Original Article

ASSESSMENT OF AI BONE AGE CALCULATORS

Ahmed H.K. Abdelaal[1,2(*)], Ahmad Mokhtar Abodahab[3]

[1]Orthopaedic Unit, General and Specialized Surgery dept., Taibah Univ., Almadina Almonawara, KSA
[2]Orthopedic surgery dept., Faculty of Medicine, Sohag Univ., Sohag, Egypt
[3]Radiology dept., Faculty of Medicine, Sohag Univ., Sohag, Egypt

E-mail: Dr.ahmadabodahab@gmail.com

Abstract

Background: In Bone age assessment is an essential process in many specialties (radiology, orthopedic, pediatric and forensic medicine) and for many medical purposes of assessment. Appearance of ossification centers, and fusion of the epiphyseal lines in different joints are a continuous progressive process in correlation to age and variable between both genders. Assessment of bone age is a confusing topic for many specialties that may be a difficult process and need reviewing of many charts for accurate assessment. Artificial Inelegance (AI) is a very important branch of technology and computer science. It has many applications in medical field like calcium score of cardiac imaging, chest CT, Carotid doppler, fetal medicine, fractures detection and bone age assessment. AI has different applications in orthopedic, as assessment of leg length, scoliosis and bone age. Many AI calculators are currently available online either paid or free of charge. These AI calculators enable very fast calculation, but accuracy is quite variable. This study aimed to assess accuracy of these calculators and discuss the importance and faults of their use.
Aim of the study: *The purpose of this study was to evaluate the use of the bone age AI calculators* ***Patients and methods:*** *This retrospective study was conducted on 50 cases of X ray wrist. The scans were assessed by 2 online AI bone age calculator and compare the results of both and the real age of the case* ***Results:*** *50 cases of X ray Lt wrist PA view were studied and by 2 online AI bone calculators, 34 males and 16 females. 0.8 y to 22, median age was 10 years. Significant variation between diagnosed age and chronological age diagnosed by each Bone age calculator was recorded and revealed that not all AI bone age calculator has the same accuracy.*

Keywords: *Bone age, AI Calculators, X-ray Hand.*

1. Introduction

Bone age assessment is an important medical topic either in forensic aspects or clinical diagnosis of many diseases [1-3]. Bone age assessment is done depending on X ray assessment of ossification centers in certain joints [1,4-5]. X ray of the wrist joint (mainly Lt wrist) is considered the main radiological examination for assessment of bone age [1-6,7]. Bone age assessment considered one of the confusing topics for radiologists due to multiple calcification centers at the wrist and wide variability of duration of appearance or ossification of each. Artificial Intelligence (AI) is a wide branch of technology and computer sciences has a very wide range applications in different fields of life generally and in medical fields especially radiology. AI bone calculators are automated tools used for assessment of bone age and other medical topics are freely available online for medical use [8-10].

2. Patients and Methods

This retrospective study was conducted on 50 cases of X ray wrist of both sexes aged from 0- to 20-year-old, in Sohag University Hospital, Egypt. The scans were assessed by 2 online

AI bone age calculator (**C1:** *Rad Sherpa Bone Age Calculator* and **C2:** *Stanford Bone Age Calculator*) and compare the results of both and the real age of the case (Both AI calculators are a free online calculator and their websites frontpages notice that this AI-powered bone age calculator is for research purposes only and is not intended for clinical use). Using of these bone age calculators is depending on uploading data to the calculator online including X-ray scan of different extensions as JPEG, PNG and BMB are accepted by the website, fig. (1). More than 200 cases were viewed and excluded from the study. Exclusion criteria were: other age groups, non-complete scan of wrist and hand, Rt hand, fractures or foreign bodies around wrist, fig. (1).

Figure (1) The front page of AI bone age calculator A- (**C1**) and B- (**C2**), explaining the required date for each as gender, birth of date, study date and X-ray image type, and explains that the calculator is for research purpose only.
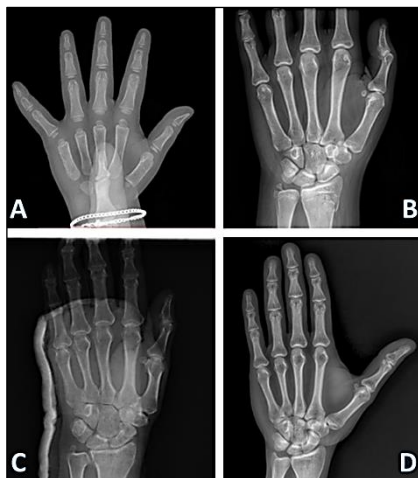

Figure (2) Examples of excluded cases from the study A- Foreign body B- Fracture C- Cast 4- Other age group.

3. Results

This retrospective study was conducted on 50 cases of X ray Lt wrist PA view. The scans were assessed conventionally and by 2 online AI bone calculators, the results were recorded in excel sheet, compared and analyzed. Sex distribution of the study cases was 34 males and 16 females, fig. (3). Age distribution represented in figure which illustrating that minimum age was 0.8 y, maximum age was 22 and the median age was 10 years, fig. (4). The results, tab. (1) according to C1 AI bone calculator, 28% of cases (14) were Normal, while 30% (15 cases) were diagnosed as delayed bone age, and 42% of cases (21) were diagnosed to have an advanced bone age. The variation between diagnosed age and chronological age ranged from -3 to +3. C1 calculator results are a definite numbers of bone age in years and months, while C2 calculator always giving a range +/- 12 months added to the resulted number of bone age. The results according to C2 AI bone calculator, 14% of cases (7) were Normal, while 28% (14 cases) were diagnosed as delayed bone age, and 58% of cases (29) were diagnosed to have an advanced bone age. C2 calculator results were more variated than chronological age, fig$_s$. (5 & 6). C1 calculator has non mandatory option to insert birth date and study date, and it calculate chronological age and compare it with the automatically estimated bone age and gives a conclusion with the result: normal, delayed or advanced according to this comparison with the inserted dates, it also gives the AI estimated date alone if these dates weren't inserted with no affection of the calculation process, fig. (7-a). While the C2 calculator only gives an estimated number of bone age +/- 12 months, fig. (7-b).
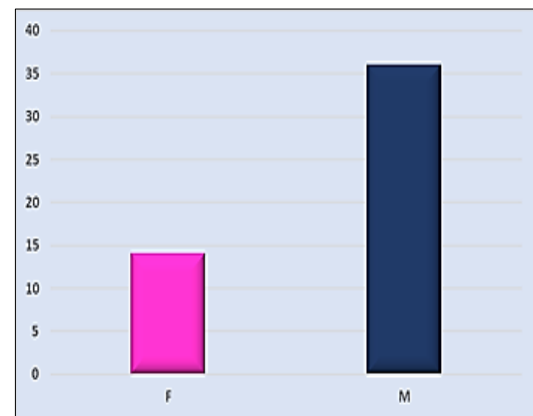

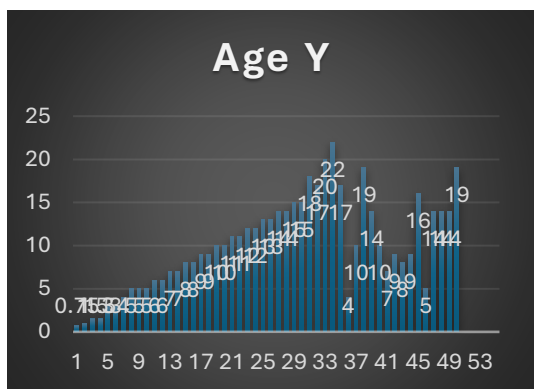Figure (3) Gender distribution of the study

Figure (4) Age distribution of the study cases in years

Table (1) Data and results of the study

| Result	C2 Age	Result	C1 Age	Age Y	Sex	Case
Advanced	6		2	0.75	M	1
	12	Advanced	3	1	M	2
	6		3	1.5	M	3
	6		3.5	1.5		4
	15	Normal	3	3	F	5
	6	Advanced	4.5	3	M	6
	13	Delayed	2.5	4	F	7
	14		5	5		8
	6	Normal	5	5	M	9
	15		5	5	F	10
	13	Delayed	5	6		11
Normal	6		4.5	6		12
Delayed	6	Advanced	8	7		13
Advanced	11	Normal	7	7		14
	10		8	8	M	15
	11	Advanced	9	8		16
Delayed	6	Delayed	8	9		17
Advanced	12	Advanced	11	9		18
	12		12.5	10		19
	13		13	10	F	20
	12	Normal	11	11	M	21
	12		9	11	F	22
Normal	12	Delayed	11.5	12		23
	12		11.5	12		24
	13		12.5	13		25
Delayed	12		11	13	M	26
Normal	14	Normal	14	14		27
Advanced	15	Advanced	15	14		28
	16		18	15		29
	6		16	15	M	30
Delayed	13	Normal	18	18	F	31
	16	Advanced	18	17		32
	16	Delayed	18	20	M	33
	16		19	22		34
	15	Normal	17	17	F	35
Advanced	6	Advanced	6	4	M	36
	12	Normal	10	10	F	37
Delayed	16		19	19	M	38
Advanced	15		17	14	F	39
	13	Advanced	13	10		40
	8		8	7	M	41
Delayed	8	Delayed	8	9		42
	7		7	8	F	43
Advanced	11	Advanced	11	9		44
Normal	16		18	16		45
Advanced	6	Normal	5	5	M	46
Delayed	12	Delayed	13	14		47
Normal	14	Normal	14	14		48
Advanced	16	Advanced	17	14		49
Delayed	15	Delayed	17	19	F	50
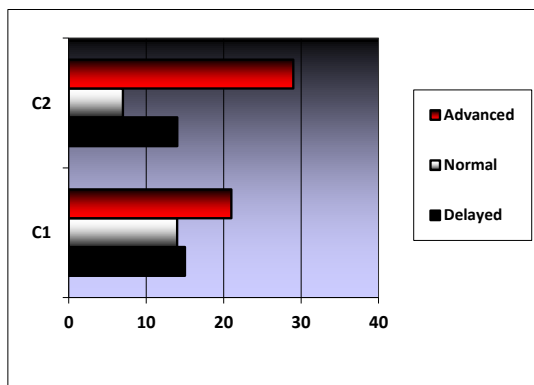
Figure (5) Different results of AI estimated bone age of the study cases by C1 & C2 calculator.
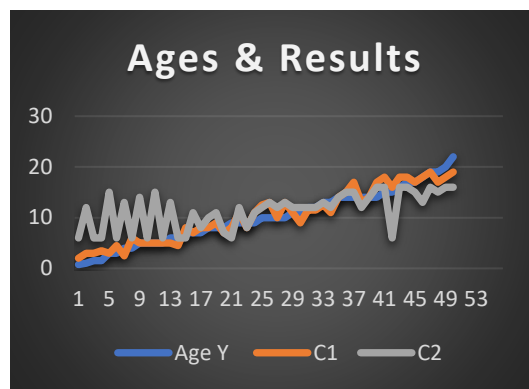

Figure (6) Ages of the study cases in corelation to results of both calculators

Figure (7) **a.** & **b.** Forms of automated results in both AI calculators used in the study: A- C1 calculator, B- C2 calculator

4. Case Presentation

In this section we are presenting some selected cases from our study in comparison with the standard cases of normal bone age, figs. (8-12).

Figure (8) A- (Case 5) X-ray Lt wrist PA view, female patient, 3 y. with normal bone age as diagnosed by C1 calculator and compared with (B) normal bone age of female 3 years old (1), while C2 calculator diagnosed it as advanced bone age of 15 years old, tab. (1).

Figure (9) A- (Case 31) X ray Lt wrist PA view, female patient, 18 y. with normal bone age as diagnosed by C1 calculator and compared with (B) Normal bone age in female 18 years old (1) - while C2 calculator diagnosed it as delayed bone age of 13 years old, tab. (1).

Figure (10) (Case 1) Male patient, 8 months. Diagnosed by C1 calculator as advanced bone age 2 years and by C2 calculator as 6 years, while compared with normal z and error in assessment by both calculators.
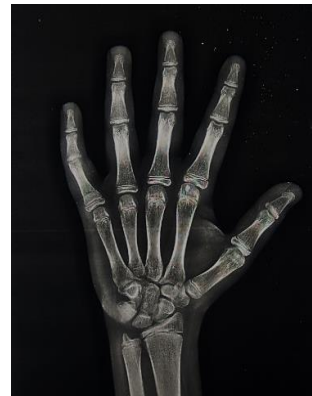

Figure (11) (Case 27) X ray Lt wrist of a boy 14 years old, diagnosed as normal bone age by both calculators.

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Figure (12) 6 Cases (5, 8, 14, 21, 27 & 31) different cases involved in the study with normal bone ages (**M**: Male / **F**: Female)

5. Discussion

AI is an important branch or field of computer sciences and technology which has a wide range of applications in medical field generally and in in radiology specifically [2,5,8,9,11]. Other links and calculators for bone age are also available, tab. (2). AI has many applications in orthopedic field, fig. (13)

Table (2) Different Bone age AI calculator's links:

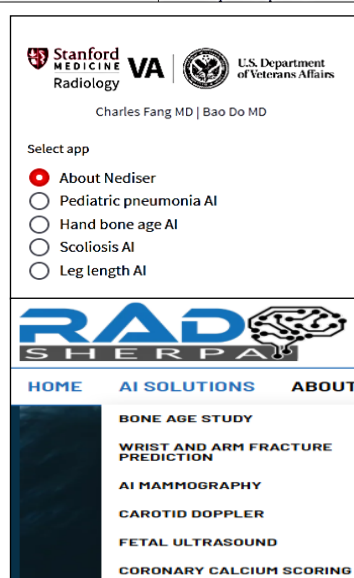| Website name	Link	Price
Stanford Radiology Hand Bone Age AI	http://www.xrayhead.com:8080/	Free
RAD SHERPA Bone Age Calculator	https://freeboneage.com/	Free
16 BIT	https://www.16bit.ai/	(7 Days free Trial)
Pediatric bone age calculator	https://kerbyradres.github.io/BoneAge/	
BoneXpert	https://bonexpert.com/	Free Trial

Figure (13) Different applicatons of AI in orthopedics (Stanford Medicine website)

5.1. *AI calculators faults of use*

Our study approved that some faults can occur during using of AI bone age calculators, this fault may relate to none proper gender of the cases on the calculator which results in significant variation in the calculated result and diagnosis as explained in fig. (14). Unclear scans by a foreign body or fingers of other person holding the hand of the patient can significantly alter the calculated bone age, fig. (15). Changes in the dimensions, direction and zoom of the calculated scan can change the calculated results, fig. (16). Calculating of bone age of elder patients (30th and more) is usually estimated as a delayed bone age, fig. (17), this may be due to AI calculators' big data is depending on previous date of ages up to 20th, so it hasn't the ability to estimated elder ages. Uploading of scan of other joints as Rt hand or even foot is not estimated by the calculators, and it gives a result as if it scanning of Lt hands, fig. (17). Our study is agreeing with Booz et al that AI assessment of bone age is an important tool with variability of accuracy between different web sites or editions and it may improve efficiency in routine clinical work by reducing reading times without impairing the accuracy [2]. No interference with the conclusion of Lee et al that Currently, AI in medical imaging is perform as an assistant that can reduce the burden of doctors rather than competing against them. AI- bone age calculations can reduce the burden of radiologists who handle a large number of images to determine bone age [3]. The burden of doctors rather than competing against them. AI- bone age calculations can reduce the burden of radiologists who handle a large number of images to determine bone age [6]. Our study is agreeing with Cheng, et al that AI bone age calculators when accurate enough and calibrated it provides more timely, and efficient results of bone age diagnosis, and can be applied for clinical teaching in hospitals, thus reducing the workload of physicians and provides physician-assisted diagnoses [6]. C Cheung, JPK Chan, CWK Ng, et al and many other studies were discussing the accuracy of different AI calculators in different orthopedic and other medical topics which approved variable accuracy with overall improvement with more advanced editions [6-10,12-19].
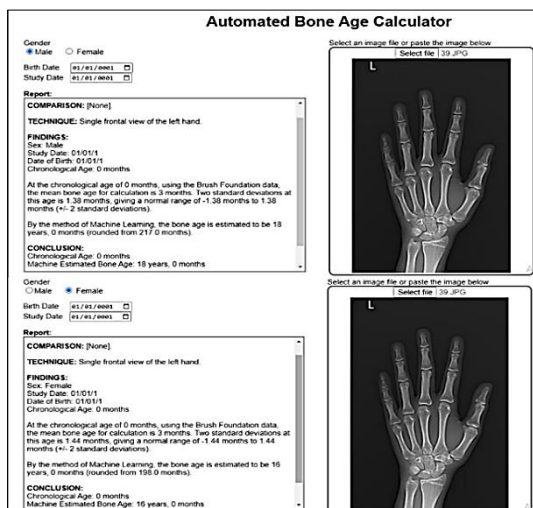
Figure (14) AI automated calculation of the same X ray scan with choosing of different gender. Notice the difference of result which is estimated equals 18 years as male while 16 years as female.
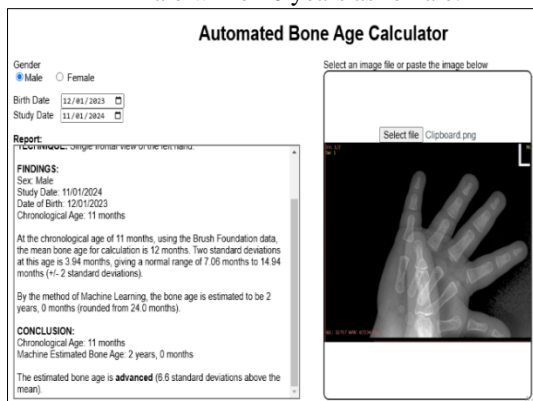

Figure (15) Male patient aged 11m, diagnosed as advanced bone age 2 y, likely due to image distortion by imaging of parent fingure holding the infant hand.
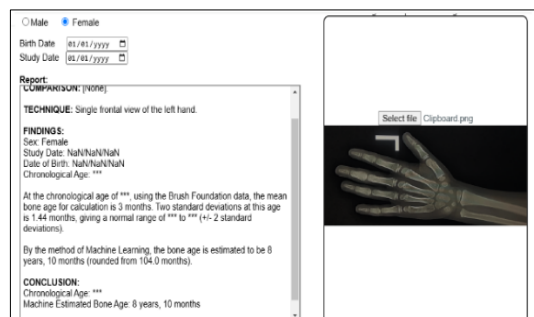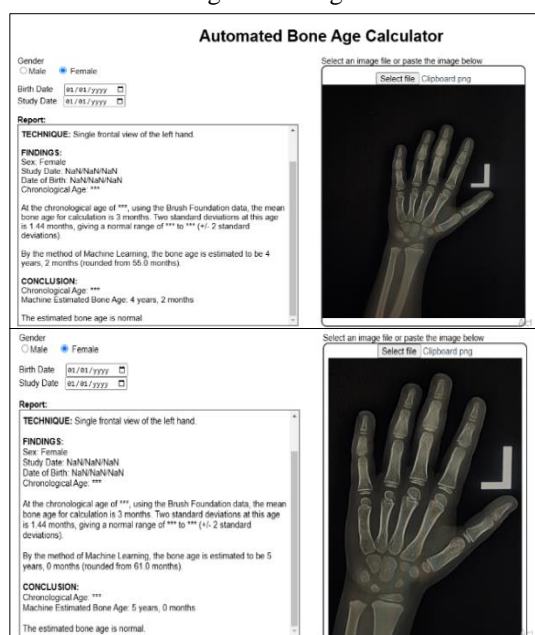

Figure (16) Female patient 5 years old, with variable results of bone age estimation of the same X ray image (4y, 2 m to 8y,10 m) due to changes in zoom and rotation of the image.
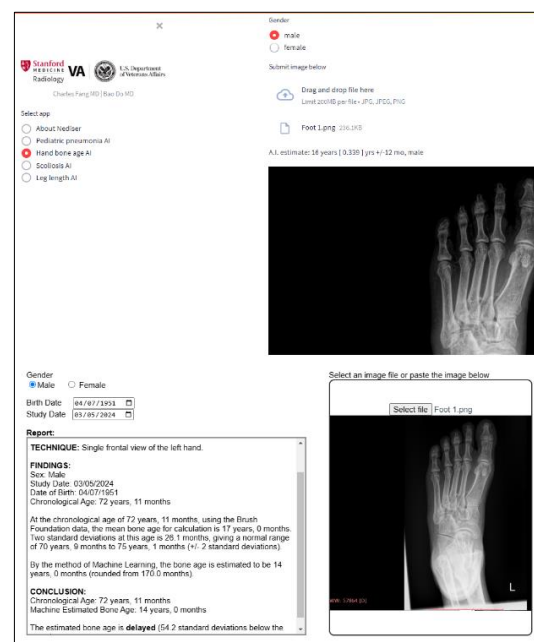

Figure (17) X ray Lt foot of male patient 74 years old, estimated by both calculators as Lt hand X ray with bone age 14 and 16 years old

6. Conclusion

AI bone age calculator is a very important tool for rapid assessment of bone age which is a confusing topic for many radiologists and can improve results of assessment when accurate enough. Using of it requires using of X-ray images of accurate non impaired or changed dimensions. Changes in X ray image dimensions by non-accurate angle of imaging for conventional images or editing changes by pasting on word file can significantly alter the results and impair AI calculators' measures. Accuracy of all AI bone calculators are not the same and it should be calibrated and compared well with conventional charts before being dependent for diagnosis. The radiologist using it must have enough knowledge about at the least the main and essentials of bone age assessment findings.

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