

Methodology for the Paleopathological Study of Human Skeletons

منهجية الدراسة الباليوباثولوجية للهياكل العظمية الإنسانية

Saliha Derbal صليحة دربال saliha.derbal@univ-constantine2.dz	Prehistoric Archeology	Laboratory of History, Heritage and Society/ Abdel Hamid Mehri University of Constantine 2 / Algeria
DOI: 10.46315/1714-013-001-39		

Received: 26/06/2023 Accepted:10/ 11/ 2024 Published :16/ 01/ 2024

**

Abstract:

The study of ancient diseases in prehistoric is based on human skeletons as an important source for knowledge of some aspects of human life in that period, and the paleopathological study relies mainly on a comprehensive microscopic examination of bones and teeth with the naked eye to detect pathological lesions, If necessary, X-rays and MRIs are used to improve or confirm the diagnosis. This research paper presents the methodology adopted in the diagnosis of pathological lesions of human bones with the proposal to rely on some means to facilitate the organization of data and their precise analysis to achieve correct results.

Keywords: Prehistoric; Paleopathology; human skeleton; Pathologic Lesion; Diagnosis.

ملخص:

ترتكز دراسة الأمراض القديمة في عصور ما قبل التاريخ على الهياكل العظمية البشرية باعتبارها مصدرا هاما لمعرفة بعض الجوانب من حياة الإنسان في تلك الفترة، وتستند الدراسة الباليوباثولوجية بشكل رئيسي على الفحص المجهرى الشامل للعظام والأسنان بالعين المجردة للكشف عن الآفات المرضية، وإذا اقتضى الأمر تستخدم الأساليب التي تتجاوز الفحص البصري كالأشعة السينية والتصوير بالرنين المغناطيسي بغرض تحسين أو تأكيد التشخيص. تُقدم هذه الورقة البحثية المنهجية المعتمدة في تشخيص الآفات المرضية في العظام الإنسانية مع اقتراح الاعتماد على بعض الوسائل لتسهيل تنظيم البيانات وتحليلها تحليلًا دقيقًا للوصول إلى نتائج صحيحة.

كلمات مفتاحية: ما قبل التاريخ؛ الباليوباثولوجيا؛ هيكل عظمي إنساني؛ أفة مرضية؛ التشخيص.

**

1- Introduction

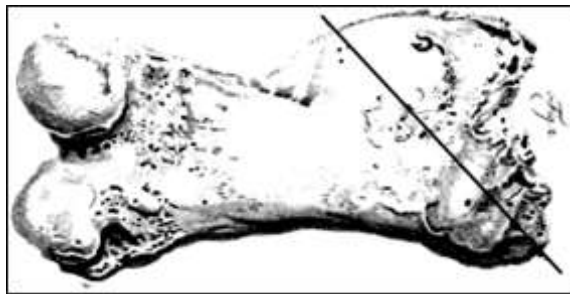
The paleopathological study is considered one of the most important studies that arouse the interest of researchers in the prehistoric period, as it allows identifying the various features and aspects of life that characterized that era. It is concerned with the study of ancient diseases by looking for disease and its progression in human and animal skeletons over long periods of time in order to know how humans adapt to changes in their environment.

The problem of this research revolves around the methodology adopted by archaeologists to diagnose pathological lesions of human bones, and the most important methods used to obtain precise and clear results. In this regard, we make several hypotheses as follows:

- The comprehensive examination to different aspects of the human skeleton;
- Use simple examination methods, such as visual examination with the naked eye;
- Rely on precise and highly reliable methods: such as X-rays, CT scanning and chemical analysis.

The science of paleopathology first appeared in 1774 by the German researcher Johan Freidrich Esper, who noticed a lesion on some fossil bones of a cave bear in the caves of Bavaria, which he considered osteosarcoma (Waldron, 2015, p9). After that, research in this field has been developed and included human skeletal remains, as the first medical thesis in the field of human palaeopathology was discussed in 1881 by Jules Le Baron under the title "Bone Lesions of Prehistoric man in France and Algeria." (Billard, 2009-2010, p2) (Pales, 1929-1930, p26)

Fig.1. Schematic diagram of the femur of a cave bear carrying the lesion pathological referred to by the researcher Esper



Source: Waldron.T, 2015, p 10

The term paleopathology was first used by Schufeldt in 1892 as "the term under which all diseases or pathological conditions found in the remains of extinct or fossil animals may be described" (Cerdá, Prósper, & Romero, 2010, p98).

The term "Paleopathology" consists of three parts: paleos « ancient », pathos « disease », and logos « science », hence the meaning of the term is ancient pathology (Billard, 2009-2010, p 1). It is a historical medical specialty that contributes to the knowledge of the natural history of diseases and the health status of human groups in the past (Thilaud.P.L, 1994, p11).

Paleopathology is a recent discipline, defined in 1913 by Franco-British bacteriologist, Sir Marc Armand Ruffer, as being the science of diseases, whose existence can be demonstrated on human and animal remains from ancient periods (Dutour & Coqueugniot, 2016, p67).

This science is located at the interface of two basic fields: the field of biomedical sciences, which uses the diagnostic approach, and the field of archaeological sciences, which provide study

materials. Paleopathology investigates the development and progression of disease over long periods of time, as well as how humans adapt to changes in their environment; It thus provides essential evidence of our ancestors health status by combining biological and cultural data. Paleopathology can be considered as one of the sub-disciplines of biological anthropology as the study of palaeopathology relies mainly on skeletal (Roberts & Manchester, 2010, p3).

Paleopathology has a long history stretching back to the seventeenth century. Most of the early work focused on animal remains (Roberts, et al., 2012 , p6). This history can be summarized through three main phases:

- The first phases: From 1774 to 1870, this phase was marked by writing articles on diseases discovered on the bones of animals in the Quaternary.
- The second phase: From 1870 to 1900, researchers focused mainly on traumatic lesions on human skeletons, and the search for the origin of Syphilis, at the same time the study of infectious diseases has begun.
- The third phase: From 1900 to the present day, the research focused on infectious diseases and researchers tried to know what medicine and surgery were in prehistoric, and they also worked to extend their observations to include fossil animals of the first geological eras. During this stage, laboratory methods were applied to study the bony lesions which were previously diagnosed with the naked eye only (Pales, 1929-1930, p20).

These phases summarize the most important changes and developments known to the study of ancient diseases until it becomes a science in itself.

2- Paleopathology Study Methodology

Paleopathology relies on three main disciplines: archaeology, anthropology and medicine, which provide it with different materials, methods and techniques. Where archeology provides human skeletal remains and determines the period to which they belong, while anthropology allows reconstruction of the biology of populations in the past, and medicine is seen as the diagnostic tool of paleopathology because their diagnostic methods are similar (Daouda, 2012-2013, p90-91).

In palaeopathology, the study methods vary, but are mostly based on macroscopic observation and description of abnormal changes seen in bony remains. The description and distribution of these changes is a prerequisite of trying to diagnose the observed disease process. But sometimes diagnosis is difficult even with a range of diagnostic tests available (Roberts & Manchester, 2010, p9).

2.1. Methods for identifying pathological lesions on human skeletal remains:

Three methods are used to analyze the pathological lesions observed on the skeleton: macroscopic examination, microscopic examination, and biochemistry.

2.1.1. Macroscopic examination:

Macroscopic examination is based on examining the nature and status of the pathological lesion (localized, diffuse), and this is done by means of visual observation, radiography imaging and endoscopy (Billard, 2009-2010, p7-8).

➤ visual observation :

It is relatively easy to describe observable pathological lesions such as arthritis or infection, but a more definitive diagnosis is often impossible, especially with the presence of more than 2,000 types of joint disease and many types of injuries; However, an accurate and clearly detailed description of the lesions allows researchers to make a definite diagnosis, with photographic documentation especially necessary in difficult and mixed cases.

Fig.2. Non-metric trait/normal variation in the skeleton (bregma bone in skull) (visual observation)



Source: (Roberts, et al., 2012, p4)

➤ radiography imaging:

The beginnings of using radiography on bones start with König Holland (1896) and Culin (1898) on Egyptian and Peruvian mummies. This method was used to identify changes in various parts of the skeleton, (Billard, 2009-2010, p9) where radiography is a complement to the macroscopic examination as it provides valuable information about bone anomalies and the health status of the ancient population (Panuel et al, 1998, p179). Among the pathological lesions revealed by radiography, we mention the fractures that the individual was exposed to during his life, through the signs of the bone callus (Cayotte, 1976, p286-289).

This method includes several techniques:

- *Simple radiography*: simple or classic radiography is done by projection. It is used in all cases. However, it is not accurate for anomalies characterized by skeletal overlays (Periostitis, Synostosis, Ankylosis...)

-
- *X-rays*: were used in the 1970 on mummies to highlight the structure of soft tissues, but this technique has been superseded by L'imagerie Digitalisée and Scanner (Billard, 2009-2010, p9-10). X-rays and CT scans provide accurate information, and in many cases are the only techniques allowed as they do not damage the archaeological specimen (Fernández, 2012, p222).
 - *Computed tomography*: this technique allows to determine the relationships between anatomical structures, pathological lesion and bone tissue reactions without destroying the bone. The cost in this technique is more expensive than the simple radiography technique and is not transferable (Billard, 2009-2010, p10). This technique is able to detect bone tumors such as osteoid osteoma, which often affects the bones of the skull and femur (Maehara, et al., 2019, p322).
 - *Magnetic resonance imaging*: It is used on wet or frozen materials only, while it cannot be used on solid tissues, as protons from hydrogen atoms must be present (Billard, 2009-2010, p10). MRI has a very wide field of application in osteo-articular pathology through its morphological and functional information on bone marrow, cortical bone and the soft tissues adjacent to the bone (Panuel, Pálfi, & Dutour, 1998, p180-181). This type of imaging is the best technique for detecting Paget's disease (Malghem, et al., 2005, p287), It is a chronic bone disorder characterized by an increase in bone thickness (Baslé, et al., 1986, p907). Paget's disease affects the pelvic bones, the spine, the femur and the skull (Juvin, 2002, p1) and to a lesser extent the tibia, clavicle, humerus and facial bones (Makhloufi, et al., 2013, p 6).

Fig.3. CT image showing an osteosarcoma in the right mandible



Source: Maehara, 2019, p 323

➤ endoscopy:

Visual and photographic exploration of (cranial) cavities and mummified bodies by introducing optical fibers (eg: ENT endoscope); It allows directed biopsies on mummies, observation of the endocranial surface (microcamera coupled to a computer screen (Billard, 2009-2010, p10).

2.1.2. Microscopic examination:

Microscopic examination is a destructive technique based on the study of bone tissue by conducting analyses on a part of the bone, which allows knowing the activity of bone cells that varies according to the degree of bone maturity (age), the rate of bone deposition and the type of disease.

The microscopic examination includes a group of techniques that differ among themselves in means quality, the sample used, and even the type of diseases that allow them to be detected. These techniques are:

➤ Light transmission optical microscopy :

It is a destructive technique (thin sections of bone mounted on a blade, magnification 20x to 200x) allowing to see the differences between mature and immature bone, the increase in mineralized bone (sclerosis) or its decrease (rarefaction). It allows the study of osteoporosis, osteopenia generalized, and localized lesions. Polarized light makes it possible to more precisely appreciate the structural aspect of the bone (birefringence of the collagen fibers). The fluorescence of certain natural substances ingested by individuals in certain foods such as grain stored in reserves (tetracycline-like, fluorochrome) which can be demonstrated with reagents and an appropriate light source. The dyes make it possible to assess the osteoblastic and osteoclastic activity of metabolic diseases (Billard, 2009-2010, p10).

Light microscopy is also used to study pathological lesions in mummified tissues to detect some diseases such as: schistosomiasis, tuberculosis and atherosclerosis (Fernández, 2012, p222).

➤ Transmission electron microscopy:

Transmission electron microscopy uses thin sections of mummified tissue, highlighting viral agents and cell nuclei impossible to observe with optical microscopy and staining (300,000x magnification and more) (Billard, 2009-2010, p11).

3D high-resolution images can be obtained through scanning electron microscopy, which provides valuable information of the surfaces and inner structure of mummified tissues (Fernández, 2012, p223).

➤ Microradiography:

Contact radiograph of a thin bone section observed under an optical microscope. It specifies the mineral distribution in the bone (metabolic diseases) and the taphonomy alterations.

➤ Stereomicroscope:

Allows the study of bone and dental surfaces without destruction of the piece, and at a distance from it. (40x to 400x). Lighting by reflected light of the halogen type or flexible optical fibers. Observation of microtopographic variations of lesions.

➤ Scanning electron microscopy (SEM):

It is a surface examination; the part must be covered under vacuum with an atomic layer of gold or carbon (the use of replicas in elastomeric or epoxy resins avoids altering the original). SEM is used for the study of the bones surfaces, teeth, microfractures, Howship gaps (1000x to 40000x).

➤ **Electronic microprobe:**

Allows the study of surfaces under atmospheric pressure and at room temperature (no vacuum preparation); determines the chemical composition of the sample surface. This technique is not commonly used in pathology (Billard, 2009-2010, p11).

2.1.3. Biochemistry :

Molecular biology is now usefully used in the retrospective diagnosis of infectious diseases, as a new subfield called "paleomicrobiology" (Dutour, 2011, p168)

There are three types :

➤ **Analysis of trace elements**

Trace elements are essential for the normal development of animals and humans (catalyses). Their study requires bone destruction and spectrometric analysis.

➤ **Immunohistochemistry**

Immunohistochemistry (IHC) is an important aid method for pathologists because it specifically visualizes the distribution and amount of a specific molecule in tissues using specific antigen, antibody reaction (Kim, Roh , & Park, 2016, p411).

Immunohistochemical and immunofluorescence analyzes can be performed in rehydrated tissues. Although they frequently give negative results, some antigens in some tissues of some mummified subjects show surprising antigenic conservation of immunogens, e.g. collagens, neuropeptides or even biological agents (Fernández , 2012, p223).

➤ **The study of ancient DNA (ADNA)**

DNA analyzes have made it possible to discover the presence of microorganisms associated with certain diseases and have provided important evidence about their dispersion and evolutionary history (Suby, Luna, Aranda, & Flensburg, 2017, p13).

The study of DNA allows the analysis of differences accumulated over generations: kinship relations, history of settlements (genetic polymorphism). It also allows the analysis of point mutations by substitution of one base by another (sequence polymorphism) on the ADMt and on nuclear DNA. The technique is delicate, expensive, the results subject to the vagaries of contamination and the degradation of the DNA molecule (Billard, 2009-2010, p14).

2.2. The protocol for examining the skeleton of an adult

Before diagnosing pathological lesions in the skeleton, it is necessary to determine the bone group to be studied by determining the number of skeletons, and then create an anthropological

database that includes sex, age, type and number of bones for each skeleton separately, with reference to the status of preservation, we propose an identification card of the skeleton based on the use of colors to identify the type of bones available and their status of preservation, and this is in order to facilitate the organization of data for each skeleton. The card includes the following information:

- Card number: this element is important for organizing archaeological data, especially when there are several skeletons. We use the following coding: SID01, SID02,...(S: skeleton, ID: identification)
- Skeleton number: unique and non-repeating. Conventionally, the initials are used for the area or location where the skeleton was discovered.
- Site Name: the location where the skeleton was discovered.
- Sex: male or female.
- Age: define the age group, which varies from one skeleton to another.
- Conservation place: the museum or institution that reserves the bone collection.
- Preservation status : good, medium, bad, very bad.
- Notes: explanation, clarification, addition.
- A table for teeth: it consists of 32 cells, the same number of teeth in an adult.
- Sketch of the parts of the skeleton: it consists of the various parts of the skeleton. Its purpose is to identify the bones in each skeleton and their status of preservation.
- Legend : explains the colors used in the diagram and the meaning of each color, as we suggest using colors as follows: red color « the bone is present and complete», blue color « the bone is present but fragmented due to poor preservation », pink color « the bone is present but not sure which bone is exactly », especially in the bones of the thorax and vertebrae with very poor preservation, while the white color « in the absence of bone »

The locus of change should be sought on the entire skeleton of an individual because it the following questions:

- Which side is affected in double bones?
- Is the change bilateral in double bones?
- Are there similar changes elsewhere in the skeleton?
- Are there different changes in the skeleton that indicate complications? (Billard, 2009-2010, p7).

The phase of general diagnosis is very important, as the parts of each skeleton are examined with the naked eye with the use of a loupe, and the observed changes are recorded by describing their appearance and determining their position on the bones, to adjust the data obtained through the general diagnosis, we propose relying on a diagnostic card that includes the following elements :

- Card number: this element is important for organizing archaeological data, especially when there are several skeletons. We use the following coding: SD01, SD02,... (S: skeleton, D: diagnostic)
- Skeleton number: The same number used on the identification card.
- The number of bones affected: we mean the number of bones that have unnatural changes.
- The type of bone affected: vertebrae, skull bones, femur, scapula...
- The number of affected teeth: by the decay or any other dental lesion.
- Type of teeth affected: incisors, canines, molars. Notes: explanation, clarification, addition.
- A table for teeth: it consists of 32 cells, the same number of teeth in an adult. Sketch of the parts of the skeleton: It consists of various parts of the skeleton. Its purpose is to identify which bones have unnatural changes.
- Legend : shows the colors used in the sketch and the meaning of each color, where the orange color «affected bones», the green color « unaffected bones ».

- Knowing the limits of defining and recording data related the status of bone preservation of bone and the factors that cause it: as a result of the application of physical and mechanical techniques on old bones, knowledge has increased on of the factors affecting the decomposition of the skeleton in the soil (taphonomia) and the mechanisms that modify its composition (deformation).
- Accurately describe observed lesions to determine their cause before giving a retrospective diagnosis of a definite or indefinite status: a simple comprehensive examination is usually sufficient, but sometimes medical imaging techniques, microscopic and biomolecular analyzes are complementary and in some cases necessary (Billard, 2009-2010, p6-7), in the case of a bone lesion that is difficult to interpret, paleopathologists can only identify it using microscopy and x-rays, as well as analysis of the archaeological record (Thilaud & Charon, 1994, p12).
- Exact identification of the effect of the observed lesions on the fragmented and incomplete remains: to better understand the pathologic status of the studied skeletal series, while evaluating prevalence rates the severity of the lesions observed should be assessed as well as their active status or not at the time of the death of the individual (Billard, 2009-2010,p7).

4- Conclusion

Finally, the paleopathological study of skeletons must be based on a very precise scientific methodology, because any error in diagnosis necessarily can cause in wrong results. Therefore, in order to reach correct results, it is necessary to rely on certain methods, most notably: the macroscopic examination method, which mostly depends on the examination using the naked eye with the help of a magnifying lens, but this type of examination is not sufficient to detect some pathological lesions, which requires resorting to radiography, whether simple radiography, X-ray imaging, computed tomography, magnetic resonance imaging, or endoscopy. Choosing the appropriate examination method depends on the nature and type of the sample being examined and its purpose, as well as the type of lesion to be searched for in the bone remains.

Because a mistake in diagnosis necessarily results in wrong results

Researchers resort to using the microscopic examination method to detect pathological lesions if the macroscopic examination is not sufficient, as this method allows to identify the activity of bone cells, the speed of bone deposition and the type of disease. Microscopic examination includes a group of techniques that differ among themselves in the type of means, the sample used, and even the type of diseases that allow them to be detected. These techniques are: light microscopy,

electron microscopy, microradiological examination, stereoscopic microscopy, and electron microscopy, in addition to the method of analysis Biochemistry.

Although there are several modern and accurate methods that allow the identification and analysis of pathological lesions in the human skeleton, however, the paleopathological faced study encounters several difficulties, the most important of which are:

- Limitations related to the nature and status of the studied material.
- Difficulties associated with the nature and status of the observed lesion.
- Obstacles to the application of methods for collecting and interpreting results

As a general rule, the certainty of the diagnosis is directly related to the amount and state of the skeleton, the more complete the skeleton and in a better status of preservation, the more likely it is that pathological lesions will be identified.

There are also some parts of the skeleton that must be present for certain diseases to be diagnosed, regardless of the appearance of suggestive signs elsewhere.

**

5- The bibliography :

- Baslé, M. F., Fournier, J. G., Rozenblatt, S., Rebel, A., & Bouteille, M. (1986). Measles Virus RNA Detected in Paget's Disease Bone Tissue by in situ Hybridization. *Journal of General Virology*(67), 907-913. Retrieved from: <https://pubmed.ncbi.nlm.nih.gov/3701300/pdf>
- Billard, M. (2009-2010). Paléopathologie: principe et méthodes. Master1, «Histoire, philosophie et didactique des sciences», option philosophie du soin et Anthropologie médicale [PDF document]. Retrieved from: <http://www.laboratoireanthropologieanatomiqueetdepaleopathologie.delyon.fr/BILLARD%20CM%20PALEOPATHOLOGIE%202010.pdf>
- Cayotte, J. (1976). La médecine aux temps préhistoriques. *Mémoires de l'Académie nationale de Metz, 5-1979*, 285-304. Retrieved from: <https://gallica.bnf.fr/ark:/12148/bpt6k12937845/f295.item>
- Daouda, C. (2012-2013). Les collection osteoarchéologiques humaines en côte d'ivoire: de leur conservation à l'analyse archéothanatologique et anthropobiologique. *Thèse de doctorat, Spécialité: archéothanatologie*. Korhogo: Institut des sciences anthropologique de développement, Université Felix Houphouët Boigny.
- Dutour, O., & Coqueugnot, H. (2016). Paléopathologie et épidémiologie sur les collections de musées. *La revue Techné* (44), 67-70. Retrieved from: <http://journals.openedition.org/techné/1077>
- Dutour, O. (2011). Paleopathology: an archaeological approach of diseases. *TUBA-AR 14*, 165-172. Retrieved from: https://www.researchgate.net/publication/288475926_Paleopathology_An_archaeological_approach_of_diseases
- Fernández, P. (2012). Palaeopathology: The Study of Disease in the Past. *Pathobiology*, 221-227. Retrieved from: <https://sci-hub.st/https://doi.org/10.1159/000335165>
- Juvin, R. (2002). La maladie de paget. 1-12. Grenoble, Corpus Médical – Faculté de Médecine de Grenoble. Retrieved from: <https://pdf4pro.com/cdn/corpus-m-233-dical-facult-233-de-m-233-decine-de-grenoble-1d67e2.pdf>
- Kim, S.-W., Roh, J., & Park, C.-S. (2016). Immunohistochemistry for Pathologists: Protocols, Pitfalls, and Tips. *Journal of Pathology and Translational Medicine* (50), 411-418. Retrieved from: <https://sci-hub.st/https://doi.org/10.4132/jptm.2016.08.08>

- Maehara , T., Murakami, Y., Kawano , S., Mikami , Y., Kiyoshima, T., Chikui, T., et al. (2019). Osteoid osteoma of mandibular bone: Case report and review of the literature. *Journal of Oral and Maxillofacial Surgery, Medicine, and Pathology*, 31, 322-326. Retrieved from ScienceDirect. <https://doi.org/10.1016/j.ajoms.2019.04.002>
- Makhloufi, C., Zehraoui, N., & Abtroun Benmadi, S. (2013). Complications ostéoarticulaires de la maladie de Paget. *Revue Médicale Internationale Maghrébine*(204), 5-12. Retrieved from: <https://www.researchgate.net/publication/323945457>
- Malghem, J., Vande Berg, B., Lecouvet, F., & Maldague, B. (2005). Maladie de Paget. *EMC-Radiologie*(2), 288–310. Retrieved from: <https://doi.org/10.1016/j.emcrad.2005.05.003>
- Pales, L. (1929-1930). Etat actuel de la paléopathologie contribution a l'étude de la pathologie comparative. *thèse de doctorat, Spécialité: Médecine*. Faculté mixte de médecine et de pharmacie: Université de Bordeaux.
- Panuel, M., Pálfi, G., & Dutour, O. (1998). Radiologie des infections osseuses en paléopathologie. In: *Bulletins et mémoires de la société d'anthropologie de Paris, Tome 10 fascicule 1-2*, 179-187. Retrieved from: http://www.persee.fr/doc/bmsap_0037-8984_1998_num_10_1_2511
- Polo-Cerdá, M., García-Prósper, E., & Romero, A. (2010). Bioantropología y paleopatología. Herramientas para la investigación histórico-arqueológica. 95-116. Retrieved from: <https://www.researchgate.net/publication/259485211>
- Roberts , C., & Manchester, K. (2010). Archaeology of disease «The Study of Palaeopathology». In: Durham Research Online [PDF document]. Retrieved from: <http://www.thehistorypress.co.uk/products/The-Archaeology-of-Disease-Third-Edition.aspx>
- Roberts, C., Alves Cardoso, F., Bernofsky, K., Henderson, C., Jakob, T., Plomp, K., et al. (2012). Palaeopathology: studying the origin evolution and frequency of disease in human remains from archaeological sites. Encyclopedia of Life Support Systems (EOLSS), Retrieved from: <https://www.researchgate.net/publication/255723475>
- Suby, J., Luna, L., Aranda, C., & Flensborg, G. (2017). Paleopatología. *ARTÍCULO*, 26(153), 11-15. Retrieved from: https://www.researchgate.net/publication/315877332_Suby_J_Luna_L_Aranda_C_y_G_Flensborg_2017_Paleopatologia_la_evolucion_de_nuestra_salud_Revista_Ciencia_Hoy_26157_11-15
- Thilaud, P., & Charon, P. (1994). *Lésions ostéo-archéologiques*. Kronos B.Y.
- Waldron, T. (2009). *Palaeopathology*. New York: Cambridge University Press, [PDF document]. Retrieved from: http://www.academia.dk/BiologiskAntropologi/Paleopatologi/PDF/Palaeopathology_Cambridge_Manuals_in_Archaeology_.pdf
- Waldron, T. (2015). Roy Lee Moodie (1880–1934) and the beginnings of palaeopathology. In: *Journal of Medical Biography*(23 (1)), 8–13. Retrieved from: https://www.researchgate.net/publication/313566586_Roy_Lee_Moodie_1880-1934_and_the_beginnings_of_palaeopathology