

# Age Determination by Employing Radiological Technique in Pediatric Age Groups

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## ABSTRACT

**OBJECTIVES:** To establish radiological parameter of chronological age by observing the appearance of ossification centers of bones comprising wrist in different pediatric age groups of our population.

**STUDY DESIGN:** Prospective descriptive study.

**SETTING:** Department of Radiology and Imaging, Liaquat University Hospital Jamshoro / Hyderabad Sindh, from January 2007 to December 2008

**METHOD:** Radiological study of wrist bones of 1544 children divided in 13 groups on the basis of 1 year age interval including both females and males representing the heterogeneous population of Hyderabad district of Sindh province was conducted. Reliable age record and freedom from any musculo-skeletal, nutritional and endocrinal disorders were the criteria for the selection of the study subjects.

**RESULTS:** The study reveals that the meantime of ossification of carpal bones and distal ends of ulna and radius is earlier in female subjects compared to their counterpart of same age group and also shows advancement in ossification time in both genders when compared with most of the countries of the world where bony age is scrutinized. By using these standards, bony age of child can be reliably expressed exactly in months.

**CONCLUSION:** The practice of estimating age in Pakistan remained dependent on the data charts of other countries and / or more on guess work with a margin of error  $\pm 1-2$  years because of non availability of our own data. Comparing the west, more subjects were included in this study; therefore the outcome provides more accurate age estimation with a margin of  $\pm 1-2$  months, by referring this presented study data. The Medical professionals, law enforcers and even the courts and public at large would be benefited from this study.

**KEY WORDS:** Bony age, Medicolegal, Ossification, Radiology.

## INTRODUCTION

Age represents progressive change in the childhood. Various pediatric milestones like muscular activity, eruption of teeth, height and weight gain, intelligence are observed to check the growth of child proportionate to age, to label him/her as normal or otherwise. Further, after name, parenthood, gender, age is considered as vital as other routine parameter used for any individual's recognition and placement in any society. Granting of certain civil rights and privileges, vesting of certain responsibilities and obligations to any citizen are age dependant phenomenon. No proper study has been conducted regarding the medicolegal and other age related issues in our country.

In Pakistan, due to illiteracy, unawareness about legal obligations, general ignorance, distant and scattered inhabitant of people and official's apathy, recording of births and deaths is not properly practiced, though the laws are promulgated and centers for registration purpose are identified by the state. When need arises, entries are made on verbal statement depending upon the memory, guess or interest of the needy. Hence

recorded age is often unreliable and lacks authenticity. Confusion and uncertainties arise in certain delicate decisions particularly in courts, where criminal responsibility, exoneration and gravity of punishment become age dependant affair. In today's deteriorating law and order situation, crime against children, by the children and use of children for commitment of crime by the hardened criminals is no more a hidden secret<sup>1</sup>.

It is observed by the researchers that radiological appearance and fusion of epiphyses of different body bones follow a definite sequence and a measurable time period so promises to give more accurate assessment<sup>2,3</sup>. The purpose of this study is to elucidate physical age of a child with its corresponding bony change that can be transpired and conveniently inspected on radiograph. The most commonly used skeletal standards in our country and majority of world for comparison and evaluation are those which were compiled and published by Grulich and Pyle in 1932-1942.<sup>4-6</sup> These standards are derived from American white children belonging to upper Socio-economical class. Such standards can not be of any help for our

population. Very few studies utilizing ossification of bones as parameter for age determination have been conducted in Pakistan, India and abroad with limited sample size.<sup>7-15</sup>

Perceiving the need for our own data and taking an account of varying socioeconomic conditions, inhabitation pattern, ancestral background, ethnical, religious profile and other variables that prevails in our society, it becomes necessary to research on our population in order to devise some objective parameter with lesser chances of error, so that the cropped up issues relevant to pediatric age can be resolved more professionally and reasonably.

## MATERIAL AND METHODS

This prospective descriptive study was conducted at the department of radiology and imaging, Liaquat University of Medical & Health Sciences, Jamshoro from January 2007 to December 2008 on 1544 subjects.

Subjects representing the heterogeneous population of the Hyderabad city and surroundings were selected from Obstetric and Pediatrics departments of Liaquat University Hospital, private clinics and maternity homes, and from the schools of Hyderabad and adjoining areas with confirmed dates of birth. Reliable age record and clinically freedom from musculoskeletal, nutritional and endocrine disorders are the two chief criteria utilized for selection of subjects. Some of the selected subjects (both males and females) belonging to educational institutes and known families have been followed up from 1-2 years. The difficulties, however, been faced when few of the subjects were shifted from their original localities or even migrated to other towns. Efforts made to keep contact with them for follow up as much as is humanly possible. The subjects that could not be followed up were dropped out from the study.

The parents of the children were informed about the purpose of study and methodology. A consent form was designed and presented to them for willingness to include their offspring's for study purpose.

The radiographs of wrist of the selected subjects were taken in the department of radiology Liaquat University Hospital to observe the ossification activity of the carpals and lower ends of radius and ulna bones. Sophisticated X-ray machine i.e. 300 MA, 500 MA and 50 MA portable machines were used. The method required a single radiograph of hand and wrist posterior-anterior view involving only a small radiation dose without significant bone marrow or gonadal exposure.

The pediatric age group in this study was further divided into 13 groups along with sexes, labeling them as group A to M indicating age group, (0 to 3months), (3 months to 1 year), (1 to 2 years), (2 to 3 years), (3 to 4 years), (4 to 5 years), (5 to 6 years), (6 to 7

years), (7 to 8 years), (8 to 9 years), (9 to 10 years), (10 to 11 years) and (11 to 12 years) respectively. This division is done for comprehensive and closer study of the changes that could have occurred within a year time. Group C to M shows 1 year gap. Time range for group A and B is further narrowed, that is from 0-3 months and from 3 months to 1 year, as maximum bony changes are expected in these time range.

The radiographs were inspected and interpreted by the authors and observation noted on the pre-designed proforma. Medicolegal importance and the relevant legal enactments are tabulated for instant reference (Table I). Additionally the record of all the subjects under study with regard to their gender, height, weight, chronological age, socioeconomic condition, geographical inhabitant, Ancestral background, mother tongue and religion have been tabulated.

## RESULTS

Total subjects numbered 1544, including 858 (55.6%) male children and 686 (44.4%) baby girls. **(Table I)** The age group under study ranged from 0-12 years. (Table I)

Amongst the number of children studied, majority of the subjects (51%) belong to average socioeconomic income group (Monthly income ranging from Rs. 10000 to Rs. 15000 with family size <5 or monthly income ranging from Rs. 15000 to 20,000 with family size >5), where as 631 (40.9%) of the subjects were from poor families (monthly income < Rs. 8000 family size <5 or monthly income < Rs. 10,000 family size >5). the socioeconomic class subjects with good monthly income of parents (8.1%) occupied the 3<sup>rd</sup> place.

Total 89.2% (1378/1544) of the subjects are based at urban areas; the remaining 10.8% are inhabitants of rural surroundings.

Capitate and Hemate bones show appearance at the age of 00-01-05 in either sex.

The present study shows agreement with the other researchers of the world in certain findings as well as disagreement on the some of the observations, so far age of appearance of carpal bones is concerned.

Comparable as well contrasting results are also found about the time of appearance of lines for distal epiphyses of Radius and ulna between our study and studies carried out in other countries.

The meantime of ossification of the 8 carpal and distal ends of radius and ulna bones found to be earlier in female children and even more earlier when compared with the residents of other countries of the world. **(Table II)**

The study resulted in accuracy of age estimation with the margin of  $\pm 2$  months by studying radiographs of wrist joints in pediatric age group.

**TABLE I: DIVISION OF AGE GROUPS ALONG WITH THEIR IMPORTANCE (MEDICAL – LEGAL – SOCIAL)**

GROUP	Appearance of Epiphyses	Cases Examined (No. of cases)			Importance
	Year Month-Day (Y-M-D)	Females (F)	Males (M)	Total	
<b>A</b> 0-3 M	-Two Carpals (one month after birth) <b>Fig:1</b>	62	76	138	<b>Medical &amp; Legal</b> - Skeletal Maturity
<b>B</b> 3M-1 Yr	-Two Carpals (One month after birth)	57	93	150	<b>Medical &amp; Legal</b> - Skeletal Maturity
<b>C</b> 1 Yr – 2 Yrs	- Two Carpals <b>Distal Radius</b> Females: 1 Yr & 6 M Males: 1 Yr & 9 M	44	64	108	<b>Medical &amp; Legal</b> - Skeletal Maturity
<b>D</b> 2 Yrs-3 Yrs	Females: 3 Carpals Males: 2 Carpals <b>Fig:2</b>	20	33	53	<b>Medical &amp; Legal</b> Normal findings will differentiate from Nutritional, Metabolic and Endocrine Disorders - Skeletal Maturity
<b>E</b> 3 Yrs- 4 Yrs	Females: 4 Carpals Males: 3 Carpals	40	40	80	<b>Medical &amp; Legal</b> - Skeletal Maturity
<b>F</b> 4 Yrs – 5 Yrs	Females: 5 Carpals Males: 4 Carpals	35	40	75	<b>Medical, Legal &amp; Social</b> - Skeletal Maturity
<b>G</b> 5 Yrs – 6 Yrs	Females: 6 Carpals Males: 5 Carpals	40	50	90	<b>Medical, Legal &amp; Social</b> - Skeletal Maturity
<b>H</b> 6 Yrs – 7 Yrs	Females: 7 Carpals Males:7Carpals (7 Years) <b>Distal Ulna</b> Females: 72% Males: 35% <b>Fig:3</b>	64	60	124	<b>Medical, Legal &amp; Social</b> - Skeletal Maturity
<b>I</b> 7 Yrs – 8 Yrs	<b>Carpals: 07 F &amp; M</b> <b>Distal ULNA</b> <b>Females &amp; Males 100%</b>	63	60	123	<b>Medical, Legal &amp; Social</b> · In capable of committing crime below 7 years · No criminal responsibility - Skeletal Maturity
<b>J</b> 8 Yrs – 9 Yrs	<b>Carpals: 07</b> <b>Females &amp; Males</b>	53	78	131	<b>Medical, Legal &amp; Social</b> - Skeletal Maturity
<b>K</b> 9 Yrs- 10 Yrs	<b>Females : 8 Carpals</b> <b>Males : 7 Carpals</b>	50	80	130	<b>Medical &amp; Legal</b> - Skeletal Maturity
<b>L</b> 10 Yrs–11 Yrs	<b>Carpals: 08</b> <b>Females &amp; Males</b> <b>8<sup>th</sup> Carpal i.e Pisiform</b> <b>(80% in Males)</b>	82	93	175	<b>Medical &amp; Legal</b> - Skeletal Maturity
<b>M</b> 11 Yrs–12 Yrs	<b>Carpals: 08</b> <b>Females &amp; Males</b> <b>Fig:4</b>	76	91	167	<b>Medical &amp; Legal</b> - Capable of committing crime if there is sufficient maturity of mind 7 to 12 yrs - Skeletal Maturity
<b>Total</b>		<b>686</b>	<b>858</b>	<b>1544</b>	

**TABLE IIa: COMPARISON OF PRESENT STUDY WITH OTHERS, WITH RESPECT TO APPEARANCE OF THE CARPAL BONES AND DISTAL RADIUS ULNA**

Author with year	Capitate		Hamate		Triquetrum		Lunate		Scaphoid		Trapezium		Pisiform	
	F	M	F	M	F	M	F	M	F	M	F	M	F	M
Paterson (1929)	0.5	0.5	0.5	0.5	2-3	3-4	3-4	4-5	6	6	4-5	6	9-10	12-14
Galstaun (1937)	0.5	0.5	0.5	0.5	2-3	3-4	5	6	6	7-11	5-6	7	9-12	12-14
Flecker (1942)	0.5	0.5	0.5	0.5	3-4	4	3	4	4	6	5	5	10	11
Mackay (1952)	0.5	0.5	0.5	0.6	1.5	3	3.5	4.5	5.25	6	5.5	6.5	11	14
Hansman (1962)	0.5	0.5	0.5	0.5	2	3	3	4.5	4.5	7	4.2	6.5	8.5	11.5
Hasan & Narayan (1963)	0.5	0.5	0.5	0.5	3	5	6	6	7	7	6	8	11	13
Rikhasor M and Qureshi (1991)	0.5	0.5	0.5	0.5	3	3-5	4.5	5.5	6	7	4.5	7	11	12
Present study (2007-2008)	Y-M-D 0-1-5	Y-M-D 0-1-5	Y-M-D 0-1-5	Y-M-D 0-1-5	Y-M-D 3-0-0	Y-M-D 4-0-0	Y-M-D 4-0-0	Y-M-D 5-0-0	Y-M-D 5-0-0	Y-M-D 6-0-0	Y-M-D 6-0-0	Y-M-D 6-5-0	11	12

**TABLE IIb: COMPARISON OF DIFFERENT NATIONS**

Author (with year)	Subjects	Appearance in years			
		Radius		Ulna	
		Females	Males	Females	Males
Paterson (1929)	English	1	1- 1.5	--	8
Sindos & Derr (1931)	Egyptians	--	--	--	--
Galstaun (1937)	Bengalis	1	1	8-10	10-11
Flecker (1942)	Australians	1	1	5.0	6
Mackay (1952)	East Africans	1	1.5	8	9
Hansman (1962)	Americans	1	1.5	6	7.5
Rikhasor M and Qureshi (1991)	Pakistanis	1	1.5	6.5	8
Present study (2007-2008)	Pakistanis	<b>Y-M-D 1-6-0</b>	<b>Y-M-D 1-9-0</b>	<b>Y-M-D 7-0-0</b>	<b>Y-M-D 8-0-0</b>

**Sequence of Appearance of Carpal Bones**

1-2 Capitate and Hemale 3. Triquertrus 4. Lunate  
5. Scaphoid  
6. Trapezium 7. Trapezoid 8. Pisiform

**DISCUSSION**

Life starts with the conception within mother's womb. With this blessed eventuality, days are counted and arrangements are done for the safety, persistence, health and finally safe delivery of this unseen guest in this world at an appropriate time. This counting of the day's in fact represents the age of the baby. Then in this world age becomes a mandatory indicator of his

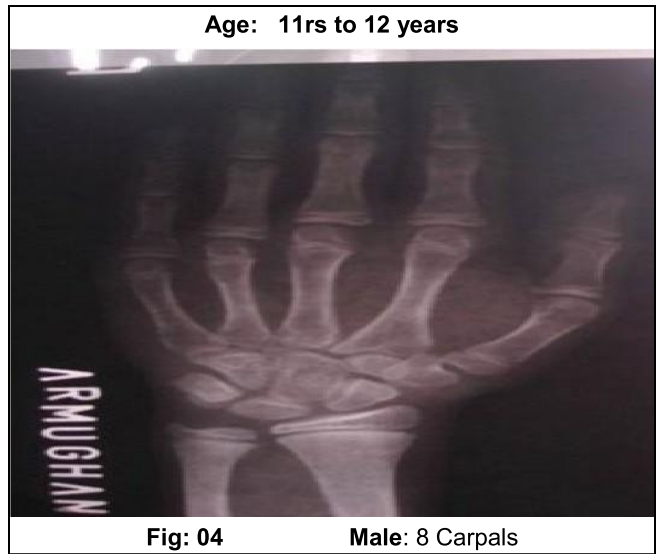
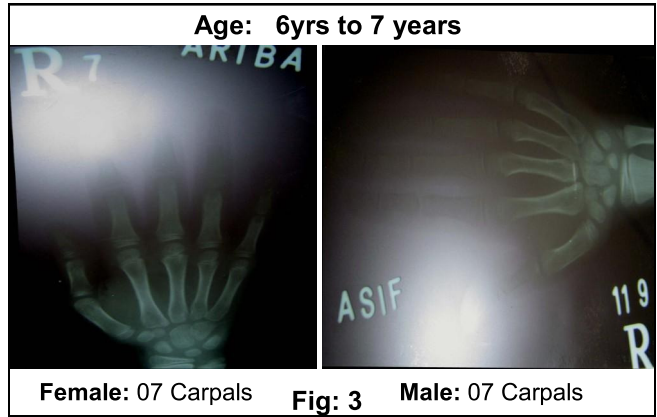
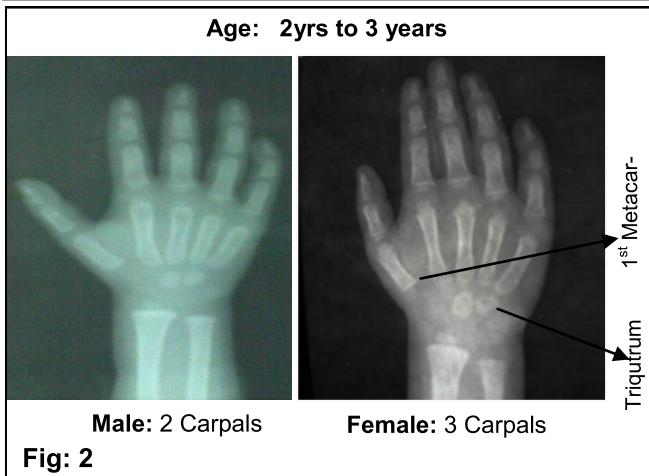
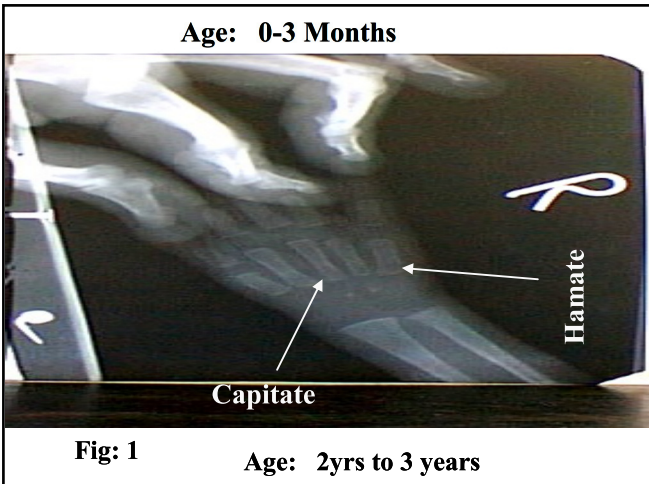
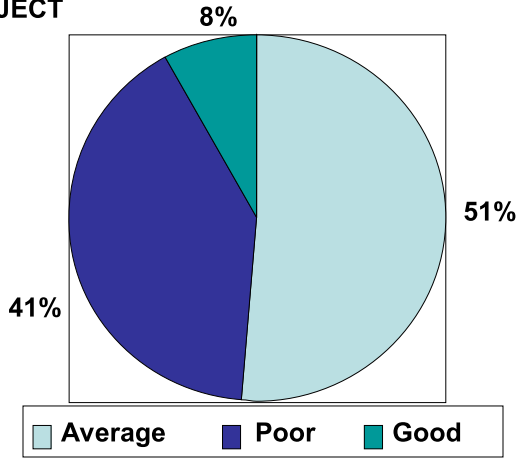
personality and is written on every paper he fills and asked at every step he is interviewed.

Determination of age, otherwise, is a very simple mathematical calculation and a professed entity. Sometimes the claim of the person is challenged, especially in court proceeding and where personal gains are attached with the age factor. In such situations, an objective indicator is required that can settle the issue justly, promptly and of course, cheaply.

Many determinants for age has been devised and studied but bony changes in the form of development and retrogression are considered as more reliable.

In the childhood, the appearance of the lines of carpal

**CHART II: SOCIO-ECONOMIC PROFILE OF THE SUBJECT**



bones and distal ends of radius and ulna (jointly comprising wrist) is a better option of age determination. During development, carpals appear as dense pin points on a radiograph; with time they increase in size till attaining their optimal sizes and characteristic shapes. In the present study Capitate and Hamate ossified during infancy (1-2months), the event is not

coinciding with other studies. (Table-II)  
 The estimation of age in pediatric age group in this study is based on study of ossification and skeletal maturity of all bones comprising of wrist that is 8 carpals and 2 centers, one each for distal ends of radius and ulna.  
 The most commonly referred skeletal standard throughout the globe is that are published by Grulich and Pyles<sup>5,6</sup>. These standards are derived from white children of upper socioeconomic status and cultured class of American population. Our finding coincided with their only up to the age of first year of life. In the later years our study reveals advancement in the appearances of epiphyses.  
 The time of appearance of ossification centers is found earlier in girls than boys, this finding is in agreement with other researchers of the world and it is also seen that after 2 to 7 years of age the female has one more carpal than males (Table-I). This project also displays that our children show advancement in appearance of the centers when compared with most of the countries of the world. (Table-II)

This study is more extensive, (involving 1544 subjects and having a narrow gap of 1 year between the observations noticed), hence more reliable, as it expresses age, in years and months, therefore it gives idea of age more exactly than the study of other authors where the age is mentioned in years only.

### CONCLUSION

The outcome provides more accurate age estimation with a margin of  $\pm$  1-2 months. By referring this presented study data, the Medical professionals, law enforcers and even the courts and public at large would be benefited.

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