Qafzeh 9 Early Modern Human from Southwest Asia: age at death and sex estimation re-assessed

Dany Coutinho-Nogueira, Hélène Coqueugniot, Anne-Marie Tillier, Dany Coutinho Nogueira

Qafzeh 9 Early Modern Human from Southwest Asia: age at death and sex estimation re-assessed

Dany Coutinho-Nogueira [1,2, 3], Hélène Coqueugniot [1,2], Anne-marie Tillier[1]

1 – University of Bordeaux . CNRS, MCC, PACEA, UMR 5199, F-33600 Pessac, France
2 - EPHE- PSL University, PACEA, F-75014 Paris, France
3 – University of Coimbra, CIAS - Research Centre for Anthropology and Health, Department of Life Science, PT-3000-456 Coimbra, Portugal

Corresponding author: Dany Coutinho Nogueira

e-mail adress: dany.nogueira@uc.pt

Address: CIAS - Research Centre for Anthropology and Health, Departamento de Ciências da Vida, Universidade de Coimbra, Calçada Martim de Freitas, 3000-456 Coimbra, Portugal

with 5 figures and 6 tables

Keywords

Early modern human; Southwestern Asia; sex estimation; age at death estimation; biological profile

Abstract

Qafzeh 9 is an almost complete skeleton commonly employed as representative of the population of the eponymous site. However, its biological profile is still largely based on the age at death and sex estimation methods in use at the time of its discovery. Moreover, post-mortem damage to the skeleton has made difficult the observation of some morphoscopic features, particularly pelvic ones currently used in sex estimation.

Here, we apply recent methods and paleoimaging to re-evaluate the biological profile of Qafzeh 9, taking into account post-mortem damage. The results suggest a young age at death, indicating that Qafzeh 9 died before reaching complete dental and bone maturity; they also support a male sex assignment.

1. Introduction

The period between 220-45 ka B.P. is crucial for understanding the evolution and dispersal of early anatomically modern humans from Africa, especially in Southwestern Asia (Bar Yosef 2000). In this context, Qafzeh Cave in Lower Galilee (Israel) is of particular interest (Vandermeersch and Bar Yosef 2017) with regard to its anthropological documentation. Dated to 92 ± 5 ka B.P. (Schwarcz et al. 1988; Valladas et al. 1988), the site yielded a unique sample of individuals (Vandermeersch 1981; Tillier 1999; Tillier 2014) that represent all age classes from perinatal to adulthood. In addition, the site provides evidence for unique Middle Palaeolithic funerary practices, the presence of engraved artefacts and the use of ochre and marine shells (Vandermeersch 1969a, b; Tillier 1995; Hovers et al. 1997, Hovers et al. 2003; Bar Yosef Mayer et al. 2009).

Qafzeh 9 was discovered together with a child ca. 6 yrs old at death (Qafzeh 10) in a double burial found during the third excavation season (Vandermeersch 1969). As it is one of the most complete skeletons, Qafzeh 9 is often used as the “type” of the Qafzeh group. However, partly due to post-mortem distortions, the biological profile of Qafzeh 9 has sometimes been questioned, primarily its sex. Various analyses favoured identification as a female (Vandermeersch 1981; Brůžek and Vandermeersch 1997) or probably female (Trinkaus 1984). Vandermeersch (1981) used several pelvic morphological features such as the Schultz's ischio-pubic index (Schultz 1930), the opening of the sciatic notch, the cotylo-sciatic width as well as the subpubic angle. Finally, Vandermeersch (1981) noted the general level of gracility of the cranial and infracranial skeleton. The pelvic morphologic observations were later confirmed in a metric and statistical study (Brůžek and Vandermeersch 1997).

A number of researchers supported a male diagnosis, based on other pelvic morphoscopic features (Rosenberg 1986; Rosenberg et al. 1988; Rak 1990; Frayer et al. unpublished). For example, Rak (1990) drew attention to the similarities with contemporary male pelves, quoting several indices calculated from measurements taken on the pubis and ischium that lie within the range of male variation. For Rosenberg (1986: 114), several characters of the hipbone "leave little doubt that it is a male specimen". In particular, she pointed to the morphology of the ischio-pubic rami, the absence of ventral arch and the concavity of the lower pubic ramus. She also noted that the index determined from the length of the pubis in relation to the diameter of the femoral head squared was completely outside the range of female variation (Rosenberg et al. 1988). Furthermore, in her doctoral dissertation, Rosenberg mentioned an unpublished study conducted by Frayer and colleagues (n.d.) that suggested the young age of the individual could be the reason for the overall gracility of the skeleton. Later, these authors also identified Qafzeh 9 as a male (Frayer et al. 2006: 1999, note 10). Coqueugniot et al. (2000) also suggested a male assignment, based on the mandibular ramus posterior flexure.

These differing sexual diagnoses can, in fact, be partly explained by the young age at death of Qafzeh 9, "at the limit between adolescence and adulthood" (Vandermeersch 1981:49), but also by the distortions of the pelvic bones due to post-mortem processes and sediment weight (Fig.1).

Despite the first study indicating a young age at death, Qafzeh 9 is often described as an adult (e.g. Ponce de Leon and Zollikofer, 2001; Vandermeersch and Bar-Yosef, 2009; Schwartz and Tattersall, 2010; Quam et al. 2011; Franciscus and Holliday, 2013), or with an age at death of 20-21 years (Rak, 1990).

Given the number of differing interpretations of the biology of the Qafzeh 9 specimen, we propose to re-evaluate its age at death and sex employing recently developed methods.

2. Material and methods

Qafzeh 9 is housed at the Department of Anatomy and Anthropology, Sackler Faculty of Medicine, Tel Aviv University. In order to re-evaluate the biological parameters of this fossil, we examined the original bones and used radiographs and micro-CT scans (Coutinho Nogueira 2019). Micro-CT-scans of the Qafzeh 9 mandible (isometric voxel size of 80 μm) and skull (voxel isometric voxel size of 200 μm) were employed to estimate its dental age at death. Micro-CT slices and 3D reconstructions were analyzed using TIVMI® software (Dutailly et al., 2009; Guyomarc'h et al., 2012) based on the HMH (Half Maximum Height) algorithm (Spoor et al., 1993). A plain X-ray of the mandible was also used for observing ~~of~~ the degree of calcification of the teeth.

2.1. Age at death estimation

Several sources of information can be used for estimating the age at death of Qafzeh 9. The dental age of Qafzeh 9 was re-evaluated from micro-CT images and radiographs according to the charts of tooth formation stages developed by Moorrees *et al* (1963), AlQahtani *et al* (2010) and Esan (2017), studies involving population samples from different continents. Only complete teeth preserved in the alveolar bone are included in the analysis, as post-mortem damage may bias the observations. It is not possible to observe and score the complete dental series of Qafzeh 9, which excludes the methodological approach proposed by Demirjian et al. (1973).

Skeletal age and infracranial bone maturation were evaluated following the practical criteria of developmental osteology published by Coqueugniot and Weaver (2007) and Coqueugniot *et al.* (2010). The estimation was calculated by the BAE package (Bayesian Age Estimation for Anthropological Purposes, v. 1.3.1) in R and with the MACROS ARCHEO software (Coqueugniot et al. 2018). In addition, radiographs of the two hand bones were employed to evaluate ossification of the metacarpal heads and fusion of the phalangeal epiphyses; the age at death estimation is given according to Birkner (1978) and Scheuer and Black (2000).

Previous paleopathological studies carried out on the Qafzeh 9 infracranial bones (Dastugue 1981; Arensburg et al. 2006) did not reveal any conditions that might involve a change in maturation rate. Minor bone growth disorders were detected on the mandible (Coutinho Nogueira et al. 2019).

2.2. Sex estimation

It is primarily pelvic morphology that provides a reliable sex estimation. We use the method of Probabilistic Sexual Diagnosis version 2 that takes into account hip bone measurements (Brůžek et al. 2017). Measurements were taken on the Qafzeh 9 hip bones housed in Tel Aviv and then by other observers on a high quality cast at the PACEA laboratory (University of Bordeaux). Because of the plastic deformations suffered by the fossil, two of the authors (DCN and HC) as well as three other observers familiar with the DSP2 method took measurements to account for inter-observer error. No instructions were given to the observers concerning the management of distortions.

We also applied the methodological approach employed by Klales and colleagues for adults and non-adult~~s~~ individuals (Klales et al., 2012; 2017) adapted from Phenice (1969) and based on a small number of pelvis morphological features.

Finally, as the talus and calcaneus of Qafzeh 9 are well preserved, we applied discriminant function equations recently developed for paleoanthropological purposes and sex assignment by Alonso-Llamazares and Pablos (2019). Dimensions of the left bones were used preferentially.

3. Results

3.1. Age at death estimation from dental maturation

The micro-CT slices allowed a precise visualization of tooth development, especially the most advanced stages of root apex closure. The observations were performed on the left side of the mandible and maxilla, the alveolar bone being less affected by post-mortem processes. The two permanent incisors, the first premolar and the first mandibular molar with complete maturation were scored Ac (apical closure complete), according to the stages listed by Moorrees et al (1963). Two mandibular teeth, the canine and the second premolar, have roots whose apex is not completely closed; they are scored A½ (Apex half closed). As the roots of the second and third molars are affected by post-mortem damage, and the underlying alveolar bone is no longer present, M2 was scored as between Rc (root length complete) and Ac and M3 was scored Rc in order to provide a minimal stage of development. The roots of the two maxillary premolars are complete (Fig.2).

Accurate observations on the plain X-ray of the mandible show the taphonomic damage on the lower part of the mandibular body and the uncertainties concerning the apex opening/closure of M2 and M3 roots (Fig.3). Tooth formation stages are given in table 1.

The method of Moorrees et al (1963), based solely on mandibular teeth, provides a broad estimation of the age at death, around 14.5 by combining the two sexes (12-14.5 for a female individual and 13.5-15.5 for a male individual). Clearly, the lower limit of this variation, based on the non-closure of the canine and 2nd premolar root apex, underestimates the age at death of the individual. Including upper premolars and reference to the tables of AlQahtani et al. (2010), the minimal estimation is 14.5 years. If we exclude the canine and 2nd premolar, whose stage of development could be influenced by the quality of our images (micro-CT scan) compared to the radiographs used for developing the two methods, we can only propose a minimal age of 13.5 according to Moorrees et al (1963) and at least 17.5 according to AlQahtani et al. (2010).

The WITS Atlas of tooth formation and emergence (Esan 2017) gives an age estimation ranging between 14.5 and 16.5 years. If we exclude the canine and the 2nd premolar, a minimal age of 15.5 years can be proposed. As the WITS Atlas only provides a mean age for the M3 occlusion, maturation stage of M3 was not considered.

3.2. Bone maturation and age at death

X-ray examination of the Qafzeh 9 hand bones permits an evaluation of ossification stages. The distal phalanges of left digits 1 to 4 and that of the right digits 1 and 3 show evidence of an endochondral ossification line. The status of some proximal phalanges is more difficult to evaluate due to the normal shape of the proximal articular facet of the base as illustrated by the right third digit (fig.4).

In modern populations, the completion of hand bone osseous development occurs between 13 and 14.5 for the female sub-adults; 13 and 16.5 for the male ones (Birkner, 1978; quoted by

Scheuer and Black 2000). As the visibility of a fusion line can persist radiographically after full fusion, these observations provide a minimal age of 13 for Qafzeh 9.

The scoring of bone fusion of other infracranial remains was carried out taking into account their state of preservation. Stages of fusion are given in table 2.

Ossification of Qafzeh 9 lower limbs appear~~s~~ more advanced than that of the upper limbs. Some epiphyseal fusion is complete on the lower limbs while still in progress on the upper limbs. For example, the distal and proximal extremities on the left tibia are fused while the distal end of the ulna is still clearly in the process of fusion (Fig.5)

The BAE package (Coqueugniot and Weaver 2007) estimates the age of Qafzeh 9 between 18 and 21 years with a higher probability for 19 years (p=0.557).

The MACROS software (Coqueugniot et al. 2018) estimates the age of Qafzeh 9 between 18.5 and 20.3 years (estimate: 19.4195; Mean Error: 1.843811; Pseudo R^2: 0.8592267) from a sample of 211 individuals.

The results between the BAE package and the MACROS software are therefore similar with an estimated age around 19 years, the range being slightly smaller with MACROS.

From the results, it appears that Qafzeh 9 died before reaching complete bone maturity, however epiphyseal union was ongoing before death; in this context we can expect to sex the skeleton with some degree of reliability.

3.3. Sex estimation

For sex estimation, we first examined the coxal bones and the DSP2; the results including inter-observer variation are summarized in table 3:

For all observers, a reasonable conclusion is a male with a probability of more than 95%. The test with the maximum and minimum values of each variable also results in a male sex identification. Adding or removing the two less discriminating variables, SIS and VEAC, slightly alters the probabilities of observers 2 and 3, increasing the probability of a male result.

The results of macroscopic methods (Klales et al 2012, 2017) adapted from Phenice (1969) are summarized in table 4.

In Klales et al (2012) ordinal scores range from 1 (female) to 5 (male). In Klales et al (2017) ordinal scores range from 1 (female) to 3 (male). The VA is not scored on non-adults. Our observations confirm Rosenberg’s (1986) descriptions concerning the subpubic concavity and ventral arc. However, due to taphonomic distortions, we do not score the medial aspect of the ischio-pubic ramus. Overall, the results are consistent with a male assignment.

Of the 24 discriminant equations using the tarsal bones tested on Qafzeh 9, 18 give a male result and 6 a female result, i.e. 75% male and 25% female. Taking into account only the multivariate equations that have a slightly higher rate of an accurate determination on average, 91.6% of the equations give a male result (Table 5).

From the application of three methods of sex estimation, we thus obtain a male attribution for Qafzeh 9.

4. Discussion

The cross-checking of the different methods of age at death estimation provide an age estimation comprised between 18.5-20.5 years old (Table 6). Indeed, this range age is provided by all used methods. However some differences can be noted between the different methods.

There may be several reasons for the differences between methods. Age estimation methods are population-dependent and lose precision when they are applied to other populations (Franklin 2010). The collection studied by Moorrees et al (1963) consisted of 346 North American children who lived in the 20th century. The London Atlas proposed by AlQahtani et al. (2010) refers to truly documented samples and radiographs from dental institutes: 704 individuals from the 18th to the 20th century (children from England and Bangladesh). The recent study reported on 540 South African children (Esan 2017) provides evidence of discrepancies with the London Atlas established by AlQahtani and colleagues. However, there are some inconsistencies in the ages of M3 eruptions in this work, so the estimations should be taken with caution.

The dental ageing developed by Moorrees et al. (1963) refers to radiographic observations. We have established our analysis on three types of images: a classical X-ray, a radiograph made from a micro-CT scan and on micro-CT sections directly. The plain X-ray of Qafzeh 9 mandible shows the opening of the canine apex. The microtomodensitometric sections allow a finer observation of the apex of the second premolar and its scoring. In the case of Qafzeh 9, the method of observation could have influenced the scoring, and under estimate the age when using the canine and the 2nd premolar maturation stages.

The age estimation based on the third molar maturation is significantly different using either Moorrees et al (1963) or AlQahtani et al (2010) charts. The reasons for this could be different maturation rates between populations. Indeed, Liversidge (2008) noted that Southern African have significant faster maturation rates for the third molar than White and Bangladeshi children. A similar observation was noted by Blankenship et al (2007) with Black Americans having faster maturation rates compared to White Americans, and Legović et al (2010) discussed differences in maturation between Croatian children and those of several other populations (Sweden, Japan, South Africa, Israel, Turkey, etc.). In a comparative study of dental development in Upper Pleistocene hominins (Neanderthals/archaic Homo sapiens and Early Modern/Upper Paleolithic samples) and two recent samples, Tompkins (1996:113) underlined “similarities between the two fossil groups and Southern Africans in advanced relative M2 and especially M3 development” compared to French-Canadians. Regarding Qafzeh 9, the M3 is fully erupted, while the lower canine and second premolar have roots whose apex is not completely closed. Besides population differences, sex, health status and diet have also to be considered in the variation of third molar development and eruption (Garn et al. 1961, Garn et al 1965).

The parameters from the definition of ossification stages (Coqueugniot and Weaver 2007; Coqueugniot et al 2010) are implemented after the study of the Coimbra documented collection in Portugal (137 individuals aged between 7 and 29 years old from the 20th century). Accuracy of age estimation from skeletal development is thought to be more sensitive to environmental factors (Lewis and Garn 1960; Liversidge et al 1998; Cardoso 2007; Colombo et al 2013). In addition, as for the use of dental references, bone maturation criteria originate from current populations and might therefore lead to slight discrepancies in age estimations of prehistoric populations having different lifeways.

Based on a combination of the results brought by examination of tooth and bone development, it appears that Qafzeh 9 was an individual who had not achieved full skeletal and dental maturity at the time of death. An average of between 18.5 and 20.5 years at the time of death would appear to be most reasonable.

The application of the DSP2 method provides some discrepancies between the measurements made by different observers, due in part to post-mortem distortions of the pelvic bone. Yet all results favour identification as a male. Sex estimation methods based on pelvic parameters defined on recent populations has already been tested on early modern humans. Indeed, the 1st version of the DSP (Murail et al 2005), using the same variables as for the DSP2, was applied to European Upper Palaeolithic and Mesolithic adult hominins (Gambier et al 2006; Hansen et al 2017); in the case of the Danish study, molecular analyses confirmed the sex estimation following the DSP2 (Hansen et al op. cit.). Interestingly, sex estimation based on pelvic morphology applied to young Upper Palaeolithic individuals (same age class as Qafzeh 9) from Dolní Věstonice (Brůžek 2002; Brůžek et al., 2006) has also been confirmed by DNA data (Mittnik et al. 2016). The 3D reconstruction methods do not currently permit the correction of these distortions; the measurements are dependent on the interpretation of the observers, even if the 5 observers are familiar with the method. It is therefore advisable to exercise caution and to cross-validate the DSP2 with other methods, both on the pelvis and on other anatomical regions.

The methods adapted by Klales et al (2012; 2017) for adult and non-adults result in the identification of Qafzeh 9 as male, supporting the results of the DSP 2. The discriminant equations developed on the posterior tarsal bones (Alonso-Llamazares and Pablos 2019) are established from a Northern American recent population (United States). Again, their application to fossil specimens may be subject to discussion. The biomechanical constraints on the foot bones of current sedentary populations are different from those of ancient nomadic peoples. Nevertheless, 75% of the equations result in the identification of Qafzeh 9 as a male, a percentage that rises to 91.6% when the equations include several variables. In cases where the results were negative and therefore female, the values are always close to 0 (between -0.521 and -0.0032), while the positive results are in some cases much higher than 0 (between 0.419 and 2.59). This would appear to give greater weight to the identification as male. Sexual dimorphism of tarsal bones is strongly correlated with size, with male individuals having larger bones (Steele 1976; Introna et al. 1997; Bidmos and Asala 2003, 2004). If the maturation of Qafzeh 9 was not fully achieved, measurements taken on the bones would then be underestimated. Higher values would increase the results of the equations.

The results and observations based on metric and morphologic analyses of the pelvis and tarsal bones presented here suggest Qafzeh 9 was a male, in agreement with previous publications on the pelvis (Rosenberg 1986, 1988; Rak 1990; Frayer et al. 2006) and on the mandible (Coqueugniot et al 2000).

It is widely accepted that the pelvic morphometrics furnish the best indications of sex. Yet, a few traits of Qafzeh 9 skull do not clearly align it with other Qafzeh adult hominins (6 and 25) who were referred to as male using the general cranial robusticity (Vandermeersch 1981, Schuh et al., 2017, Coutinho Nogueira et al. 2021). The age reached by Qafzeh 9 cannot constitute an argument for interpreting the morphology of the skull distinct from that of other Qafzeh males, ignoring post-mortem alterations (Tillier in preparation). Such results lead to a reconsideration of the importance previously given to skull features in female sex determination of Qafzeh 9, as in those of many other fossil hominins. As a consequence, the choice of Qafzeh 9 as the “holotype”(type specimen) can be challenged regarding the mixture of traits and the differences with other Qafzeh male individuals. These observations affect the homogeneity of the Qafzeh sample.

Conclusion

While the discovery of new fossils is crucial for the understanding of the evolutionary processes of our species, the re-examination of previously discovered fossils with new methods can provide valuable information.

The sex identification of the Qafzeh 9 skeleton has been debated in the literature. It was even suggested that the Qafzeh 9-10 double burial represented a mother and her baby buried together soon after their death during or just after childbirth (Cohen, 2003:29). Qafzeh 9 was later nicknamed Eve (Waddell, 2015). The application of improved methods based on biological identity parameters provides evidence that in fact this individual was a male with an age at death estimated between 18.5 and 20.5 years.

Certainly, a paleogenetical investigation, using SRY gene detection (Sinclair et al. 1990) or DNA shotgun sequencing (Skoglund et al., 2013), might support male sex assessment based on morphometric traits. Unfortunately, at the present time, genetic studies on the Qafzeh hominin sample, as well as those of other hominins from Southwest Asia, have to confront technical problems due to the biochemical preservation of the bones and thus require some improvements of the methods. It might be also possible in the future to use enamel proteins, which may preserve ancient biogenetic data more effectively than DNA, to more confidently confirm sex assignment (Parker et al 2019; Welker et al 2020).

Acknowledgments

We are grateful to the Prof. Israel Hershkovitz, Curator of the anthropological collection of the Tel Aviv University, for the access to the original fossil and for the 3D images, also to Julia Abramov, collection manager, for the reception and the logistics support (Dan David Center, Department of Anatomy, Sackler School of Medicine, Tel Aviv University). The Irene Levi Sala Care Archaeological Foundation financially supported D. Coutinho Nogueira. Additional support was provided by the LaScArBx (ANR-10-LABX-52)

We would like to thank Olivier Dutour, Antony Colombo (Chaire d'Anthropologie biologique Paul Broca, EPHE-PSL) and Patrice Courtaud (UMR 5199 PACEA), confirmed users of the DSP2 method, for accepting to take measurements for inter-observer tests.

We are grateful to Alan E. Mann who provided valuable comments and gave his time to improve the English version of the manuscript.

References

AlQahtani, S. J., Liversidge, H. M. & Hector, M. P. (2010): Atlas of tooth development and eruption. *American Journal of Physical Anthropology* 142(3), 481-90

Alonso-Llamazares, C. & Pablos, A. (2019): Sex estimation from the calcaneus and talus using discriminant function analysis and its possible application in fossil remains. *Archaeological and Anthropological Sciences*, 1-20.

Arensburg, B., Duday, H. & Tillier, A.-m. (2006): Approche paléopathologique de la sépulture double de Qafzeh (Israël). *Communication au colloque du Groupement des Paleopathologistes de Langue Française,* Lille, 25-26 mars 2006

Bar-Yosef, O. (2000): The Middle and Early Upper Paleolithic in Southwest Asia and neighbouring regions. In: Bar-Yosef O, Pilbeam D (eds) *The geography of Neandertals and modern humans in Europe and the Greater Mediterranean. Peabody Museum 8,* Harvard University, Cambridge, 107–56

Bar-Yosef Mayer, D.E., Vandermeersch, B. & Bar-Yosef, O. (2009): Shells and ochre in Middle Paleolithic Qafzeh Cave, Israel: indications for modern behavior. *Journal of Human Evolution* 56, 307–314

Bidmos, M. A. & Asala, S. A. (2003): Discriminant function sexing of the calcaneus of the South African whites. *Journal of Forensic Science* 48, 1213–1218.

Bidmos, M. A. & Asala, S. A. (2004): Sexual dimorphism of the calcaneus of South African Blacks. *Journal of Forensic Science*, 49, 446–450.

Birkner, R. (1978): *Normal radiologic patterns and variances of the human skeleton. An X-ray atlas of adults and children.* Urban & Schwarzenberg, München Baltimore 536 pages

Blankenship, J.A., Mincer, H.H. & Anderson, K.M. (2007): Third molar development in the estimation of chronologic age in american blacks as compared with whites. *J Forensic Sci*, 52(2), 428–33.

Bräuer, G. (1988): Osteométrie, In: R. Knussman dir., *Anthropologie: Handbuch der vergleichenden Biologie des Menschen,* Band1, Stuttgart, Éd. Gustav Fischer Verlag, 160-232.

Brůžek, J. & Vandermeersch, B. (1997): Reassessment of the sex of the Qafzeh 9 individual based on multivariate statistical analysis. *American Journal of Physical Anthropology*, Supplement, 24, 84

Brůžek, J. (2002): A method for visual determination of sex, using the human hip bone. *American Journal of Physical Anthropology*, 117, 157-168.

Brůžek, J., Franciscus, R.G., Novotny, V. & Trinkaus, E. (2006): The Assessment of Sex In: Trinkaus, E, Svoboda, J, editors. Early Modern Human Evolution in Central Europe: The People of Dolní Věstonice and Pavlov. Dolní Věstonice Studies 12. New York: Oxford University Press; 46–62.

Brůžek, J., Cunha, E., Dutailly, B., Murail, P. & Santos, F. (2017): Validation and reliability of the sex estimation of the human os coxae using freely available DSP2 software for bioarchaeology and forensic anthropology, *American Journal of Physical Anthropology*, 164(2), 440-449

Brůžek, J. & Murail, P. (2006): Methodology and reliability of sex determination from the skeleton. In: A. Schmitt, E. Cunha, and J. Pinheiro, eds. *Forensic Anthropology and Medicine: Complementary Sciences from Recovery to Cause of Death*. New York: Springer, 225-242.

Cardoso, H. F. V. (2007): Environmental effects on skeletal versus dental development: using a documented subadult skeletal sample to test a basic assumption in human osteological research. *American Journal of Physical Anthropology*, 132, 223–233

Cohen, C. (2003): *La femme des origines. Images de la femme dans la préhistoire occidentale*, Belin-Herscher, Paris

Colombo, C., Coqueugniot, H., Dutailly, B., Desbarats, P. & Tillier, A.-m., (2013): Nouvelles données sur l'édification des molaires et l'estimation de l'âge dentaire des enfants par imagerie médicale et 3D : apports et perspectives. *Bulletins et Mémoires de la Société d'Anthropologie de Paris*, 25, 127-146.

Coqueugniot, H., Tillier, A.-m. & Bruzek, J. (2000): Mandibular ramus posterior flexure: a sex indicator in Homo sapiens fossil hominids? *International Journal Osteoarchaeology* 10, 6, 426-431

Coqueugniot, H. & Weaver, T.D. (2007): Brief communication: infracranial maturation in the skeletal collection from Coimbra, Portugal: New Aging Standards for Epiphyseal Union. *American Journal of Physical Anthropology,* 134, 424–437

Coqueugniot, H., Weaver, T.D. & Houët, F. (2010): A probabilistic approach to age estimation from infracranial sequences of maturation. *American Journal of Physical Anthropology*, 142, 655-664.

Coqueugniot, H., Colombo, A., Dutailly, B., Dutour, O., Rittemard, C. & Santos, F. (2018): Logiciel MACROS ARCHEO: IDDN.FR.001.500008.000.S.P.2018.000.31230

Coutinho-Nogueira, D., Dutour, O., Coqueugniot, H. & Tillier, A.-m. (2019): Qafzeh 9 mandible (ca 90–100 kyrs BP, Israel) revisited: μ-CT and 3D reveal new pathological conditions, *International Journal of Paleopathology*, 26, 104-110, https://doi.org/10.1016/j.ijpp.2019.

Coutinho-Nogueira, D. (2019): *Paléoimagerie appliquée aux Homo sapiens de Qafzeh (Paléolithique moyen, Levant sud). Variabilité normale et pathologique*. Thèse de Doctorat de l'Université PSL, Ecole Doctorale 472 de l'Ecole Pratique des Hautes Etudes, Spécialité Anthropologie

Coutinho-Nogueira, D., Coqueugniot, H. & Tillier, A.-m. (2021): The bony labyrinth of Qafzeh 25 *Homo sapiens* from Israel, *Archaeological and Anthropological Sciences* (in press)

Dastugue, J. (1981): Pièces pathologiques de la nécropole moustérienne de Qafzeh. *Paléorient*, 7, 135–140

Demirjian, A., Goldstein, H. & Tanner, J. M. (1973): A new system of dental age assessment. *Human Biology*, 45, 211–27.

Dutailly, B, Coqueugniot, H, Desbarats, P, Gueorguieva, S & Synave, R. (2009): 3D surface reconstruction using HMH algorithm. *Proceedings of the 16th IEEE International Conference on Image Processing*, 2505-2508.

Esan, T.A., (2017): *Dental development in a Southern African sub adult population: Determination of reference values for permanent tooth formation and emergence*. (doctoral dissertation), University of the Witwatersrand, Johannesburg

Franciscus, R.G. & Holliday, T.W. (2013): Crossroads of the Old World. In *The Origins of Modern Humans* (eds F.H. Smith and J.C.M. Ahern). https://doi.org/10.1002/9781118659991.ch2

Franklin, D., (2010): Forensic age estimation in human skeletal remains: current concepts and future directions. *Legal Medecine,* 12, 1–7

Frayer, D.W., Jelinek, N., Minugh, N., Smith, F.H. & Wolpoff, M.H., unpublished, *Upper Pleistocene human remains from Backova Dira Cave at Mladeč (Lautsch), Moravia: Burnt, trampled and ignored, they now return to haunt.*

Frayer, D.W., Jelinek, N., Oliva, M. & Wolpoff, M.H. (2006): Aurignacian Male Crania, Jaws and Teeth from the Mladeč Caves, Moravia, Czech Republic. In: M. Teschler-Nicola (Ed.) *Early Modern Humans at the Moravian Gate. The Mladeč Caves and their remains*. Springer-Verlag/Wien: 185-272.

Gaillard, J. (1960) : Détermination sexuelle d'un os coxal fragmentaire. *Bulletins Et Mémoires De La Société D'Anthropologie De Paris, XIe Série,* 2, 255–267.

Gambier, D., Bruzek, J, Schmitt, A, Houet F., & Murail P. (2006): Révision du sexe et de l'âge au décès des fossiles de Cro-Magnon (Dordogne, France) à partir de l'os coxal. *Compte Rendu Palevol*, 5, 735-741.

Garn S.M., Lewis, A.B. & Bonné B. (1961): Third molar polymorphism and the timing of tooth formation. *Nature,* 192, 989

Garn, S.M., Lewis, A.B. & Kerewsky R.S. (1965): Genetic, nutritional and maturational correlates of dental development. *Journal of Dental Research*, 44, 228-242

Grün R. & Stringer C. B, (2000): Electron spin resonance dating and the evolution of modern humans. *Archaeometry* 33, 153–99

Guyomarc'h, P., Santos, F., Dutailly, B., Desbarats, P., Bou, C. & Coqueugniot, H. (2012): Three-dimensional computer-assisted craniometrics: A comparison of the uncertainty in measurement induced by surface reconstruction performed by two computer programs, In Forensic Science International, 219, Issues 1–3: 221-227, doi.org/10.1016/j.forsciint.2012.01.008

Hansen, J., Petersen H.C., Frei, K.M., Courtaud, P., Tillier, A-m., Fischer, A. & Allentoft, M.E. (2017): The Maglemosian skeleton from Koelbjerg, Denmark revisited: identifying sex and provenance. *Danish Journal of Archaeology,* DOI .org. 10.1080 :21662282.2017

Hovers, E., Vandermeersch, B. & Bar-Yosef, O. (1997): A Middle Palaeolithic engraved artefact from Qafzeh Cave, Israel. *Rock Art Research*, 14, 79-87

Hovers, E., Ilani, S., Bar-Yosef, O. & Vandermeersch, B. (2003): An Early Case of Color Symbolism: Ochre Use by Modern Humans in Qafzeh Cave. *Current Anthropology* 44, n°4, 491-522.

Introna, F., Divella, G., Campobasso, C., Dragone, M., (1997): Sex determination by discriminant analysis of Calcanei measurements. *Journal of Forensic Science*, 42, 725–728.

Klales, A.R., Ousley, S.D. & Vollner, J.M. (2012): A revised method of sexing the human innominate using Phenice's nonmetric traits and statistical methods. *Am. J. Phys. Anthropol.*, 149, 104-114. doi:10.1002/ajpa.22102

Klales, A.R. & Burns T.L. (2017): Adapting and Applying the Phenice (1969) Adult Morphological Sex Estimation Technique to Subadults. *J Forensic Sci*, 62: 747-752. doi:10.1111/1556-4029.13332

Legović, M, Sasso, A, Legovic, I, Brumini, G, Cabov, T, Slaj, M et al. (2010): The reliability of chronological age determination by means of mandibular third molar development in subjects in Croatia. *J Forensic Sci*., 55 14–8

Lewis, A. B. & Garn, S. M. (1960): The relationship between tooth formation and other maturational factors. *Angle Orthodontist*, 30, 70–74.

Liversidge, H. M., Herdeg, B. & Rösing, F. W. (1998): Dental age estimation of non-adults. A review of methods and principles. In: Sprin-ger (ed) *Dental anthropology: fundamentals, limits and prospects*, 419–42

Liversidge, H. M. (2008): Timing of human third molar formation, *Annals of Human Biology* 35(3), 294-32

Mittnik, A, Wang, CC, Svoboda J. & Krause, J. A (2016): Molecular Approach to the Sexing of the Triple Burial at the Upper Paleolithic Site of Dolní Věstonice. *PLoS One*, 11(10):e0163019.. doi:10.1371/journal.pone.0163019

Moorrees, C.F.A., Fanning, E.A. & Hunt, E.E. (1963): Age Variation of Formation Stages for Ten Permanent Teeth. *Journal of Dental Research*. 42, 1490–1502.

Murail, P., Bruzek, J., Houët, F. & Cunha, E. (2005): DSP: a probabilistic sex diagnosis tool using worldwide variability in hip bone measurements. *Bulletins et Mémoires de la Société d'Anthropologie de Paris*, 1.17, 3-4, 167-176

Parker, G. J., Yip, J. M., Eerkens, J. W., Salemi, M., Durbin-Johnson, B., Kiesow, C., Haas, R., Buikstra, J. E., Klaus, H., Regan, L. A., Rocke, D. M., & Phinney, *B. S.* (2019): Sex estimation using sexually dimorphic amelogenin protein fragments in human enamel. *Journal of Archaeological Science* **101**, 169–180

Phenice, T.W. (1969): A newly developed visual method for sexing the os pubis. *Am J Phys Anthropol*, 30, 297–302.

Ponce de León, M. & Zollikofer, C. (2001): Neanderthal cranial ontogeny and its implications for late hominid diversity. *Nature* **412,** 534–538. https://doi.org/10.1038/35087573

Quam, R., Martínez, I., & Arsuaga, J., (2011): New Observations on the Human Fossils from Petit-Puymoyen (Charente). *Paleoanthropo*, 95−105

Rak, Y. (1990): On the differences between two pelvises of Mousterian context from the Qafzeh and Kebara caves, Israel. *American Journal of Physical Anthropology*, 81, 323–332

Rosenberg, K. (1986): *The functional significance of Neandertal pubic morphology*, PhD Dissertation, University of Michigan

Rosenberg, K. (1988): The functional significance of Neandertal pubic length. *Curent Anthropology*. 29, 595–617.

Scheuer, L. & Black, S. (2000): *Developmental Juvenile Osteology*. Elsevier Academic Press, San Diego, CA

Schuh A., Dutailly B., Coutinho Nogueira D., Santos F., Arensburg B., Vandermeersch B., Coqueugniot H., Tillier A-m., (2017) La mandibule de l'adulte Qafzeh 25 (Paléolithique moyen), Basse Galilée : reconstruction virtuelle 3D et analyse morphométrique. *Paléorient* 43-1:49-59

Schulter-Ellis, F.P., Schmidt, D.J., Hayek, L.C. & Craig J. (1983): Determination of sex with a discriminant analysis of new pelvic bone measurements: Part I. *Journal of Forensic Sciences*, *28*, 169–180.

Schultz, A. H. (1930): The skeleton of trunk and limbs of higher primates. *Human biology*, 2, 303 - 348.

Schwarcz H, Grün R, Vandermeersch B, Bar Yosef O., Valladas H. & Tchernov E. (1988): ESR dates for the hominid burial site of Qafzeh in Israel, *Journal of Human Evolution*, 17, 8, 733738

Schwartz, J.H. & Tattersall, I. (2010): Fossil evidence for the origin of *Homo sapiens*. *Am. J. Phys. Anthropol.*, 143, 94-121. https://doi.org/10.1002/ajpa.21443

Sinclair, A., Berta, P., Palmer, M., Hawkins, J.R , Griffiths, B.L., Smith, M., Foster, J.W., Frischauf, A.M., Lovell-Badge, R. & Goodfellow, P.N. (1990): A gene from the human sex-determining region encodes a protein with homology to a conserved DNA-binding motif. *Nature* 346, 240–244 https://doi.org/10.1038/346240a0

Skoglund, P., Stora, J., Gotherstrom, A. & Jakobsson, M. (2013): Accurate sex identification of ancient human remains using DNA shotgun sequencing, *Journal of Archaeological Sciences*, 40, 4477-4482

Spoor, C.F., Zonneveld, F.W. & Macho, G.A. (1993): Linear measurements of cortical bone and dental enamel by computed tomography: applications and problems. *American Journal of Physical Anthropology* 91, 469-484.

Steele, D. G. (1976): The estimation of sex on the basis of Sex Assessment from Talus and Calcaneus 47 the talus and calcaneus. *American Journal of Physical Anthropology*, 45, 581–588.

Tillier, A.-m. (1995): Paléoanthropologie et pratiques funéraires au Levant méditerranéen durant le Paléolithique moyen : le cas des sujets non adultes. Anthropologie du Proche-Orient, Données récentes. *Paléorient*, 21 n°2, 63-76.

Tillier, A.-m. (1999): *Les enfants moustériens de Qafzeh. Interprétation phylogénétique et paléoauxologique*. Paris: Cahiers de Paléoanthropologie, CNRS Editions. 239 pages.

Tillier, A.-m. (2014): New Middle Palaeolithic Hominin Dental Remains from Qafzeh, Israel. In: *Paléorient*, vol. 40, n°1, 13-24

Tillier, A.-m. (in preparation) Middle Paleolithic hunter-gatherers in Southwest Asia and demographic indicators. The Qafzeh hominins.

Tompkins, R.L. (1996): Relative dental development of Upper Pleistocene hominids compared to human population variation. *American Journal of Physical Anthropology*, 99, 103-118.

Trinkaus, E. (1984): Neandertal pubic morphology and gestation length. *Current Anthropology*, 4, 509-514. DOI: 10.1086/203173

Valladas, H., Reyss, J.L., Joron, J.L., Valladas, G., Bar Yosef, O. & Vandermeersch, B. (1988): Thermoluminescence dates for the Mousterian Proto-Cro-Magnons from Qafzeh Cave (Israel), *Nature*, 331, 614-616.

Vandermeersch, B. (1969a): Les nouveaux squelettes moustériens découverts à Qafzeh et leur signification. *Comptes Rendus l'Académie des Sciences de Paris*. 268, D, 2562-2565

Vandermeersch, B. (1969b): Découverte d'un objet en ocre avec traces d'utilisation dans le Moustérien de Qafzeh (Israël). *Bulletin de la Société préhistorique française. Comptes rendus des séances mensuelles,* tome 66, n°5, 157-158.

Vandermeersch, B. (1981): *Les hommes fossiles de Qafzeh*, Cahiers de Paléoanthropologie, CNRS Editions, Paris

Vandermeersch, B. & Bar-Yosef, O. (2017): Qafzeh Cave and Terrace In: Enzel Y., Bar-Yosef O. (eds), *Quaternary of the Levant: environments, climate change, and humans*. Cambridge: Cambridge University Press, 251-253.

Vandermeersch, B. & Bar-Yosef, O. (2019): The Paleolithic Burials at Qafzeh Cave, Israel, *PALEO,* 30, 256-275

Waddell, P. J. (2015): Expanded Distance-based Phylogenetic Analyses of Fossil Homo Skull Shape Evolution, *arXiv*, 1512.09115

Walker, P.L., Dean, G. & Shapiro, P. (1991): Estimating age from tooth wear in archaeological populations. In: Kelley, M.A. and Larsen, C.S., Eds., *Advances in Dental Anthropology*, WileyLiss, Chichester, 13-31.

Weber, G.W., Schäfer, K., Prossinger, H., Gunz, P., Mitteröcker, P. & Seidler, H. (2001): Virtual anthropology: the digital evolution in anthropological sciences. *Journal of Physiological anthropology and Applied Human Science*, 20, 69– 80.

Weber, G.W. & Bookstein, F.L. (2011): *Virtual Anthropology. A guide to a new interdisciplinary field.* Wien, New York: Springer Verlag, Welker, F., Ramos-Madrigal, J., Gutenbrunner, P., Mackie, M., Tiwary, S., Rakownikow Jersie-Christensen, R., Chiva, C., Dickinson, M.R., Kuhlwilm, M., de Manuel, M., Gelabert, P., Martinón-Torres, M., Margvelashvili, A., Arsuaga, J.L., Carbonell, E., Marques-Bonet, T., Penkman, K., Sabidó, E., Cox, J., Olsen, J.V., Lordkipanidze, D., Racimo, F,. Lalueza-Fox, C., Bermúdez de Castro, J.M., Willerslev, E. & Cappellini, E. (2020): The dental proteome of Homo antecessor, *Nature*, 580(7802):235-238. doi: 10.1038/s41586-020-2153-8.

Figures and captions

Fig.1 Qafzeh 9 bony pelvis (Anne-marie Tillier)

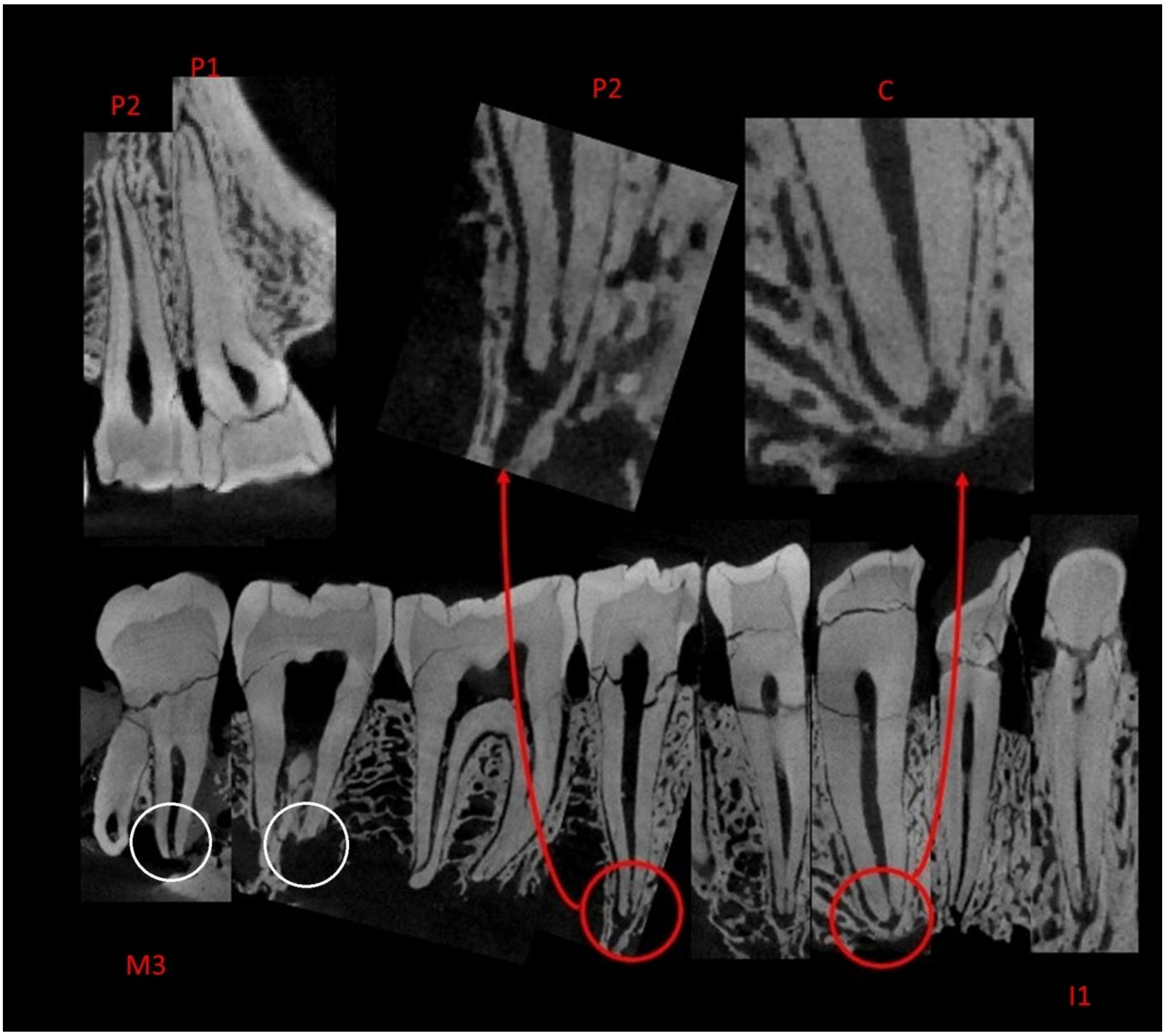

Fig.2: CT sections showing the dental roots of Qafzeh 9 (white circles indicate taphonomic alterations) (Dany Coutinho Nogueira)

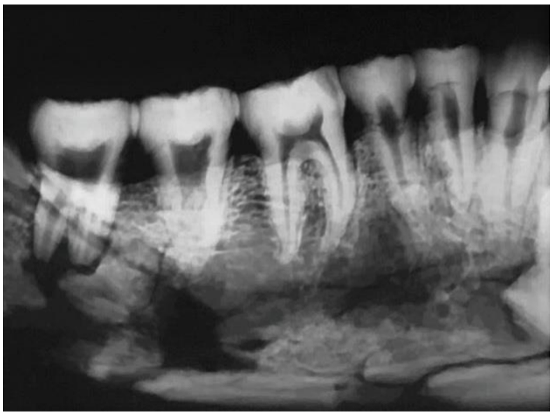

Fig.3: Plain X-ray of Qafzeh 9 mandible showing the bone damage under the second and third molars (Anne-marie Tillier)

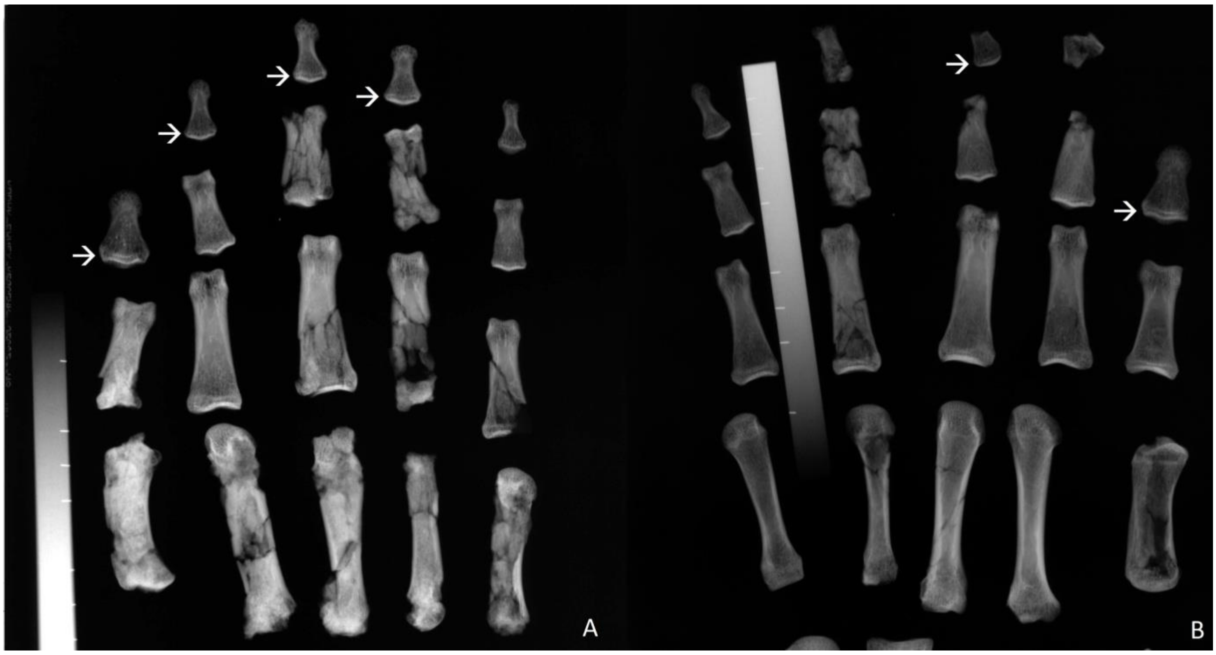

Fig. 4: Radiographs of the left (A) and right (B) metacarpals and phalanges of Qafzeh 9. Arrows show endochondral lines indicating the very end of ossification of distal phalanges (Anne-marie Tillier)

Fig.5 Distal extremities of the left tibia and ulna showing different degrees of bone maturation (Dany Coutinho Nogueira)

Tables

Mandible (Moorrees et al 1963)		Age in years	
tooth	stage	Females	Males
I1	Ac	>6	>6.5
I2	Ac	>7	>7.5
C	A1/2	8 – 12	9.5 - 14.5
P1	Ac	>10	>11
P2	A1/2	9.5 – 14.5	10 - 15.5
M1	Ac	>7	>7.5
M2	Rc to Ac	9 – 18	9.5 - 18
M3	Rc	14 - 21	13.5 - 20.5

Mandible (AlQahtani et al 2010)		Age in years
tooth	stage	combine sex
I1	Ac	> 8.5
I2	Ac	> 8.5
C	A1/2	11.5 – 14.5
P1	Ac	> 12.5
P2	A1/2	11.5 -15.5
M1	Ac	> 9.5
M2	Rc to Ac	>14.5
M3	Rc	>17.5

Maxilla (AlQahtani et al 2010)		Age in years
tooth	stage	combine sex
P1	Ac	>13.5
P2	Ac	>13.5

Table 1: tooth formation stages and age estimation according to Moorrees et al (1963) and AlQahtani et al (2010)

	Right	**Left**
Os Coxae		
Ilium-Pubis	F	/
Upper Ischium-Pubis	/	/
Lower Ischium-Pubis	/	/
Iliac crest	F	F
Ischial Tuberosity	F	F
Anterior inferior iliac spine	/	TF
Sacrum		
Medial Sacral Segments 1_2	/	
Lateral Sacral Segments 1_2	/	/
Posterior Sacral Segments 1_2	/	/

Medial Sacral Segments 2_3	F	
Lateral Sacral Segments 2_3	/	F
Posterior Sacral Segments 2_3	/	/
Medial Sacral Segments 3_4	F	
Lateral Sacral Segments 3_4	/	F
Posterior Sacral Segments 3_4	/	/
Medial Sacral Segments 4_5	F	
Lateral Sacral Segments 4_5	/	/
Posterior Sacral Segments 4_5	/	/
Scapula-Clavicle		
Coracoid process	/	/
Acromion	/	/
Sternal End	NF	NF
Upper Limb		
Humerus Head	/	F
Humerus Medial Epicondyle	/	TF
Humerus distal End	/	/
Radius Proximal End	/	/
Radial Distal End	F	F
Ulna Proximal End	/	.
Ulna Distal End	F	F
Lower Limb		
Femur Head	/	TF
Femur Greater Trochanter	/	F
Femur Lesser Trochanter	/	F
Femur Distal End	TF	/
Tibia Proximal End	/	TF
Tibia Distal End	/	TF

Fibula proximal End	/	/
Fibula Distal End	F	/
Calcaneus Posterior End	F	F

Table 2: Maturation stages of Qafzeh 9 infracranial bones following parameters proposed by Coqueugniot and Weaver (2007). NF: Non fused; F: Fusing; TF: Totally fused; /: unobservable

Obs	PUM	SPU	DCOX	IIMT	ISMM	SCOX	SS	SA	Female probability	Male probability	SEX
Obs 1 original	62.80	28.00	201.00	33.33	101.15	155.00	78.41	78.82	0.001	0.999	Male
Obs 1 cast	61.30	26.60	201.00	34.80	101.50	155.00	78.90	78.40	0.001	0.999	Male
Obs 2	62.40	26.90	194.00	28.10	99.20	153.00	65.40	76.50	0.016	0.984	Male
Obs 3	59.00	23.40	197.00	36.00	97.00	155.00	78.00	73.00	0.026	0.974	Male
Obs 4	58.80	26.50	194.00	26.90	101.20		78.90	80.10	0	1	Male
Obs 5	57.94	25.30	192.00	38.84	104.50		76.70	79.80	0.001	0.999	Male
max	62.80	28.00	201.00	36.00	104.50	155.00	78.90	80.10	0	1	Male
min	57.94	23.40	192.00	26.90	99.20	153.00	65.40	76.50	0.007	0.993	Male

Table 3: Results of the DSP v2 achieved by five observers and inter-observer variation. Pelvic variables are defined in Brůžek *et al* (2017). Abbreviations: PUM (M14)- Acetabulo-symphyseal pubic length (Bräuer, 1988); SPU- Cotylo-pubic width (Gaillard, 1960); DCOX (M1)- Innominate or coxal length (Bräuer, 1988); IIMT (M15.1)- Greater sciatic notch height (Bräuer, 1988); ISMM- Ischium post-acetabular length (Schulter-Ellis et al., 1983); SCOX (M12)- Iliac or coxal breadth (Bräuer, 1988); SS- Spino-sciatic length (Gaillard, 1960); SA- Spino-auricular length (Gaillard, 1960); SIS (M14.1): Cotylo-sciatic breadth (Bräuer, 1988); VEAC (M22):Vertical acetabular diameter (Bräuer, 1988)

	Klales et al. (2012), adults	Klales et al. (2017) non-adults
SPC (subpubic concavity)	4 (left) and 5 (right)	3
MA (medial aspect of the ischio-pubic ramus)	distorted	distorted
VA (ventral arc)	5	-
	Male	Male

Table 4: Ordinal scores using the two Klales methods for adult and non-adult individuals

discriminant equations	**Results**	**Estimated sex**
CM1 x 0.216-17.003	-0.371	F
CM3 x 0.471-12.259	0.5522	M
CM5 x 0.263-14.977	-0.3542	F
CM9 x 0.465-13.755	1.125	M
CM10 x 0.681-14.669	1.8112	M
CM3 x 0.219 + CM9 x 0.238 + CM10 x 0.297 - 19.260 (stepwise)	1.5002	M
CM1 x 0.020 + CM3 x 0.210 + CM5 x 0.032 + CM9 x 0.199 + CM10 x 0.265 - 20.568	1.2442	M
CM1 x 0.040 + CM3 x 0.207 + CM9 x 0.209 + CM10 x 0.267 - 20.528	1.3318	M
CM1 x 0.065 + CM3 x 0.235 + CM9 x 0.242 - 18.511	0.63	M
CM5 x 0.057 + CM9 x 0.302 + CM10 x 0.327 - 19.206	1.5406	M
CM9 x 0.348 + CM10 x 0.358 - 18.014	1.7856	M
M1 x 0.390-20.567	-0.521	F
M2 x 0.430-17.491	2.59	M
M4 x 0.533-17.620	-0.1376	F
M6 x 1.103-9.276	1.754	M
M9 x 0.249-8.021	-0.0032	F

M12 x 0.540-16.753	0.419	M
M13 x 0.687-14.629	2.1338	M
M1 x 0.177 + M6 x 0.279 + M12 x 0.226 + M13 x 0.210 - 23.155 (stepwise)	0.8333	M
M1 x 0.205 + M12 x 0.226 + M13 x 0.201 - 22.138	0.4082	M
M4 x 0.212 + M12 x 0.246 + M13 x 0.279 - 20.569	1.0574	M
M1 x 0.245 + M12 x 0.289 - 21.939	-0.2538	F
M6 x 0.476 + M13 x 0.623 - 17.265	2.4582	M
M6 x 0.418 + M12 x 0.497 - 18.934	0.8416	M

Table 5: The discriminant equations of Alonso-Llamazares and Pablos (2019) applied to Qafzeh 9 ankle. Talus and calcaneus measurements were defined by Martin and Saller (see Braüer 1988).

		13	13.5	14	14 ; 5	15	15 ; 5	16	16 ; 5	17	17.5	18	18.5	19	19.5	20	20.5	21	21.5	22
dental age	upper premolars and lower teeth (1)																			
	lower teeth (2)																			
	upper premolars and lower teeth (3)																			
Bone maturation	Hand bones (4)																			
	long bones and pelvis (5)																			
	long bones and pelvis (6)																			
	ulna (distal end, fusing) (5)																			
	radius (distal end, fusing) (5)																			
	tibia (distal end complete fusion) (5)																			

Table 6: Comparison of ranges of individual age estimates according to different methods (1- AlQahtani et al. 2010; 2- Moorrees et al. 1963; 3- Esan 2017; 4- Birkner 1978; 5- Coqueugniot and Weaver 2007; 6- Coqueugniot et al. 2018)