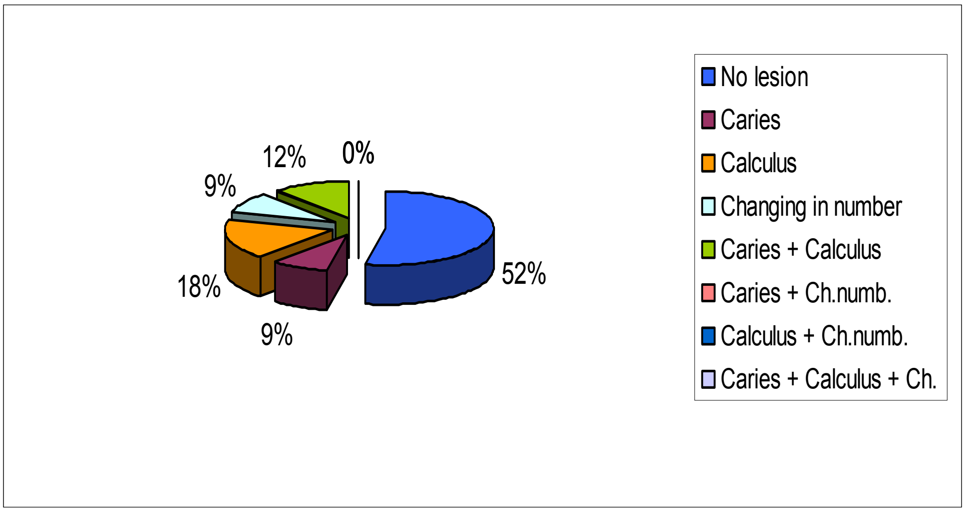
Individual	Left orbital roof	Right orbital roof	Type
459 (M, 26yrs)	x		a
470 (F, 18yrs)	x	x	c
1437 (M, 26yrs)	x	x	c
1438 (M, 31yrs)		x	c
1477 (M, 26yrs)	x	x	b

Ortner (2008) highlights the importance of not attributing cribra orbitalia to a specific disease, such as anemia, because these orbital lesions may reflect a vascular response to chronic infection of the eye. In Individual 1477 (M, 26yrs), a porosity of cranial vault is also remarkable.

Different stages of osteoarthritis are found in 3 mandibles. In the temporomandibular joint of individual 1454 (M, 22yrs) and 1467 (F, 20yrs) osteoarthritis involves only the left condyles, while in Individual 1581 (M, 24yrs) both condyles have the typical pattern of lipping, porosity and eburneation. This pathology can be caused by stress factors such as chewing or the use of teeth as power tools (Capasso, 1999). No job information (itinerant, housewife, and farmer) can help to distinguish the real cause of these diseases.

Teeth are recovered in 34 individuals. The different dental marks found in T.O.C. are reported in Fig. 7.3.

Fig. 7.3 Dental pathology



48% of all the individuals presents one of the following dental pathologies: caries, calculus or changing in teeth number. 21% of the samples shows caries evidence and the 30% shows calculus.
In 3 individuals (9% of all samples) some changing in teeth number are detected:

- Individual 594 (M, 42yrs): an extra tooth in maxilla bone;
- Individual 1579 (M, 28yrs): an extra tooth in incisor foramen;
- Individual 1438 (M, 31yrs): lacking of 2nd upper incisor.

Campillo (1994*b*), states that *hyperodontia* (individuals 594 and 1579) is a feature that can regard atrophic teeth (never canine) and it is more common in males than in females (as in the present cases). On the contrary, *hypodontia* (1438) is the absence or the atrophic size of teeth. This pathology can involve the 3rd molars, the 2nd incisors and the 2nd premolars and regards more females than males.

Generalized periodontitis or abscesses occur in 10 individuals, 27% of all the individuals recovered with cranium or mandible or both. Kerr (1998, cited by Ogden, 2008) observes that in all the three skeletal populations studied (prehistoric, medieval and 18th century AD) a small number of individuals (6-10%) had already widespread destructive periodontitis, while a contrasting group (5-17%) appeared to be virtually immune. Ogden (2008) reports that about 10% of individuals particularly susceptible to this pathology, a similar number resistant, while the vast majority are only moderately susceptible. The percentage in T.O.C. sample is higher than expected: surely, this pathology reflects the general health status of individuals affected with TB. Furthermore, as remembered in chapter 2, the identification of this dental disease in archaeological material is problematic, because signs of inflammatory pitting or new bone formation on the jaw bones are more likely to allow a positive diagnosis for this dental disorder.

Spine

The spine is recovered in 17 individuals (28%) and several features are noted. In table 7.4 all bipartite transverse foramens are reported.

Tab. 7.4 Bipartite foramen transverse

Individual	C1		C2		C3		C4		C5		C6		C7		Total	
	R	L	R	L	R	L	R	L	R	L	R	L	R	L	Transverse Foramen	Vertebrae
1436											x	x			2	1
1438									x	x					2	1
1439							x	x	x	x					4	2
1479					x	x	x	x	x	x					6	3
1482	x														1	1
1583							x	x	x	x	x	x			6	3
1588													x	x	2	1
7individuals	1	-	-	-	1	1	3	3	4	4	2	2	1	1	19	10

As cited, the bipartite transverse foramen is an epigenetic variant, with totally non-pathological characteristic.

There are two other specific characteristics concerning the cervical vertebrae:

- Individual 1486 (M, 36yrs) shows the complete occipitalization of atlas. As noted before, this is one of the most common spinal anomalies with a general frequency around 1% (Aufderheide and Rodriguez-Martin, 1998).
- Individual 1477 (M, 26yrs) has total fusion of vertebra C6 with C7.

An injury is visible in Individual 1583 (M, 29yrs), in which T2 shows a trauma in the lamina.

The further features detected can be part of the tuberculosis evidences.

Ribs and sternum

Ribs are recovered in 16 individuals (27%) and sterna are 11 (19%). In all these cases, sterna are complete (manubrium, body and xiphoid process), and only in one case (Individual 1439, M, 35yrs) the manubrium is the only section recovered. A specific trauma is detected in the 5^{th} left rib of Individual 1479 (M, 28yrs).

The other characteristics of these sites are due to general periostitis, part of tuberculosis evidences.

Shoulder

Scapulae recovered are 33; in 16 individuals (27%) both bones are present and only 1 shows only the left one. The clavicles recovered are 28; 12 individuals have both bones and 4 individuals have only 1 element. In total, 12 individuals present complete shoulders. The only remarkable pathological feature is periostitis that is part of TB evidence.

Arm and hand

Arm bones recovered are 30 humeri, 30 radii and 29 ulnae, with a total of 8 individuals with the entire arms available (1436, F, 21yrs; 1477, M, 26yrs; 1483, F, 50yrs; 1485,M, 43yrs; 1579, M, 28yrs; 1580, M, 25yrs; 1583, M, 29yrs; 1588, F, 21yrs). In detail, in 2 humeri the epigenetic variant of *olecranial foramen* is found (Individuals 1438, M, 31yrs and 1601, M, 25yrs), both on the left bone. Capasso (1999) reports that in 1921 Testut stated that in ancient human population this characteristic was more frequent than today showing data concerning French Neolithic (from 14% to 26%) versus current parigine data (from 4.1% to 4.7%). This frequency may confirm the idea that *olecranial foramen* is an arcaic mark allowing iper- extension of elbow.

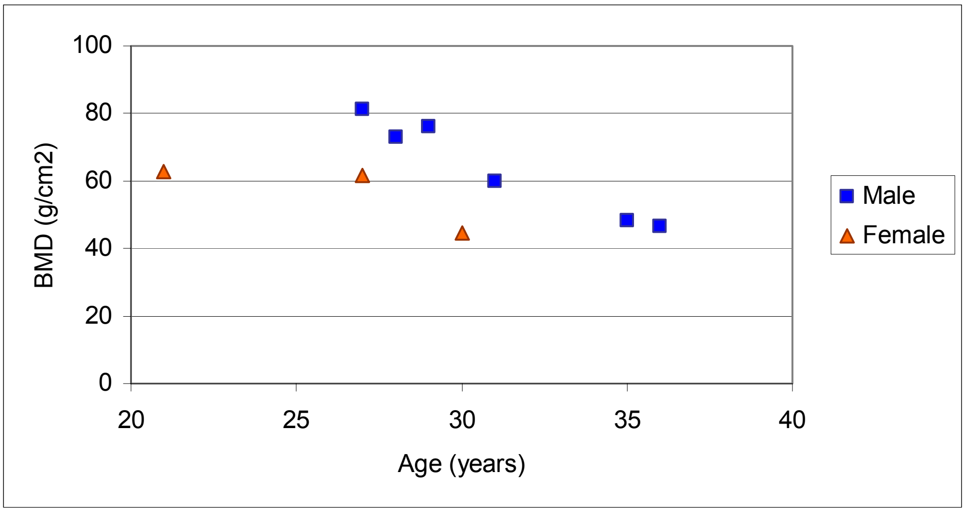
For 13 Individuals (22%), hands are recovered (10 with both hands, 3 with only one hand), but only in 9 cases fingers are available to carry out the bone density assessment with Metriscan technique. As noted before, this technique tests the fingers of non-dominant hand; we hypothesized that left hand was non-dominant in all individuals. Unfortunately, the exam was carried out analyzing only 2 fingers (2^{nd} and 3^{rd}) versus the 3 required. The following table (Tab. 7.5) presents the results.

Tab. 7.5 Metriscan results

Individual		Age (years)	BMD (g/cm^2)	T-score	Z-score
1436	F	21	62.75	1.41	2.22
1437	M	27	81.28	4.83	N.D.
1439	M	35	48.26	-2.06	N.D.
1482	M	31	59.86	0.71	N.D.
1484	F	30	44.50	0.03	-0.20
1486	M	36	46.71	-2.45	N.D.
1487	F	27	61.52	3.41	3.53
1579	M	28	73.15	3.94	N.D.
1583	M	29	76.21	4.31	N.D.

As remembered in Chapter 6, this is the first time this new technique is used on osteological remains, thus similar data are not available to compare the results, the only data processing are the ones concerning the age: Fig. 7.3 shows the correlation of BMD with age by gender.

Figure 7.3 Correlation of BMD with age by gender.



Although data collected are not enough to make a statistical analysis, the graphical representation seems to confirm the expected BMD decrease with age.

No individual shows a T-score less than -2.5 therefore, according to World Health Organization, our sample does not present osteoporotic disease.

<u>Pelvis girdle</u>

Sacrum is recovered in 9 individuals, while coccyx is found only in 2: in 468 (M, 33yrs) and in 1482 (M, 31yrs). In the former, the sacralization of coccyx is detectable. Aufderheide and Rodríguez-Martín (1998) report that the sacralization of the coccyx is a common malformation, more frequent in males than in females. Another common malformation noted is sacralization of L5 in individual 438 (F, 22yrs) and in 439 (F, 18yrs). As quoted in their personal forms, the same authors state that these types of anomalies occur in 3-5% of the population and two-thirds of them are the sacralization of L5. During sacralization, the anomalies in development of one or both of the transverse processes of the fifth lumbar vertebra may produce fusion with the base of sacrum, producing a “butterfly wing” appearance (Duthie and Bentley, 1987, cited by Aufderheide and Rodríguez-Martín, 1998). The posterior view of individual 438 appears of this particular shape, while individual 439 presents a normal complete fusion of the elements.

In total, 23 coxal elements are found, belonging to 15 individuals (8 with both elements, 7 with only one element).
Aufderheide and Rodríguez-Martin (1998) remember that the dislocation of the hip can be caused by 3 malformations: 1) acetabulum (aplasia of the lunate surface), 2) femoral head and neck (ossification development of the femoral head is delayed) or 3) pelvis (its development is impared or assumed a vertical position in bilateral position). In the case of T.O.C., individual 470 (F, 18yrs), is plausible suggesting the aplasia of lunate surface of acetabulum. Unfortunately, the femurs are not found to confirm or reject this hypothesis. Except for this case of bilateral dislocation of hip, all pathologies noted concerning TB evidence.

<u>Leg and foot</u>
Table 7.6 shows the bones found concerning legs and feet.

Table 7.6 Legs and feet

	Femur	Patella	Tibia	Fibula	Foot
Number	41	26	13	33	30
Individuals	32 (23 one, 9 both)	13	11 (9 one, 2 both)	18 (3 one, 15 both)	16 (2 one, 14 both)

Only individual 1477 (M, 26yrs) presents complete both legs with their feet, all others individuals are lacking one long bone, at least.

In detail, the femurs show a variety of signs in both epiphyses, particularly in the proximal end. Table 7.7 reports the frequencies of these pathological markers.

Tab. 7.7 Femur markers

Markers	Allen's fossa	Plaque	Poirier's fat	Charles' facet	Peritrochlear groove	Tibial imprint
Frequency	10 (24%)	7 (17%)	1 (2%)	1 (2%)	1 (2%)	1 (2%)
Position	Anterior superior margin of femoral neck	Nearby or covering Allen's fossa	Femoral head toward the anterior portion of neck	Articular surface of the medial epicondyle	Groove in the medial trochlear margin	Superior and medial to Charles' facet in popliteral surface
Causes (Capasso, 1999)	Walking and running	Prolonged walking and running	Normal walking	Squatting posture	Squatting posture and prolonged standing or walking	Squatting posture

As reported before, each trait has a peculiar description:

- Allen's fossa can vary from a small depression to a large 1 cm^2 eroded area where cortical bone has been lost exposing underlying trabeculae that must be visible. Its rim may have a ridge or thickening around it, reminiscent of an inflammatory response (Finnegan, 1978);
- Plaque formation is scored as present when an overgrowth or bone scar can be defined extending from the area of Poirier's facet on the femoral head on to the femoral neck where it often surrounds or covers Allen's fossa (Finnegan, 1978);
- Poirier's facet is produced by the extension of the articular surface of the femoral head onto the anterior surface of the neck. It is necessarily smooth, however slight, bulging off the articular surface of the femoral

head toward the anterior portion of the femoral neck (Finnegan, 1978, Capasso, 1999);

- Charles' facet originates superior to the articular surface of the medial epicondyle and extends proximally to the adductor tubercle (Finnegan, 1978);
- Peritrochlear groove is a gutter formed by the medial trochlear margin which may become converted into a tunnel in periarticular osteoarthritis (Capasso, 1999);
- Tibial imprint is a depression found superior and medial to Charles' facet on the posterior aspect of the distal femoral diaphysis. It is especially present above the medial condyle, but it may also be on the lateral (Capasso, 1999).

In particular, Allen's fossa and its development in a plaque occur in 17 individuals (41%), as shown in table 7.8.

Tab. 7.8 Allen's fossa and plaque

Allen's fossa	Plaque	Allen's fossa and plaque
8	5	2
402 – M, 37yrs, butcher; *458 – M, 60yrs, farmer;* *1438 – M, 31yrs, blacksmith;* *1483 – F, 50yrs, housewife;* *1484 – F, 30yrs, farmer;* *1581 – M, 24yrs, farmer;* *1586 – F, 19yrs, housewife;* *1601 – M, 25yrs, carpenter.*	*657 – F, 27yrs, housewife;* *411 – M, 33yrs, porter;* *432 – F, 33yrs, housewife;* *1440R and L –M, 31yrs, postman.*	*468 – M, 33yrs, employee;* *1584 – M, 24yrs, blacksmith.*

No job results particularly relevant to associate it with femur markers, although most of them were manual labourers. It is interesting to note that the individual 1440 was a postman and consequently for his job he was a great walker: he shows extremely well formed plaque formations in both femurs.

Individual 454 (F, 33yrs, housewife) presents 3 different femur markers (Charles' facet, tibial imprint and peritrochlear groove): all of them agree with squatting as possible occupational activity. Unfortunately, no other bone is recovered to confirm this particular aspect and the general job referred does not complete the information.

The periostitis is the most common marker in femoral remains, but in this particular sample it can be considered as TB evidence.

7.3 TB evidences in T.O.C.

Skull and teeth

In the 29 crania recovered, only one case (individual 1457, M, 69yrs) presents a typical TB lesion in the parietal bone. Its characteristics agree with lesion descriptions of several authors, Ortner (2008); Hackett (1976), cited by Roberts and Buikstra, (2003); Aufderheide and Rodríguez-Martin (1998); Ortner and Putschar (1985); Steinbock (1976):

- lesion is in the parietal bones;
- lesion shows a circle shape of about 2 cm in diameter;
- lesion is larger in the inner table than in the outer;
- lesion margin shows active resorption;
- in adults, the cranial vault lesion is almost always solitary.

All authors agree on the rarity of cranial injury (with percentages from 0.1% to 2%) and on the young age of individuals, although Ortner (2008) reports an example case of a destructive lesion in a modern female, age 55 years.

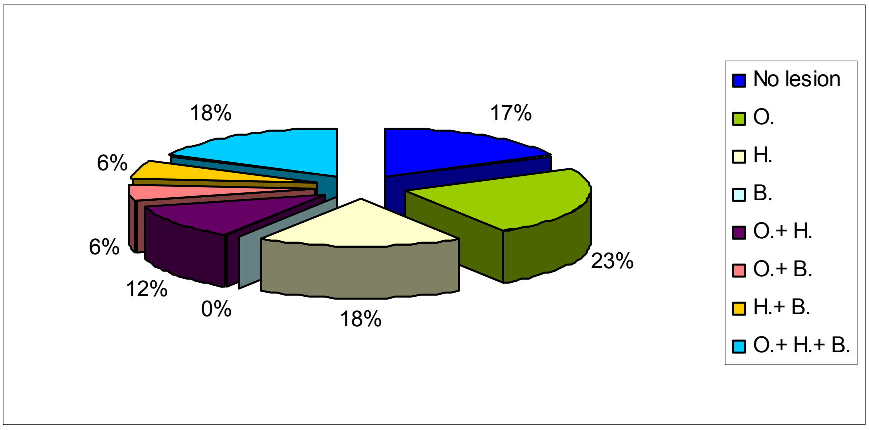
Individual 1588 (M, 21yrs) shows, along the internal sagittal suture, new bone formation which is indicated as TB-induced meningitis by Roberts and Buikstra (2003).

Two individuals show some particular lesions that could be caused by lupus vulgaris. In particular, individual 594 (M, 42yrs) and individual 1490 (F, 28yrs) present a slight adsorption of the tissue close to nasal hole. The lupus vulgaris is a pathology characteristic of young age, before 20 years old, and it persists throughout life as Roberts and Buikstra (2003) remember. Like leprosy and treponematosis, TB can cause bone destruction of the rhinomaxillary region (Ortner, 2008).

Spine

Vertebral lesion is the most typical representation of skeletal TB. The following figure (Fig. 7.2) shows the vertebral TB lesions recovered in T.O.C. sample.

Fig. 7.2 TB evidences in spine



O.: Osteophytes; H.: Hypervascularization; B.: Apposition of new bone tissue.

In total the spines recovered are 17 and 14 show TB evidences versus only 3 without lesion. 18% present all the three characteristic injuries recovered: osteophytes, hypervascularization and apposition of new bone tissue. In

T.O.C. sample the hypervascularization is associated with other typical TB evidences: in 53% of total spines and in 63% of pathological spines. These results could support the idea that hypervascularization is caused by TB disease, although it is part of the MOLAT, without the general agreement of the paleopathologists.

<u>Ribs and sternum</u>

Although the periostitis is a non-specific inflammatory reaction, some authors consider it an additional diagnostic criterion for tuberculosis and that should be included in the modern clinical literature (Roberts *et al.,* 1998). In T.O.C. samples, only 5 of 16 individuals (31%) with ribs show periostitis. This result can not support the sure evidence that these periostitis markers are caused by TB, as Pfeiffer (1991) claimed that it could rather be interpreted as a non-specific indicator of chronic respiratory disease stress within a population.

Only one of 11 sterna (individual 1486, M, 36yrs) presents a serpentine remodelling of tissue due to an inflammatory reaction.

The histological analyses (Haematoxylin-Eosin and Masson Tricromic stain) carried out in 8 individuals show a rarefaction of trabecular tissue with a proceeding similar to osteoporosis.

<u>Shoulder</u>

In 5 of 33 scapulae and 1 of 28 clavicles recovered, signs of inflammatory reaction are present with sharply demarcated erosive marks. In these particular individuals (1477, M, 29yrs; 1479, M, 28yrs; 1484, F, 30yrs; 1580, M, 25yrs; 1584, M, 24yrs; 1601, M, 25yrs), the TB evidences are widespread in many other anatomical sites. Although the involvement of the shoulder is much less common than that of the other joints (hip or knee), in these cases we can consider the shoulder signs as due to TB.

<u>Arm and hand</u>

Concerning arms, only the individual 1584 (M, 24yrs) shows evident bone changes due to periostitis in both ulnae. This individual shows strong periostitis in all long bones recovered, therefore this sign in ulnae can be considerated a TB evidence.

<u>Pelvis girdle</u>

In the following table (Tab. 7.9) data of acetabular fossae damaged are reported.

Tab. 7.9 Acetabular fossae damaged

	Acetabular fossa	
Individual	Right	Left
403	---	X
422	X	X
439	X	
445	X	X
461	X	---
935	X	---
6 of 15 individuals	5 of 5 found remains	3 of 4 found remains

Literature reports that hip joint represents 20% of the cases of skeletal involvement. Messner (1987, cited by Aufderheide and Rodríguez-Martin, 1998) states that tuberculous bacilli can escape from capillaries located in the synovial membrane, in the acetabulum or in proximal femur. Unfortunately, in T.O.C. only one femur of the joints with pathological signs is present, therefore we can not complete the study about TB signs in the hip.

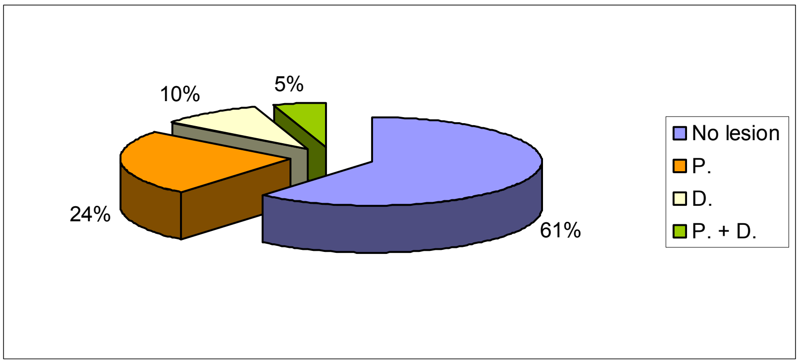
<u>Leg and foot</u>

34 of the analyzed individuals present at least one of femur or tibia. 26% show TB involvement of the knee joint. Data reported in literature (Aufderheide and

Rodríguez-Martin, 1998; Ortner and Putschar, 1985) agree with a percentage of 16% which is 10% lower than our results.

Data about femur TB lesions are presented in Fig. 7.3.

Fig. 7.3 Femur involvement



P.: Periostitis; D.: Distal lesion

Generally, periostitis alone can not be considered one of major diagnostic criteria for TB, since it is a non-specific infection disease. Only within a general pattern of pathological signs, we can consider it as a TB marker. In our study, about 30% of the recovered femurs show periostitis.

In particular, in individuals with more complete skeletons (1439, M, 35yrs; 1482, M, 31yrs; 1485, M, 43yrs; 1584, M, 24yrs; 1588, F, 21yrs; 1601, M, 25yrs), periostitis can be considered a TB marker, since they all show different widespread signs of the pathology (i.e. spine involvement).

Histological analyses carried out in long bones of 8 individuals show the primary and secondary lamellae, particularly in the external rim.

7.4 Conclusion

During this research, for the first time T.O.C. was ordered and analyzed with traditional and modern techniques. This collection could be a potential source of information, but it was unknown till now.

Some characteristic TB evidences, that are part of MOLAT, have been studied for their diagnostic value. Our results could support the idea that vertebral hypervascularization is caused by TB disease: in T.O.C. sample it is associated with other typical TB evidences and it has been found in 53% of total spines and in 63% of spines with pathological evidences. In T.O.C. samples, only 5 of 16 individuals (31%) with ribs show periostitis. This result can not support the sure evidence that periostitis is caused by TB, as Pfeiffer (1991) claimed that it could rather be interpreted as a non-specific indicator of chronic respiratory disease stress within a population.

The histological analyses emphasized several unknown aspects concerning histology of ancient remains, i.e. the remodelling shown with haematoxylin-eosin and tricromic stain technique.

The molecular tests demonstrate the presence of mycobacterium on the osteological samples analyzed, although they were partial and limited as the osteological collection was used for didactical purposes by different researchers during these years and the perfect idea of a “virgin bone” is extremely distant to our sample situation.

Also densitometry, that is carried out with the new technique of Metriscan, appears a potential instrument for further investigations.

In conclusion, many considerations were formulated to create the basis for further and deepened investigations not only to study TB individuals, but also to amplify the study with other skeletal pathologies described as causes of death (i.e. syphilis). In particular, molecular and morphological analyses should be furtherly considered.

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