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Emerging researcher article

The chronology of the radiographic visibility of the periodontal ligament and the root pulp in the lower third molars

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ABSTRACT

Eruption and mineralization of third molars are the main criteria for dental age estimation in living adolescents. As the validation of completion of the 18th year of life appears not to be possible with the forensically necessary probability even if all the third molars of a person are completely mineralized, degenerative dental characteristics might be used for this purpose. In previous publications by Olze et al. (2010a,b) the radiographic visibility of the periodontal ligament and the root pulp in lower third molars were suggested as methods for this purpose. The aim of this study was to validate these characteristics in a large study population with a wide age range. In a material of 2346 orthopantomograms of 1167 female and 1179 male Germans aged from 15 to 70 years the radiographic visibility of the root pulp in the lower third molars with completed mineralization were studied according to stage classifications proposed by Olze et al. (2010a,b). 1541 orthopantomograms of 705 females and 836 males with a sufficient quality of the radiograph showed at least one third molar. The suitability of the studied characteristics for age estimation in living individuals could be confirmed. Males and females presenting stage 1 of both characteristics were older than 18 years of life. Males and females presenting stage 2 of both characteristics were older than 21 years of life. The high number of missing third molars in the studied age group (46–60%) must be considered as a limitation of the methods. In further studies the influence of ethnicity, dietary habits and modern dental health care on the characteristics in question should be investigated.

1. Introduction

Aside from legal issues and issues related to refugees, age estimation in living individuals today also concerns the field of competitive sports [3,4,15,21,23,25,36]. The validation of the completion of the 18th and 21st year of life is of particular importance in all of these areas. For age estimation in living individuals undergoing criminal proceedings, the Study Group on Forensic Age Diagnostics recommends the combination of a physical examination with radiographic examination of the left hand, a dental examination including the determination of dentition status, and the evaluation of an orthopantomogram. In case of completed hand ossification, an additional radiological examination of the clavicles by means of conventional radiography and/or computed tomography should be performed [24]. Mineralization and eruption of third molars are the main criteria for dental age estimation in adolescents [2,17]. However, the validation of the completion of the 18th year of life is not possible with the forensically necessary probability even if all third molars of a person are completely mineralized, as the mineralization may be completed before the 18th birthday [34]. Therefore, other criteria for dental age estimation after the completion of third molar mineralization are needed. To this end, the characteristics of the radiographic visibility of the periodontal ligament and the radiographic visibility of the root pulp in the lower third molars were evaluated in two publications by Olze et al. [18,19]. They evaluated 1198 orthopantomograms from 629 females and 569 males in the age range of 15–40 years [18,19]. The aim of the present study was to validate these methods described by Olze et al. [18,19] within a large study population with a wide age range.

2. Materials and methods

The subject of study were 2346 conventional orthopantomograms from 1167 female and 1179 male Germans aged from 15 to 70 years, collected from two dental practices and one maxillofacial surgery practice in the north-western part of Germany. The orthopantomograms were taken between 1985 and 2011. Table 1 shows the number of cases in the sample per age cohort, divided by sex.

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Table 1
Distribution of the sample by age and sex.

Age (in years)	Females	Males	Total
15	21	21	42
16	22	27	49
17	41	23	64
18	32	30	62
19	25	25	50
20	25	27	52
21	24	26	50
22	21	23	44
23	17	26	43
24	24	24	48
25	22	24	46
26	28	30	58
27	25	23	48
28	23	23	46
29	25	26	51
30	22	20	42
31	24	28	52
32	21	25	46
33	23	23	46
34	21	28	49
35	24	22	46
36	14	20	34
37	21	26	47
38	22	23	45
39	19	23	42
40	20	23	43
41	21	23	44
42	22	19	41
43	23	20	43
44	21	21	42
45	18	23	41
46	21	19	40
47	20	21	41
48	19	22	41
49	21	19	40
50	21	22	43
51	22	21	43
52	19	21	40
53	18	21	39
54	19	19	38
55	22	21	43
56	19	22	41
57	21	17	38
58	23	18	41
59	16	18	34
60	22	18	40
61	11	18	29
62	21	19	40
63	19	11	30
64	10	15	25
65	17	12	29
66	6	9	15
67	15	11	26
68	15	15	30
69	12	12	24
70	24	10	34
Total	1167	1179	2346

The studied characteristics were the radiographic visibility of the periodontal ligament and the root pulp in the lower third molars with completed mineralization using stage classifications proposed by Olze et al. [18,19]. Figs. 1 and 2 show schematic drawings of these stage classifications.

The examination of the orthopantomograms was undertaken on a randomized and blinded basis, i.e. without knowledge of the dates of birth or the dates of the radiographic examination. Each orthopantomogram was assigned an identification number. The identification number, the date of birth and the sex of each test subject, the date of the examination as well as the stages of the teeth included in the study were recorded. In addition, the number of missing teeth and the teeth being not evaluable were noted. 1541 orthopantomograms of 705 females and 836 males with a sufficient quality of the radiograph showed at least one third molar. Table 2 presents the distribution of these cases by age and sex.

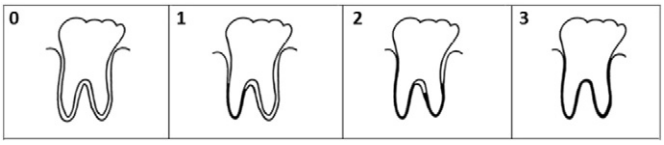

Fig. 1. Stage classification to determine the radiographic visibility of the periodontal ligament. Stage 0: The periodontal ligament is visible along the full length of all roots. Stage 1: The periodontal ligament is invisible in one root from the apex to more than half of the root. Stage 2: The periodontal ligament is invisible along almost the full length of one root or along part of the root in two roots or both. Stage 3: The periodontal ligament is invisible along almost the full length of two roots.

For each stage an age minimum and an age maximum were found. Also a median with lower and upper quartiles, and a mean with standard deviation were calculated. Possible side differences for cases with data for both lower third molars were analyzed using a Wilcoxon test. Significance was assumed at $p < 0.05$ (exact, two-sided).

The first examiner was a dentist with profound professional experience including the examination of orthopantomograms. Prior to the study he had intensively become acquainted to the issue and also discussed it with a forensic dentist experienced in evaluating the radiographic visibility of the periodontal ligament and the root pulp in third molars. After intensive training, the first examiner was very qualified in this method. The second examiner was a dentist without experiences in dental age assessment. For the purpose of intra-rater agreement evaluation 100 randomized orthopantomograms were reevaluated. The same 100 orthopantomograms were also evaluated by a second examiner for an inter-rater agreement evaluation. Cohen's kappa coefficients were then calculated as measures for intra- and inter-rater agreement.

3. Results

Table 3 shows the number and percentage of teeth that could not be used for statistical evaluation as well as the number of missing teeth. Depending on the respective tooth, 36–46% of the cases were evaluable. The main reason for unevaluated teeth was the insufficient quality of the radiographs.

Tables 4–7 show the statistical data concerning the age for both characteristics of teeth 38 and 48 per sex.

For the radiographic visibility of the periodontal ligament of both teeth and both sexes the following results have been reached:

Stage 0 was first observed at the age of 16.7 years in females and at the age of 16.9 years in males. The earliest onset of stage 1 was at the age of 20.1 years in females and at the age of 20.2 years in males. Stage 2 was first achieved at the age of 21.4 in females and at the age of 26.3 years in

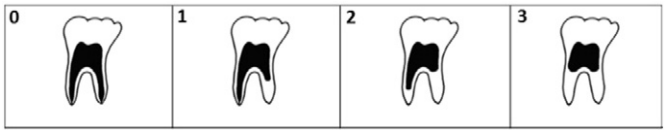

Fig. 2. Stage classification to determine the radiographic visibility of the root pulp. Stage 0: The lumina of all root canals are visible all the way to the apex. Stage 1: The lumen of one root canal is not fully visible to the apex. Stage 2: The lumina of two root canals are not fully visible to the apex or one canal may be virtually invisible in full length. Stage 3: The lumina of two root canals are virtually invisible in full length.