AGE ESTIMATION OF PAWON MEN THROUGH TEETH IDENTIFICATION USING JOHANSON METHOD THROUGH CBCT 3D RADIOGRAPH

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Abstrak. **Estimasi Usia Manusia Pawon melalui Identifikasi Gigi dengan Metode Johanson pada Radiograf CBCT 3D.** Manusia Pawon merupakan manusia prasejarah yang ditemukan di Gua Pawon. Di dalamnya, terdapat sisa tulang yang telah rapuh dan gigi yang masih tertanam pada tulang alveolar meskipun telah tertimbun tanah ribuan tahun lamanya. Gigi tersebut kemudian dijadikan sebagai alat identifikasi primer dalam penelitian forensik odontologi. Tujuan penelitian ini adalah untuk mengetahui estimasi usia Manusia Pawon melalui identifikasi gigi menggunakan metode Johanson pada radiograf CBCT 3D. Jenis penelitian yang dilakukan adalah deskriptif. Pengambilan sampel menggunakan purposive sampling. Sampel sebanyak 21 gigi yang tertanam pada tulang alveolar dan tidak terdapat pada garis fraktur. Pengukuran estimasi usia dengan metode Johanson dilakukan dengan perangkat lunak Ez-Implant menggunakan teknik non-invasif CBCT 3D. Hasil penelitian pada Rangka I (R.I) menghasilkan estimasi usia dengan kisaran antara 32,00-33,92 tahun, Rangka III (R.III) dengan estimasi usia 32,94-36,28 tahun, Rangka IV (R.IV) dengan estimasi usia 34,42 tahun, dan Rangka V (R.V) dengan estimasi usia 27,36-31,35 tahun. Simpulan penelitian menunjukkan estimasi usia Manusia Pawon dengan metode Johanson pada radiograf CBCT 3D berkisar antara 27,36-36,28 tahun.

Kata Kunci: Manusia Pawon, Estimasi usia, Metode Johanson, Radiografi CBCT 3D, Perangkat lunak ez-implant

Abstract. *Pawon men are prehistoric humans who lived in Pawon cave. The skeletons found in the cave consist of remains of brittle bones and teeth which are still attached to alveolar bone even though it had been buried in soil since thousands of years ago. The teeth are then used as primary identification in forensic odontology research. This research's aim is to compare the existing age estimation of Pawon men with more recent method, namely Johanson method through CBCT 3D Radiograph. Previously, the age estimation was only based on visual observation of posterior molars' attrition by Brothwell method. This research is a descriptive study using purposive sampling. The samples are 21 teeth that are intact and attached to the alveolar bone without any fracture line. The age estimation with Johanson method using Ez-Implant software is non-invasive age measurement by Cone Beam Computed Tomography 3D radiograph. The results showed that the age of the first Pawon man is 32-33.92 years old, the third Pawon man is 32.935-36.275 years old, the fourth Pawon man is 34.42 years old, and the fifth Pawon man is 27.36-31.35 years old. The second Pawon man is not included in sampling criteria. The measurement using Johanson method through CBCT 3D is more specific and detailed in yielding the age estimation compared to the Brothwell method.*

Keywords: *Pawon men, Age estimation, Johanson method, CBCT 3D radiograph, Ez-implant software*

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1. Introduction

Human skeletons that buried by piles of stones are found in Pawon cave (Tjoa-Bonatz et al 2012, 99). Pawon cave was formed in karst region and is located in Masigit Mountain Village, Cipatat sub-district, Bandung regency. The prehistoric humans who had ever lived in Pawon cave were called Pawon man. Inside the cave, archeologists found obsidian tools, bone tools, fragments of animal bones, and five human skeletons (Yondri 2005, 5).

Prehistoric humans used their teeth as tools or a third hand. This kind of habit has caused characteristic changes in their teeth (Molnar P 2010, 681). This phenomenon happened in Pawon men, too. Teeth characteristics' change can be identified because the process is accurate and not to complicated. In identifying skeletons, teeth identification is accurate because teeth are highly resistant to destruction process, erosion, and have more robust structure than other parts of the body. The other parts of the body are unlikely to be used again in the identification process (Pretty 2001, 359)

Nevertheless, teeth identification in prehistoric human plays an important role because teeth are not easily damaged and will still stable despite their being buried under the ground for thousands of years to millions of years (Verma 2014, 2). Therefore, teeth identification in prehistoric human can be used to identify ages, diet, and health (Molnar P 2010, 681). With regard to age, it is crucial to be known as the embodiment of human identity (Adams 2014, 1-3).

Various methods can be used to identify age using teeth, both invasive and non-invasive techniques (Jain 2013, 84). Methods of determining age using teeth in invasive techniques are biomarkers method, root dentin translucency, incremental line analysis, and biochemistry method. Meanwhile, non-invasive techniques are tooth eruption method, scheme development method and maturation of calcified root, morphological method, radiographic method, and method of measurement (Jain 2013, 84).

One of the methods that is used in identifying age of Pawon men is non-invasive technique using morphological method approach, which is Johanson method. Johanson method is mostly used by forensic odontologist experts in determining age estimation based on morphological method (Jain 2013, 85).

The Johanson method can be supported by Cone Beam Computed Tomography 3D (CBCT 3D) because it can display picture in three dimensions, namely in terms of axial, sagital, coronal, and the image generated precisely with the original size (Senn 2010, 196-199). In addition, CBCT 3D wield software and viewing software to support the Johanson method measurement (Adams 2014, 93). CBCT 3D radiograph is also not invasive to the object that has been examined. Therefore, it does not cause any damage to the object of research.

2. Method

2.1 CBCT 3D Imaging with Ez-Implant Software

The samples of the research are obtained from CBCT 3D radiograph, such as the first Pawon man that consists of four teeth that attached to maxilla alveolar bone, the third Pawon man consists of four teeth that attached to maxilla alveolar bone, the fourth Pawon man consists of two teeth that attached to mandible alveolar bone, and the fifth Pawon man consist of eleven teeth that attached to maxilla and mandible alveolar bone.

The second pawon man is excluded because there is no tooth at all that is attached to the alveolar bone. The teeth that are included in this research must be attached to the alveolar bone without fracture line.

CBCT 3D radiograph that is supported with Ez-Implant software can be applied in the computer. After the software is downloaded to

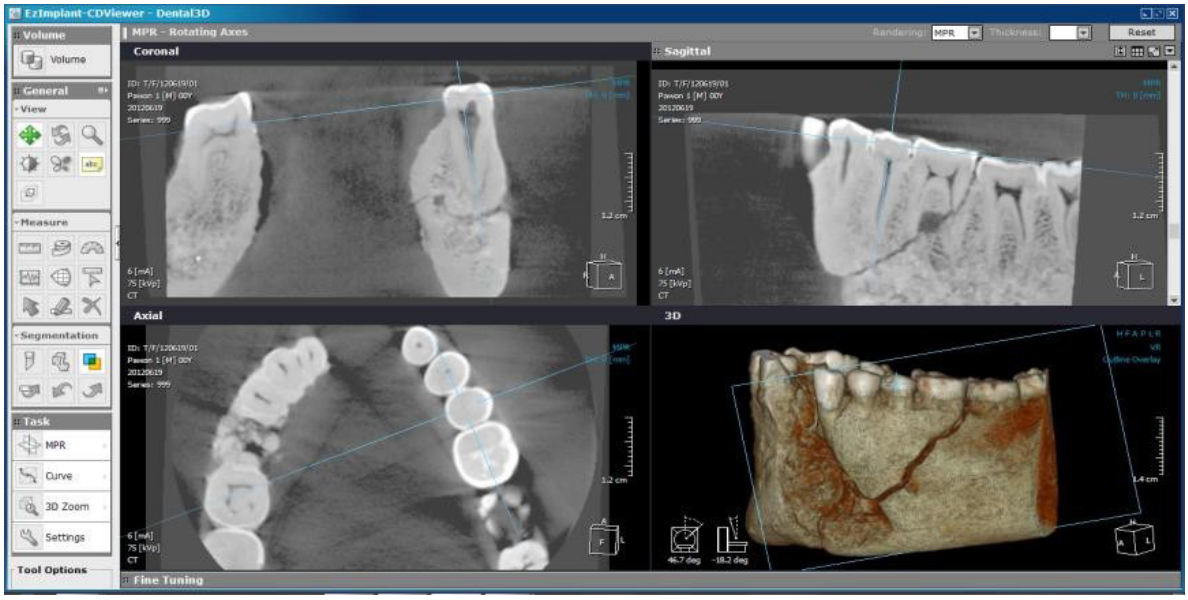

Figure 1. CBCT Imaging with Ez-Implant Software (Elizabeth 2016, 38)

the computer, the radiograph of Pawon men can be run and the view menu at the left bar is used to measure the variables in Johanson method. Cross-sectional technique is used to slice the teeth to find out the most precise and clear radiograph imaging.

2.2 Determining Age Estimation using Johanson Method

Johanson method is used to determine age estimation of Pawon men using teeth identification. This method consists of six variables, such as attrition, secondary dentin, clinical attachment level or periodontium, apposition of cementum, apical root resorption, and transparency apical. These variables can be measured by using CBCT 3D radiograph within the range of 0,0 to 3,0.

Age = 11.02 + (5.14*A)+(2.3*S)+(4.14*P)+(3.71 *C)+(5.57*R)+(8.98*T)

A = Attrition
S = Secondary dentin
P = Periodontium/Clinical Atachment Level
C = Cementum
R = Root Resorption
T = Translucency of Root

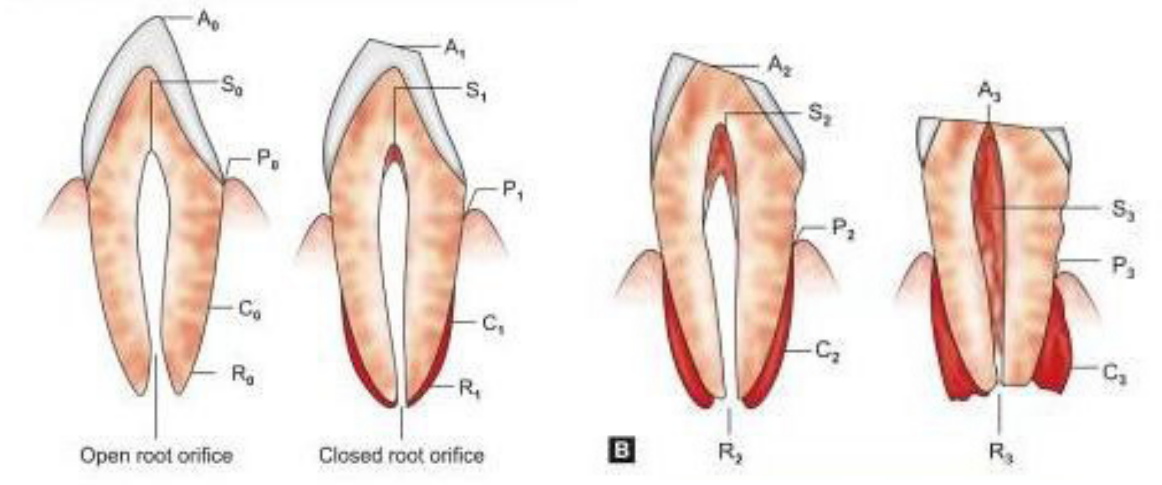

Figure2. Variables of Johanson Method (Jain 2013, 84)

Table 1. The Measurement of Johanson Method

Variables	Operational Definition	Unit
Attrition	Attrition can occur at incisal, oclussal, and proximalsurface of a tooth. Attrition of the tooth is determined by the area that suffered the deepest attrition	A0.0-A3.0
Secondary dentin	Secondary dentin located between dentin and pulp, precisely in internal pulp cavity. Secondary dentin is measured by the length of pulp chamber and compare it to the length of cemento enamel junction to the peak of pulp chamber, then measure the average	S0.0-S3.0
Periodontium	Periodontium in each Pawon man is Clinical Attachment Level (CAL). CAL is measured from cemento enamel junction the crest of alveolar bone from the mesial and distal area, then measure the average	P0.0-P3.0
Cementum	Cementum aposisition is the widest cementum expansion at one third of the root length	C0.0-C3.0
Resorption	Apical resorption is a destruction that occurs at root apical area	R0.0-R3.0
Root transparency	Root transparency is a transparent area at the apical of root. Root transparency is measured from the apical of root until the coronal direction and ended at the radiolucency at the root	T0.0-T3.0

(Jain 2013, 85)

A. Atrition/ Dental Wear

Atrition can be found at incisal, occlusal, and proximal surface of teeth. It is determined in area with the deepest atrition, and pointed from A0.0 to A3.0:

A0.0 = No atrition
A0.5 = Small atrition at enamel surface
A1.0 = Atrition is limited to ½ of enamel surface
A1.5 = Small amount thickness of enamel, dentin not yet exposed
A2.0 = Atrition spread to small amount of dentin
A2.5 = Atrition spread to ½ portion of dentin
A3.0 = Atrition spread to pulp

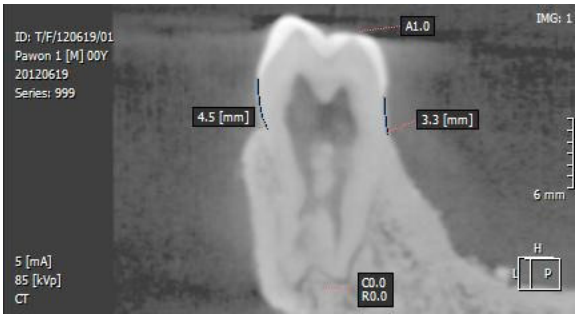

Figure 3. Measuring criteria A1.0 (Elizabeth 2016, 46)

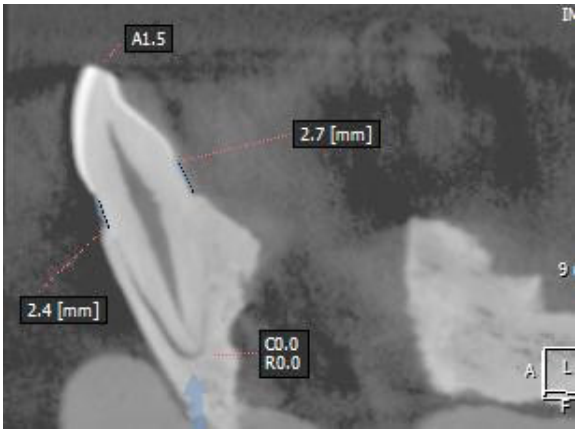

Figure 4. Measuring criteria A1.5 (Elizabeth 2016, 46)

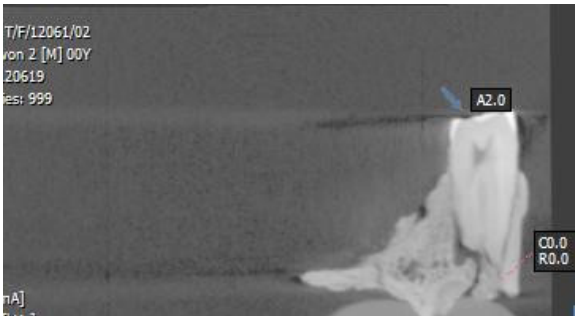

Figure 5. Measuring criteria A2.0 (Elizabeth 2016, 47)

B. Periodontium

Periodontium in Pawon men skeletons are measured by using clinical attachment level. This is measured from cemento-enamel junction (CEJ) to alveolar bone crest. Periodontium ranged from P0.0 to P3.0:

P0.0 = Normal Periodontium
P0.5 = Little retraction from CEJ to alveolar bone crest
P1.0 = 2 mm of retraction from CEJ to alveolar bone crest
P1.5 = 4 mm to 7 mm of retraction from CEJ to alveolar bone crest
P2.0 = 10 mm of retraction from CEJ to alveolar bone crest
P2.5 = 15 mm of retraction from CEJ to alveolar bone crest
P3.0 = Only few mm of root that is still surrounded by alveolar bone.

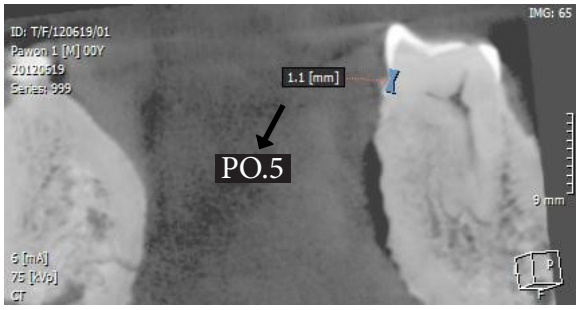

Figure 6. Measuring criteria P0.5 (Elizabeth 2016, 48)

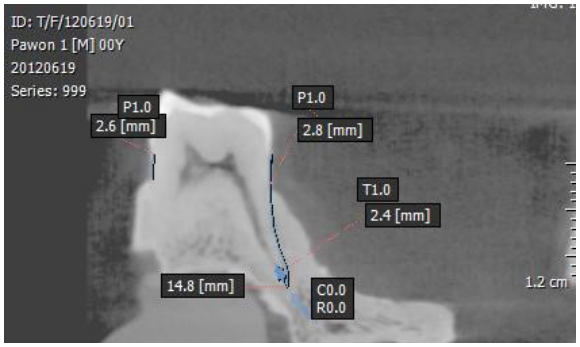

Figure 7. Measuring criteria P1.0 (Elizabeth 2016, 48)

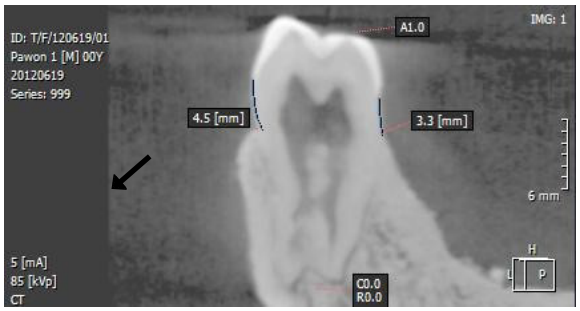

Figure 8. Measuring criteria P1.5 (Elizabeth 2016, 48)

C. Secondary Dentin

Secondary dentin is located between dentin and pulp, precisely in the internal area in pulp cavity. It is measured from the height of pulp, then measured mesiodistally from CEJ. The extension from CEJ to coronal pulp is secondary dentin and pointed from S0.0 to S3.0:

S0.0 = No secondary dentin
S0.5 = A bit deposition at coronal of pulp and covered ¼ of pulp height
S1.0 = Moderate deposition at coronal of pulp and covered ¼ of pulp head coronal of pulp and covered ½ of pulp height
S1.5 = Deposition covered all of pulp coronal chamber
S2.0 = Deposition covered all of pulp coronal chamber and a little of pulp root chamber
S2.5 = Deposition covered ½ area along pulp chamber
S3.0 = Deposition covered mostly 2/3 area along pulp chamber.

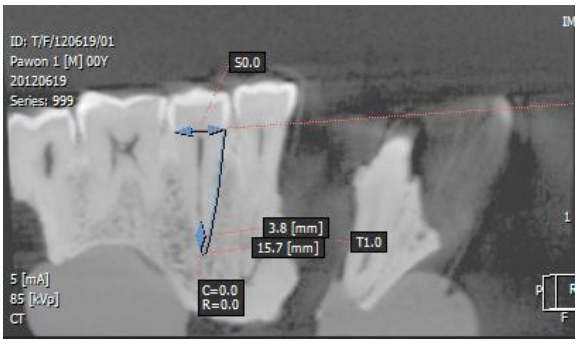

Figure 9. Measuring criteria S0.0 (Elizabeth 2016, 50)

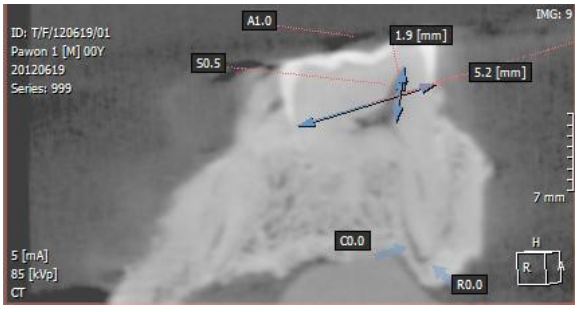

Figure 10. Measuring criteria S0.5 (Elizabeth 2016, 50)

D. Apposition of Sementum

Sementum Aposition is the extension of the wider sementum at $^{1}/_{3}$ apical of root, then compare the root's height from CEJ to apical of the root. It is pointed from C0.0 to C3.0:

C0.0 = No apposition of sementum
C0.5 = Sementum thickening very slightly at apical area C1.0
C1.0 = Sementum thickening involve ¼ of root height C1.5
C1.5 = Sementum thickening involve 1/3 of root
C2.0 = Sementum thickening involve ½ of root height
C2.5 = Sementum thickening involve ½ but less than 2/3 of root height
C3.0 = Sementum thickening more than 2/3 of root height.

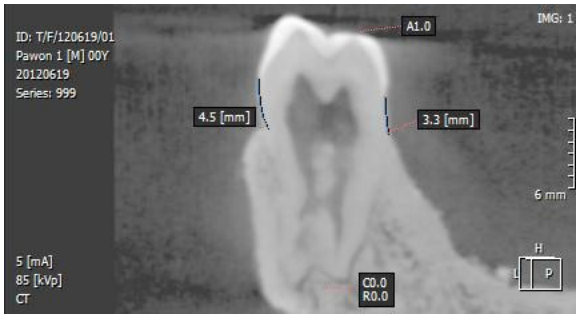

Figure 11. Measuring criteria C0.0 (Elizabeth 2016, 51)

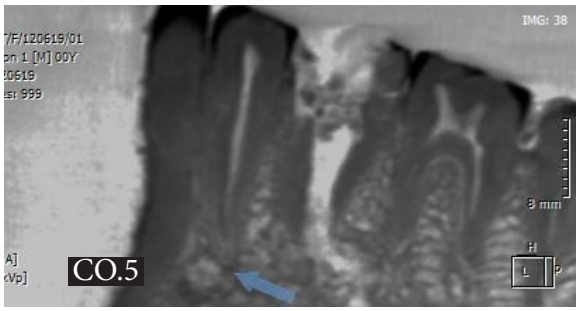

Figure 12. Measuring criteria C0.5 (Elizabeth 2016, 52)

E. Root Resorption

Root Resorption is seen as destruction at apical of root. It ranged from R0.0 to R3.0:

R0.0 = No resorption at apical of root
R0.5 = A little resorption at apical of root and include 1 area
R1.0 = Resorption at apical of root include more than 2 areas
R1.5 = Resorption has extended
R2.0 = Resorption deeper and more extended
R2.5 = Resorption include all of root apical surfaces
R3.0 = Resorption extended to dentin area.

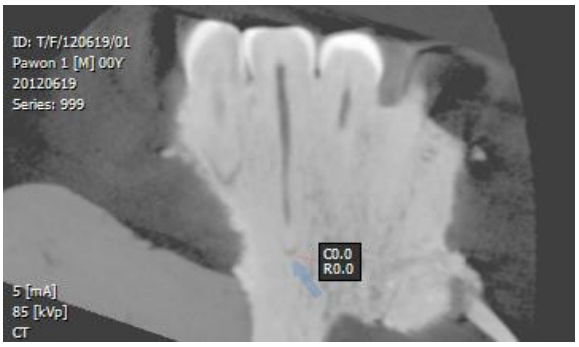

Figure 13. Measuring criteria R0.0 (Elizabeth 2016, 53)

F. Root Transparency

Root Transparency is measured by the transparency at apical tooth surface. It is measured from apex of root to coronal and ended to radiolucency at root of pulp chamber and pointed from T0.0 to T3.0:

T0.0 = No transparency
T0.5 = Very slightly of transparency at apex area
T1.0 = Slightly of transparency less than ¼ height of root
T1.5 = Transparency less than 1/3 but more than ¼ height of root
T2.0 = Transparency more than 1/3 but less than ½ height of root
T2.5 = Transparency more than ½ but less than 2/3 height of root
T3.0 = Transparency more than 2/3 height of root.

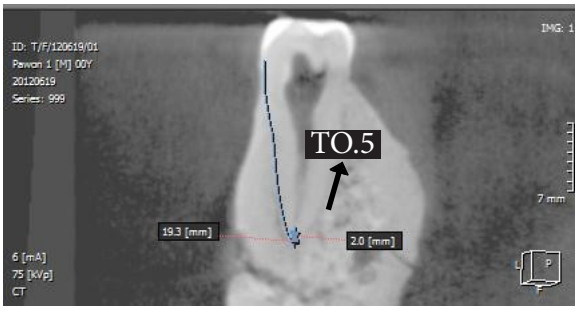

Figure 14. Measuring criteria T0.5 (Elizabeth 2016, 54)

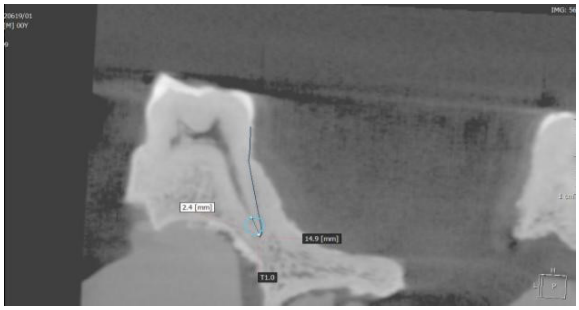

Figure 15. Measuring criteria T1.0 (Elizabeth 2016, 55)

3. Result and Discussion

Age estimation of human skeletons from Pawon cave had been done on the first, third, fourth, and fifth of Pawon Man's teeth. Based on analysis result through some aspects of Johanson variables used CBCT 3D radiograph, had list some data related to age estimation. From first Pawon man teeth, the age estimation had counted on 2.4, 2.5, 2.6, and 2.7 teeth, and had listed on table 2.

Table 2. Age Estimation of First Pawon Man using Tooth Identification with Johanson Method through CBCT 3D Radiograph

First Pawon Man							
Tooth	**A**	**S**	**P**	**C**	**R**	**T**	**Age**
2.4	A2.0	S0.0	P1.5	C0.0	R0.0	T0.5	32
2.5	A1.5	S0.0	P1.5	C0.0	R0.0	T1.0	33,92
2.6	A2.0	S0.5	P1.0	C0.5	R0.0	T0.5	32,935
2.7	A2.0	S0.0	P1.5	C0.0	R0.0	T0.5	32

(Elizabeth et al 2016, 62)

The data related to age estimation on the third Pawon Man had counted on 2.2, 2.4, 2.5, and 2.7 teeth, and had listed on table 3.

Table 3. Age Estimation of the Third Pawon Man using Tooth Identification with Johanson Method in CBCT 3D Radiograph

Third Pawon Man							
Tooth	**A**	**S**	**P**	**C**	**R**	**T**	**Age**
2.2	A1.5	S0.0	P1.0	C0.5	R0.0	T1.0	33,705
2.4	A2.0	S0.0	P1.0	C0.5	R0.0	T1.0	36,275
2.5	A2.0	S0.0	P1.0	C0.5	R0.0	T1.0	36,275
2.7	A2.0	S0.5	P1.0	C0.5	R0.0	T0.5	32,935

(Elizabeth et al 2016, 64)

From fourth Pawon man not many teeth can be used as samples for age estimation analysis because some of the teeth were destroyed. Analysis only counted on 4.4 and 4.7 teeth, and had listed on table 4.

Table 4. Age Estimation of Fourth Pawon Man using Tooth Identification with Johanson Method in CBCT 3D Radiograph

Fourth Pawon Man							
Tooth	**A**	**S**	**P**	**C**	**R**	**T**	**Age**
4.7	A2.0	S0.0	P1.0	C0.0	R0.0	T1.0	34,42
4.8	A2.0	S0.0	P1.0	C0.0	R0.0	T1.0	34,42

(Elizabeth et al 2016, 63)

Finally, from the first Pawon man, the datas are related to age estimation had counted on 1.1, 1.5. 1.6 and 2.3, 2.4, 2.5, 3.5, 3.7 and 4.3 teeth, and had listed on table 5.

Table 5. Age Estimation of the Fifth Pawon Man using Tooth Identification with Johanson Method in CBCT 3D Radiograph

First Pawon Man							
Tooth	**A**	**S**	**P**	**C**	**R**	**T**	**Age**
1.1	A1.5	S1.0	P1.0	C0.0	R0.0	T0.5	29,66
1.5	A1.0	S0.0	P1.5	C0.0	R0.0	T1.0	31,35
1.6	A1.0	S0.5	P1.0	C0.0	R0.0	T1.0	30,34
2.3	A1.5	S0.5	P1.0	C0.0	R0.0	T0.5	28,51
2.4	A1.0	S0.5	P1.0	C0.0	R0.0	T1.0	30,43
2.5	A1.0	S0.5	P1.0	C0.0	R0.0	T1.0	30,43
3.5	A1.5	S0.0	P1.0	C0.0	R0.0	T0.5	27,36
3.7	A1.5	S0.5	P1.0	C0.0	R0.0	T0.5	28,51
4.3	A2.0	S0.0	P1.0	C0.0	R0.0	T0.5	29,93
4.4	A1.5	S0.5	P0.5	C0.5	R0.0	T0.5	28,295
4.6	A2.0	S0.5	P0.5	C0.0	R0.0	T0.5	29,01

(Elizabeth et al 2016, 60)

The age estimation of Pawon men can be measured by Johanson method through CBCT 3D radiograph by identifying anterior and posterior teeth of Pawon men (Jawaid et al 2014, 179). CBCT 3D radiograph that is supported with Ez-Implant software is used to determine age estimation of Pawon men with

non-invasive technique using teeth that are visualized in sagital, axial, coronal and three dimensions imaging. Considering that Pawon men are protected by the Law of Indonesian Cultural Heritage Regulation, a non-invasive age measurement by Cone Beam Computed Tomography 3D radiograph is needed (Jain 2013, 97). CBCT 3D that is supported by Ez-Implant software yield more specific and detail measurement of age estimation with precision up to 0,05 mm (Oscandar 2103, 89). This can be compared to previous study that calculate the age of Pawon men through visual observation of wear pattern on molar tooth by Brothwell method. The Brothwell method is using British skull diagram in estimating age, such as 17-25 years, 25-35 years, 35-45 years, and above 45 years. Therefore, the age estimation of Pawon men with Brothwell method by previous study is 25-35 years old for first, third, and fifth Pawon man (Yondri 2005, 5).

Table 6. Age Estimation of Pawon Man with Brothwell Method

Pawon Man	Method	Age Estimation
First Pawon Man	Brothwell	25-35years
Third Pawon Man	Brothwell	25-35years
Fourth Pawon Man	Brothwell	25-35years

(Yondri 2005, 5)

Meanwhile, the age estimation of Pawon men by Johanson method yield more specific and detail range of minimum and maximum age. There are 32-33.92 years in the first Pawon man, 32.935-36.275 years in the third Pawon man, 34.42 years in the fourth Pawon man, and 27.36-31.35 years in the fifth Pawon man. Johanson method yielding more specific and detail measurement of age estimation because this method has increased in non-invasive technique and has a concrete formula.

Based on the explanations, the Johanson method can be used to identify only one tooth. It is contraindicated from other methods in determining age estimation. If the identification of tooth is more than two, then the bias will be lower compared to only one tooth (Senn and Richard 2013, 80-81). In addition, this method is specifically used to determine age estimation; in other words, this method cannot be used to determine differences of gender, race and one's ancestors (Senn and Richard 2013, 82-83).

Table 7. Age Estimation of Pawon Man with Johanson Method

Pawon Man	Method	Age Estimation
First Pawon Man	Johanson	32-33,92 years
Third Pawon Man	Johanson	32,935-36,275 years
Fourth Pawon Man	Johanson	34,42 years
Fifth Pawon Man	Johanson	27,36-31,35 years

(Elizabeth et al 2016, 67)

4. Conclusion

Age estimation of man can be done by several methods such as clinics and no clinics. Johanson method is one of several non-clinic methods that can be used in age estimation analysis of Pawon men. Based on analysis using Johanson method on age estimation on Pawon men, the result is more specific and detail compared to previous study using Brothwell method. It can be used for other remains of man in archeological research in Indonesia.

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