

AGE ESTIMATION USING THE PERIODONTAL LIGAMENT SPACE VISIBILITY IN MANDIBULAR THIRD MOLAR ASSESSED WITH DIGITAL PERIAPICAL RADIOGRAPHY

Trelia Boel*, Dennis**, Rini Octavia Nasution***, Annisa Fakhirah*

Department of Dental Radiology*

Department of Conservative Dentistry**

Department of Periodontia***

Faculty of Dentistry, Universitas Sumatera Utara, Medan, Indonesia

Jl. Alumni No.2 Kampus USU Medan 20155

Telp. 061 8216131, Fax. 061 8213421

Abstract

Olze et al (2010) introduced a method of estimating age by the visibility of the periodontal ligament space which is specialized with conditions where the root formation of mandibular third molars has been finished. This research aims to assessing the appropriateness of the periodontal ligament space visibility method with digital periapical radiography in estimating age. The design of this research is analytic observational with cross sectional approach. This research involved 21 samples aged 19-24 years, consisting of 7 male and 14 female. The research was done in the Radiology Installation, Faculty of Dentistry, University of North Sumatra. Observations were made on the periodontal ligament space of mandibular third molars as seen from radiographs and determined the periodontal ligament space visibility stage of each tooth. Finally, age estimation according to the visibility stage could be given. The results of the research found that there was a significant difference in age estimation using the periodontal ligament space visibility method with digital periapical radiographs and chronological age ($p=0,000$). The correlation test result showed that the relationship between the stages of the periodontal ligament space visibility and the chronological age had a very low correlation coefficient ($r = 0.028$). Based on the results of these statistical tests, it can be stated that periodontal ligament space visibility method through digital periapical radiographs was deemed not suitable for use in estimating age.

Key words: periodontal ligament space visibility, age estimation, mandibular third molar

Abstrak

Olze *et al* (2010) menjelaskan suatu metode estimasi usia melalui visibilitas ruang ligamen periodontal, metode ini dikhususkan pada kondisi dimana pembentukan akar dari gigi molar ketiga mandibula telah selesai. Penelitian ini bertujuan untuk menilai metode visibilitas ruang ligamen periodontal melalui radiografi periapikal digital. Penelitian berjenis observasi analitik ini mengadopsi metode *cross sectional* sebagai metode pendekatan. Penelitian ini melibatkan 21 sampel berusia 19-24 tahun yang terdiri atas 7 pria dan 14 wanita yang dilaksanakan di Instalasi Radiologi Fakultas Kedokteran Gigi Universitas Sumatera Utara. Ruang ligamen periodontal gigi molar ketiga mandibula pada radiograf diobservasi dan ditentukan tahap visibilitas dari setiap gigi kemudian diberikan estimasi usia sesuai dengan tahap visibilitas tersebut. Hasil dari penelitian ini memperlihatkan adanya perbedaan yang signifikan antara estimasi usia menggunakan metode visibilitas ruang ligamen periodontal melalui radiografi periapikal digital dengan usia kronologis ($p=0,000$). Hasil uji korelasi memperlihatkan hubungan antara tahap visibilitas ruang ligamen periodontal dengan usia kronologis memiliki koefisien korelasi yang sangat rendah ($r=0,028$). Berdasarkan hasil uji statistik tersebut, maka dapat disimpulkan bahwa metode visibilitas ruang ligamen periodontal melalui radiografi periapikal digital belum sesuai untuk digunakan dalam mengestimasi usia.

Kata kunci: visibilitas ruang ligamen periodontal, estimasi usia, gigi molar ketiga mandibula

INTRODUCTION

One of the crucial activities in forensic dentistry is estimating the age of individuals. Age estimation is carried out for both living and dead individuals.¹ Due to differences in the legal process between children and adults, age identification is necessary for legal evidence.² The formation of tooth is one of the indicators in the assessment that were used to determine maturity and estimate age.³ Estimation of age by teeth can be made by clinical, radiographic, histological, or biochemical methods of examination. In this case, the radiographic method is non-destructive and easy to use.⁴

The essential criteria in age estimation of late juvenile are mineralization and eruption of third molars.⁵ Mineralization of the third molars is often found to be complete at the age of under 21 years but in some populations, mineralization of the third molars has been reported to have been completed under the age of 18. Several new techniques in estimating dental age have been proposed, specifically to determine whether the individual is under or beyond the 18 year threshold with a greater possibility, particularly after root formation of the third molar is complete.

Olze et al (2010) describe an age estimation method using teeth that are specialized in conditions in which the root formation of mandibular third molars has been completed. This method is used in the identification of living individuals by observing the visibility of periodontal ligament space on mandibular third molars with dental radiographs. The visualization of the periodontal ligament space in this method is categorized into 4 stages, from stage zero (the periodontal ligament space is fully visible in both roots) to stage three (periodontal ligament space are almost completely invisible in both roots).⁷ There are several studies that have tested this method on some population.

Olze et al (2010) evaluated 1198 panoramic radiographs from 629 female and 569 male aged 15-40 years in Germany. The results showed that stage 0 features were first seen in male aged 17.6 years and in female aged 17.2 years. Stage 1 was found to be first seen in male between the ages of 20 and 20.2 years, while in female between the ages of 18.9 and 20 years. Furthermore, stage 2 features were first seen in male aged 22.3 years and in female between 22.5 and 23.1 years. Stage 3 was found to be first seen in individuals between the ages of 25.4 and 26.2 years in male and between 24.6 and 25.2 years in female. Based on these data, Olze et al concluded that stage 1, 2 and 3 can be used to estimate age 18 years. In addition, stages 2 and 3 are also considered to have the potential to be used to estimate 21 years of age.⁸ The results of Olze's research are supported by further research conducted by Guo et al (2018)⁶ and Timme *et al* (2017).⁵

Sequeira et al (2014) conducted the same study using a sample of 487 panoramic radiographs that were taken from the Portuguese population with a sample age range of 17-31 years. The conclusion of his study was that stage 3 of the periodontal ligament space visibility was considered to be used to estimate 21 years of age in male. In addition, it was also found that there was a high connection among the visibility stage of the periodontal ligament space and chronological age.⁹

Another study was conducted by Lucas et al (2016) using a panoramic radiograph with sample totaling 2000 which was divided evenly into several age groups ranging from 16 to 25.9 years. The sample consisted of 50 female and 50 male in each age group. In this study, Lucas et al (2016) concluded that stage 2 and 3 of periodontal ligament space visibility can be used to estimate age 18 years with a very high degree of probability.

The same study was also conducted by Chaudary et al (2017) involving a smaller number of samples, namely 163 panoramic radiographs. In his research, stage 0 was first

seen in individuals ranging in age from 17.38 to 18.04 for male and at ages 17.70 for female. Stage 1 was first seen between the ages of 16.76 and 17.38 for male and the ages 17.64 and 17.86 for female. Stage 2 was first seen between the ages of 16.76 and 17.79 for male and between the ages of 16.32 and 17.46 for female. Stage 3 was first seen between the ages of 18.93 and 20.86 for female and between the ages of 16.32 and 18.16. Based on the data described above, it is seen that the chronological age overlaps at each stage of periodontal ligament space visibility.⁷

Based on differences in the results of several studies mentioned, one factor that may contribute is the number and age range of the samples used. From previous studies, it was stated that the roots of the mandibular third molars were not very clear from panoramic radiographs. Therefore, the aim of this study was to assess the appropriateness of the periodontal ligament space visibility method in estimating age, particularly determining the age threshold of 18 years through digital periapical radiographs.

MATERIALS AND METHODS

The type of this research is analytic observational, which is to determine the estimated age by observing periodontal ligament space visibility on mandibular third molars assessed with digital periapical radiography and observing the relationship between the stages and chronological age using a cross sectional approach. This research was performed at the Radiology Installation, Faculty of Dentistry, University of North Sumatra. The population in this study were patients who came to the Dental and Oral Hospital of the University of North Sumatra. Purposive sampling technique was used as the sampling method by selecting samples based on inclusion and exclusion criteria.

The inclusion criteria in this study were patients with completely erupted right and left mandibular third molars (M3), aged 17-24 years, mandibular M3 teeth were not impacted, there was no caries or large fillings on mandibular M3 teeth, the patient was not currently under orthodontic treatment and and is not undergoing root canal treatment on his mandibular M3 tooth. The exclusion criteria in this study were the root growth of mandibular M3 teeth that had not been completed and the presence of pathological conditions in the periodontium and periapical tissues.

The study began with filling out a questionnaire by the sample and clinical examination of the patients to obtain data and history of the treatment they received and also a description of their mandibular M3 teeth condition. Patients who matched the inclusion criteria subsequently received an explanation and were asked to fill out an informed consent if they agreed to be the study subjects. Patients who have agreed are asked to fill out the Covid-19 screening sheet which is followed by a body temperature check. If the patient has no symptoms and the risk of Covid-19, and the patient's body temperature is known to be normal, then the patient can then undergo x-rays.

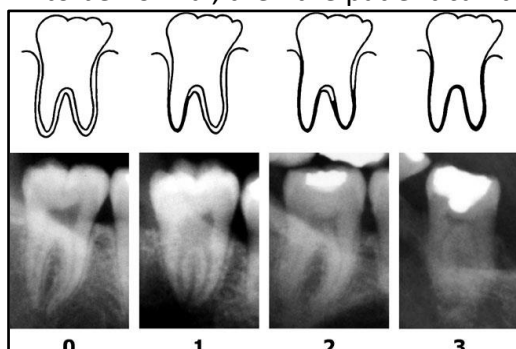


Figure 1. Illustration of periodontal ligament space visibility stages on mandibular third molar

Periapical radiographs were taken of the mandibular third molars on both sides (left and right) and all of the radiographs were evaluated based on consideration of the exclusion criteria. All of the periapical radiographs were observed using the Cliniview software. The next step was to determine and record the stages of periodontal ligament space visibility (Figure 1) that was seen on each periapical radiographs. The description regarding each stage of the periodontal ligament space visibility proposed by Olze et al (2010) consists of:

- a. Stage 0: The periodontal ligament space is visible along the entire root
- b. Stage 1: The periodontal ligament space is partially invisible on one root (starting from the apex to half the root).
- c. Stage 2: The periodontal ligament space is not fully visible at one root (apex to cemento enamel junction) or partially invisible at both roots
- d. Stage 3: The periodontal ligament space are not visible along almost the entire of two roots.

The interpretation of the estimated age at this visibility stage is as follows:

- a. Stage 0 : Estimated age <18 years
- b. Stage 1, 2 and 3 : Estimated age ≥ 18 years

The data obtained were processed using a computerized system through SPSS software. The data that has been collected, is firstly tested by normality test. The data will be further analyzed with paired t-test if the collected data was distributed normally. In contrast, the data will be analyzed using the Wilcoxon test if it is not distributed normally. This research has received approval from the Research Ethical Committee, University of North Sumatera with letter number 155/KEP/USU/2020 and and the subject that will be the sample of this research has also been given an explanation sheet and informed consent.

RESULTS

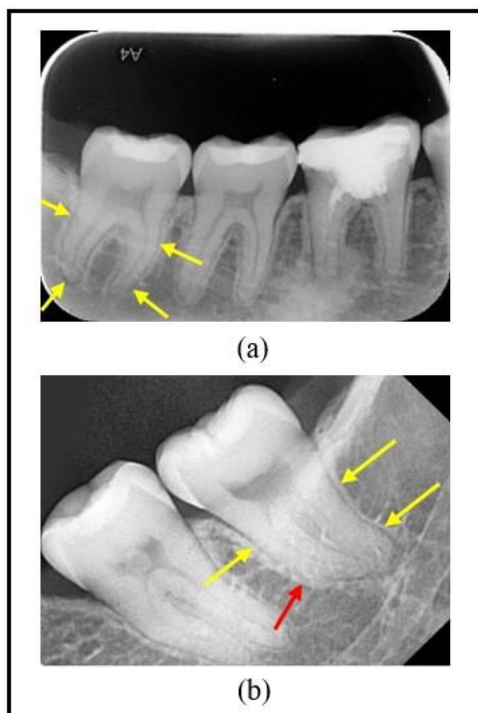


Figure 2.

- (a) Stage 0 seen on periapical radiograph in sample aged 20.83 years old (personal documentation)
- (b) Stage 1 seen on periapical radiograph in sample aged 21.83 years old (personal documentation)

The distribution of the samples number from the ages of 19 to 24 years with a total sample size of 21 people was presented in Table 1.

Table 1. Sample Distribution by Age

Age (Year)	The Number of Sample
19	1
20	3
21	5
22	2
23	6
24	4
TOTAL	21

Table 2 presents the descriptive analysis data of chronological age at each stage of the periodontal ligament space visibility in all samples seen on periapical radiographs. Based on table 2 it is known that stage 0 was found firstly at the age of 19.91 years. Stage 1 features were firstly seen between the ages of 21.83 and 24.58 and stage 2 was first seen in individuals aged 20.75 years.

Tables 3 present the descriptive analysis data of chronological age at each stage of periodontal ligament space visibility seen on periapical radiographs based on gender. Based on table 3, it is known that stage 0 in male was first seen at 19.91 years of age and stage 2 was seen at 23.91 years of age. Stages 1 and 3 were absent in the male sample. Whereas it is known that stage 0 in female was seen firstly between the ages of 20.75 and 20.83 years, stage 1 was found to be first seen between the ages of 21.83 and 24.58 year and stage 2 features was first seen at the age of 20.75 years. Stage 3 was not found in the female sample.

In Figure 2 (a), the yellow arrows show that the whole periodontal ligament space is still visible in the two roots of the tooth (48), so it is categorized as stage 0. In Figure 2 (b) in the red arrow part, it can be seen that the periodontal ligament space is blurry at half of the root in the mesial part (38) so it is categorized as stage 1 (yellow arrows indicate the visible periodontal ligament space).

Table 2. Descriptive Analysis of Chronological Age at Each Stage of the Periodontal Ligament Space Visibility in All Samples

Teeth	Stage	n	Mean	Median	SD	Min	Max
38	0	18	22.65	22.91	1.57	19.91	24.67
	1	1	21.83	21.83	-	21.83	21.83
	2	2	22.33	22.33	2.23	20.75	23.91
48	0	20	22.48	22.70	1.51	19.91	24.67
	1	1	24.58	24.58	-	24.58	24.58

Table 3. Descriptive Analysis of Chronological Age at Each Stage of the Periodontal Ligament Space Visibility Based on Gender

Gender	Teeth	Stage	n	Mean	Median	SD	Min	Max
Male	38	0	6	22.33	22.83	2.06	19.91	24.50
		2	1	23.91	23.91	-	23.91	23.91
	48	0	7	22.55	23.91	1.97	19.91	24.50
Female	38	0	12	22.81	22.91	1.34	20.83	24.67
		1	1	21,83	21.83	-	21.83	21.83
		2	1	20.75	20.75	-	20.75	20.75
	48	0	13	22.44	22.58	1.30	20.75	24.67
		1	1	24.58	24.58	-	24.58	24.58

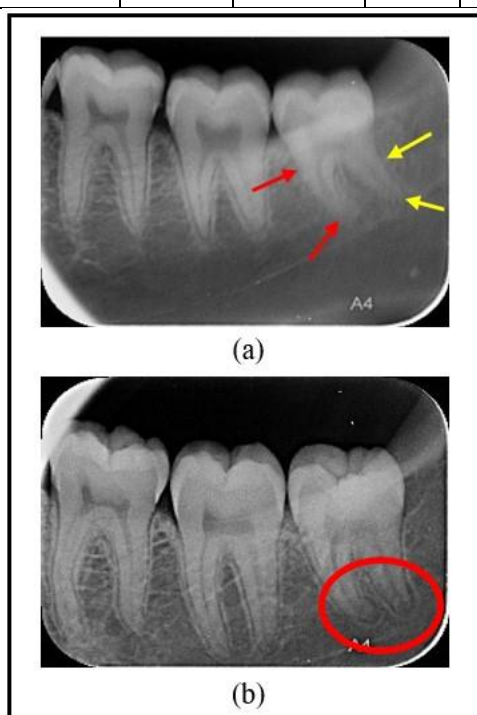


Figure 3.

- (a) Stage 2 seen on periapical radiograph in sample aged 20.75 years old (personal documentation)
- (b) Periapical radiograph of left mandibular third molar (38) in a patient aged 18 years (personal documentation)

In Figure 3 (a) in the red arrow section, it can be seen that on one side of tooth root at the mesial part (38), the periodontal ligament space is not visible from the apex to the

cemento enamel junction and the yellow arrows indicate the visible periodontal ligament space. Figure 3 (b) shows mandibular third molar (38) that have not undergone apical closure (sample aged 18 years). Samples with criteria like this are included in the exclusion criteria so that they cannot be included in the research sample.

Table 4 presents the results of the normality test on the research variables. The normality test used in this study is the Saphiro Wilk test. In Table 5, it can be seen that the p-value for the chronological age variable (0.011) and the estimated age variable (0.000) has a lower value than the significance level ($\alpha = 0.05$), so it can be said that the age variable and age estimate are not normally distributed. Because both data are not normally distributed, the statistical test used to answer the objectives of this study is the Wilcoxon non-parametric test.

Table 4. Normality Test Results on Research Variables

Research Variable	Normality test	Information
Chronological Age	$p = 0.011$	Not Normal
Estimated Age	$p = 0.000$	Not Normal

Table 6 presents the results of the Wilcoxon nonparametric statistical test. Based on the results of this statistical tests, it can be seen that the p-value is smaller than the significance level (5%), it can be stated that there was a discrepancy between the estimated age based on the periodontal ligament space visibility stages and the chronological age.

Table 7 shows the results of the Spearman correlation, which aims to see the connection between the visibility stages of periodontal ligament space and the chronological age. Based on the results of the Spearman correlation test, it can be stated that the association between variables has a very low correlation coefficient or it can be assumed that it has no correlation.

Table 6. Statistical Test Results on the Comparison between Estimated Age and Chronological Age

Variable 1	Variable 2	Wilcoxon Test Results
Age Estimation	Chronological Age	$P = 0.000$

Table 7. Statistical Test Results on The Correlation Between The Visibility Stages of Periodontal Ligament Space and Chronological Age

Variable 1	Variable 2	N	Correlation coefficient
------------	------------	---	-------------------------

Periodontal Ligament Space Visibility Stage	Chronological Age	42	0.028
---	-------------------	----	-------

DISCUSSION

The need for the importance of estimating age in the forensic field has increased every year, especially for individuals who are still living as a requirement for legality. In children, age estimation can be made by assessing their seven permanent teeth mineralization, start with the incisors until second molars. However, in late juvenile and initial adulthood, only the third molars can be used to estimate age.¹¹ The determination of the age of 18 years is of great importance for legal requirements in some countries. The main indicator for estimating age in this age group is the stages of mineralization in third molars. However, the mineralization process in some individuals has even been completed when they are under the age of 18. Therefore, the development of new methods for estimating age is needed.⁶

There was a difficulty found when the study was conducted, namely the difficulty of finding samples aged 17-18 years with fully erupted mandibular third molars and had apical closure. Based on the results of Wilcoxon's non-parametric statistical test, it was found that the comparison between estimated age based on visibility stages of the periodontal ligament space and the chronological age had a p-value = 0.000 with a significance level of 5%. Thus it can be concluded that there was a significant discrepancy between the estimated age based on periodontal ligament space visibility stages through digital periapical radiographs and the chronological age. This finding indicates that this method is still not suitable for use in estimating age, especially in determining the 18 year age threshold. These results are in line with research conducted by Chaudary et al (2017) which states that all stages of periodontal ligament space visibility have a large age range, one of which is stage 0, where the age range starts from 18 years of age to the late twenties, with overlapping age ranges at each stage. These results lead Chaudary et al (2017) to conclude that this method is not suitable for use in estimating age.⁷

Olze et al (2010), stated that the teeth observed in estimating age using the periodontal ligament space visibility method were only mandibular third molars because on the radiograph, the appearance of the maxillary third molars would be overshadowed by the surrounding bone structure.⁸ His method is based on observations of the periodontal ligament space, which over time it becomes narrower so that it is difficult to see on a radiograph. In addition, tooth's root surface also turn to be more coarse and the alveolar bone is closer to root surface.^{6,8} This method is used to estimate the age of living individuals in previous studies.⁵ The appearance of the periodontal ligament space on the radiograph is one of the points that can be used for post-mortem identification. This identification was carried out by matching the periodontal ligament space pattern on post-mortem radiographs with ante-mortem radiographs.¹² However, there are still no reports of using the periodontal ligament space visibility method to estimate the age of individuals in post-mortem conditions.

Based on the results of a study conducted by Olze et al (2010) in Germany with a sample size of 1198 aged 15-40 years. They concluded that stages 1,2 and 3 could be used to predict the age of 18.¹⁰ The results of Olze's study are supported by a further study by Vora et al. (2019)¹³, Guo et al. (2018)⁶ and Timme et al. (2017)⁵. Whereas in this study with a total

sample size of 21 people aged 19-24 years, a descriptive analysis of the periodontal ligament space visibility stages seen on periapical radiographs (tables 2 and 3) shows that most of the third molar mandibular teeth observed were at stage 0 and the number of teeth that have reached stages 1 and 2 is very small. Neither male nor female had teeth that had reached stage 3.

Based on descriptive analysis data in the research of Olze et al (2010), all individuals appear to be over 21 years old, starting from stage 2, so Olze et al (2010) concluded that stages 2 and 3 can be used to estimate ages over 21 years.⁸ This statement is bolstered up by the results of research by Timme et al (2017)⁵ and Guo et al (2018)⁶. Meanwhile, based on descriptive analysis data in this study, from table 3 it can be seen that there are individuals who are under 21 years of age in stage 2. Thus, based on these data, stage 2 is also considered not suitable for use in determining that someone is over 21 years of age. This result is in line with the descriptive analysis data in the research of Vora et al (2019)¹³, Chaudary et al (2017)⁷, Lucas et al (2017)¹⁰ and Sequeira et al (2014)⁹ where not all individuals are over 21 years of age are in stage 2 and 3.

Different results may occur due to several factors, one of which is the radiographic instrument used. The tool used in previous studies was panoramic radiography. The resolution of third molar mandibular roots in radiograph specifically in panoramic radiographs was found to be less good when compared to periapical radiographs.⁷ On periapical radiographs, the tooth structure and surrounding supporting tissue can be seen clearly and in detail.¹⁴ This examination makes the visibility of the periodontal ligament space on mandibular third molar roots more visible and clear on periapical radiographs. Another factor lies in the differences in the samples and the number of samples used. This study used a sample aged 19-24 years old, whereas in previous studies, the age range of the sample used was wider and the number of samples used was also larger.

The Spearman correlation test was also carried out in this study with the aim of looking at the correlation between the visibility stages of periodontal ligament space and chronological age. Based on the Spearman correlation test result, it was found that the correlation between variables had a very low correlation coefficient ($r = 0.028$) or it could be assumed that it had no correlation at all. This result is in accordance with the research of Chaudary et al (2017) which states that the periodontal ligament space stages has no correlation with age which is getting older.⁷ Another case with the research of Sequeira et al (2014), where the correlation test results showed a strong relationship ($r = 0.541$) between chronological age and the visibility stage.⁹ The results of Sequeira et al research is also in line with the results of research by Guo et al (2018) where the higher the visibility stage of the periodontal ligament, the minimum and median age also increases so that there is a robust relation among the visibility stages and the subject's chronological age.⁶

Chaudary et al (2017) suggested that the visualization of the periodontal ligament space is influenced by several factors, such as variations in the morphological anatomy of the mandibular third molar roots and the definition of the periodontal ligament space visibility stages. The variation in this case is the variation in the number, shape and curvature of the roots, the separation or fusion of the roots, the length of the root trunk, the shape of the branching and the apical curvature of the third molars. For example, if the roots are in close proximity for their entire length, the periodontal ligament space between the roots and at the furcation is not clearly visible. The definition of the stages of periodontal ligament space visibility proposed by Olze et al also has limitations. In stages 1 and 2, the periodontal ligament space is not visible from the apex to the root trunk. However, in a study by

Chaudary et al (2017), it was found that there were areas where the periodontal ligament space was not visible on the bifurcation, while other ligaments were visible. In addition, there were also areas where the ligaments were not clearly visible on one lateral surface of the root, but were clearly visible on the apex and other roots. These limitations indicate the need for a modified development of the periodontal ligament space visibility method.⁷

CONCLUSION

Based on the research results, the following conclusions were obtained:

- It was found that there was a discrepancy between the chronological age and the estimated age based on periodontal ligament space visibility method with digital periapical radiography examination
- The association between the visibility stages of the periodontal ligament space and the chronological age has a very low correlation coefficient or it can be assumed that no association is found.

REFERENCES

1. Bérigamo AL, de Queiroz CL, Sakamoto HE, Alves da Silva RH. Dental age estimation methods in forensic dentistry: Literature review. *Peertechz J Forensic Sci Technol* 2016; 2(1): 4-9.
2. Putri AS, Nehemia B, Soedarsono N. Prakiraan usia individu melalui pemeriksaan gigi untuk kepentingan forensik kedokteran gigi. *Jurnal PDGI* 2013; 62(3): 55-63.
3. Karaarslan B, Karaarslan ES, Ozsevik AS, Ertas E. Age estimation using orthopantomographs. *Eur J Dent* 2010; 4: 389-93.
4. Namalee J, Daggalli N. Challenges in forensic odontology age Estimation methods. *Int J Forensic Odontol* 2018; 3: 46-9.
5. Timme M, Timme WH, Olze A, Ottow C, Ribbecke S, Pfeiffer H *et al*. The chronology of the radiographic visibility of the periodontal ligament and the root pulp in the lower third molars. *Sci Justice* 2017; 57(4): 257-61.
6. Guo Y, Li M, Olze A, Schmidt S, Schulz R, Zhou H *et al*. Studies on the radiographic visibility of the periodontal ligament in lower third molars: can the olze method be used in Chinese population?. *Int J Legal Med* 2018; 132(2): 617-22.
7. Chaudhary MA, Liversidge HM. A radiographic study estimating age of mandibular third molars by periodontal ligament visibility. *J Forensic Odonto-Stomatology* 2017; 35(2): 79-88.
8. Olze A, Solheim T, Schulz R, Kupfer M, Pfeiffer H, Schmeling A. Assessment of radiographic visibility of the periodontal ligament in the lower third molars for the purpose of forensic age estimation in living individual. *Int J Legal Med* 2010; 124: 445-8.
9. Sequeira CD, Teixeira A, Caldas IM, Afonso A, Perez Mongiovi D. Age estimation using the radiographic visibility of the periodontal ligament in lower third molars in a Portuguese. *J Clin Exp Dent* 2014; 6(5): 546-50.
10. Lucas VS, McDonald F, Andiappan M, Roberts G. Dental age estimation: periodontal ligament visibility (PLV)-pattern recognition of a conclusive mandibular maturity marker related to the lower left third molar at the 18 year threshold. *Int J Legal Med* 2017; 131: 797-801.
11. Sujatha R, Goutham BS, Dhull KS, Meda I, Mathaputri S, Posarla CS: Age estimation using radiographic stages of third molar in Odisha population. *J Int Oral Health* 2015; 8(2): 238-42.

12. Emiliano GBG, Marinho FS, Oliveira RN. Potential contribution of periapical radiographic film image processing for forensic identification. *Rev Gauch Odontol* 2016; 64(4): 484-9.
13. Vora S, Kardjokar F, Sansare K, Patankar S. Age estimation based on radiographic visibility of periodontal ligament surrounding mandibular third molars- A retrospective study. *J Forensic Sci & Criminal Inves* 2019; 11(Issue 5): 1-4.
14. Gupta A, Devi P, Srivastata R, Jyoti B. Intraoral periapical radiography-basics yet intrigue: A review. *Bangladesh J Dent Res Educ* 2014; 4(2): 83-7.

