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The First Metacarpal is the Thumb First Phalange. EvoDevo Implications

El Primer Metacarpiano es la Primera Falange del Pulgar. Implicaciones en EvoDevo

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SUMMARY: We examined the status of the first metacarpal bone whose shape, fetal and post-natal development correspond to those of the thumb proximal phalanx. Galen already described this, circa 170 CE. Our radiographic data confirm that the pre-axial (radial or anterior) side of the hand matures, later than the post-axial (ulnar or posterior) side, both, pre- and post-natally. A new perspective on thumb primate and human ontogeny is discussed and comparative observations on the Evolutionary Development (EvoDevo) of the thumb and the first toe are proposed along with a nomenclature honoring Galen's original proposition.

KEY WORDS: Bone maturity; Thumb EvoDevo; First metacarpal; Thumb's first phalanx.

INTRODUCTION

Our longitudinal follow-up study of Chilean children confirms that the ossification pattern of the first metacarpal bone (MC-I) follows rather the ossification pattern of a phalanx (Patri *et al.*, 1984; Avendaño & Valenzuela, 1988; Canals *et al*., 1985, 1986, 1988, 1993; Valenzuela *et al.*, 1985; Valenzuela & Canals, 1988), a well-known fact in pediatric radiology. Metacarpal epiphyses (II, III, IV and V) ossify postnatally at the distal extremity, but MC-I ossification occurs at its proximal extremity just as a phalanx (Greulich & Pyle, 1959; Tanner *et al*., 1975; Canals *at al.*, 1993). However, this disagreement has not influenced the *Nomina Anatomica* (Feneis, 1984; Aiello & Dean, 2002; Prochel *et al.*, 2004), even though it was proposed by Galen, circa 170 AD (Testut & Latarjet, 1969). Pediatric radiology indicates that the radial carpus (trapezium, trapezoid and scaphoid) is delayed in maturation in relation to the ulnar carpus (hamate, triquetral and lunate). The aim of this article is to confirm these traits of the human carpus with population data and suggest an evolutionary new approach.

SAMPLE AND METHOD

The samples belong to two longitudinal follow-up studies of Chilean male and female newborns, infants, children and adolescents. The first study included infants and children from 0 to 6 years of age (Patri *et al*.), and the second, 5 to 20 year old children and adolescents (Avendaño & Valenzuela). Periodical radiographies of wrist and hand were performed to assess skeletal maturity. Bone maturity stages were calculated according to the TW20 method (Tanner *et al*.). Parameters of the age at which 50 % of the population showed a defined stage were estimated by the probit method (Valenzuela *et al*.; Valenzuela & Canals). When there were two parameter values for the same stage, one from the first, and another from the second study, a weighted estimate was calculated. Other methodological details are mentioned in the original articles. These data were published to provide the pediatrician for standards of bone development in Chilean children. In this article, they are seen from an evolutionary and developmental perspective.

RESULTS

Tables I and II show, for males and females, respectively, the mean age at which 50% of the population reach the maturing stages, according to the ulnar or radial edge of carpal, metacarpal and first phalanx bones.

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Table I. Age in months at which 50% of the male population attain the maturing stages. 5º Phal Prox = 5º proximal phalanx.

Males								
Ulnar edge bones								
	B	C	D	E	F	G	H	I
5º Prox Phal	27.2	29.9	37.5	63.4	134.1	160.5	185.8	197.1
5º Metacarpal	29.5	34.7	45.3	67.9	120.4	155.6	189.8	196.8
Hamate		-6.0	37.1	54.9	73.9	116.7	145.9	164.0
Triquetral	34.9	43.6	60.8	81.4	114.7	139.4	162.1	----
Lunate	57.5	64.0	80.3	98.4	124.8	146.6	168.8	----
Radial edge bones								
1º Prox Phal	36.8	48.8	54.2	83.8	130.8	164.0	192.4	204.0
1º Metacarp	36.4	46.6	61.7	98.9	134.0	157.9	177.5	204.0
Trapezium	78.7	90.7	88.7	106.2	123.9	144.4	160.9	179.9
Trapezoid	75.5	81.2	89.0	101.4	120.9	142.7	159.9	----
Scaphoid	71.9	82.6	89.7	104.7	124.4	145.4	172.2	----

Table II. Age in months at which 50% of the female population attain the maturing stages

Females								
Ulnar edge bones								
	B	C	D	E	F	G	H	I
5º Prox Phal	17.1	19.6	26.0	44.2	106.3	129.4	154.4	172.4
5º Metacarpal	18.2	23.3	32.4	54.7	105.7	130.7	161.7	177.0
Hamate		-2.6	27.3	40.4	62.3	96.8	118.5	139.3
Triquetral	26.3	32.4	46.9	62.5	98.7	114.9	134.3	----
Lunate	42.1	48.7	63.1	75.3	106.2	125.2	149.6	----
Radial edge bones								
1º Prox Phal	27.2	32.8	35.6	60.2	107.1	130.9	161.6	174.2
1º Metacarp	23.4	28.6	42.3	76.5	108.9	128.6	152.9	176.0
Trapezium	50.6	57.4	60.3	78.1	97.2	118.4	132.7	159.1
Trapezoid	55.1	62.2	66.6	76.6	99.1	120.0	140.3	----
Scaphoid	53.1	60.6	69.0	82.4	101.1	120.5	152.4	----

Females mature earlier than males; the exception is the hamate at stage C for which the negative values indicate that intrauterine maturing occurs earlier in males. It is also evident that post-axial (ulnar) bones mature earlier than pre-axial (radial) bones. In both edges and sexes the proximal phalanx bone develops at similar ages as the metacarpal bone.

DISCUSSION

It is evident from developmental features that MC-I maturates postnatally as a Phalanx. However, this picture seen among anthropoids is a relict of a more complex pattern of maturation. In phylogeny, the pattern with only one end of ossification (distal for MC-II-III-IV-V and proximal for MC-I) is found in mammals Eutheria and Metatheria (marsupials); Prototheria mammals (Monotremes) show two ossification ends (OE) at the five MC bones, and most non-mammalian tetrapods show often two OE at the five MC and phalanges (Reno *et al.*, 2007). Thus, our proposition may be contra-argued from these evolutionary developmental (EvoDevo) findings. The delayed maturation of the radial carpal bones, where the thumb and its joint with the trapezium articulation are found, could be due to adaptive neoteny to a more complex function. Thus, MC I could be the Trapezium shortened by selection to function as a new evolutionary adaptation. However, these hypotheses should be taken critically, because the Radius' ossification occurs earlier than the ulnar's ossification. Also, in the foot, the pre-axial (tibial) bones mature later than the post-axial (fibular) tarsal and metatarsal bones, while the Tibia matures earlier than the Fibula (Vogt & Vickers, 1931; Newell-Morris & Tarrant, 1978). From an evolutionary viewpoint the first toe lost functions with bipedalism. The fine heterochrony of the foot and hand deserves future research. We do not intend such a fine and exhaustive analysis, but simply to emphasize the evidence that shows nomenclature inconsistency and to look at EvoDevo of the hand and foot from a fresh and older perspective.

Fig. 1. Radiography of the left hand and wrist of a 9 years old boy. Metacarpal I (corresponding to the thumb) has a proximal point of ossification as the other phalanges have. Metacarpal II, III, IV and V have distal point of ossification. The radial carpal bones are less ossified than the ulnar carpal bones. The ossification of the radial distal epiphysis is more advanced than the ulnar distal epiphysis.

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RESUMEN: Se analiza el estado del primer metacarpiano cuya forma y desarrollo embrionario, fetal y postnatal corresponde a los de la primera falange del pulgar. Galeno notó que éste era la primera falange del pulgar cerca de 170 DC. Esto no es un simple cambio de nomenclatura, ya que da una nueva luz a los problemas evolutivos de ontogenia (EvoDevo). Nuestros datos radiográficos confirman que el lado radial (anterior o pre-axial) de la mano madura, pre y post-natalmente, mas tardíamente que el lado cubital (posterior o post-axial). Se discuten nuevas perspectivas sobre la ontogenia y filogenia humana y de primates, y se proponen estudios comparativos del desarrollo del pulgar y del ortejo mayor.

PALABRAS CLAVE: Madurez ósea; Pulgar EvoDevo; Primer metacarpiano; Primera falange del pulgar.

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