

Research Article

Estimation of Age by Pulp-Tooth Area Ratio Using Three Computer Aided Software's

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ABSTRACT

Estimation of age in an individual whether living or dead has received a considerable attention in forensic science. Recently, the dental maturation system has gained impetus as a valuable index for age estimation, as teeth are more resistant to most peri- and post mortem changes. Radiological age estimation using teeth rely on developmental stages of teeth especially in children while in adults; the continuous deposition of secondary dentin throughout life is depicted by reduction in pulp area. Through this paper we bring across a radiological study to estimate the age of an individual via 3 computer aided software's on maxillary central incisor. 30 periapical radiographs of individual aged ≥ 12 to ≤ 30 years were taken

using radiovisiography (RVG). Radiographic images were processed using the software; data was statistically analyzed to compare the age. There was no statistical significant difference in age calculated by Adobe Photoshop and Auto CAD, Adobe Photoshop $p=0.432$ and Auto CAD $p=0.004$; though there was significant statistical difference in age calculated by Image J, $p<0.001$. It was concluded that pulp/tooth area ratios of maxillary central incisor are reliable for estimation of age and AutoCAD gave the most accurate results.

Keywords: Age estimation; Forensic odontology; Maxillary central incisor; Pulp/tooth area

Introduction

Humans often categorize themselves in terms of race or ethnicity, age and gender. There arises the difficulty in differentiating them on the basis of race, age and gender; Forensic science is the application of a broad spectrum of sciences to answer questions of interest to a legal system pertaining to identification of an individual. When considering age estimation, certain applications of Forensic odontology are undulating of which age estimation is one of the essential tools in identification of an individual.

Forensic odontology demands the interest in determining biological indicators for age estimation in individuals using dental development. It uses methods which include the analysis of Gustafson and Johanson as well as the assessment of dentinal translucency and of cementum annulations.¹⁻⁵ These methods are destructive for tooth structure therefore not appropriate for living individuals. Hence there arises a need for an optimal age estimation procedure. Dentin and the various age related changes in dentin have been more often used in age estimation methods. A commonly used method found to be effective is the evaluation of secondary dentine apposition.⁶ This apposition is a continuous, age-associated process, which alters the size of the pulp chamber.

Recently the research has shown utility of pulp space for age estimation by using pulp/tooth area ratio with the help of

softwares.⁷⁻⁹ Pulp/tooth area ratio is a morphological variable obtained by dividing the surface area of pulp to tooth calculated by measuring the surface area of the outline of pulp and tooth. Radiographic evaluation done by Kvaal *et al.* age estimation method by indirectly measuring secondary dentin deposition on radiographs and similar and more acceptable and relatively accurate method was established by Cameriere *et al.* in 2004 using pulp/tooth area ratio taking measurements with the help of computers by utilizing the AutoCAD 2000 software and later in Indian population also validation of the same was done by Jeevan *et al.* with Adobe photoshop CS3 giving relatively accurate and acceptable results.¹⁰⁻¹³

Since recent reports construct population-specific equations to enhance age prediction, this study was done to estimate age from pulp/tooth area ratio from Haryana population using periapical dental radiographs. Aim of the study was to assess and compare age of an individual via 3 computer aided softwares (Image J, Adobe Photoshop and Auto CAD) on Maxillary Central Incisor. The objectives were to know whether the softwares help in age estimation; to compare and correlate one imaging software with other, to know the best software and the ease of working among the 3 software.

Materials and Methods

The participants for the study were enrolled amongst the patients reporting to the OPD of Dept. of Oral Medicine and

Radiology of the SGT Dental College and Hospital and a total of 30 subjects of North Indian, Haryana population origin in the age range of ≥ 12 to ≤ 30 years fulfilling the inclusion and exclusion criteria as appended below.

Inclusion criteria

- 30 individuals aged between ≥ 12 to ≤ 30 years.
- Normally erupted Maxillary Central Incisor.
- Fully formed root of Maxillary Central Incisor

Exclusion criteria

- Any pathology such as caries, periodontitis, severe attrition, abrasion, erosion, fracture or impaction.
- Restoration, endodontic fillings.
- Any prosthetic appliances.
- Malaligned or Rotated Maxillary Central Incisor

A total of 30 periapical radiographs were made after the necessary radiation safety precautionary measures have been taken by paralleling cone technique on radiovisiography (RVG). Radiographic images were saved in a digital format (JPEG format). Radiographic images of maxillary central incisor were imported to the softwares accordingly and processed using the computer-aided softwares, Image J (Wayne Rasband, National Institute of Health, USA), Adobe photoshop (Adobe systems incorporated, San Jose, Californis, USA) and Auto CAD (Autodesk Inc., San Rafael, USA) to calculate the pulp/tooth area ratio; which is a morphological variable obtained by dividing the surface area of pulp to tooth calculated by measuring the surface area of the outline of pulp and tooth on the radiograph taken (Figure 1).

AutoCAD is a software application for 2D and 3D computer aided design (CAD), developed and marketed by Autodesk, Inc. AutoCAD is used across a range of industries, including architects, project managers and engineers, among other professions, basically being engineers software which requires prior training schedule to know how to operate. Hereby we are utilizing the AutoCAD 2008 version.¹⁴

Adobe Photoshop is a raster graphics editor developed and published by Adobe Systems Photoshop was created in

1988 by Thomas and John Knoll. Since then, it has become the industry standard in raster graphics editing, It can edit and compose images in multiple layers. Photoshop has vast support for graphic file formats. Here by we are utilizing Adobe Photoshop CS6 version.

Image J is a public domain, Java based image processing program developed at National Institute of Health (NIH), a biomedical research facility located in Maryland, USA. It can display, edit, analyze, process, save and print images. It can calculate area and pixel value statistics of user defined selections. Hereby we are utilizing 1.45s version.¹⁵

The pulp and tooth area were measured using the command 'area' in the AutoCAD software with 20 predestinated points for tooth surface outline and 10 for pulp outline. In Adobe Photoshop pen tool was used for the tooth surface and pulp surface outline. For Image J, polygonal tool was used to draw the outline of tooth and its pulp chamber.

The ratio derived used to calculate the predicted age using the formula as given by Jeevan *et al.* (modified Cameriere *et al.* for India population), i.e., $\text{age} = 96.795 - 513.561 \times (\text{pulp/tooth area ratio})$ were applied to predict the chronological age.¹³ The chronological and actual age was noted as in the patient record or told by the patient and rounded off to the nearest number. All measurements were carried out by the single observer; Data was tabulated (Table 1), and then subjected to statistical analysis using Statistical Program for Social Sciences (SPSS), Version 16 (IBM Company, Chicago, IL). Paired t-test was applied to test the difference in age.

Results

The significant differences of the predicted age calculated from the measurements obtained by the softwares i.e. Image J, Adobe photoshop and AutoCAD included in the study is given in Table 2 and Figure 2. Deviation of age by the 3 software's is shown in Figure 3. The results showed that the predicted age calculated using maxillary central incisor by the 3 softwares was in accordance to the chronological age. There

Table 1: Paired t-test was applied to test the difference in age.

S. No.	Image J	Adobe photoshop	Auto CAD	Actual Age	S. No.	Image J	Adobe photoshop	Auto CAD	Actual Age
1	19	28	27	24	16	30	24	25	24
2	25	17	18	21	17	19	20	21	21
3	17	21	22	21	18	20	14	17	16
4	26	20	22	22	19	26	20	24	22
5	27	19	20	22	20	29	23	25	23
6	28	20	24	23	21	25	28	28	30
7	28	26	26	22	22	24	21	22	18
8	17	15	16	12	23	29	25	27	23
9	29	25	21	23	24	30	26	26	24
10	24	18	20	20	25	30	25	25	24
11	28	22	21	23	26	30	20	24	25
12	30	25	27	22	27	27	23	24	20
13	29	27	26	24	28	19	28	28	24
14	29	23	24	24	29	29	21	22	23
15	30	26	25	22	30	30	27	27	23

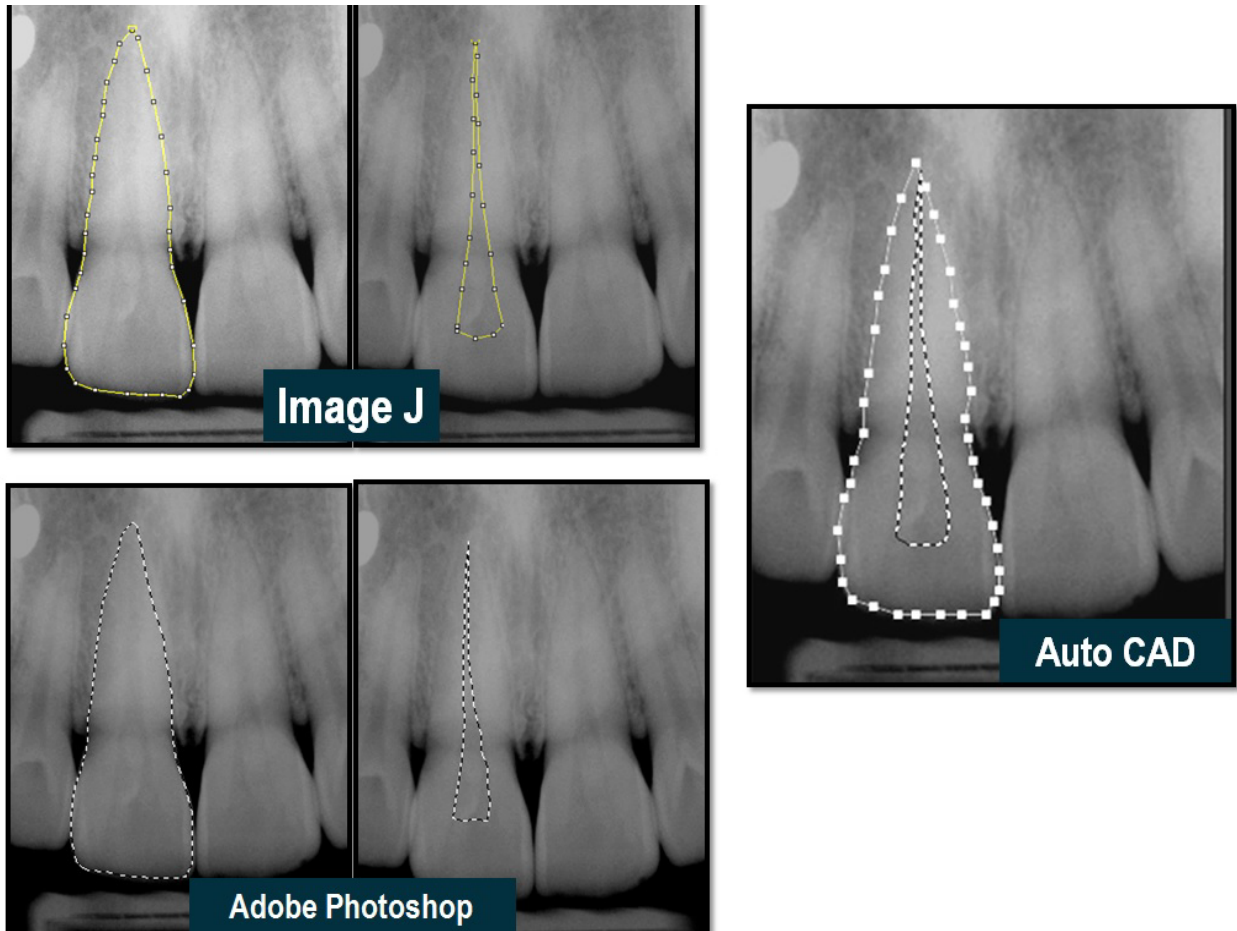


Figure 1: Surface area of the outline of pulp and tooth on the radiograph.

Table 2: Paired samples statistics.

		N	Mean	Std. Deviation	t-value	p-value
Pair 1	Actual Age	30	22.2	3.05	5.557	<0.001
	Image J	30	26.1	4.29		
Pair 2	Actual Age	30	22.2	3.05	0.797	0.432
	Adobe Photoshop	30	22.6	3.83		
Pair 3	Actual Age	30	22.2	3.05	3.107	0.004
	Auto Cad	30	23.5	3.21		
Pair 4	Image J	30	26.1	4.29	4.194	<0.001
	Adobe Photoshop	30	22.6	3.83		
Pair 5	Image J	30	26.1	4.29	3.429	0.002
	Auto Cad	30	23.5	3.21		
Pair 6	Adobe Photoshop	30	22.6	3.83	2.919	0.007
	Auto Cad	30	23.5	3.21		

was significant statistical difference in age calculated by Image J, $p < 0.001$. There was no statistical significant difference in age calculated by Adobe Photoshop and Auto CAD (Adobe Photoshop $p = 0.432$, Auto CAD $p = 0.004$). On comparison of the 3 softwares the predicted age was best measured by AutoCAD followed by Adobe Photoshop and then the Image J (Figure 2).

Discussion

Forensic is derived from the Latin word *forens (is)*: of or belonging to the forum, public. The forensic science encompasses the application of specialized scientific and/or

technical knowledge to questions of civil and criminal law, especially in court proceedings. One of the most common questions asked by the legal system is a request to provide proof of identity of an item/person and age of the person.¹⁶

In the last decade, a number of new methods for age assessment from teeth have been developed, or existing methods refined, all of which claim relatively precise estimates which includes the analysis of Gustafson and Johanson as well as the assessment of dentinal translucency and of cementum annulations.¹⁷

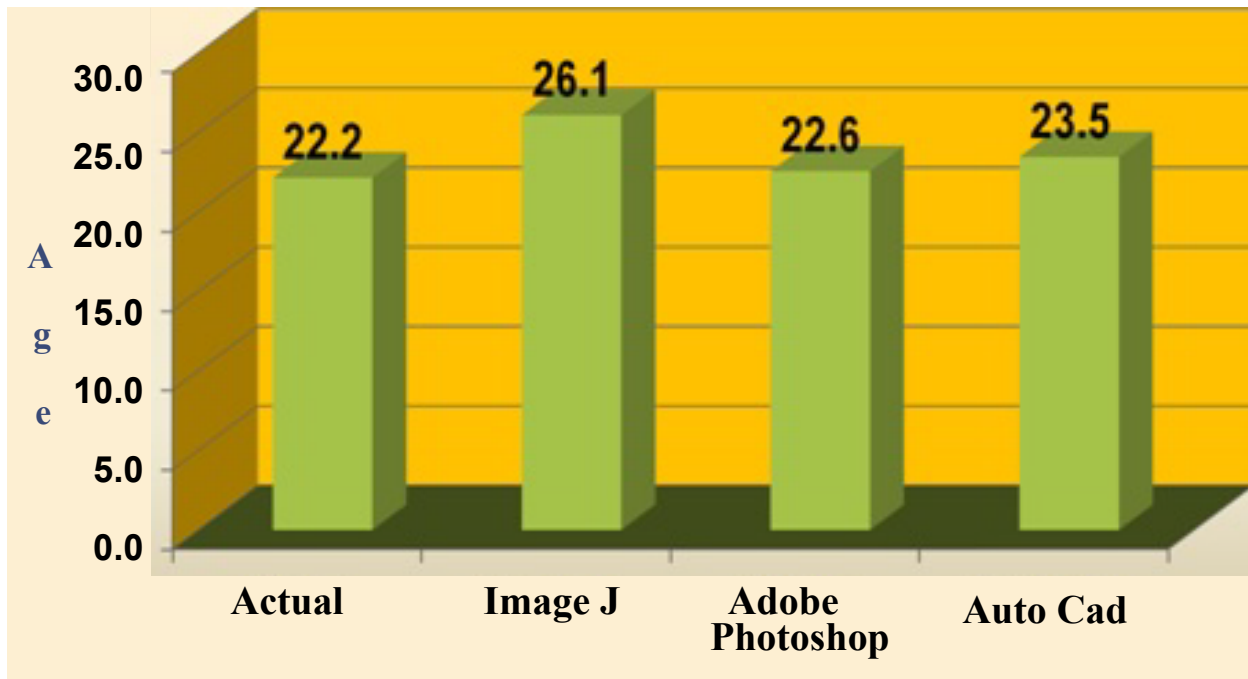


Figure 2: Significant differences of the predicted age calculated.

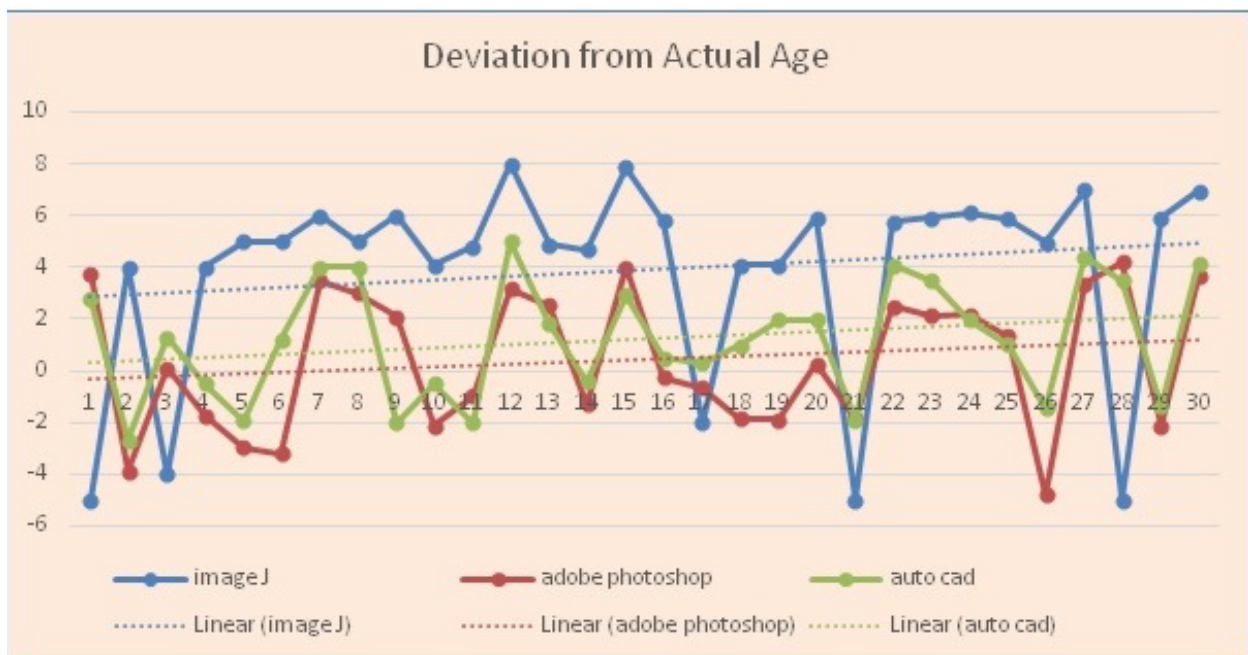


Figure 3: Deviation from actual age.

The Gustafson's Method for Age Determination from Teeth which is based on the evaluation of ground sections of teeth. According to Johanson, the correlation of the transparency of dentin with age is the highest, while that of apical resorption is the lowest.¹⁷ One major drawback of these methods, however, is the need to extract and process teeth, precluding their use in living subjects.

Cameriere working extensively on the use of non-invasive radiological methods for age estimation showed the utility of pulp space for age estimation by using pulp/tooth area ratio with the help of softwares.^{18,19} Pulp/tooth area ratio is a morphological variable obtained by dividing the surface area of pulp to tooth calculated by measuring the surface area of the outline of pulp and tooth as on the dental radiographs with the help of various

softwares/programs which are integral part of computers.

AutoCAD is a software application for 2D and 3D computer aided design (CAD) and drafting available since 1982. Developed and marketed by Autodesk, Inc. In 2004 and 2007 Roberto Cameriere *et al.* processed using AutoCAD2000.²⁰

Adobe Photoshop is a graphics editing program developed and published by Adobe Systems. Adobe Photoshop CS6 is the 13th major release of Adobe Photoshop having 3D image creation, motion graphics editing, and advanced image analysis features, etc. In 2004, 2009 and 2012, Roberto Cameiere *et al.* processed using Adobe photoshop7.0.¹⁸⁻²⁰ Then in 2011 M.B. Jeevan *et al.* processed using an Adobe Photoshop CS3.¹³

Image J is a public domain, Java based image processing

program developed at National Institute of Health (NIH), a biomedical research facility located in Maryland, USA established in the forensic by Dias *et al.* designed a technique to check the correlation between cementum thickness and actual age using Image J software, version 1.43s and S. Reddy *et al.* assessed bite mark using imaging software Image J.^{21,22}

When we considered assessing age using the AutoCAD software, there were practical problems encountered initially as a clinician to work with ease, as this software is an engineer's software and has lot of tools to work with agile. There is a practical requirement of prior training schedule to use this software, though adobe photoshop and Image J were easy to use and did not require much expertise.

As discussed earlier computer softwares are useful in estimation of age by various methods. But the pulp/tooth area ratio method developed by Cameriere *et al.* is the recent one has been tested on contemporary subjects and skeletonized human remains, on different teeth and populations, and has mostly yielded accurate age estimation.^{18,19} However, the method was untested on diverse classes of teeth of various population group and later M. babshet *et al.* and M.B. Jeevan *et al.* tested the same on Indian population.^{13,23}

Radiographs were made using RVG similar to the M.B. Jeevan *et al.*, digital intraoral sensor have advantage of immediate imaging on the computer screen, high quality of the digital image that can be analyzed and processed, saving images in the patient's file and possible to enlarge or edit the images.¹³

Maxillary teeth were used than the mandibular teeth as they are more convenient for age determination; Brkic *et al.* found that the correlation coefficient was stronger for all of the types of teeth in maxillary arch.²⁴ The results were in accordance with the study done by Zaheer *et al.* on central incisors which showed that the estimated age were very close to the chronological age with insignificant difference in between p value >0.05.²⁵

Computer softwares are useful in estimation of age by various methods. However, the method was untested on diverse classes of teeth of various population group and later Babshet *et al.* and Jeevan *et al.* tested the same on Indian population.^{13,23} On comparison of the 3 softwares, there was no statistical significant difference in age calculated by Adobe Photoshop and Auto CAD, Adobe Photoshop p=0.432 and Auto CAD p=0.004; though there was significant statistical difference in age calculated by Image J, p<0.001.

Conclusion

It's fair to say that personal computers have become the most empowering tool we've ever created. They're tools of communication, they're tools of creativity, and they can be shaped by their user" - Bill Gates As accuracy of age prediction is the closeness of estimated age to chronological age consequently, it was concluded that, this research showed promising results for dental age estimation in a non-invasive manner using dental radiographs from maxillary central incisor teeth among Haryana population.²⁶ The results of this study confirms that the AutoCAD and adobe photoshop showed the most accurate results for the measurements of pulp/tooth area ratio for age estimation. It is recommended that further research

should aim at involving larger samples which include varying geographic regions and races to be carried out to throw further light for betterment of the future aspect of age estimation using these softwares.

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