Bi4041 Paleopathology

Trauma and ageing bone signs: the osteological paradox

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Trauma & ageing

The osteological paradox

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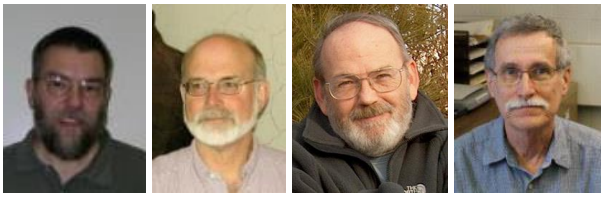
The osteological paradox (1)

« Better health
makes for worse skeletons »



Current Anthropology Volume 33, Number 4, August–Octob

The Osteological Paradox

Problems of Inferring Prehistoric Health from Skeletal Samples[1]

by James W. Wood,
George R. Milner,
Henry C. Harpending,
and Kenneth M. Weiss

The osteological paradox (2)

- Epidemiological perspective of the paleopathology
- Quantification (prevalence) of the lesions in the osteoarcheological collection

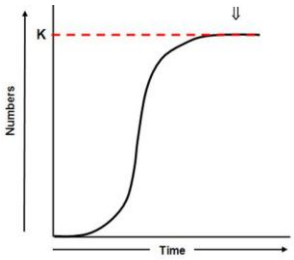
- Link between ↗ lesions frequencies & **"bad health"** in osteoarcheological collections
- ↗ lesions frequencies & diseases' prevalences (as a **cause of death**)

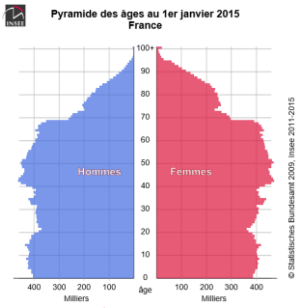
FALSE ASSUMPTION
ACCORDING TO THE OSTEOLOGICAL PARADOX
➔ 3 biases

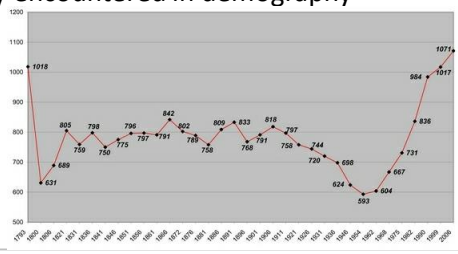
The osteological paradox (3)

Assumption of stationary demographics

- Unchanging age structure of the population, constant number in each age groups
- Required to assess disease prevalence for a given age group
- Assumes during the study period
  - ➔ Zero growth rate / Natality = Mortality / no migration
- Situation rarely encountered in demography

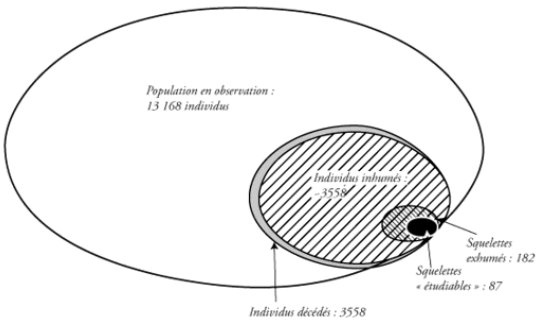


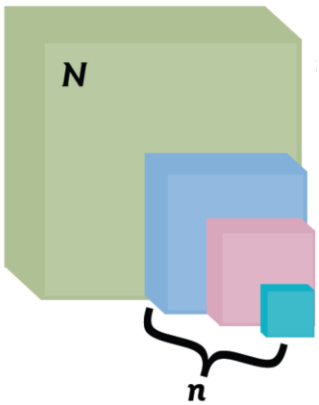




population of Rians (Cher, France)

The osteological paradox (4)





- Population
- Other non-bone signs
- Non spécific bone signs
- Spécific bone signs

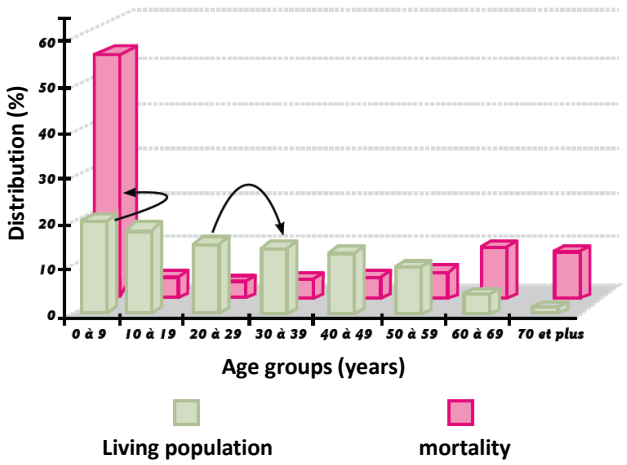
- 73 % of loss in comparison to the living population (inhumated population)
- Studyable population : 0,7% of the living population

 Dutour 2011, CTHS éd *La Paléopathologie;* Buchet & Séguy 1999, *Ancien cimetière d'Antibes. Réflexions méthodologiques en paléodémographie*

The osteological paradox (5)

Mortality selectivity

- Osteo-archeological collections: non-survivors by age categorie
- Over-representation of the diseases specific to an age categorie (cumulative effect)



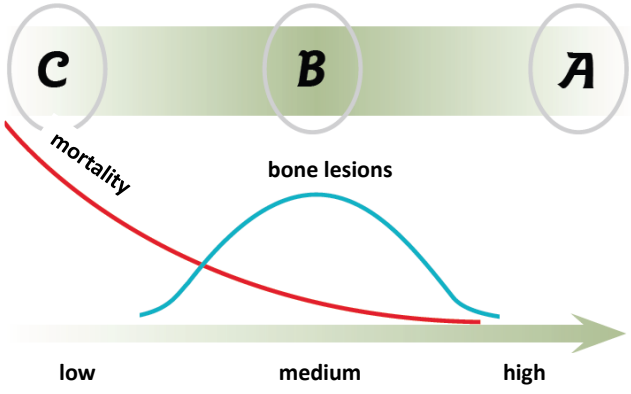
The osteological paradox (6)

Hidden heterogeneity

- Population exposed to a specific disease increasing the mortality and leaving lesions on survivors bones

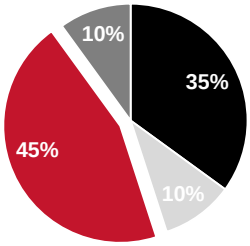
(needed for paleopathological recognition)

- 3 groups composing the population:
  - A: highly resistant
  - B: resistant
  - C: sensitive



The osteological paradox (7)

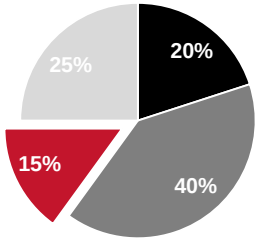
Resistant population



- 65% of sick individuals
- 10% dead
- 45 % with bone signs

➔ Apparent « bad health status »

Sensitive population



- 80% of sick individuals
- 40% dead
- 15% with bone signs

➔ Apparent « good health status »

- X No disease
- Y1 Dead
- Y2 Healed with bone signs
- Y3 Healed without bone signs

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Trauma & ageing

Paleotraumatology

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The trauma, today (1)

- 3rd group of causes of death according the WHO (≈ 5 millions death / year)
  - non intentional traumas (road accidents, falls, fires, drowings)
  - intentional traumas (self-harm, homicide, violence, war…)
- Socio-economical development related to the death frequencies by trauma
  - low = 22%; middle = 10%; high = 8%
- indicative of a sanitary transition

Trauma in the past (1)

- Global information on the "level of exposure" to trauma of ancient populations (bio-archaeological approach)
- Daily life, division of labor (accidental)
- Interpersonal violence
- Inter-population conflicts
- Information on medical, religious and cultural practices

Trauma in the past (2)

TABLE 1. Variation in the categorization of traumatic injuries by different authors

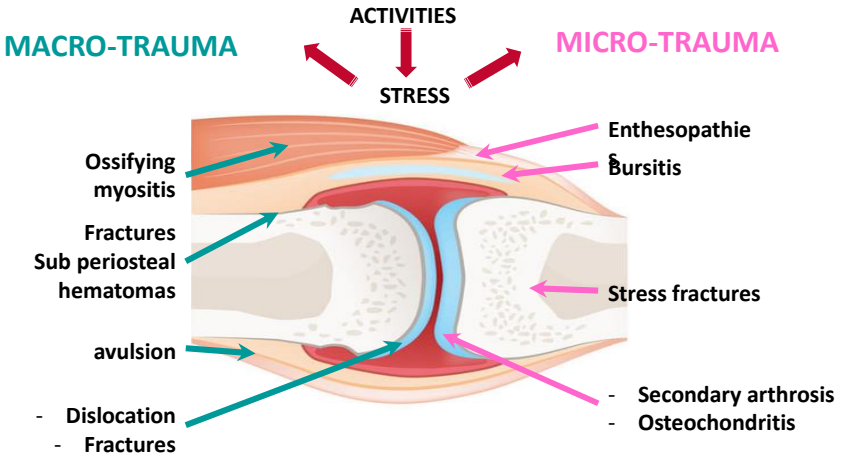
Knowles (1983)	Merbs (1989a)	Ortner and Putschar (1981)	Steinbock (1976)	Roberts and Manchester (1995)	This study
Fractures	Fractures	Fractures	Fractures	Fractures[3]	Fractures[4]
Dislocations	Dislocations	Dislocations	Dislocations	Dislocations	Dislocations
Trephination and amputation	Surgery	Trephination	Sharp Instruments[2]	Osteochondritis dissecans	
Weapon wounds	Weapon wounds	Weapon wounds	Growth arrest lines		
Exostoses	Scalping	Scalping	Crushing injuries		
Schmorl's nodes	Dental trauma[1]	Deformation[1]			
Osteochondritis dissecans		Pregnancy-related			

[1]Includes cranial deformation, filing of teeth, and other modifications performed for aesthetic purposes.
[2]Includes surgery and weapon wounds.
[3]Includes piercing injuries caused by knife and sword cuts, scalping, and projectile points (i.e., surgery and weapon wounds).
[4]Includes piercing injuries caused by knife and sword cuts, scalping, and projectile points (i.e., surgery and weapon wounds), and crush fractures caused by foot binding and by cranial binding and flattening.

 Lovell 1997, *Yearbook Phys. Anthropol.*

Trauma in the past (3)

- Classified according the **topography**:
  - Bone, articular, peri-articular
- & the **intensity** of the trauma:
  - Macro-trauma (*fast & intense*)
  - Micro-trauma (*repetitive)*

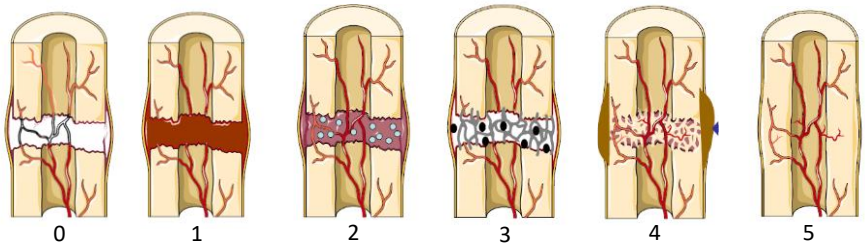


 Dutour 2011, CTHS éd *La Paléopathologie*

Fractures in the past (1)

- Dating the “age” of the fracture
- Identification of mechanism (line of fracture)
- Assessment of the functional consequences
- Inference on treatment and management
- Determination of complications

Fractures in the past (2)



A- Hématoma
(~24 hours)

B- cells proliferation
(~3 weeks)

C- cal production
(~3 to 9 weeks)

D- Consolidation
(~weeks to months)

E- Remodeling (~years)

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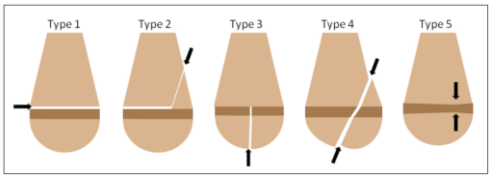
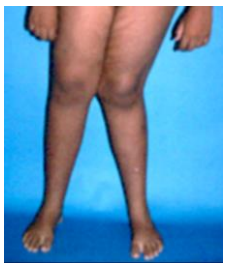
Fractures in the past (3)



Salter-Harris classification

The specific case of growth cartilage trauma

- Traumatic destruction of the GC = post-traumatic epiphysiodesis:
  - Central = shortening
  - Lateral = angulation
- Pseudarthrosis
- Bone malunion



Humerus varus

 Kacki *et al.* 2013, *Int. J. Osteoarchaeol.*

Fractures in the past (4)

- **Before the death** (different stages of **consolidation**)

- **Close to death:**

peri-mortem (**absence of consolidation**)

Before ?

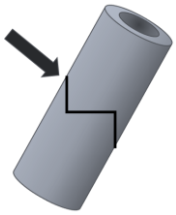
trauma as the **cause of death ?**

After ?

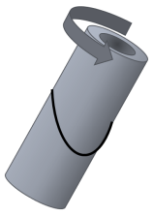
Taphonomy *as a cause ?*

Fractures in the past (5)

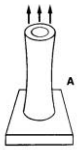
- **Direct forces:**
  Fracturing by direct action of an external agent (blunt, penetrating, *etc.*),
  whether mobile or fixed (fall)



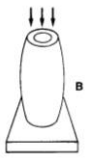
- **Indirect forces:**
  Forces exerted at a distance from the fracture site



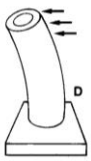
Indirect fractures in the past (1)



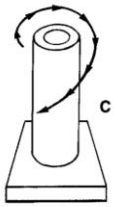
- Tension: Traction force carrying away a bone fragment (avulsion)



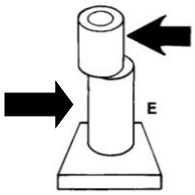
- Compression: Force in the bone axis leading to impaction (settlement)



- Flexion: Forces in the same direction (angulation)



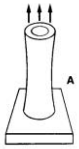
- Torsion: Forces in opposite directions (rotation)



- Shear :Forces in opposite directions, perpendicular to the axis

Indirect fractures in the past (2)

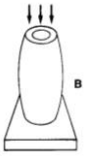
Avulsion

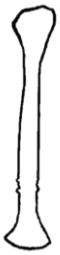


- traction forces
- Violent muscle contractions

ex : avulsion of the ulnar tuberosity (m. triceps brachialis)

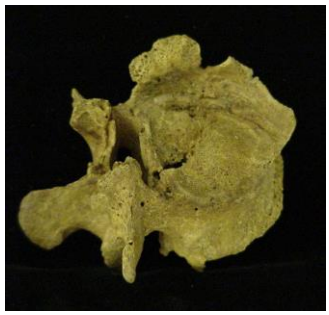
Impacted fractures





- **Young individual** (thick periosteum)
- Vertebral collapse
- (old individual = osteoporosis, other= trauma)

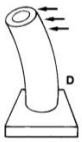
- Trabecular bone less resistant
  - Little displacement
  - Moderate shortening



Pouteau-Colles fracture

 Ortner 2003; Lovell 1997, Yearbook Phys. Anthropol.

Indirect fractures in the past (3)

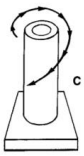


- **Oblique** = adult
- Combined mechanism of flexion and axial rotation
- Increased risk of displacement (shortening)

- "**Green stick**" = children
- Flexion forces on young bone: incomplete fracture
- resistance of the thick periosteum

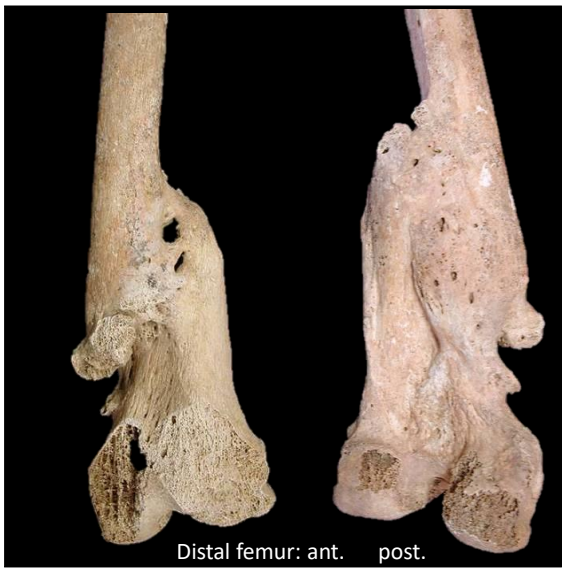
 Ortner 2003; Lovell 1997, Yearbook Phys. Anthropol.

Indirect fractures in the past (4)



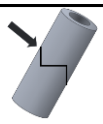
Spiroid fractures

- Risk of displacement and skin opening
- Shortening
- Secondary infection (sharp pieces)

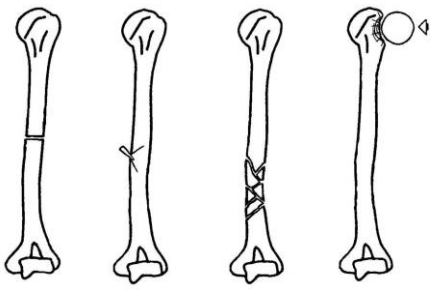


 Ortner 2003; Lovell 1997, Yearbook Phys. Anthropol.

Direct fractures in the past (1)



- Transverse
- Penetrating
- Comminuted
- Crush (blunt force trauma)



 Ortner 2003; Lovell 1997, Yearbook Phys. Anthropol.

Direct fractures in the past (2)

- Projectiles (bullets, arrows)
- Held weapons (sharp, penetrating)

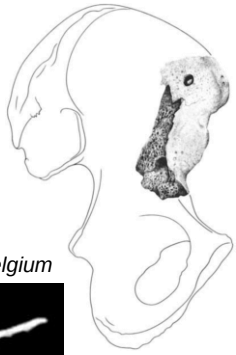
Russian saber « Chachka », 1812

ulna – defense wound

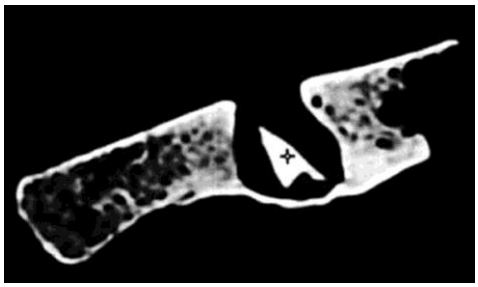
 Ortner 2003; Lovell 1997, Yearbook Phys. Anthropol., Coutinho Nogueira *et al.* 2019, *Int. J. Osteoarcheol.*

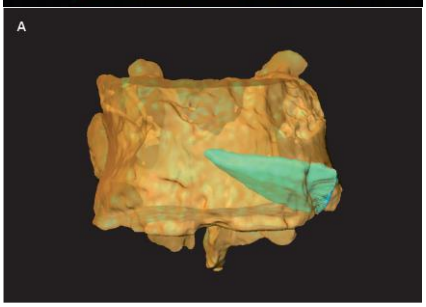
Direct fractures in the past (3)

- Projectiles (bullets, arrows)
- Held weapons (sharp, penetrating)



Neolithic, Belgium



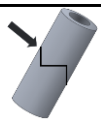


Neolithic, Tell Mureybet, Syria

 Ortner 2003; Lovell 1997, Yearbook Phys. Anthropol., Polet *et al.* 1996; *Chamel* et al. 2017, *Int. J. Osteoarcheol*

Direct fractures in the past (4)

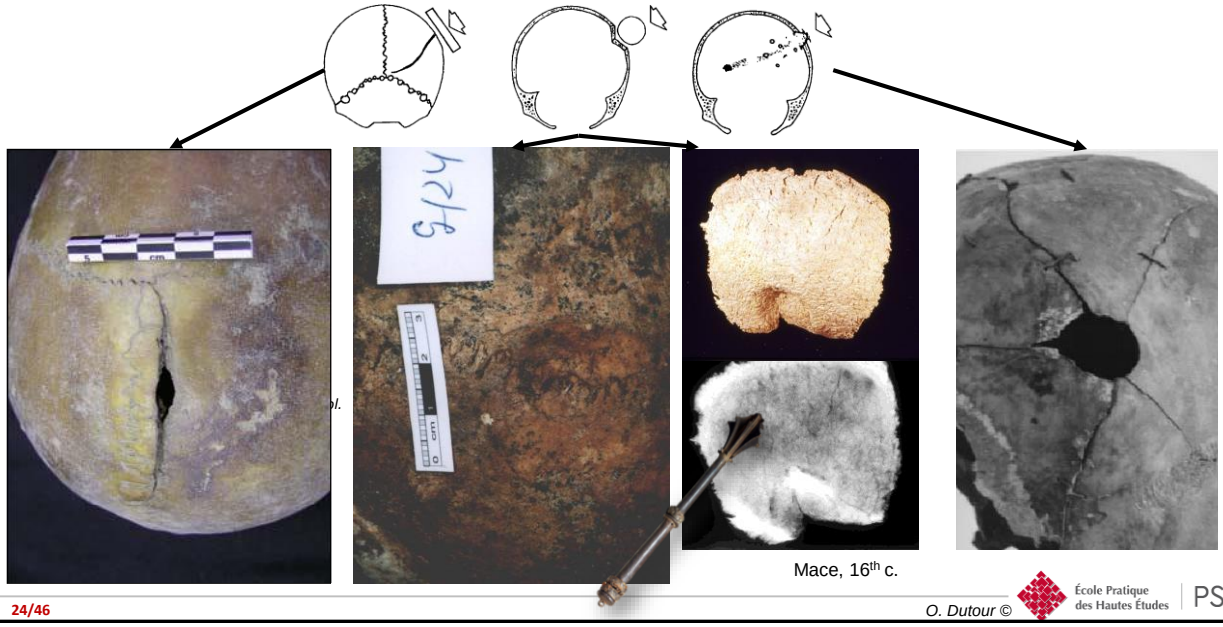
- Fragmentation at fracture site (>2)
- Direct: blunt (crushing) or high-velocity projectile (bullet)
- Indirect: flexion



Russia retreat campaign, 1812
Femur comminuted fracture
Lead bullet shotgun
© LIA – K 1812

 Ortner 2003; Lovell 1997, Yearbook Phys. Anthropol., Coqueugniot et al. 2020, Int. J. Osteoarcheol.

Skull fractures in the past (1)

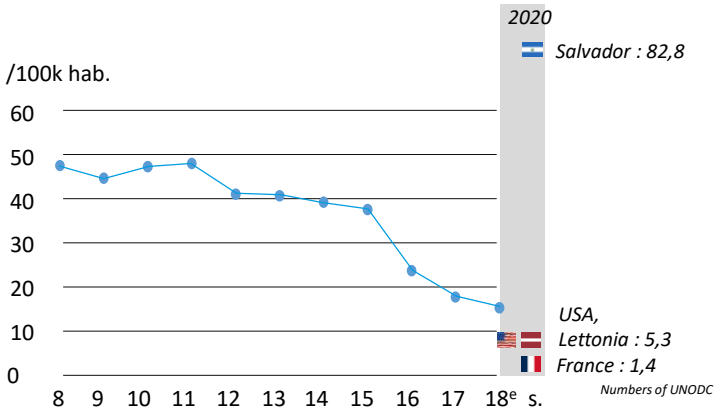


Mace, 16th c.

Interpersonal violence (1)

Interpersonal conflicts

- Between individuals (*e.g.* murder)
- Group / individual (*e.g.* execution)
- Between groups (*e.g.* war)



Interpersonal violence: homicides in Europ from the 8th to the 21th c.

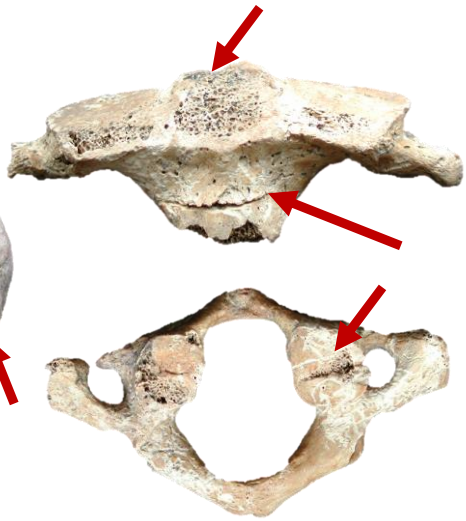
Interpersonal violence (2)

Throat cutting

Decapitation

16th c., France

Middle Age, France



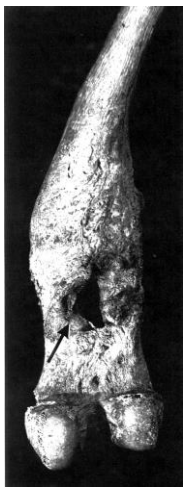
Middle Age, France

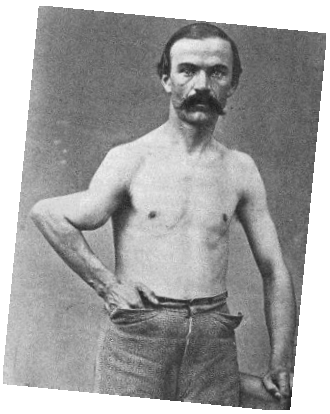
To sum up

Type	Mechanism	Force	Origin
Transverse	direct	Perpendicular	Accidental
Blunt	direct	crushing	Accidental / **voluntary**
Star fracture	direct	Penetrating	**Voluntary**
Penetrating	direct	Penetrating	**Voluntary**
Comminuted	Direct/indirect	compression	Accidental / **Voluntary**
Oblique	indirect	flexion	accidental
Spiroid	indirect	torsion	accidental
Impacted	indirect	compression (+)	accidental
Avulsion	indirect	traction	accidental
Greenstick	indirect	flexion	accidental

Trauma complications (1)

- Pseudarthrosis (no consolidation)
- Malunion (angulation, shortening)
- Secondary arthrosis
- Secondary infection





How to record the paleotrauma? (1)

Long bones & infracranial skeleton

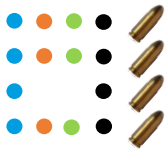
Skull vault

Nasal trauma

Non-nasal trauma

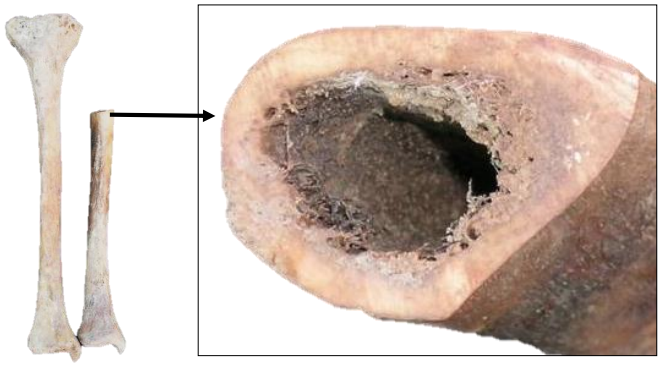
Description

Bone(s)
Side
Type
Healing status
Dimensions
Topographie
Complications



"Cultural" paleotrauma (1)

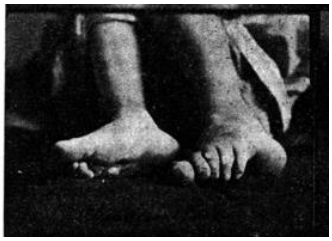
- Medical / medico-"religious" practices
  - surgery (amputations)
  - Trephinations
- Cultural practices
  - Feet deformation (China)
  - Cranial deformations



Prieuré Saint-Cosme, 11th-13th

“Cultural” paleotrauma (2)

- Medical / medico-"religious“ practices
  - surgery (amputations)
  - Trephinations
- Cultural practices
  - **Feet deformation (China)**
  - Cranial deformations



- *10th-20th c.*
- *Reduction of the feet volume and bandage shaping during children growth*
- *Only girls*

 Variot & Chatelin 1914, *Bull. Mém. Soc. Anthropol. Paris*

Bi4041 Paleopathology

Trauma & ageing

Degenerative paleopathology: Arthrosis

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Arthrosis (1)

- ***Arthrosis,*** *degenerative joint disease*

Destruction of the articulation cartilages with marginal osteophytes and subchondral osteosclerosis

Etym. gr. arthron : articulation ; -osis : chronic, degenerative

- *≠ Arthritis*

Inflammatory process (multiple etiologies: infection, immune, metabolic)

Etym. gr. arthron : articulation ; -itis : inflammation

Arthrosis (2)

Degenerative lesions:

- ~1/3 of all paleopathological observations

- Useful for past populations studies, dependency to
  - **Age:**
    - 50% > 60 years old, 85% > 70 y.o. (occidental countries)
    - *WHO: 10% of males & 20% of females > 60 y.o. worldwide*
  - **Activities**: trauma & microtrauma
  - Other factors: **Sex,** F/M = 3/1 to 2/1 (knee) ou 1/1 (hip), **genetic, obesity** *(mechanical, metabolic, hormonal)*

Severity & distribution

➔ Interpretations for the populations of the past

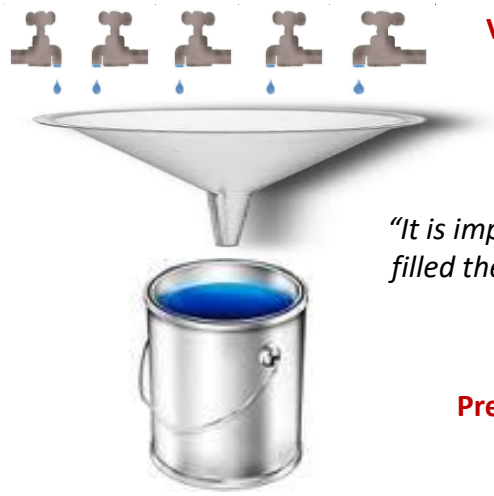
Population? Environment? Chronology? Culture?

➔ Social differences between men & women?

Arthrosis (3)

"Taps & Bucket model"

Modern epidemiologists



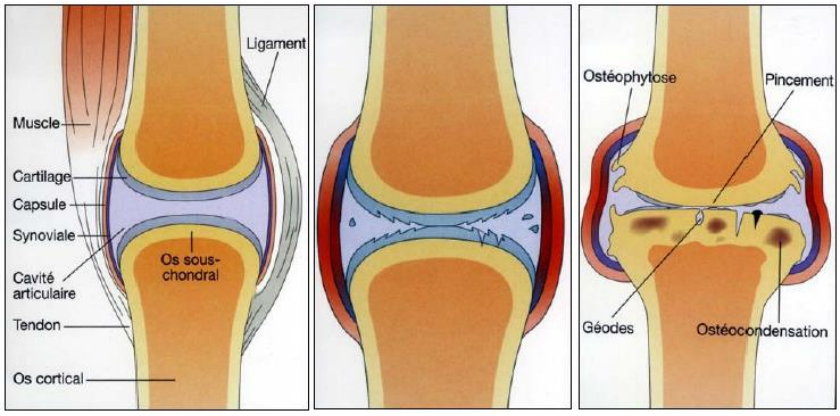
Various factors interacting to cause DJD

"It is impossible to tell which tap(s) filled the bucket merely by looking at the water in it"

Paleo-epidemiologists

Prevalence of DJD

Arthrosis (4)



Normal articulation | starting arthrosis | severe arthrosis

Signs

- (micro)porosities – *pitting*
- Osteophytes, geodes, sclerosis/eburnation

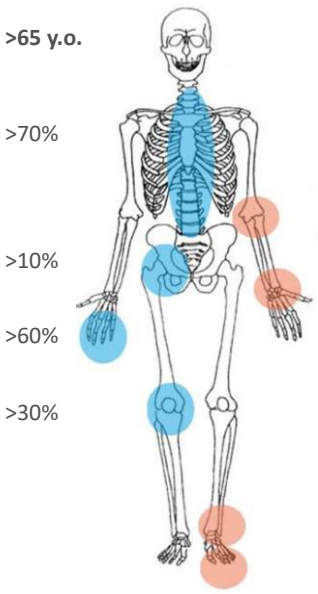
Arthrosis (5)

Primary (idiopathic)

- Multiple causes (including biomechanics)
- Late during life:
  - Vertebras
  - Hip, knee
  - Fingers

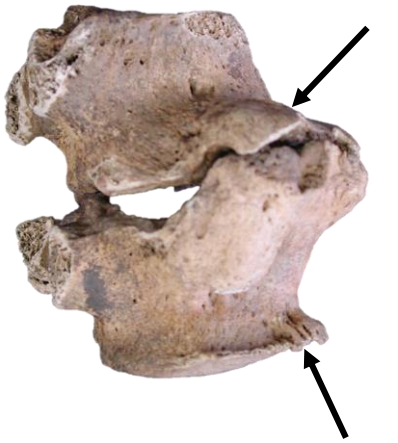
Secondary

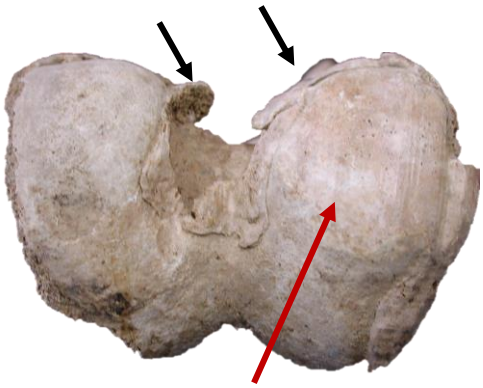
- Trauma, biomechanics, early during life:
  - elbow, wrist
  - ankle, foot

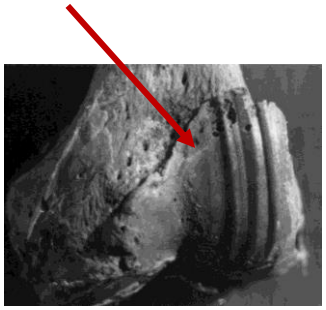


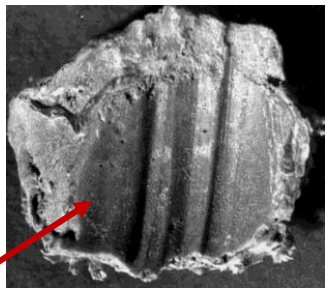
Arthrosis (6)

osteophytes **eburnation**









Arthrosis (7)

Articular deformation

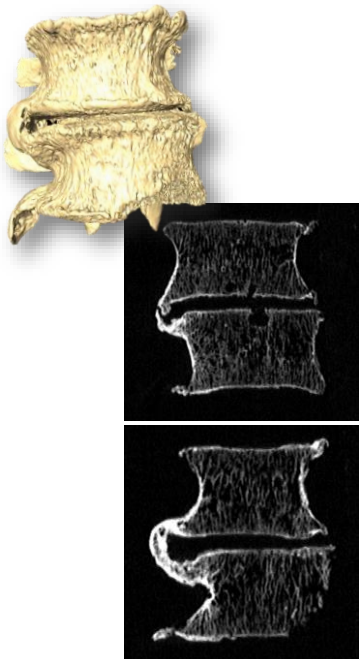
hips

Severe deformation ➔ destruction

shoulder

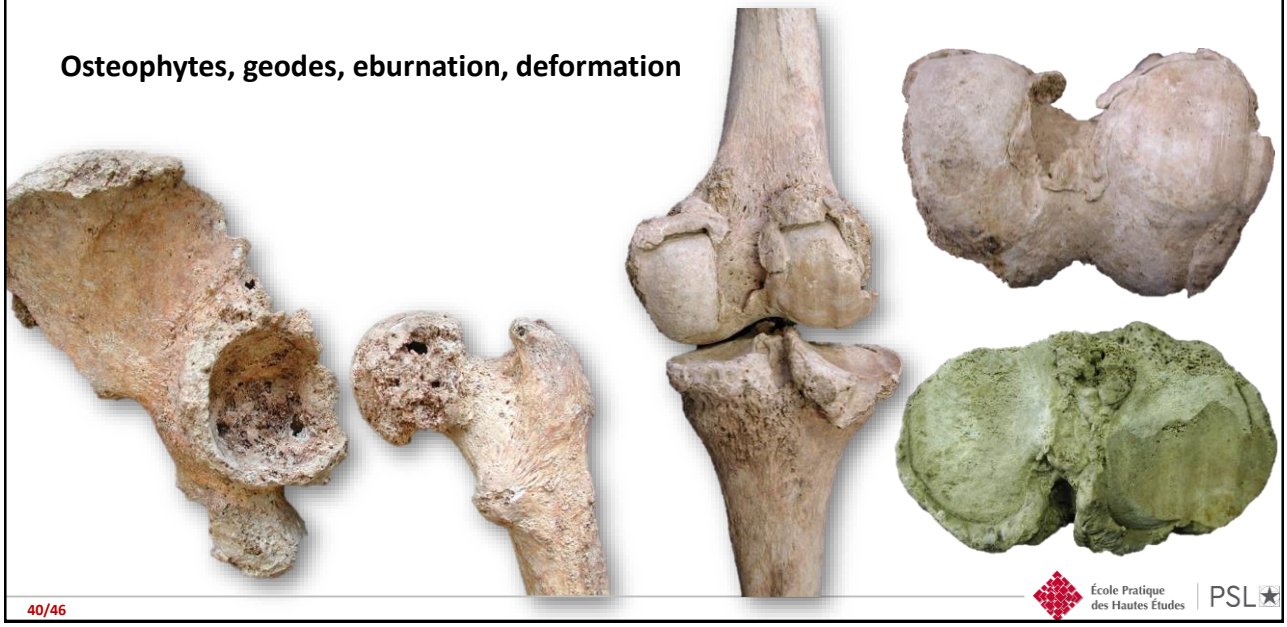
Arthrosis (8): vertebral

Osteophytes, porosities, syndesmophytes



Arthrosis (9): gonarthrosis, coxarthrosis

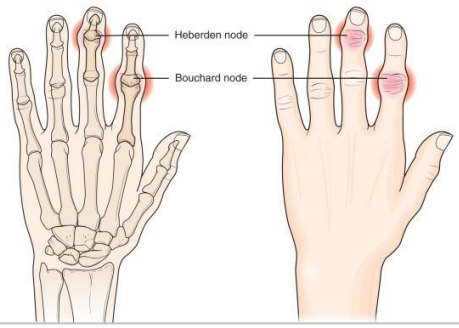
Osteophytes, geodes, eburnation, deformation



Arthrosis (10): interphalangeal arthrosis

Genetic determinism:
F >>> M
Mother/daughter heredity

- Distal location, Heberden's form (frequent)
- Proximal location, Bouchard's form (rare)

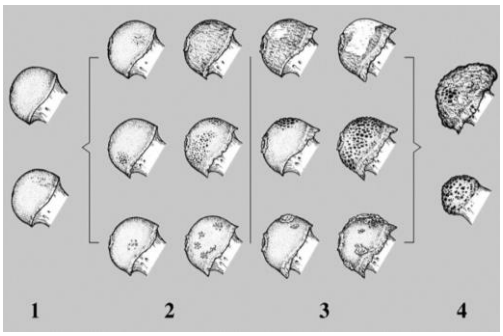


How to record the arthrosis (DJD) ?

Non-vertebral arthrosis :

- shoulder, elbow, hip, knee, hand/foot, wrist/ankle
- > 1 articular surface (higher score)

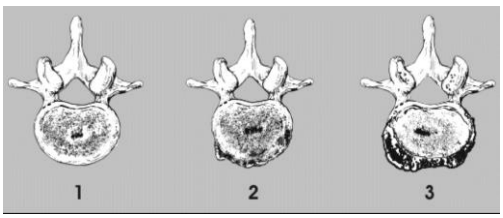
0 = non observable articulation
1 = articulation without pathological sign
2 = slight marginal osteophytes (< 3 mm), no eburnation, +/- microporosities
3 = big marginal osteophytes (> 3 mm), +/- eburnation, porosities
4 = articular surface destruction (>80%)
5 = synostosis



Vertebral arthrosis:

- Cervical, thoracic, lumbar levels
- Only vertebral bodies

0 = non observable VB
1 = without pathological sign
2 = small osteophyte at least on one vertebra
3 = big osteophyte at least on one vertebra



Bi4041 Paleopathology

Trauma & ageing

Degenerative paleopathology:
Other pathologies

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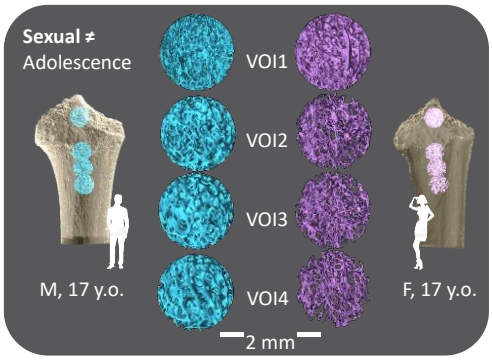
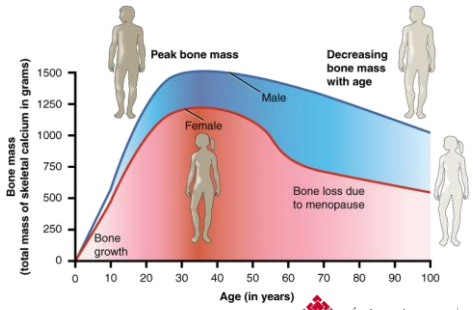
Osteoporosis (1)

Systemic affection of the skeleton
- Bone mass decreasing
- Degradation of the internal microstructures
- Fragile bones & **high risk of fractures**
- *(wrist, vertebras, femoral neck)*

In France: ~40% of the F >65 y.o. (70%, F >80 y.o.), cause of ~ 400 000 fractures/years (Inserm)

- **Primary osteoporosis**
  - type 1 : post-menopause
  - type 2 : elders (men **&** women)
- **Secondary osteoporosis**
  - Multiple factors: diseases, treatments by *corticoids* –, immobilization, weightlessness





43/46 *Colombo 2014, PhD thesis*

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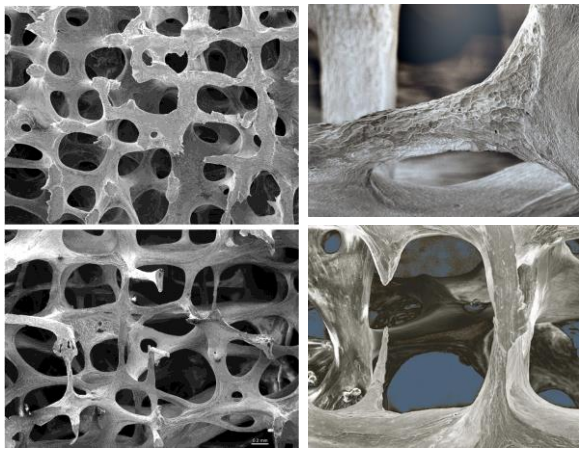
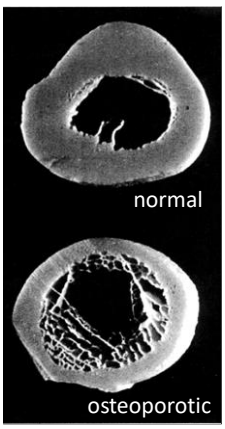
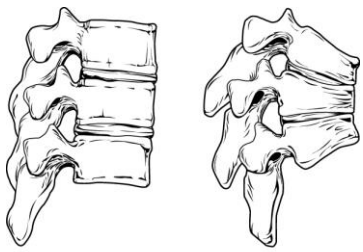
Osteoporosis (2)

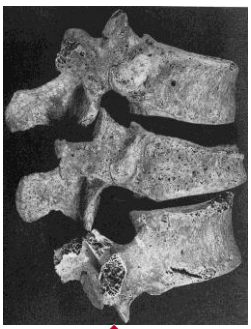
Rarefaction of the trabecular bone



Cortical thinning







44/46 Ortner, *2003*

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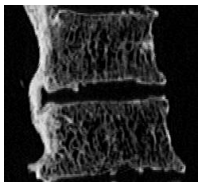
Hyperostosis (1)

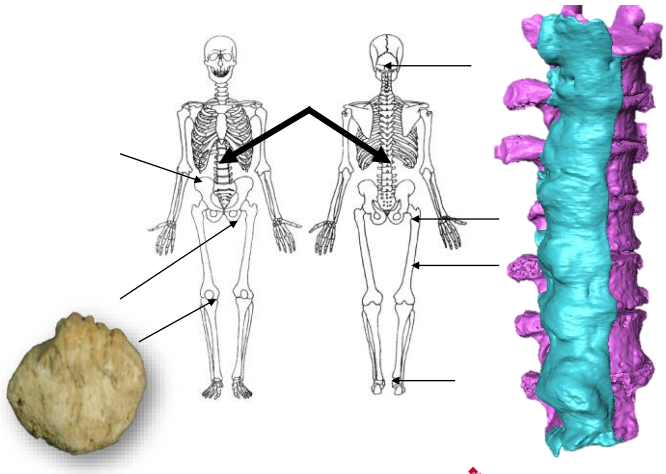


Diffuse Idiopathic Skeletal Hyperostosis (DISH)

- Frequent in paleopathology
- **Mainly men >40 y.o.**
- Multifactorial etiology: metabolic (obesity, diabetes)

New bone formation at the tendinous and ligamentous insertion sites

- **Spine** - ossification along the **right anterolateral** of the thoracic spine
- Peripheral regions: calcaneum, iliac crest, patella, olecranium, *etc.*

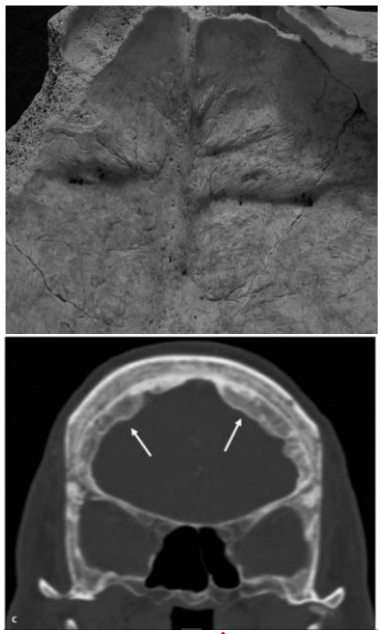


 Resnick *et al.*, 1975

Hyperostosis (2)

Internal Frontal Hyperostosis

- **F >>> M**
- > 50 y.o. (postmenopause)
- Endocranial expansion of the diploe (increasing internal porosity)
- Asymptomatic
- Hormonal regulation?



https://radiologykey.com/

 Brickley et Mays 2019, Metabolic diseases in Buikstra, Ortner's Identification of Pathological Conditions in Human Skeletal Remains, 3rd ed.

Děkuji !

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