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RESEARCH ARTICLE

Radiographic Age Estimation with Tooth Coronal Index (TCI) Benindra Method at Sultan Agung Dental Hospital Semarang

Niluh Ringga Woroprobosari*, Dinda Vinca Rosa, Adisty Restu Poetri*****
*Department of Oral and Maxillofacial Radiology and Forensic, Faculty of Dentistry, Sultan Agung Islamic University
**Dentistry Study Program, Faculty of Dentistry, Sultan Agung Islamic University
***Department of Periodontics, Faculty of Dentistry, Sultan Agung Islamic University

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ABSTRACT

Background: *Age estimation through dental approaches is often an option for establishing identity in forensic cases. Age estimation can clarify statements of death, legal and civil matters. One way to identify victims is using periapical radiographs. The use of periapical radiographs in age estimation requires certain methods, one of them is using TCI (Tooth Coronal Index) Benindra method modified from Drusini's TCI method. Tooth age assessment using the Benindra TCI method was based on pulp chamber height measurements.* ***Objective:*** *The research was carried out to clarify the possibility of the TCI Benindra method application in estimating biological age in the Sultan Agung Dental Hospital Semarang population.* ***Methods:*** *This study used 23 periapical radiographs from 7 male and 16 female patients of Sultan Agung Dental Hospital Semarang. The age estimation by Benindra TCI method was performed at the age of 9-21 years towards the mandibular premolar tooth. Tooth age assessment was based on measuring the pulp chamber height using the TCI formula. Results of TCI measurements were entered into the prediction age formula to determine the patient's biological age.* ***Results:*** *The difference between the average estimated biological age using the Benindra method and the average chronological age was up to 0,46 years in the 9-21 years age group. 7 data were underestimated, 6 data were overestimated, and 10 data were accurately estimated.* ***Conclusion:*** *The application of the Benindra TCI method showed precise results for dental patients in Semarang, so that could be used to estimate the biological age of the general population.*

Keywords: *Benindra TCI method, periapical radiograph, biological age*

Correspondence: *Niluh Ringga Woroprobosari, Faculty of Dentistry, Sultan Agung Islamic University, Jln. Kaligawe KM 4 Semarang 50012 ph. (024) 6583584 fax. (024) 6594366, niluh.ringga@unissula.ac.id*

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INTRODUCTION

Accidents and natural disasters are events that usually take many lives, for example, the Bali Bombing I in 2002, the JW Mariott Hotel explosion in 2003, the Bali Bombing II in 2005, the Aceh Tsunami disaster in 2004, and the GA-152 plane crash in 2007. Victims are often found or evacuated in poor conditions, such as incomplete or damaged bodies, which complicates the identification process. Meanwhile, identification is the basis for clarifying the identity of individuals related to death reports for legal and civil purposes.[1,2]

Indonesian Health Law No. 36/2009 mentions the need to identify victims whose identities are unknown. This is done not only to reveal the victim's identity such as age and gende, but also to investigate crimes and disasters that occur. Teeth are proven to have many biological markers that are reliable in estimating biological age.[3] One way to identify age and gender is through dental radiographs. Dental identification using the radiographic technique is often chosen due to it is non-invasive. Compares to morphological, histological, and biochemical tooth identification which are invasive methods because they require tooth extraction.[2,4]

Forensic identification through dental and bone radiographs is often used to estimate a person's age. Age estimation through dental radiographs uses several parameters, such as the formation of a dental crown to complete root canal closure and measurement of the width of the dental pulp chamber. Teeth have characteristics that differ from one population to another.[4,5] Age estimation makes identification simpler by classifying the age of the victim in cases of accidents and disasters.[6]

Teeth were chosen as one of the ways to identify victims because they have high resistance to impact and heat resistance. Teeth are the strongest part of the body, and their condition does not change long after death. Teeth are made up of enamel as the outermost layer and there is dentin underneath, both of which are hard tissues and take a long time to break down.[2]

One of the methods used to predict an individual's chronological age is the Tooth Coronal Index (TCI). Study of TCI using panoramic radiographs to view the mandibular second premolars and second molars to predict bilogical age or dental age.[7] Drusini's research concluded that it is necessary to try other types of modalities for premolar assessment.[1,7] Benindra modified Drusini's TCI method using a periapical radiograph of the mandibular first premolars.[8] Periapical radiographs are expected to provide more accurate views with minimal distortion so that the results of age estimation measurements are more accurate.[1] This study aimed to clarify the possibility of TCI Benindra method application in estimating biological age in Sultan Agung Dental Hospital Semarang population.

METHOD

The research began with the approval of this research by the Ethics Commission of the Faculty of Dentistry, Sultan Agung Islamic University, Semarang (No. 126/B-1-KEPK/SA-FKG/X/2019). This research was using cross-sectional design. The periapical radiographic data were obtained from radiology patients of Sultan Agung Dental Hospital.

Total of 23 samples from 2018-2019 radiographs met the inclusion (age of 9-21 years, diagnostically acceptable radiograph of mandibular first premolar) and exclusion criteria (mandibular first premolar had to be free of caries, restoration, attrition, abrasion, erosion, prothesis, or fracture). The samples were measured and calculated using Benindra TCI method with 3 interobserver operators (2 research assistants and 1 dentist with 4 years of radiographic interpretation experience). The software used is CorelDRAW X7 (Corel corp). To reduce the subjectivity between operators, the ICC (Intraclass Correlation Coefficients) CPCH and CH tests were carried out and, showing that the 3 operators did not have a significant

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difference value (p = 0.876 and p = 0.958), it can be concluded that each operator has the same perception of judgment in calculating biological age using the Benindra TCI method.

Measurement of radiographic data using the mandibular first premolar, by measuring the crown height measured vertically from the cemento-enamel junction line to the tip of the highest crown cusp and measuring the coronal pulp height was carried out vertically, measured from the cervical line to the highest tip of the pulp horn. The measurement is entered into the formula for estimating age.[1,3,7]

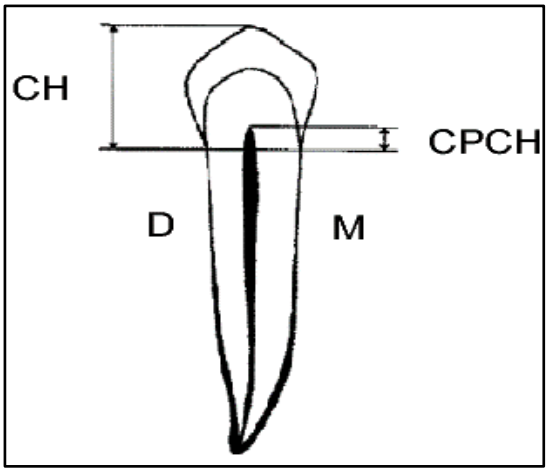

Figure 1. Measurement of mandibular first premolar in Benindra TCI method[8]
D = Distal; M = Mesial; CH = Crown height; CPCH = Coronal pulp cavity height

$$TCI = \frac{CPCH \times 100}{CH}$$

$$Estimated\ Age = 29{,}16 + (-0{,}4)TCI$$

Figure 2. The formula for estimating age using TCI[8]
TCI = Tooth coronal index; CH = Crown height; CPCH = Coronal pulp cavity height

Chronological age data were obtained from the age information at the time of the radiography examination listed in the medical record. The data were processed using the SPSS ver.22 (IBM, USA).

RESULT

Data analysis with descriptive statistics from estimated biological age data calculation with the Benindra TCI method is presented in Table 1. The table provided an overall picture of the results of applying the Benindra TCI method to the sample radiographs. The average between chronological age and estimated biological age of the TCI Benindra method showed 0.46 years gap. This means that the gap in age estimation was narrow or small enough in the general view.

Table 1. Average of the chronological and estimated age of samples

	N	Mean (years)	SD
Chronological age	3	19,65	±2,58
Estimated age	3	20,11	±2,51

The average and age difference based on sex was presented in Table 2. This was due to sex was also one of the factors that influence growth and aging process in human metabolism.[2,4]

Table 2. Estimation average and gap based on sex groups

Sex	Type of age	N	Mean ± SD (years)	Estimation gap (years)
Male	Chronological Age	7	19,57 ±2,29	0,66
	Estimated Age		20,23 ±2,31	
Female	Chronological Age	16	19,68 ±2,77	0,37
	Estimated Age		20,05 ±2,66	

Table 2 showed that estimated biological age in both sex groups were higher than the chronological age. However, the difference between the two sex groups could be seen in the age gap in estimated biological age and chronological age. The male sample group had 0.66 years gap which are higher than the

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average age gap of female sample group (0.37 years).

Table 3. Description of estimation accuracy

Estimation gap	N	Percentage
Under estimation	7	30,4%
Over estimation	6	26,1%
On estimation	10	43,5%
Total	23	100%

Accuracy level of the method was summarized in Table 3. On-point estimation or no age estimation gap found was categorized as 'on estimation' in the table. Meanwhile, 'over estimation' was when the estimated biological age was older than chronological age, and 'under estimation' was when the estimated biological age was younger than the chronological age. Table 3 showed the accuracy of the Benindra TCI method age estimation is good because 43.5% of the sample showing on-point estimation.

DISCUSSION

This study used the Benindra TCI method with an age range of 9-21 years which was carried out in the City of Semarang, the difference in the mean age value was 0.46 years. The results of this study were almost similar to the results of research by Yulianti et al., in the Banjar tribe with 70 samples using the Benindra TCI method and the difference in the average age value of 0.43 years.[4] The two studies above were the same because they use the same method. The results of this study were different from the research conducted by El Morsi et al., using the TCI Drusini method with 234 samples in the Egyptian population with an age range of 8-74 years, the difference in the mean age value is 0.84 years.[2] The difference in the results of the research above shows that the Benindra TCI method in Semarang City and the Banjar tribe shows results that were closer to chronological age than the Drusini TCI method. This was due to differences in the population used and the predicted age formula modified by Benindra so that the estimated biological age is closer to the chronological age.

The Tooth Coronal Index method was earlier introduced by Drusini using the mandibular second premolars and second molars and using panoramic radiographs.[7] Panoramic radiographs were used to evaluate the entire dentition, evaluate the growth of the permanent dentition, evaluate the position of the impacted tooth, and check for intraosseous abnormalities. Modification of Drusini's method by Benindra using mandibular first premolar and periapical radiographs.[1] Periapical radiographs are commonly used to assess the extent of caries, evaluate trauma to teeth and alveolar bone, evaluate root morphology, and assess pulp morphology.[10] The premolars were chosen because they have only one root canal and the changes due to secondary dentin deposition are visible, showing a significant correlation with chronological age.[1]

In this study, the average age difference between male age was 0.66 years, in women the average age difference of 0.37 years. The results of this study were similar to the results of research by Yulianti et al., in the Banjar tribe and the results of the study by El Morsi et al., in Egypt where the average age difference in men is greater than women.[2,4] The difference in age difference occurred because the size of male teeth is greater than women. Differences in the size of teeth between men and women could be influenced by genetic factors. The Amelogenin gene (AMEL) can encode tooth enamel proteins that have special characteristics in the form of size and patterns in nucleotide circuits in men and women. The onset of teeth development in female individuals tends to be earlier compared to males. The age of development of male secondary sexual characteristics is the turning point of dental development in male individuals, hence the formation of the third molar begins earlier in males than in female individuals. The timing of teeth development also affects the mineral deposition process in the teeth.[11] Dental maturation in women occurs faster because the

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process of amelogenesis in men lasts longer and the calcification of the crown occurs earlier in women, so this causes men to experience a longer teeth growth and has a greater tooth size than women.[12]

The tooth growth process was influenced by the hormone estrogen. This was due to the activity of estrogen in amelogenesis and dentine formation. The estrogen in femalfemalesa strong influence on the formation of secondary dentin because the estrogen receptors on the odontoblasts of the pulp tissue cause a significant decrease in the size of the pulp chamber with age. Estrogen levels in men are less than women. Both indicate that at the same age, the formation of secondary dentin in women is more formed than in men.[13]

In this study, 7 underestimation data were obtained, namely biological age is younger than actual age, 6 overestimation data, namely biological age is older than actual age, and 10 on estimation data, namely biological age is the same as actual age. Overestimation and underestimation are common when estimating age. This also happened in the research of Yulianti et al., in the Banjar tribe of 70 samples there were 44 on estimation data and 26 data that experienced over estimation and under estimation.[4] Over estimation and under-estimation could occured due to nutritional factors such as vitamin A, calcium, and erupted teeth. Vitamin A deficiency caused a decrease in epithelial tissue and odontoblast differentiation.[12] Calcium and phosphorus form hydroxyapatite crystals which function to provide strength to teeth, lack of calcium and phosphorus could cause tooth density to decrease making it more susceptible to caries.[14] A fully erupted tooth would experience a decrease in the size of the pulp chamber. This occurred because the dentin changes because odontoblasts form secondary dentin during responses such as caries and tooth attrition. Secondary dentin was formed unevenly on the surface of primary dentin. Continued deposition of secondary dentin would cause rapid and uneven narrowing of the pulp chamber size, especially on the roof of the pulp, which can cause difficulty in measurement.[1]

Research that had been conducted using the TCI Benindra method in Sultan Agung Islamic Dental Hospital Semarang, on average shows results that were close to chronological age. These results were influenced by the quality of the radiographs used. The better quality of periapical radiographs made it easier for researchers to conduct research. Radiographs with low image quality results might caused difficulties in age estimation measurement and interfere with the results. Differences in the intraoral radiographic modality used, variations in the ability of the radiographer or operator, as well as several other factors could affect the results of periapical radiographs. Radiographs with poor quality could be detrimental to the patient because they must be exposed to additional doses that should not be needed. Holder film aids can be used to align X-rays with a long axis of teeth when doing periapical radiographs so that good quality is obtained.[10,15] The quality criteria for good quality periapical radiographs should include images without distortion, and no overlapping images due to technical errors at the time of radiograph making, images also must match the actual situation both in density and contrast.[16] Therefore, this study applies strict selection of radiographic quality within the diagnostically acceptable category. CorelDraw X7 software (Corel Corp) was used because the selected samples were entirely in JPG format. In addition, the zooming and measurement features in this software are easy to use so that they can simplify the measurements needed in the Benindra TCI method and minimize errors in use and measurement.

Other factors that were difficult to control were bad habits such as bruxism. The presence of bad habits such as bruxism could stimulate the natural protection of secondary dentin deposition, so the thickness of secondary dentin deposition may differ in individuals with these habits.[2] This deposition has the potential to affect the coronal pulp height. A larger sample

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size is required in the future development of this study, or combining Drusini and Benindra's approach of TCI method by applying the measurement of mandibular first premolar in panoramic radiograph. This consideration is based on the availability of panoramic radiographs with healthy mandibular first premolars is far higher in numbers compared to periapical radiographs in Semarang city.

CONCLUSION

The application of the Benindra TCI method showed precise results towards dental patients in Semarang, so that could be used to estimate the biological age of the general population. This could be seen from a quite small difference of less than 1 year between the estimated age and chronological age produced by this method.

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