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Araştırma/ Research Article

ASSESSMENT OF DENTAL DIVERSITIES ON PANORAMIC RADIOGRAPHS FOR HUMAN IDENTIFICATION: A RETROSPECTIVE STUDY

İNSANLARIN KİMLİKLENDİRİLMESİNDE PANORAMİK RADYOGRAFİLER ÜZERİNDEN DENTAL ÇEŞİTLİLİKLERİN DEĞERLENDİRİLMESİ: RETROSPEKTİF ÇALIŞMA

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ABSTRACT

Aim: The correct identification of a person after death is an important process with respect to moral, social and legal consequences. The aim of this study is to evaluate the diversity of dental patterns, which is seen in dental panoramic radiographs for personal identification in the Turkish population.
Materials and Methods: Five hundred and three radiographs were randomly selected from the patient database of different 3 private dental clinics. Teeth observed on the dental radiographs about seventeen major dental patterns for each tooth by a well-trained dentist. Generally, permanent dentition was considered for major evaluation for the patient older than 18 years of age and dentulous or partially edentulous. Each radiograph was matched to the sex, age and educational status of every individual.
Results: Distributions of observed population were 57.3% female, 42.7 male; 66.4% young, 30.2% middle age, 3.4% old; and 40.2% primary-educated individual, 59.8% high-educated individual. The dental pattern data were grouped and analyzed by categorical data analysis and experimental design. The most observed dental patterns were virgin tooth (54.98%) in all cases. The missing tooth (13.46%) and dental fillings (11.45%) followed virgin tooth respectively. However, other the least commonly observed 14 dental patterns were showed lower than 5% frequency.
Conclusion: The healthy teeth are mostly observed in the lower anterior sextant in both male and female. In young adults, the present a more balanced distribution compared to other age groups. Also, the people with low education have more rarely healthy teeth in the upper and lower molar regions according to odds-ratios.
Keywords: Forensic Dentistry, Disaster Victims, Dental Diversity, Dental Records, Panoramic Radiography.

ÖZ

Amaç: Ölüm sonrasında bireyin doğru şekilde kimliklendirmesinin yapılması her toplum için dini, ahlaki, sosyal ve yasal bir zorunluluktur. Bu çalışmanın amacı örnekleme yapılan Türk popülasyonun dental nedenlerle daha önceden alınmış panoramik diş filmleri üzerinden dental durumlarının değerlendirilerek kimlik tespitinin yapılıp yapılamayacağının değerlendirilmesidir.
Gereç ve Yöntem: Üç farklı diş muayenehanesinden daha önce teşhis ve tedavi amacıyla hekimlerin talep ettiği ve hasta arşivinde bulunan toplam 503 dental panoramik radyografi rastgele seçilmiştir. İyi eğitimli bir diş hekimi tarafından bu radyografiler üzerinden 17 temel dental durum ayrı ayrı sayısal olarak analiz edilmiştir. Seçilen radyografilerin ait olduğu hastaların 18 yaşından büyük olmasına ve tam dişsizlik durumunun bulunmamasına dikkat edilmiştir. Her radyografi, sahibinin yaşı, cinsiyeti ve eğitim durumuyla da eşleştirilmiştir.
Bulgular: Örneklemde kullanılan popülasyonun % 57.3'ü kadın, % 42.7'si erkek; % 66.4'ü genç, % 30.2'si orta yaşlı, % 3.4'ü yaşlı ve % 40.2'si ilk öğretim seviyesinde eğitimli, % 59.8'i de lise ve üstü eğitim almış olarak tespit edilmiştir. Tüm vakalar için en fazla gözlenen durum %54.98 olarak sağlıklı diş varlığıdır. Bunu sırasıyla %13.46 olarak diş eksikliği ve %11.45 olarak dolgu izlemektedir. Diğer dental durumların %5 sıklığın altında olduğu tespit edilmiştir.
Sonuç: Hem kadın hem de erkeklerde en fazla sağlıklı dişler alt ön bölgede görülmektedir. Genç bireylerdeki sağlıklı diş dağılımı diğer yaş gruplarına göre daha dengelidir. Odds oranı dikkate alındığında da diğer gruplardan farklı olarak düşük eğitim seviyesine sahip bireylerde molar bölgelerde sağlıklı dişe daha nadir rastlandığı gözlenmiştir.
Anahtar Kelimeler: Adli Diş Hekimliği, Felaket Kurbanları, Dental Varyasyonlar, Dental Kayıtlar, Panoramik Radyografiler

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INTRODUCTION

Forensic odontology is an important discipline of dentistry, which works in parallel with the legal departments, providing evidence to explain civil and criminal cases.[1,2] This branch deals with the proper obtaining and examination of dental evidence and then the proper evaluation of dental findings in the interest of justice.[3] The main object of forensic odontologist is to identify victims, slain or culprit both in human or cadaver over their oral tissues, jaws, teeth and dental restorations. The human identification of humans using dental patterns is often applied considering the comparative approach.[4] This comparative method is based on the analogy of ante-mortem (AM) and post-mortem (PM) records obtaining dental patients' charts (odontograms), intra-oral and extra-oral radiographs, clinical photographs, and dental casts. Positive identification using this comparative method is often achieved with a high degree of reliability and accuracy. The dental patterns are defined as the combination of different codes related to specific tooth situations for example virgin, missing, filling and restored teeth in the dental arches.[5-11]

Human identification is an important challenge in forensic science.[12] It can be overcome using confident, certain and objective methods together with professional expertise to ensure that there are no doubts about the identification process. Especially teeth are sometimes the most well-preserved remains of the human body and represent useful and valuable information in the process of identification.[1,12,13] Therefore, the dental examination is even more important for disaster victims like fire or earthquake victims, as major parts of the body might be destroyed.[14] Teeth and the most of dental restorative materials resistant to biological, chemical, and physical deterioration. Because they can bear against high temperature, moisture, force and stress.[14,15] Additionally, teeth present a lot of distinctive features that establish the basis for identification. Human dentition includes incisors, canines, premolars, and molars that vary in shape and size in adults. Also, the teeth arrangement in different oral cavities is unique in everybody. The use of distinctive characteristics of the human dentition for human identification is well accepted and documented in the forensic science. The other significant features which help in comparison are dental pathologies, restorations, dental anomalies, supernumerary teeth or different characteristics that belong to jaws. Sex, age, ethnicity, occupation, and habits can be also determined from teeth.[16-18] Comparing the frequencies of dental patterns from large representative datasets, it is possible to estimate accurately the diversity of the population as a whole.[11,19]

AM dental records are obtained following visits from all patients for routine examination and treatment during their oral and dental health appointments in dental clinics.[20-22] Dental radiographs are certainly one of the most reliable pieces of AM records because of their highly objective and detailed nature as compared with other records. Also, dental radiographs show relatively fewer errors than others. Because obtaining the radiographs is not affected by the variability in person and technique is quite simple.[13,23] Dental radiographs can be kept digitally and not change for no reason. Schuller was the first to use dental radiographs in forensic practice for the identification in 1912.[8] Nowadays, dental radiographs are often used in the forensic odontology. Also, a dental panoramic radiograph (DPR) gives a comprehensive view of the teeth, jaws and numerous features and structures within in one image.[6-11,24] DPR is a broadly applied standard method in dentistry and is used for initial examinations for odontological issues in treatment. For these reasons, there is at least one dental radiograph for almost everybody at their dentist's archive and it can be obtained more practically in identifying a large number of victims from mass disasters and other calamities by communication with dental clinics. In addition, since investigators can evaluate AM and PM radiographs simultaneously, positive identification can be obtained more easily and reliable than that of other records.[12,13]

The purpose of this study is to compare the diversity of dental patterns in DPR for human identification using radiographic detectable dental identifiers. Therefore, evaluation of these parameters for the human profile estimation (age, sex, and education level) and presentation of importance for dental evidence is planned in a Turkish population. The null hypothesis of this study is that dental cases will be seen in a distribution independent of age, gender and education level.

MATERIAL AND METHODS

The present retrospective study using digital DPR captured for routine dental examination and for

this reason ethical clearance for the research was granted by the Ethics Committee of Ankara University, Ankara, Turkey (#36290600/53).

Five hundred and three DPRs were randomly selected from the patient database stored at the different 3 private dental clinics in Ankara, Turkey. All of the DPRs had been taken in different machines but same conditions with an 18 s exposure and with exposure parameters ranging from 1 to 16 mA, from 55 to 90 kVp and totally filtration equally with 2.5 mm Al. Prerequisite for usage of radiographs is their good image quality. Teeth observed on the dental radiographs were examined and converted into a consistent set of codes by a well-trained dentist following the criteria described in Table 1. In this study, permanent dentition was considered for major evaluation and also deciduous teeth were accepted as a dental pattern. The diversity of dental patterns was calculated for the patient older than 18 years of age and dentulous or partially edentulous. The radiographs of patients with a maxillofacial abnormality, cleft lip and/or palate, orthodontic devices or completely edentulous were excluded.

Table 1. The diversity of dental identifiers in DPRs

Dental Pattern	Description of Pattern
Virgin Tooth (V)	Sound: no evidence of caries, dental treatments or any abnormality
Missing Tooth (M)	Congenital missing of a tooth or extracted tooth
Caries and Defects (C)	Decay cavity or fracture in the tooth or defect by fall out of fillings
Dental Implant (DI)	Presence of dental implant in the bone
Dental Filling (F)	Restoration with amalgam, composite or other restorative materials
Dental Filling with Caries (FC)	Filling and cavity is together
Endodontic Treatment (E)	Root canal filled tooth by endodontic treatment
Single Crown (SC)	Restored tooth with a single unit crown
Abutment of Fixed Dental Prosthesis (A)	Parts of a fixed dental prosthesis on teeth that supported pontics
Pontic of Fixed Dental Prosthesis (P)	Parts of a fixed dental prosthesis that restored edentulous areas
Impacted Tooth (I)	Unerupted or impacted tooth
Deciduous Tooth (D)	Presence of baby teeth in any dental arch for adults
Residual Root (R)	Presence of remained root tissue in the bone
Alveolar Bone Loss (BL)	Loss of bone and connective tissue attachment to the root of the tooth
Unrestored Prepared Tooth (U)	Prepared tooth without a crown
Dental Mutilation (DM)	Dental modification, trimming or piercing
Fractured Root (FR)	Presence of fracture line at the root

Identity records of the persons belonging to these films were kept confidential. Each radiograph was matched to the sex, age and educational status of the individuals. FDI notation was used for dental charting. The sex of samples was classified as male or female, the age of the samples was categorized into three different groups; young adult (19 to 44), middle-aged (45 to 64) or old (more than 64) and finally education levels were specified as primary (primary school and less than) or high (high school and more than) education. The dental pattern diversities were calculated for the full dentition-32 teeth. A single operator who was well-trained dentist about forensic odontology determined the data of the samples.

The dental pattern data were grouped and analyzed by using the IBM Statistical Package for Social Sciences (SPSS) for Windows version 23 (International Business Machines Armonk, New York, United States). First, the frequencies and percentages of the parameters based on all the teeth were calculated for sex, age groups, and educational status. In addition, descriptive statistics were obtained for the data and cross tables were constructed for variables and the relationship between these variables was tested by Pearson Chi-square analysis ($p < 0.05$). In categorical data analysis, the correlation coefficients for qualitative data were examined and depending on the analysis results, this difference occurred from which cell was determined by the standardized cell residuals. Besides that, odds ratios for all parameters based on intact teeth were calculated for sex, education status, and all age subgroups.

RESULTS

The diversity of dental patterns was composed of 503 DPR images and matched the inclusion criteria mentioned above. Distributions of observed population were 57.3% female, 42.7 male; 66.4% young, 30.2% middle age, 3.4% old; and 40.2% primary-educated individual, 59.8% high-educated individual. When these parameters are ignored (the sum of all patterns), the most frequently repeated dental patterns were V (% 54.98) in all cases (503 patients X 32 teeth = 16096 patterns). M (% 13.46) and F (% 11.45) followed V respectively. However, other the least commonly observed 14 dental patterns were showed lower than 5% frequency. Furthermore, when full dentition or mandible was evaluated, it was determined that none of the randomly selected 503 DPRs were similar to each other and at least there was a diversity even in only a tooth. However, it was observed 12 similar cases especially based on observation of virgin teeth in full at maxilla.

The diversity ratio calculated for the sex groups, the most commonly observed dental pattern

was determined as V for both female (51.71%) and male (59.34%) groups. The most rarely observed dental patterns were identified as DM and FR (only one case for each of them) for the female and DM, D (absent) and FR (two cases) for the male. While there was a statistically significant difference among V, M, SC, A and P groups for females, there was a statistically significant difference among V, M, E, SC, A, P, I groups for males ($p < 0.05$) (Table 2).

Table 2. Distribution of observed dental patterns according to sex differences

DENTAL PATTERN	FEMALE		MALE		TOTAL	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
V	4766	51.71	4083	59.34	8849	54.98
M	1326	14.38	841	12.22	2167	13.46
C	174	1.88	166	2.41	340	2.11
DI	45	0.48	17	0.25	62	0.38
F	1104	11.97	739	10.74	1843	11.45
FC	26	0.29	29	0.42	55	0.34
E	354	3.84	209	3.04	563	3.50
C	332	3.60	141	2.05	473	2.94
A	444	4.82	213	3.10	657	4.08
P	410	4.48	209	3.04	619	3.85
I	141	1.53	146	2.13	287	1.78
D	3	0.03	0	0	3	0.02
R	10	0.11	14	0.20	24	0.15
BL	10	0.11	19	0.27	29	0.18
U	69	0.75	52	0.76	121	0.75
M	1	0.01	0	0	1	0.01
FR	1	0.01	2	0.03	3	0.02
TOTAL	9216	100	6880	100	16096	100

The diversity ratio assessed for the age groups, the most commonly observed dental pattern was determined as V at young people (62.96%) and any FR has not ever been seen. While V (40.17%) was also the most frequently observed dental pattern for middle age group, D and DM have not ever been detected for them. On the contrary of all groups, the most commonly seen dental pattern was M (35.66%) and V (30.51%) followed it as the second frequent case for elders. Also, DI, FC, I, D, BL and DM patterns have not ever been detected for them. It was observed that statistically significant differences were found among V, M, DI, F, SC, A, P, I, BL, U for young adults, among V, M, DI, F, E, SC, A, P, I, BL, U for middle-aged individuals, and among V, M, F, SC, I, R, U for elderly individuals ($p < 0.05$) (Table 3).

When the diversity ratio assessed for the education level of people, the most commonly observed dental pattern was determined as V for both low-educated people (primary education) (50.62%) and high-educated people (high education) (57.90%). Any D and DM cases have not ever been seen at primary education groups. The most rarely observed dental patterns were identified as DM and FR (only one case for each of them) for the high educated group. While a statistically significant difference was observed among V, M, C, F, SC, A, P, I groups in the basic educated individuals, there was a statistically significant difference among the groups of V, M, F, SC, A, P, I in highly educated individuals ($p < 0.05$) (Table 4).

Table 3. Distribution of observed dental patterns according to age differences

DENTAL PATTERN	YOUNG		MIDDLE AGED		OLD		TOTAL	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
V	6729	62.96	1954	40.17	166	30.51	8849	54.98
M	943	8.82	1030	21.17	194	35.66	2167	13.46
C	239	2.24	89	1.83	12	2.20	340	2.11
DI	12	0.11	50	1.28	0	0	62	0.38
F	1346	12.60	459	9.43	38	6.99	1843	11.45
FC	39	0.36	16	0.32	0	0	55	0.34
E	341	3.19	207	4.25	15	2.76	563	3.50
C	199	1.86	231	4.75	43	7.91	473	2.94
A	265	2.48	363	7.46	29	5.33	657	4.08
P	227	2.12	364	7.48	28	5.15	619	3.85
I	267	2.50	20	0.41	0	0	287	1.78
D	3	0.03	0	0	0	0	3	0.02
R	12	0.11	9	0.18	3	0.55	24	0.15
BL	10	0.09	19	0.37	0	0	29	0.18
U	55	0.52	51	1.05	15	2.76	121	0.75
M	1	0.01	0	0	0	0	1	0.01
FR	0	0	2	0.04	1	0.18	3	0.02
TOTAL	10688	100	4864	100	544	100	16096	100

Table 4. Distribution of observed dental patterns according to educational status

DENTAL PATTERN	PRIMARY EDUCATION		HIGH EDUCATION		TOTAL	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
V	3272	50.62	5577	57.90	8849	54.98
M	1192	18.44	975	10.12	2167	13.46
C	161	2.49	179	1.86	340	2.11
DI	20	0.31	42	0.44	62	0.38
F	507	7.84	1336	13.88	1843	11.45
FC	22	0.35	33	0.34	55	0.34
E	218	3.38	345	3.58	563	3.50
C	343	5.74	231	2.40	473	2.94
A	339	5.24	318	3.30	657	4.08
P	341	5.27	278	2.89	619	3.85
I	71	1.09	216	2.24	287	1.78
D	0	0	3	0.03	3	0.02
R	12	0.19	12	0.12	24	0.15
BL	18	0.28	11	0.11	29	0.18
U	47	0.73	74	0.77	121	0.75
M	0	0	1	0.01	1	0.01
FR	2	0.03	1	0.01	3	0.02
TOTAL	6464	100	9632	100	16096	100

Individual numerical distribution of all dental patterns was evaluated according to sex, age, and educational status; the most frequently observed dental pattern for all parameter groups was generally identified as V. When this situation was examined according to each tooth and sextant, the V was mostly observed in the lower anterior sextant in both male and female. Since the number of healthy teeth available in men was less than that in women, the number of intact teeth in this region in males was relatively close to the number of intact teeth in the upper anterior sextant in males. In young adults, the

intact teeth presented a more balanced distribution compared to other age groups. The presence of intact teeth in the middle-aged group was clearly visible between the lower premolar teeth (from 35 to 45). In elders, V was more commonly seen in the lower anterior sextant than the other sextants. It was noteworthy that low educated individuals had a more rarely V in their upper and lower molar regions. This situation was less common in the first and third molars for highly educated people.

In this study, for forensic identification, the odds-ratios were determined according to the "healthy existing tooth" that should actually be occurring for each pathological condition in order to be able to interpret which of the states of the tooth is distinguishable and these odds-ratios were shown in Table 5. According to this, for all groups, the ratios of the implant, filling and decay all together, the presence of deciduous tooth and impacted tooth, remained residual root, alveolar bone loss, dental mutilation and fractured root due to intact tooth were extremely low. Conversely, the presence of missing tooth in accordance with other pathologies had a high odds ratio for all groups. In females, the odds ratios of dental filling were almost equal to the missing tooth ratio and were seen at the highest level. In men, although these two cases had the highest odds ratio, the relationship between them was much weaker than that of women. The incidence of missing tooth in male and female individuals was similar in comparison to the intact tooth. When the highest incidence of missing tooth was assessed by age classification, it is observed that the odds ratio for each age group had distinctly increased with the passage to the older age group. When the education levels were considered, the ratio of missing tooth had decreased by almost half with the increase in education level, but the ratio of filling tooth had considerably increased.

In this study, the Cronbach's alpha was obtained by 0.828 which specified the power of the relationship between the variables. In health and social studies, the Cronbach's alpha is known as a measure of internal consistency, namely how closely a series of variables is related as a group and taken an acceptable level of a reliability coefficient of 0.70 or higher.

Figure 1. Assessment of dental diversity on panoramic radiography.

DISCUSSION

The processes of distinguishing of a living or dead people from others are called identification which becomes more important in the event of forensic cases involving doubtful deaths and also in the mass disasters like airplane crashes, wars, post-earthquakes or tsunami periods. Furthermore, disaster-victim identification (DVI) cases differ from others in terms of their complexity. The accurate identification of human remains is important in modern populations both social, religious, humanitarian, ethical reasons and for legal reasons.[25-27] Therefore, this study evaluated that effect of dental cases in people identification. The most cases which used in this study presented different distinguished effects especially in terms of age and education level. For this reason, the null hypothesis of this study was rejected.

Table 5. The frequency of observed dental patterns according to virgin teeth with the odds ratio

		M	C	DI	F	FC	E	C	A	P	I	D	R	BL	U	M	FR
SEX	Female	0.28	0.04	0.01	0.23	0.01	0.07	0.07	0.09	0.09	0.03	0.01	0.00	0.00	0.01	0.00	0.00
	Male	0.21	0.04	0.00	0.18	0.01	0.05	0.03	0.05	0.05	0.04	0.00	0.00	0.00	0.01	0.00	0.00
AGE	Young	0.14	0.04	0.00	0.20	0.01	0.05	0.03	0.04	0.03	0.04	0.00	0.00	0.00	0.01	0.00	0.00
	M. Age	0.53	0.05	0.02	0.23	0.01	0.11	0.12	0.19	0.19	0.01	0.00	0.00	0.01	0.03	0.00	0.00
	Old	0.90	0.06	0.00	0.18	0.00	0.08	0.22	0.16	0.14	0.00	0.00	0.02	0.00	0.08	0.00	0.00
EDUCATION	Primary	0.36	0.05	0.01	0.15	0.01	0.07	0.07	0.10	0.10	0.02	0.00	0.00	0.01	0.01	0.00	0.01
	High	0.17	0.03	0.01	0.24	0.01	0.06	0.04	0.06	0.05	0.04	0.00	0.00	0.00	0.01	0.00	0.01

A dental evaluation is an important method used for the analysis of mass disaster cases where there are large numbers of victims. The critical role of forensic dentistry for identification is the ability to use on the both hereditary and acquired distinctive characteristics of the teeth for different individuals like fingerprints.[28] It should be noted that an average of 32 teeth in an adult and 5 different surface-edges of them could be examined, thereby an average of 160 different evaluation areas can be found in each individual. The forensic dental comparison involves the evaluation of these important features of the teeth such as surface structure, missing teeth, caries teeth, restorations on the teeth like fillings or dental prostheses including crowns, partial or complete dentures, crowding of teeth, diastemas, or tilted teeth. Additionally, teeth are extremely resistant to adverse conditions such as trauma, high and low temperatures, humidity or environments with different pH values, thus providing a very important data for identification when examining cases, as major parts of the body might be destroyed.[14] This unique durability was also seen with dental materials, which were manufactured to replace the tooth missing, and therefore, restorations were resistant to destruction by biological, chemical and physical challenges.[11,21]

The distinctive features of dental diversities and how frequently certain dental modifications were found in a society have been the focus of various researches like the present study. For example, Adams[29] expressed that the dental diversities were enough to forensic identify even in the absence of dental radiographs. His study only compared missing, restored and unrestored teeth on a simple dental chart. Disasters and accordingly identification often involve victims of multiple nationalities but nevertheless, identification teams are the ability to collect AM data of sufficient detail to be used for a meaningful comparison.[21] Keiser-Nielsen[30] has detected 12 compatible features between AM and PM dental records to establish positive identification; although this is not a common valid standard. However, Buchner[31] stated that only a single tooth or jaw fragment might be enough to confirm a positive identification. Where a victim has any missing, decayed or filled teeth, one or more extraordinary features could be exhibited and these specific configurations should be enough for identification in most cases. Therefore, even only one remarkable feature may sometimes be adequate in certain cases, to make an accurate identification contrary of minimum requirement features of Keiser-Nielsen.[30] Angelakopoulos et al.[32] declared that clinically detectable dental identifiers were more useful for identifying the correct subject if they composed the lower potential set. In other words, the rare occurrence of situations in the dental records and radiographs increases the identification potential.

In the identification process, the collecting and comparing of AM and PM data is used to identify an individual. The most effective method for obtaining AM records is the use of dental documents.[21] However, a successful dental correlation will rely entirely on how well dental information is documented. Dental records can be obtained from written charts of patients, patient's oral and extraoral photographs, dental models or radiographs, which take in routine dental examinations. Several studies have evaluated the quality of dental recordkeeping from a forensic perspective. These studies exhibited that the quality of written dental records is often poor. This is manifested by the inadequacy of data, incorrect and outdated dental information, and not following the guidelines.[21] Consequently charting errors can seriously hinder forensic identification.

Initially, the easiest method that can be used for forensic dental documentation is recorded in written during the examination of the patient but any deficiency or error made during the registration may bring into doubt on the success of the identification. Therefore, obtaining AM dental information from written dental records is unreliable as a solitary method. Secondly, the uses of the patient's intraoral photographs or dental models will lead to the recording of the visible parts of the teeth and the oral cavity only, so that many parameters such as proximal decays or restorations, root canal treatments, alveolar lesions which can be extremely effective in individual identification cannot be monitored and evaluated. Additionally, even though they can be obtained with digital methods, there is a problem with their preservation and storage for analog methods. Considering all these facts, it is obvious that many recording problems mentioned above can be solved with using dental radiographs. Obtaining and recording AM dental data with dental radiographs, monitoring the morphological features of teeth, and physical details before and after any dental treatment are well accepted as being an optimal way to preserve this information. Therefore, nowadays using or

comparison of AM and PM dental radiographs are accepted as one of the most reliable and effective dental identification methods both for single cases and for mass disasters.[12,13,33]

AM dental radiographs are widely used since they are easily obtainable and transportable because of the current benefit of digital radiology in dentistry. Different types of traditional dental radiography methods are used for forensic identification. The most commonly used are periapical and bitewing (intraoral radiographs) or DPRs (extraoral radiographs).[34] Even a single intraoral radiograph generally includes enough data to identify an unknown victim. Still, DPRs allow evaluating both jaws and all current teeth or restorations together. On the other hand, AM and PM DPRs can be compared simultaneously, and they allow information to be transferred in a form not subject to written record errors.[13]

Indeed, the prevalence of dental diversities is closely related to the dental health status of these populations and this depends on age, oral hygiene educations and the differences in the dental caries levels among countries.[5] In some countries, a number of studies have been conducted that evaluate dental diversities.[5,6,9,13,32,34] Perez[5] observed different dental cases of the Peruvian people from totally 900 digital DPRs of 450 women and 450 men. Dental cases were determined as the healthy virgin tooth, missing teeth, tooth with caries and defects, buried tooth, root enlargement, root canal treatment, dental fillings, and prosthesis. There were diversities among dental patterns on 893 cases when both dental arches evaluated together (99.89%), 826 cases of the upper jaw (99.81%) and 834 cases of the lower jaw (99.85%). The lowest differences were observed in the lower anterior region with 142 cases (47.50%). In other words, it was revealed that the cases showed the most similarity only in the lower front region. Similarly, Lee et al.[13] evaluated dental cases in the Korean population on 300 DPRs. The diversity of dental patterns was observed with 99.92% for full dentition and with 98.22% and 99.28% for maxilla and mandible alone respectively. These findings were obtained as 99.9%, 98.2% and 98.4% for full dentition, maxilla, and mandible respectively in India.[9] These results were parallel with the present study.

As well as comparing the dental pattern diversity, it was also of great importance to establish the proportional presence of pathological cases (for example caries) according to existing virgin tooth in order to establish the discrimination of differences. Therefore, unlike other similar studies[5,9,10,11,19,29,33], the frequency of dental diversities was assessed according to the virgin tooth using the odds ratio in the present study. Compared to the expected virgin tooth in the population, it was determined that the most frequently encountered missing tooth was less deterministic than the other parameters. That's why this analysis was as important as the frequency of dental pattern diversity in forensic identification.

Madi et al.[21] conducted a study on the identification of dental diversity in a multinational population sample. 2000 cases were formed from records of 1198 men and 802 women aged between 11 and 87 years. In general, 1031 absolutely distinctive dental situations were found for every code containing a tooth. The most common situation is virgin teeth similarly to the present study. Also, the first molar teeth were determined as the most amount of missing, filling or restoring with a crown. Comparisons based on dental records reveal that certain cases of teeth were widespread and certain cases were less frequent. These distinctive diversities were important in the human identification.

In 2016, Silva et al.[2] investigated the contribution of endodontic dental radiographic evidence to forensic dentistry in real criminal cases. In the first examined case, root canal treatment in mandibular left first premolar detected with AM periapical radiographs of the victim. As PM, the endodontic treatment of this tooth was confirmed. In the second case, root canal treatment was detected in the mandibular left first molar via the dental radiographic examination of a broken body. When PM periapical radiographs were compared with AM records, view of same treatment was confirmed. In the third case, the unidentified victim, who had the only maxillary right first molar with fixed prosthetic restoration was identified with root canal treatment in the radiographic examination. This result; suggests that the retrospective study presented in terms of finalizing the identification even on a single dental situation is the important evidence. This study demonstrates the significance of the present retrospective study in terms of informative importance about crime scene investigations.

CONCLUSION

Within the limitations of this study that demonstrated the diversity of dental patterns in a

sample from a Turkish population, the following conclusions can be drawn:

1. Evaluation of AM records and DPRs that obtained during routine examination can be used as one of the most reliable and effective identification procedures at the Turkish population for both single cases and mass disasters.
2. It may be considered that V can be used to distinguish younger adults (due to greater incidence) or elders (due to lesser incidence) in the age group while in the other groups similar in terms of sex and education level.
3. V has been shown to decrease with the aging and tooth loss is thought to be a phenomenon that can be used to distinguish between age groups because it is seen in young adults relatively low compared to other age groups. More conservative restorative procedures such as F are more common in young adults; SC, A, P and U cases have increased proportionally with the aging. This situation is important to the identification.
4. It has been shown that the increase in education level is reduced to M and restorative and prosthetic procedures can be used in educational level discrimination because the priority of F which is a more conservative approach than the SC with increasing of education level.
5. It is important for human identification the DI, FC, R, BL and U that are relatively rare for all groups; also D, DM and FR cases that are very rare exhibit a very important discriminating feature.

Conflict of interest statements
The authors declare that they have no conflict of interest.

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