Periodontal Ligament Visibility (PLV): validation of PLV to determine adult status

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ABSTRACT

Background: Gradual obliteration of the Periodontal Ligament Visibility (PLV) of lower third molars indicates increasing age. This is used to help determine whether or not an age disputed subject is above or below the 18 year threshold.
Aim: The main focus was to determine, in test subjects of known age, whether the PLV system used 'blind' is able to reliably indicate whether the subject was a child (age <18 years) or adult (age >18).
Materials and methods: A total of 250 normal subjects in the age range 16 to 26 years, from the archives of Guy's Hospital in London, UK, were used to validate the system of PLV. The radiographic assessment of PLV1 was used to categorise four grades of PLV.
Results: It was found that for both females and males PLV-C and PLV-D gave very high probabilities (p = 1.000) of the test subjects being of adult status.
Conclusion: Periodontal Ligament Visibility has the potential to play an important part in the assessment of age disputed asylum seekers who look adult and claim to be children.

INTRODUCTION

Age Assessment using radiographs of the dentition is a reliable way of Forensic Age Estimation. It has been shown that Dental Age (DA) correlates more closely to Chronological Age (CA) than any other Human Biological Growth Marker.[2] This has led to the development of several techniques specific to dental development.
Once the dentition is fully mature it is not appropriate to use the Simple Average Method.[3]
This is because stage H of the Lower Left Third Molar has no further dental development to take place. It has been shown that an accurate estimate of the summary statistics for stage H in a UK Caucasian sample leads to a minimum value of 15.47 years, a mean or median value of approximately 19.40 and a maximum value of 21.64 Years.[4] It has been shown that using the summary statistics for Stage H alone the probability that a subject is over 18 years old is of the order of 90%.[5] A more realistic estimate, following appropriate censoring of the data for Stage H, is a probability that the subject is over 18 years of only 79.6%.[3] Thus using the technique of probability estimates there is an 80% chance that a subject with stage H is older than 18.00 years. The corollary to this is that there is a 20.4% chance that the subject is younger than 18 years. There are similar data from Austria. [6] The conclusion from this Austrian

article was that "As a single criterion for age estimation, wisdom teeth are not suitable, especially regarding the question of attained age of 18 years old."

One method suggested to overcome this problem is to use the Periodontal Ligament Visibility (PLV) as discernible on a Dental Panoramic Radiograph (DPT).[7] This Growth Marker extends the age range of summary statistics to over 30 years old. This fills a gap between 18 years when tooth development declines in importance and the older growth markers of stages of development of the Sterno Clavicular Joint.[8]

The principles of the work on third molars conducted in Germany was repeated in London, UK, with a balanced study on subjects between 16 years and 26 years.[7] A team in Portugal,[9] although using a slightly different age range, gave broadly similar results to the German Team.

The present study was conducted to test the validity of the data from this large study on Periodontal Ligament Visibility[7] when applied to patients of known age, gender and ethnicity, assessed 'blind', and drawn from the clinical archives of Guy's and St Thomas' Hospital in central London.

MATERIALS AND METHODS

In the UK the use of patient databases does not require Research Ethics Approval. The approach is to regard the project as an audit project. This was approved by the Lead Clinician in Orthodontics at Guy's and St Thomas' NHS Trust.

A consecutive sample of patients' records at Guy's Dental Hospital from January 2015 to March 2015 was used as the preliminary sample. Only patients for whom a Dental Panoramic Tomograph was available were isolated from the patients records archive for study. An age range filter was applied so that all subjects were aged between 16.00 years and 25.99 years. All patients with DPTs were recruited on a consecutive basis.

A Microsoft Excel spreadsheet was created to enable entry for the Demirjian Tooth Development Stages (TDS), and also for the gender, date of birth and date of radiograph. For each subject with a Dental Panoramic Tomograph (DPT) an assessment of the Lower Third Molar (LL8) was made to determine if it was mature (Demirjian Stage H).[10]

Reliability of the assessments of the TDS was performed by randomly selecting 100 cases of the subjects and re-assessing them 1 month later. This process was repeated for the reliability of the assessments of the categories for the Periodontal Ligament Visibility. Only Within Observer Agreement was explored as only one investigator (VSL) carried out the assessments for this validation study.

For subjects with a mature Stage H the appearance of the Periodontal Ligament of LL8H was then assessed (Figure 1) and entered into the Excel spreadsheet.

The assessments were performed with the age and gender of the subjects masked from the observer. The age of the subjects was then calculated using the date of radiograph and subtracting from this the date of birth. This was converted to decimal years to give the age of each subject.

These assessments were then subjected to a filter process in the Excel spreadsheet. First those subjects with a TDS other than Stage H were removed. Second, the subjects with PLV-A were then filtered according to the PLV Stage. First for PLV-A and then repeated for PLV-B, PLV-C and PLV-D. The assignment of below or above the 18 year threshold was made on the basis of the data in the original publication which is reproduced below (Table 1).[7]

RESULTS

A total of 250 subjects were recruited to the study. This comprised 145 females and 93 males (Table 2). Information from the Clinical Records was incomplete for 12 patients.

A proportion of these, approximately 7.5% overall, were unsuitable. This was by virtue of the DPT exhibiting Stage F or G or the images of the molar teeth being of poor quality. To enable appropriate utilization of the PLV characteristics it is essential that Demirjian Stage H is present in the subject or person for whom the Threshold Assignment is required.

The Within Rater Assessments for reproducibility was 97% [Kappa Value 0.9281] for the Tooth Development Stages, and 94.12% [Kappa Value 0.894] for the Periodontal Ligament Visibility categories. These values fall within the highest range i.e. Very Good.[11]

Although the Reference Data Set gives outcomes for PLV-A and PLV-B with a small number of subjects under 18 Years (less than 10%,)[7] in the present study, there are no subjects with PLV-A or PLV-B for females or males who were likely or possibly under 18 years old.

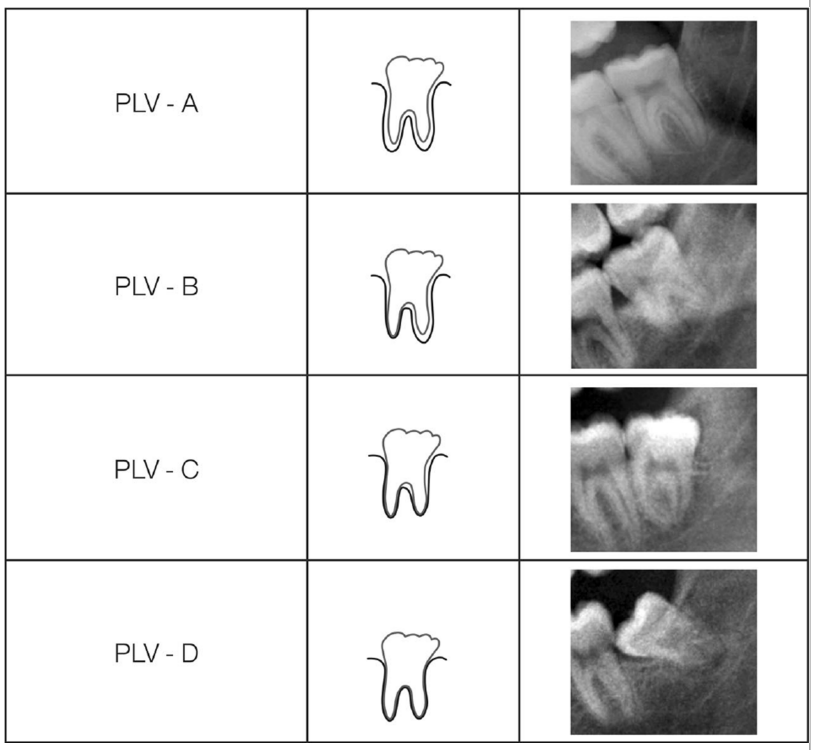


Figure 1: Schematic drawings and radiographic examples of Periodontal Ligament Visibility (reproduced from the Open Access article Lucas et al. 2017).[7]

PLV – A = 100% to 74% of the periodontal ligament around the lower left third molar is discernible on the DPT.
PLV – B = 75% to 50% of the periodontal ligament is visible.
PLV – C = 50% to 25% of the periodontal ligament of the lower left third molar is visible when summated across the mesial and distal roots.
PLV – D = 25% to 0% of the periodontal ligament is discernible.

Table 1: Reproduced reference data[7] used to assign the subjects of this validation study to an appropriate threshold status i.e. below or above 18 years old

	n-tds	$\bar{x}$-tds	sd-tds	min-tds 0th%ile	25th%ile	median 50th%ile	75th%ile	max-tds 100th %ile	Younger than 18 Years	p >18 Years
FEMALES										
PLV-Af	8	19.57	1.83	16.33	18.23	20.28	20.60	22.06	14.20%	0.858
PLV-Bf	202	21.25	2.16	16.17	19.80	21.21	22.61	25.83	5.90%	0.941
PLV-Cf	277	22.96	1.95	18.08	21.43	23.36	24.47	25.95	**0.00%**	**1.000**
PLV-Df	54	23.86	1.79	18.58	22.66	24.33	25.39	25.99	**0.00%**	**1.000**
MALES										
PLV-Am	12	20.32	1.61	17.69	19.58	20.27	21.48	22.80	9.00%	0.910
PLV-Bm	151	21.17	2.13	17.62	19.48	20.85	22.68	25.43	2.60%	0.974
PLV-Cm	308	22.49	2.11	18.10	20.86	22.63	24.22	25.43	**0.00%**	**1.000**
PLV-Dm	87	23.37	1.85	18.67	22.29	23.61	24.94	25.93	**0.00%**	**1.000**

Table 2: Age distribution of subjects recruited from Clinical Records Database

Age Range (Years)		Females	Males	All Subjects
16.00 to 16.99		6	11	17
17.00 to 17.99		2	9	11
18.00 to 18.99		10	8	18
19.00 to 19.99		11	6	17
20.00 to 20.99		9	7	16
21.00 to 21.99		16	9	25
22.00 to 22.99		15	11	26
23.00 to 23.99		27	14	41
24.00 to 24.99		28	7	35
25.00 to 25.99		21	11	32
Clinical Data Absent				12
TOTAL		145	93	250

The Within Rater Assessments for reproducibility was 97% [Kappa Value 0.9281] for the Tooth Development Stages, and 94.12% [Kappa Value 0.894] for the Periodontal Ligament Visibility categories. These values fall within the highest range i.e. Very Good.[11]

Although the Reference Data Set gives outcomes for PLV-A and PLV-B with a small number of subjects under 18 Years (less than 10%,)[7] in the present study, there are no subjects with PLV-A or PLV-B for females or males who were likely or possibly under 18 years old.

The data presented in Table 3 are taken from the radiographs in the Guy's Hospital Archives. They are all subjects whose Chronological Age is Greater than 16.00 Years. And up to 26 years old apart from one case of 26.03 years old. The information relates to males in the top half of Table 2, and females in the lower half. The subjects for whom the PLV assessment can be utilised all exhibited Stage H of the Lower Left Third Molar.

The data are focused on the utility of PLV as an indicator of the Probability or Likelihood that a male or female subject with a Third Molar at stage H is older than 18 Years. Subjects with PLV-suffix were not suitable for MMM assessment.

There are a number of subjects when the one or more of the markers was not useable. These figures are given in b II, c II, h II, and i-II.

In all subjects the Threshold Assignment Method (TAM) gave a high %age probability of the subject being over 18 years.

DISCUSSION

The data presented her show that in a validation study the RPV of a consecutive sample of normal dental hospital patients who exhibit Stage H there is a very high number of estimates in the 250 consecutive subjects who are assigned an age over 18 years. The age range 16.00 to 25.99 years was used as this covers the age range when the Lower Left Third Molar may first acquire stage H and ensures that all subjects in the sample have attained maturity. Using the criterion of PLV when Demirjian Stage H is present effectively gives a very high confidence in assigning a subject to 'Over 18 Years old'. It is clear that for a small number of our 250 validation subjects, at least in

Table 3: Periodontal Ligament Visibility - Validation Assessment of the proportion of subjects correctly assigned to over 18 years from a consecutive convenience sample of subjects with known ancestry, known gender, and known age. The probability (P) of a subject being over 18 years is given as a proportion of 1, and also as a percentage equivalent. The letters 'a' through to 'l' indicate the rows of the table, the Roman numerals indicate the columns. The lower case letter a to l and the Roman numerals I to VI are used for easy location of the cells within the table. For instance, d II is the cell with 22/87 ie 22 of the 87 male cases exhibiting Stage H also exhibited PLV-B in the data.

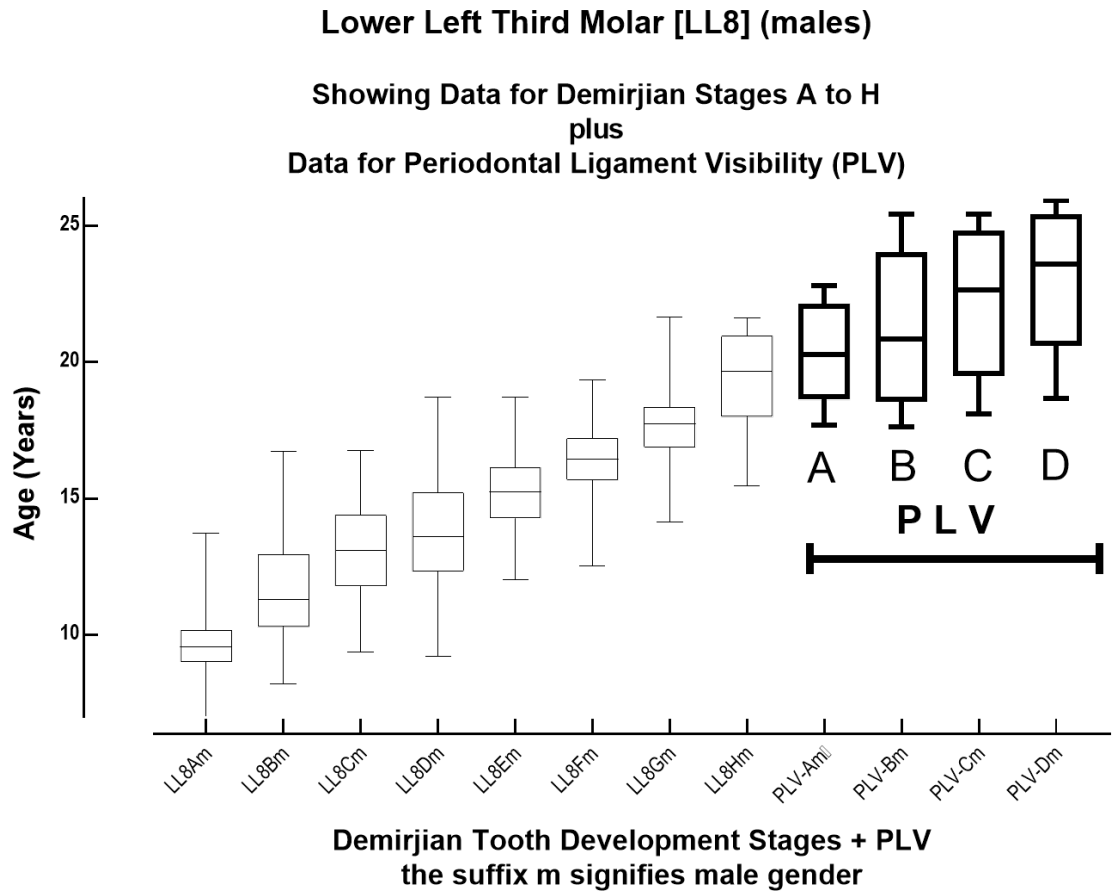
	I	II	III	IV	V	VI
a	**Males m**	**n**	**%age of Sample**	**Age Range in Years**	**P > 18 Years**	**%age Probability > 18**
b	PLV - •	0/87	0	na	na	na
c	PLV - Am	0/87	0	na	na	na
d	PLV - Bm	22/87	25.28	19.31 to 29.65	1.000	100.0
e	RPV - Cm	53/87	60.92	18.04 to 26.04	1.000	100.0
f	RPV - Dm	10/87	11.49	19.89 to 26.03	1.000	100.0
g	**Females f**	**n**	**%age of Sample**	**Age Range in Years**	**P > 18 Years**	**%age Probability > 18**
h	PLV - •	26/163	15.95	na	na	na
i	PLV - Af	0/163	0	na	na	na
j	PLV - Bf	37/163	22.70	18.55 to 25.89	1.000	100.0
k	RPV - Cf	85/163	52.15	21.88 to 25.93	1.000	100.0
l	RPV - Df	15/163	9.20	20.97 to 26.03	1.000	100.0

females, it is not possible to use PLV as a criterion. This was because the root development was at stage F or G and therefore RPV could not be assessed. The use of this criterion needs to be investigated by other research workers to determine whether or not there is wider applicability of this developmental or bony marker in other ancestral groups.

At present it is not clear as to the biological changes occurring that are responsible for the diminishing periodontal ligament visibility with increasing age. A preliminary assessment with Cone Beam Computed Tomography suggest that there is increasing bony deposition, both cortical and medullary, in the mandibular bone buccal to the lower third molars. It is emphasised that this is a preliminary assessment which requires confirmation by an appropriately designed study.

A fortuitous outcome is the way the summary percentile data for PLV extend the data for Demirjian from approximately 18 years through to 26 years. In terms of providing supporting evidence of the subject being over 18 years this information is compelling. It is helpful to see this plotted out in a simple graph (Figure 2).

Figure 2: Box and whisker plots of Demirjian Tooth Development Stages from stage A through to H. Appended at the right (older) side of the graph are the box and whisker plots for Periodontal Ligament Visibility categories



The four PLV stages form a continuum from the median value for the Demirjian tooth development stages from LL8A through LL8Hm and on through PLV stages to the values for the Sterno Clavicular Joint (SCJ) stages 4 and 5.[8]

The graph shows the box and whisker plots for LL8Am through to LL8Hm where the suffix m indicates male gender. The data for the box and whisker plots is from the UK Caucasian Reference Data Set accessible in www.dentalage.co.uk/+R

Further work is planned to extend the age range of subjects to explore the impact of PLV on the dental age assessment in different ancestral groups.

It is important to note that the use of PLV requires only a single Dental Panoramic Radiograph.

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