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Fluctuating Relations of Hip and Knee Osteoarthritis : Prevalence in Late Prehistoric French Population

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Abstract

In this paper we compare the prevalence of osteoarthritis (OA) of hip and knee joints on skeletons series and relations between them. OA was registered from 166 individuals of Neolithic and protohistorical periods. Between Neolithic and Iron Age periods the ratio [hip OA/ knee OA] increases with diminution of knee OA prevalence; the ratio [patello-femoral OA / tibio-femoral OA] rather tends to decrease with diminution of the patello-femoral OA prevalence. These results would lead to display an inverse evolution of hip and knee OA than currently, in relation with the mechanical constraints during daily activities of these periods.

Key-words : osteoarthritis (OA), prevalence, ratio [hip OA/ knee OA], ratio [patello-femoral OA / tibio-femoral OA], Neolithic, Iron Age

Résumé :

Variation de l'arthrose de la hanche et du genou : sa prévalence dans une population française de la préhistoire récente.

Dans ce document nous comparons la prévalence de l'arthrose des articulations de la hanche et du genou dans des séries de squelettes et leurs relations entre elles. L'arthrose a été analysée à partir de 166 individus néolithiques et protohistoriques. Entre le Néolithique et l'Age du Fer, le ratio [arthrose de hanche / arthrose du genou] augmente avec la diminution de la prévalence de l'arthrose du genou ; le ratio [arthrose fémoro-patellaire /arthrose fémoro-tibiale] tend à diminuer avec la baisse de la prévalence de l'arthrose fémoro-patellaire . Ces résultats tendraient à montrer une évolution de l'arthrose de la hanche et de l'arthrose du genou, inverse de celle habituellement observée de nos jours, en relation avec les contraintes mécaniques liées aux activités quotidiennes de ces populations anciennes.

Mots-clés : arthrose, prévalence, ratio [arthrose hanche/arthrose genou], ratio [arthrose fémoro-patellaire / arthrose fémoro-tibiale], Néolithique, Age du Fer

Introduction

Osteoarthritis (OA) of the knee is a disease particularly developed during the last century, with a higher prevalence than the hip OA [28]. The predominance of the knee OA over the hip OA is appeared in post-medieval population [31], while the hip OA had been prevailing during earlier epochs. We have examined the frequency of those two localizations of OA over much more ancient periods, in order to observe if there was a particular evolution of their

prevalence and to discuss the epidemiological nature of them. In the present study, we have examined osteoarchaeological samples, coming from the region of Auvergne in France, and dated of Late Prehistory.

Material and methods

The skeleton populations were interred in five nearby cemeteries located in the east surrounding of the City of Clermont-Ferrand, in the plain of Limagne, eastward of "Monts Dôme" volcanic chain (figure 1). They chronoligically spread over three periods of burial: Neolithic with Pontcharaud and Le Brezet necropolis (4500-3800 BC), Bronze Age with Gerzat-Chantemerle necropolis (2000-1500 BC), and Iron Age (La Tène), with Aulnat-Gandaillat and Sarlième-Grande Halle necropolis (160-100 BC).

The average rate of conservation for hip and knee joints elements was 80.4% for all the series. A total of 312 individuals were exhumed (190 adults and 122 non-adults); 166 adults' skeletons were examined among which age was able to be determined. They were distributed among four age groups: < 30 (20-29), ≥ 30 (30-39), <50 (40-49), ≥ 50; like this, they were comparable ($\chi^2 = 8.88$) between Neolithic, Bronze Age and Iron Age samples studied here. Owing to the fact that very few cases were studied by sex, 99 males and 57 females were distributed among two age groups: < 40 (20-39) and ≥ 40. By periods the difference of age repartition of males ($\chi^2 = 2.7$) and females ($\chi^2 = 0.309$) was no significant (table 1).

Figure 1: Region of Auvergne and late prehistoric necropolis (agglomeration of Clermont-Ferrand)
(1): Gerzat Chantemerle (2): Le Brezet (3): Pontcharaud (4): Aulnat Gandaillat (5): Sarlième

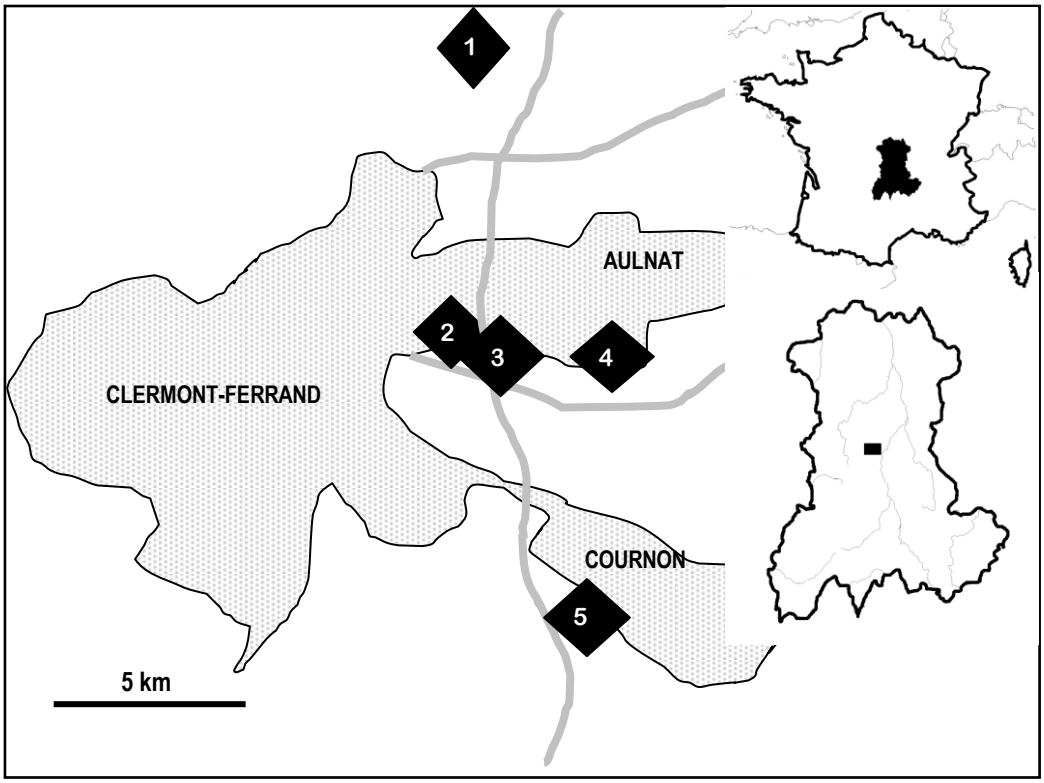

Table 1 : Distribution of the adult skeletons

	Adults (M + F + sex ?)				Males		Females	
age groups	*< 30*	*≥ 30*	*< 50*	*≥ 50*	*< 40*	*≥ 40*	*< 40*	*≥ 40*
Néolithic	10	12	18	10	9	18	13	10
Bronze Age	12	16	8	15	15	12	11	11
Iron Age	11	22	22	10	20	25	7	5

We have macroscopically registered the osteoarthritic lesions of the hip (acétabulum and femoral head) and of the knee (patellofemoral joint, medial and lateral tibiofemoral joint), working out the diagnosis of OA with the presence of osteophytes (≥ 1 mm) in all the cases, isolated or associated with eburnation. The exclusive presence of osteophytes on the side of subchondral bone is enough to diagnose OA (not very developed OA), while the presence of eburnation characterize a severe osteoarthritis [7, 12, 27]. In the "crude" prevalence calculation, the total number of individuals is used in the denominator. To make the calculation of "corrected" prevalence (paired joints with missing data), the denominator is the number of individuals with paired joints present added to number with a single diseased joint present [29].

Results

Altogether, 30 skeletons had an OA of the hip (Néolithic: 8; Bronze Age: 10; Iron Age: 12). That's square with 22.2% of males and 8.7% of females in Neolithic, 25.9% of males and 13.6% of females in Bronze Age, and 20% of males and 25% of females in Iron Age. Predominance of male hip OA is constant in time in this investigation. Bilateral forms concern all the affected females in Bronze Age and Iron Age, 33.3% of affected males in Neolithic, 71.4% in Bronze Age and 77.7% in Iron Age. 16 skeletons had an OA of the knee (Néolithic: 6; Bronze Age: 5; Iron Age: 5); here we have considered feasible the "global" knee examination when its three joints (patellofemoral, lateral and medial tibiofemoral) were present, each of them with at least one articular surface present. The patellofemoral OA concerns 13 individuals (Neolithic: 5; Bronze Age: 4; Iron Age: 4), and the tibiofemoral OA concerns 14 (Neolithic: 5; Bronze Age: 5; Iron Age: 4). The crude prevalence of OA of the knee decreases in time, whereas the OA of the hip is more constant, even slightly increased. The [hip OA / knee OA] ratio increases from Neolithic to Iron Age. The same result is observed with the corrected prevalences ratio. The [patellofemoral OA / tibiofemoral OA] ratio rather tends to decrease in time. The patellofemoral OA corrected prevalence decreases from the Neolithic to the Iron Age without particular tibiofemoral OA increasing tendency (table 2). In term of frequencies, 10 hip joints are osteoarthritic on Neolithic skeletons (10.7 %), 18 on those of Bronze Age (19.3 %) and 21 on those of Iron Age (19.4 %). With regard to the knees, 11 are osteoarthritic on the Neolithic skeletons (14.5 %), 8 on those of Bronze Age (13.1 %) and 7 on those of Iron Age (8.23 %). The osteoarthritic joints frequencies [hip / knee] ratio also increases from the Neolithic to the Iron Age (table 3). There is however no significant difference of prevalence and frequency rates between the three studied periods, but sampling size was small. (table 4). This was the case with distribution of OA in terms of age and sex, in which only higher male hip OA prevalence in ≥ 40 aged group of Bronze Age was significant (table 5).

In relation to individuals with hip OA, compared with recent prehistoric series of Auvergne, the frequency is significantly less important in modern European series (18^{th} to 19^{th} centuries). With regard to the number of hip joints with OA we note a high significant frequency in neolithics of Central Europa, and very low significant frequency in north American Hunters-Gatherers and Californian early agriculturalists. Except the low frequency of post-medieval Dutch individuals with knee OA, there is no significant difference with

another series. In opposition to hip OA, we note a high significant frequency of knee joints with OA in Hunters-Gatherers and early agriculturalists (table 6).

Table 2. Prevalence of hip and knee osteoarthritis

Period	M/F ratio	adults	P hip	P Knee	*P ratio hip/knee*	Pc Hip	Pc Knee	*Pc ratio hip/knee*	Pc PFJ	Pc TFJ	*Pc ratio PFJ/TFJ*
Neolithic	1.17	50	16.0	12.0	*1.3*	17.4 (8/46)	18.2 (6/33)	*0.9*	14.3 (5/35)	11.9 (5/42)	*1.2*
Bronze Age	1.22	51	19.6	9.8	*2.0*	22.7 (10/44)	19.2 (5/26)	*1.2*	12.5 (4/32)	14.3 (5/35)	*0.8*
Iron Age	3.75	65	18.5	7.7	*2.4*	23.5 (12/51)	13.9 (5/36)	*1.7*	9.1 (4/44)	10.0 4/40	*0.9*

M : males ; F : females ; P : crude prevalence ; Pc : corrected prevalence ; PFJ : patellofemoral joint ; TFJ : tibio-femoral joint

Table 3. Frequency of hip and knee osteoarthritic joints

	Neolithic			Bronze Age			Iron Age		
	N	n	*%*	N	n	*%*	N	n	*%*
hip OA	93	10	*10.7*	93	18	*19.3*	108	21	*19.4*
Knee OA	76	11	*14.5*	61	8	*13.1*	85	7	*8.2*
hip OA/knee OA			*0.7*			*1.5*			*2.4*

N: Total number of joints; n: osteoarthritic joints

Table 4. Differences of corrected prevalence of individuals with hip and knee OA and frequency of osteoarthritic joints (*) (Fisher's exact test).

	NEO – BRZ	NEO – IRN	BRZ - IRN
Hip OA	0.3561	0.3115	0.5613
Knee OA	0.6716	0.4365	0.4107
Hip OA*	0.0751	0.0651	0.5656
Knee OA *	0.5106	0.1579	0.2463

(NEO: Neolithic BRZ: Bronze Age IRN: Iron Age)

Table 5: hip and knee OA crude prevalence **(%)**

Age		< 40			≥ 40		
		Hip	PFJ	TFJ	Hip	PFJ	TFJ
Neolithic	M	2/9 (**22.2**)	0/9	1/9 (**11.1**)	4/18 (**22.2**)	3/18 (**16.6**)	3/18 (**16.6**)
	F	*1/13 (**7.7**)*	*0/13*	*0/13 -*	*1/10 (**10.0**)*	*2/10 (**20.0**)*	*2/10 (**20.0**)*
Bronze Age	M	0/15 -	0/15	1/15 (**6.6**)	7/12 (**58.3**)*	3/12 (**25.0**)	3/12 (**25.0**)
	F	*0/11 -*	*0/11*	*0/11 -*	*3/11 (**27.2**)*	*1/11 (**9.1**)*	*2/11 (**18.2**)*
Iron Age	M	2/20 (**10.0**)	0/20	1/20 (**5.0**)	7/25 (**28.0**)	4/25 (**16.0**)	2/25 (**8.0**)
	F	*1/7 (**14.3**)*	*0/7*	*0/7 -*	*2/5 (**40.0**)*	*0/5 -*	*1/5 (**20.0**)*

(:Fisher test= 0.0009)*

Table 6: Hip and Knee Joints : Prevalence of skeletons and joints with osteoarthritis (comparative data)

HIP (adults)	Skeletons with OA (%)		L+R hip joints with OA (%)	
(1) Auvergne Néolithic	17.4 (8/46)	*0.0 (0/45)*	10.7 (10/93)	*0.0 (0/93)*
(2) Auvergne Bronze Age	22.7 (10/44)	*13.9 (6/43)*	19.3 (18/93)	*9.7 (9/93)*
(3) Auvergne Iron Age	23.5 (12/51)	*6.0 (3/50)*	19.4 (21/108)	*3.7 (4/108)*
Central Europe Néolithic (a)			22.2 (28/126) (1)	
Hunters-Gatherers (b)			3.6 (3/84) (2) (3)	
Agricultural Mississipi (c)			1.2 (1/84) (1) (2) (3)	
Agricultural Californie (d)				*0.3 (1/281)* (2) (3)
British Post-Medieval (e)	15.4 (85/551)	*2.4 (13/550)*		
Dutch 14th - 16th centuries (f)	12.0 (11/92)			
French 11th - 17th centuries (g)	25.7 (27/105)			
Modern Dutch 18th - 19th centuries (h)	9.2 (16/173) (2) (3)			

Knee (adults)	Individuals with OA (%)		L+R knee joints with OA (%)	
(1) Auvergne Néolithic	18.2 (6/33)	*0.0 (0/32)*	14.5 (11/76)	*0.0 (0/76)*
(2) Auvergne Bronze Age	19.2 (5/26)	*4.2 (1/24)*	13.1 (8/61)	*1.6 (1/61)*
(3) Auvergne Iron Age	13.9 (5/36)	*2.8 (1/35)*	8.2 (7/85)	*1.2 (1/85)*
Central Europe Néolithic (a)			12.6 (14/111)	
Hunters-Gatherers (b)			31.9 (37/116) (1) (2) (3)	
Agricultural Mississipi (c)			11.4 (12/105)	
Agricultural Californie (d)				*6.4 (16/250)* (1) (3)
British Post-Medieval (e)	11.0 (61/554)	*4.0 (22/554)*		
Dutch 14th - 16th centuries (f)	5.2 (4/77) (1) (2)			
French 11th - 17th centuries (g)	21.9 (117/534)			
Modern Dutch 18th - 19th centuries (h)	6.4 (11/173)			

(1)(2)(3) : Significant différence with Néolithic (1), Bronze Age (2), and Iron Age (3) samples of Auvergne.
In italics: severe osteoarthritis (with eburnation of subchondral bone)
(a) 5700 BC. [7]
(b) 6000-1000 BC (age> 30) North America [4]
(c) 1200-1500 AD. (age> 30) [4]
(d) 1100-1500 AD. [13]
(e) 900-1850 AD. [26]
(f) 1375-1572 AD. [17]
(g) [9]
(h) [1]

Discussion

The greatest care must be taken before consider several causes like biological or environmental aetiologic factors of OA by reason of bias in palaeoepidemiological population [30]. Despite their small number of individuals, the samples studied here are still numbered among the necropolis of late Prehistory having the greatest amount of well preserved skeletons available for study in Auvergne. We note that hip and knee OA (tibiofemoral OA) affect young individuals, particularly males. Osteoarthritis is not ineluctably age-related, with an important worldwide variation: elderly people are habitually affected in industrial societies and young people in agropastoral communities [19]. We note that hip and knee OA

(tibiofemoral OA) affect also young individuals, particularly males. Diachronic fluctuation of OA prevalence could be debated on hardiness of life and heavier bony and muscular constraints with age emergence of adult activity in young body [6] : the earlier is adult activity, the better is skeleton adaptation to physical stress [22, 24], and the lesser is later degenerative arthropathy development [20, 23]. Higher OA prevalence in prehistoric hunter-gatherers than agriculturalists could be doing an adult activity during youth with the first, and infancy with the second [14]. The same difference was observed in ethnographic studies, the OA frequency varying with age of outset in adult activity, the sex, and duration of mechanical constraints [21]. The late prehistoric populations of Auvergne were contemporaneous with an important agricultural development, while living on the same geomorphological context. Except biological factors like polygenic factors we cannot here display to explain fluctuations of lower limbs OA, we can evoke environmental and daily activities conditions. We know that agricultural activity was progressive in this region of Auvergne, developing during the Bronze Age between 1200 and 700 BC and especially before the First Iron Age (700-450 BC); like this, the plain of Limagne at once was deforested to create meadows, then the surrounding hills during the Iron Age and the Gallo-Roman period. A decline of farming acquisition during early and middle Bronze Age with pejorative climatic period and forest extension came before the favourable climatic context of late Bronze Age: populations leaving surrounding mountains have colonized low alluvial plains to deforest and drain them; during Iron Age all biotops are inhabited with small area farms in clear lands; the unique proto-urbanization of Aulnat Gandaillat site is unique in Limagne plain, probably the first capital of Arvernes gallics. In the same time barley and millet cultivating have given way to market garden produce (lentils, peas), wheatfields, and diversified craftsmen : weaving (flax, hemp), iron and glass things manufactures [2, 3, 8, 18].

The recent development of tibio-femoral OA during the last centuries (post-medieval period), and the commonly observation of hip and patellofemoral OA on skeletons every time and everywhere in the World results in decrease of [hip OA / knee OA] and [patellofemoral OA / tibiofemoral OA] ratios in time; this would be following on a change of knee OA expression with the development of obesity and sport that destabilize the tibiofemoral joint [25]. On the contrary, in our sample of the late prehistory of Auvergne, the [hip OA/ knee OA] ratio tends to increase in time whatever the method of its calculation may be. Though it is not statistically different, the progression tendency of hip OA over knee OA could be in relation with the agricultural development which became more marked between the Neolithic and the Iron Age. The farmers indeed have a higher risk of developing hip OA than knee OA [5], however with a moderate evidence level for hard activities in hip OA apparition [16]. In the series studied here, the decrease in time of the [patellofemoral OA / tibiofemoral OA] ratio is more the fact of the patellofemoral joint OA decreasing, and especially reflects the male disease which prevails. Actually, on the contrary, the risk of progression of knee OA increases more with females, whatever their ethnic origin is, with increase of the body-mass index, a moderate defect of lower limbs alignment, or the consequence of physically painful works especially in knelling or squatting positions ([11, 15]. The OA distribution observed here on the knee joint surfaces can suggest genetic predispositions or mechanical constraints that are different with periods which could have modified the tibiofemoral alignment [10] ; the variations of the weight are although totally unknown to us during theses periods. Squatted position with bent knees and/or a more important *genu valgum* tendency development could be particularly suggested, in consideration of the lateral tibiofemoral joint is here more and more affected by OA between Neolithic and Iron Age in males. [32]. At least it’s one hypothesis to verify with complementary case reports.

Conclusion

This work shows a diachronic inverse evolution of what is known for post-medieval and modern periods, namely the increase of hip OA prevalence compared with the knee OA which dominates the clinical scene at present. If the evolution we know today has begun there two or three centuries, it would have apparently known inverse fluctuations in the past. We can incriminate particular genetic factors, but also evoke functional characters which were able to influence the progression of hip osteoarthritis, in touch with agricultural activity and increasing of cultivated surfaces after deforestation. It would be useful to spread the comparison to the current epidemiological studies on agro-pastoral populations still not benefiting from a mechanized technological contribution; these works yet remain very rare. With the progression of lateral tibiofemoral OA between Neolithic and Iron Age, we evoke the possible influence of repeated and prolonged practice of squatting with knee bending by some individuals in their daily activities, or the propensity in the knee malalignment.

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