

# Piani posturali di riferimento e ipotesi su loro origine evolutiva

Il Piano di Francoforte (Po-Or dx) (Fig. 1) rappresenta il Piano Orizzontale di Riferimento a livello craniofaciale per le misure cefalometriche sia in 2D, che in 3D [1,2,3,4,5].

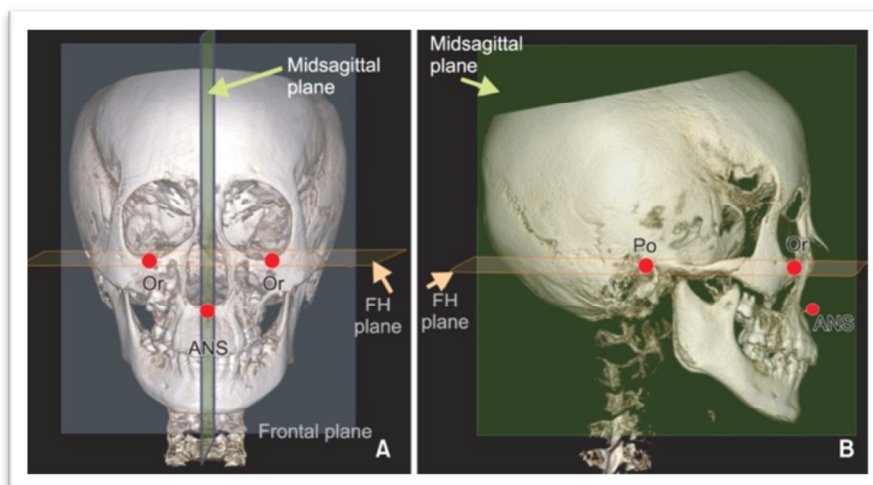


Figura 1

Per convenzione si utilizza il Punto Or destro. Il piano viene costruito perpendicolare sul piano sagittale a una retta passante per l' Apofisi Crista Galli (Fig. 1 bis).

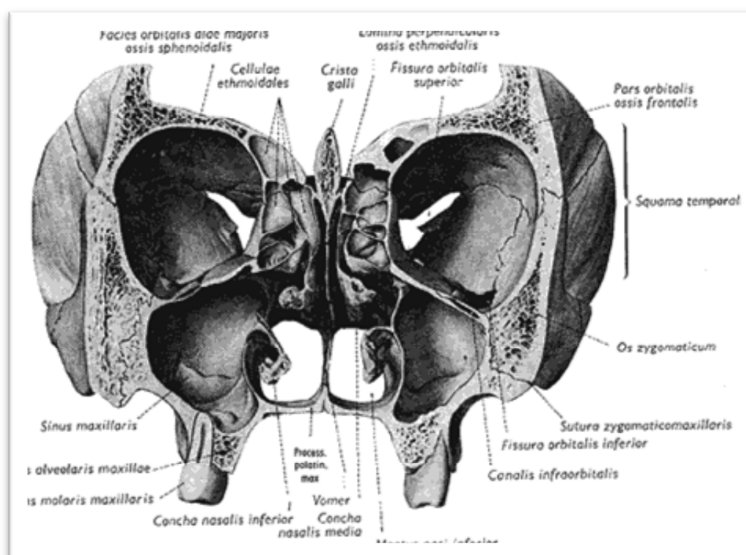
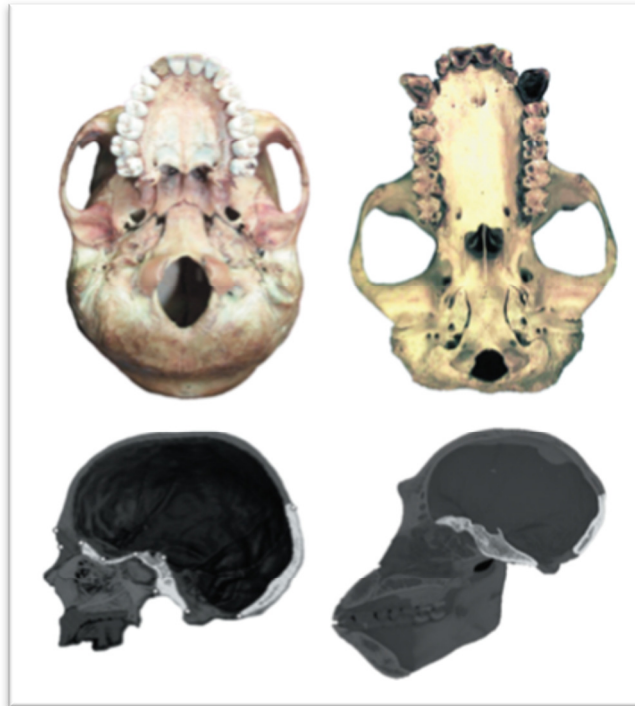


Figura 1 bis

Le ipotesi evolutive per lo sviluppo della postura prese in considerazione sono due: La prima (Fig.2)



**Figura 2: Cranial base morphology in Homo sapiens (left) and Pan troglodytes (right). Photo of the cranial base in norma basilaris (above) and in sagittal section (below). The cranial base is highlighted in sagittal section. Note the greater width of the sphenoid in H. sapiens. Sagittal section of Homo sapiens adapted from Bookstein et al. (17), of Pan troglodytes adapted from [www.digimorph.org](http://www.digimorph.org) (2008).**

ipotizzata nella review di Nevell L e Wood B. [12] *“The cranial base is the only part of the skeleton where so many important functions (e.g. respiration, feeding and ingestion, posture, and balance) converge. This has led many to assume that the cranial base must be a highly integrated structure, for modifications that might benefit one of these functions may well be detrimental to another (Lieberman et al. (18)).* La postura e l'equilibrio corporeo troverebbero la loro integrazione nella base del cranio.

*“Studies of the external morphology of the cranial base can be divided into those that have concentrated on the midline (or sagittal) morphology and those that focus on the cranial base as a whole.”* Gli studi sono stati fatti sia sul piano sagittale che sull'intero basicranio (norma basilaris nella visione dal basso,12).

*“We use a parsimony analysis of published cranial and dental data (Strait & Grine, 2004)[14] to predict the cranial base morphology expected in the hypothetical last common ancestor (LCA) of the Pan–Homo clade. We also predict the primitive condition of the cranial base for the hominin clade and document the evolution of the cranial base within the major subclades within the hominin clade.”*

*“External cranial base flexion External cranial base flexion is reduced among hominoids and we predict that this condition was shared by the Pan–Homo LCA and the stem panin. The morphology of the stem hominin with respect to external cranial base flexion remains ambiguous. A flat external cranial base angle is present in P. aethiopicus. A moderate degree of flexion is present in Au. africanus. A flexed external cranial base angle is seen in P. robustus, P. boisei, H. habilis, H. ergaster and H. sapiens. Data are not available for S. tchadensis, Au. afarensis, Ar. ramidus, Au. anamensis, Au. garhi, K. platyops or H. rudolfensis. Based on the proposed reference tree topology, a flexed external cranial base angle appears to have developed independently within Paranthropus and the (Australopithecus, Homo) clade.”*

Rispetto agli ominoidi l'Homo Sapiens presenta una flessione della base del cranio maggiore.

*“A more horizontal nuchal plane is seen in P. robustus, P. boisei, H. habilis and H. sapiens”*

*“A large longus capitus insertion is the primitive state for hominoids, is inferred to be the condition in the Pan–Homo LCA and the stem panin, and it is also seen in Au. africanus. A smaller longus capitus insertion is seen in P. aethiopicus, P. robustus, P. boisei, H. habilis, H. ergaster and H. sapiens;” (Fig. 3).*

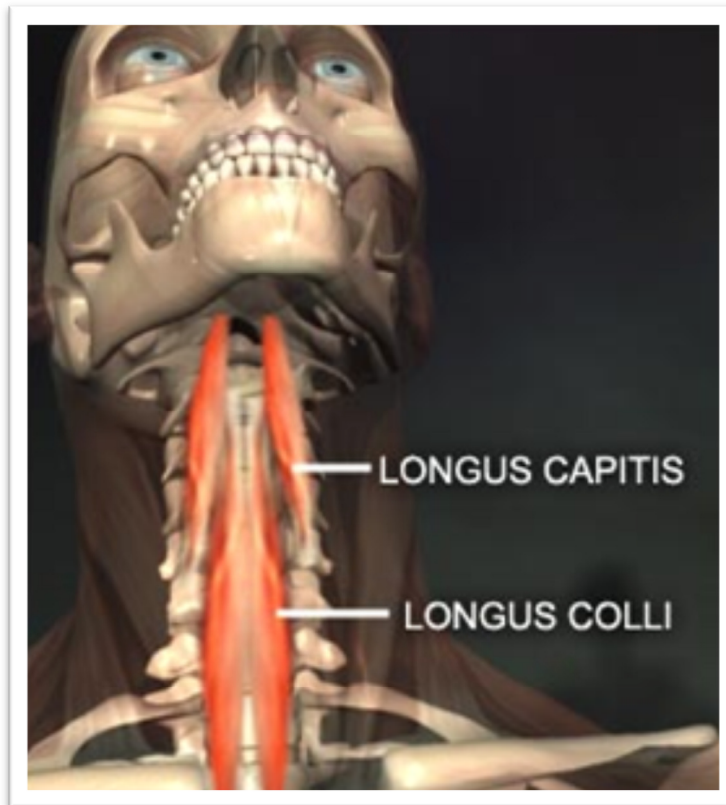


Figura 3

La flessione del cranio si accompagna ad un Piano Nucale più orizzontale e all'accorciamento del muscolo Longus capitis che determina la flessione della testa in avanti,

*“a more forwardly situated foramen magnum”*

compensata dallo spostamento in avanti del forame magno.

*“We suggest that the Pan–Homo ancestor differed from hominoids in the following ways: a shorter posterior skull length, a narrower supraglenoid gutter, greater bi-jugular foramen and bi-carotid widths, and an increase in the distance between the apices of the right and left temporal bones. Additional character states whose expression might change at the Pan–Homo LCA node include the position of the articular eminence above the occlusal plane (it may stay high, or be reduced), the distance between the mandibular fossae (it may be reduced), and the distance between the mastoid processes (it may increase)”*

Le maggiori differenze evidenziate fra gli hominoidi e il comune antenato del Pan-Homo sono: riduzione della lunghezza posteriore del cranio, cavità glenoidea più stretta, forame bigiugulare e distanza bicarotidee più ampi, incremento della distanza fra gli apici delle ossa temporali, eminenza articolare dell'articolazione temporo-mandibolare che si posiziona al di sopra del piano occlusale con riduzione della distanza dallo stesso piano occlusale, riduzione della distanza fra le fosse mandibolari e incremento della distanza fra i processi mastoidei.

*“There is now substantial agreement among molecular biologists that the Pan–Homo divergence occurred between 4 and 8 Ma (for a review of this evidence see Bradley in this issue)”.*

C'è accordo sostanziale fra i biologi molecolari che la divergenza Pan-Homo è avvenuta fra 4 e 8 Ma.

La seconda ipotesi evolutiva presentata da Preuschoft H [15] riguarda il passaggio ad un'abitudine bipedalica abituale e sulle ragioni biomeccaniche per l'acquisizione di una postura bipedalica eretta. *“Another approach might therefore be more rewarding. Looking at an orthograde trunk in side view, bending along its length must occur in semi-upright postures (Fig.4). Tensile force must be produced by dorsal muscles, mainly the erector spinae, and this requires expenditure of energy. If part of the trunk is fully*

upright, bending moments will largely be confined to the section caudal to the lordotic flexion. In the craniad section, compressive stresses should prevail.”

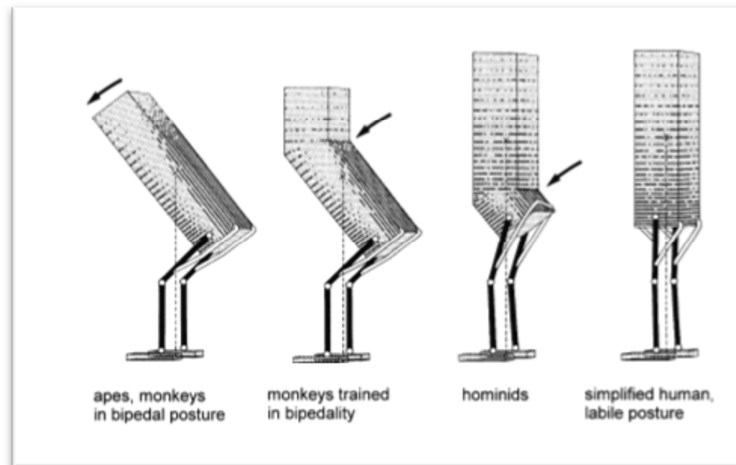


Figura 4: Schematic variation of trunk shapes to minimize the bending moments along the trunk axis. The dorsal muscles have to exert tensile forces to keep the mobile spine in its position. Left, in semi-upright posture, muscle activity is necessary along the entire trunk; second left, if a lordotic flexion is assumed, the muscle activity can be confined to the part caudal to the flexion; second right, if the flexion is shifted caudally, muscle force can be saved, but this is only possible if the pelvis is short (as in australopithecines); or right, if the pelvis itself is involved in the lordotic curvature (as in Homo). The inclined position of the long axis of the pelvis, from iliac crest to the ischial tuberosity, allows the musculature to remain without great functional change.

Le posture semierette dei primati e degli ominoidi porterebbero a un maggior dispendio di energia dei muscoli dorsali (erector spinae) e del Trapezio Superiore e Inferiore.

“Pronounced lordosis of the trunk can be observed in bipedally trained Japanese macaques (Preuschoft et al. 1988) [19], in which the long iliac ‘neck’ prevents dorsal (i.e. rearwards) shifting of the lordosis. The further caudally it is placed, the less muscular energy is wasted. Obviously, shortening of the iliac ‘neck’ would be a considerable advantage for a biped, and this feature can be seen both in Homo and Australopithecus when compared with Pan. In addition, the lordotic flexion in the trunk may even be shifted into the pelvis, forming the sciatic notch typical of Homo, not pronounced in Australopithecus and completely missing in non-human apes. We may describe this configuration by saying that the lordotic curvature in Homo is displaced caudally into the iliac ‘neck’. The lordosis of the lumbar spine in adult humans is largely confined to intervertebral joint L5/S1, forming the lumbo-sacral angle of about 135 (Preuschoft, (20). The human lumbar spine, which commonly possesses five vertebrae, is rather long for a hominoid: this is in accordance with the ability of a long trunk to provide large mass moments of inertia. The upright posture of the cervical, thoracic and lumbar spine keeps bending moments low.”

Si creano quindi ,secondo l’A.A. una serie di compensi a livello inferiore della colonna.

“In humans, the vertebral column is located dorsal to the segment centre of gravity (Fig. 5a,b), so that moderate bending moments persist, which must be counterbalanced by muscle tone. In the upper lumbar and thoracic sections of the trunk, the vertebral column of upright humans is ‘sunk’ into the thorax, so that the centres of gravity of the segments are very close to the columnar support provided by vertebral bodies (Fig. 5c), the load arms being short and the force arms long.”

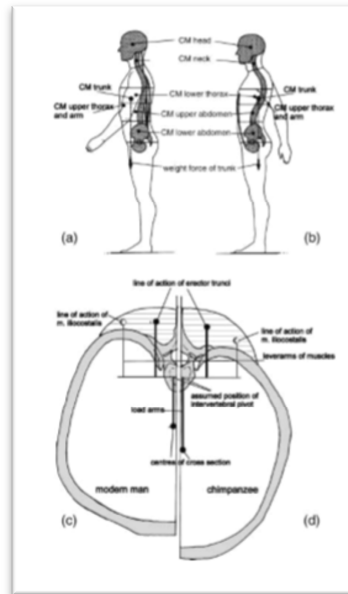


Figura 5

Questi compensi si presentano parallelamente alla progressiva anteroflessione del basicraniocranio, legata all'incremento ponderale e volumetrico dell'encefalo e alla ipotesi dell'asimmetrica riduzione antero-posteriore e latero-laterale del complesso maxillo/mandibolare (Fig. 6, Fig. 6 bis) proposta da Lacruz RS e coll.[16].

*“KNM-WT 15000: Figure 2A. Naso-alveolar clivus: The nasoalveolar clivus surface was largely depository at the time of death of KNM-WT 15000. Nasal aperture and zygomatic: The lateral walls of the nasal aperture were depository as was the right maxillary furrow. Remaining maxilla: The left side of the maxilla was characterized by depository fields from just above the alveolar bone of the I2 and dc. Orbit: The external surface of the left upper orbit was depository. Mandible: Resorption was evident on the anterior aspect of the ascending ramus of the mandible. ATD6-69: Figure 2B shows the facial remodeling map of ATD6-69 in frontal view in which both SEM and PCSOM data have been combined (see Materials and Fig. S1). We have used images largely from the left side of the ATD6-69 maxilla, mirroring the corresponding remodeling characteristics to the right side. Choosing the left side of the maxilla was fortuitous as the right is less complete permitting us to more easily set the specimen on this side for PCSOM observation. Naso-alveolar clivus: The nasoalveolar clivus shows a predominantly resorptive pattern. Nasal aperture and zygomatic: The lateral walls of the nasal aperture and the anterior portion of the zygomatic were characterized by depository fields. Remaining maxilla: Aspects of the maxilla such as portions of the anterolateral maxilla and canine fossa showed resorptive characteristics, whereas islets of depository fields were identified over the canine prominence.”*

*“The facial bone growth remodeling map of KNM-WT 15000 (*H. erectus*) shows only depositional micromorphology on the nasoalveolar clivus, right nasal and right maxillary furrow. Clearly such deposition (Fig. 2A) can contribute to the anterior growth of the anterior maxilla and so to the differences in facial prognathism between KNM-WT 15000 and *H. sapiens*.”*

La mappa facciale del rimodellamento (Fig. 6) di KNM-WT 15000 (*H. erectus*) mostra solo aree di apposizione nella zona del clivus naso alveolare e mascellare anteriore. Questa deposizione potrebbe contribuire alla crescita anteriore del mascellare ed evidenzia la differenza in prognazia fra KNM-WT di 1.5 milioni a. ed *H. sapiens* di 800.000 anni. Il maggiore riassorbimento del mascellare superiore rispetto alla mandibola dell' *H. sapiens* verrebbe confermata dallo studio su due campioni più recenti di studiati a distanza di circa 2000 anni dal nostro gruppo di ricerca su crani antichi di OPI [10].

*“The size and shape of the jaws are related to occlusion and masticatory muscle function. Consequently, teeth and muscles are considered the functional matrix for the two jaws. Existing studies did not focus on the relationship between maxillary and mandibular base but on just their absolute dimensions. As the relationship between the two is of interest to orthodontists, the aim of this study was to calculate the maxillary-mandibular ratio (m-m ratio) in individuals from Central Italy and to compare it to that of ancient skulls from the same geographic area.*

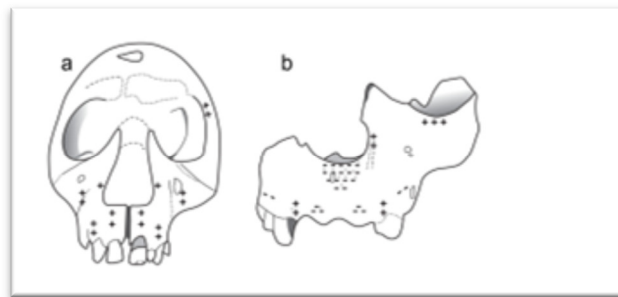
**METHODS:**

*Forty individuals from Opi, a small, isolated mountain village in Central Italy, and 40 ancient skulls from the same region were the sample of this study. The lengths of the maxillary and mandibular base were assessed on lateral cephalograms, the m-m ratio was calculated, and the measurements between the groups were compared.*

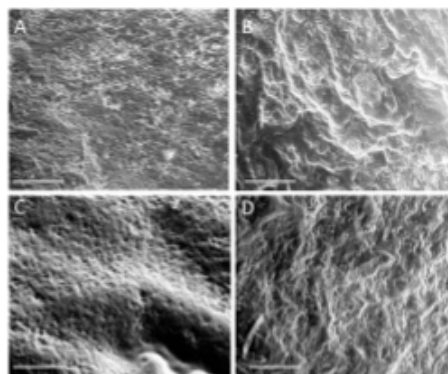
**RESULTS:**

*Due to a significantly shorter maxillary base in the modern human sample, the m-m ratio was significantly lower in these subjects.”*

Questo studio deve ancora essere confermato dallo studio in 3D a livello di microscopia elettronica.



**Figura 6: Facial growth remodelling maps. (A)** Facial growth remodelling of the H erectus specimen KNM-WT 15000 from Kenya, dating from -1,5 my showing depository fields (+) over most aspects of the anteriorly facing maxilla. Taphonomic alterations prevented a more complete analysis of the periosteal surface of this specimen which was only studied by SEM. **(B)** Facial growth remodelling of the specimen ATD6-69 representing H. antecessor, the oldest known European hominin species dating to 900-800 ky. SEM and confocal microscopy data showed resorptive fields (-) throughout the naso-alveolar clivus of the hominin, a characteristic shared with H.sapiens. Gray circles indicate the areas spot-mapped using the portable confocal microscope (PCSOM).  
Doi:10.1371/journal.phone.0065199.g002



**Figura 6 bis: Scanning Electron Micrograph of facial growth remodeling in KNM-WT 15000 and ATD6-69. Images “A” and “b” are representative of growth remodeling fields in KNM-WT 15000 (H.erectus). Image “A” shows depository fields in the clivus area of**

this specimen. For comparison "B" shows resorptive fields in the anterior aspect of the mandibular ramus of this specimen. Scale bars (A,B)=50µm. Images "C" and "D" represent growth remodeling fields of specimen ATD6-69 (H. antecessor). Image "C" shows depository fields near the zygomatic region whereas "D" is representative resorptive resorptive fields in the clivus of ATD&-69. Scale bars (C,D)=100µm. All images shown here are taken from high resolution replicas examined in the scanning electron microscope. doi:110.1371/journal.pone.0065199.g003

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