

Dental pulp stone formation during orthodontic treatment: A retrospective clinical follow-up study

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Abstract

Objective: The aim of this study was two-fold: (1) To assess the incidence of dental pulp stone formation during orthodontic treatment, and (2) to determine the correlations between the presence of dental pulp stones and age, gender, and dental arches.

Materials and Methods: A sample of 545 patients (334 girls and 211 boys, age range; 12-22 years) who had undergone nonextraction orthodontic treatment were included in this study. 8442 teeth (T1) and 8410 teeth (T2), including the first and second maxillary and mandibular premolars and molars were evaluated from the pre- (T1) and post-treatment (T2) panoramic radiographs of the patients. The Pearson Chi-square test was used to investigate the associations between the presence of dental pulp stone, gender, age, tooth type and arches.

Results: Dental pulp stones were detected in 3% of the teeth at pretreatment panoramic radiographs and 5.2% of the teeth at posttreatment panoramic radiographs. Pulp stone prevalence increased pointedly (2.2%) in the pre- and post-treatment radiographs ($P < 0.001$). Also, there was a significant difference between the age groups ($P < 0.001$). In the maxilla, dental pulp stones were found significantly more than that in the mandible at T1 and T2 panoramic radiographs. Maxillary first molars exhibited dental pulp stones the most frequently, followed by the maxillary second molars and mandibular first molars.

Conclusion: Orthodontic treatment may trigger the formation of dental pulp stones. However, further studies are required to determine the relationship between the pulp stone formation and orthodontic treatment.

Key words: Dental pulp stone, incidence, orthodontics, panoramic radiography

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Introduction

Dental pulp is an unmineralized living tissue survival of which depends on the continuous blood flow. Changes in blood flow or vascular tissue pressure can affect the health of the dental pulp.^[1-11] Dental pulp tissue may form dentin or osteodentin in the reaction to the homeostasis induced either by surgical or chemical stimulation, and the activity of pulp cells regulates the calcification of pulp tissue²¹

There are two chief morphological forms of pulp calcifications: Discrete pulp stones (denticles, pulp nodules) and diffuse calcification³¹ Pulp stones are calcified bodies

in the dental pulps of the teeth, which can be seen in the pulps of healthy, diseased, and even unerupted teeth in the primary and permanent dentition.^[1] Dental pulp stones may be free, attached, or embedded in the coronal or radicular pulp⁴¹ They are considerably more common in the pulp chamber than in the root canal and may occur in a single tooth or several teeth.¹⁵¹ Pulp stones vary in size from small microscopic particles that may occur as a single or several small radio-opacities to large masses that almost occupy the pulp chamber.¹⁴¹ Pulp stones appear radiographically as round or ovoid opacities within the pulp. Although pulp

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stones are variable in size and form, their recognition is not difficult.^[5]

The etiological factors and mechanisms of the formation of pulp stones are vastly unknown, although some factors are considered to stimulate pulpal calcifications, such as degenerative lesions of the pulp, inductive interactions between epithelium and pulp tissue/⁶¹ increased age/⁷¹ having other dystrophic soft tissue calcifications (urinary lithiasis, calcified atheromas etc.)/⁸¹ genetic predisposition/⁹¹ problems with the blood circulation of the pulp/¹⁰¹ and long-term irritation such as deep caries, restorations¹¹¹¹ and orthodontic tooth movements.^{112,131} Although the currently held clinical view is that pulp stones have no clinical significance, they lead to complications when endodontic therapy is needed. Their large size in pulp chamber may block access to canal orifices and alter the internal anatomy, and attached stones may deflect or engage the tip of exploring instruments, preventing their easy passage down the canal/¹⁴¹

During the orthodontic tooth movement, a complex series of tissue reaction occurs. The response of dental tissues to orthodontic forces are tried to be highlighted by the continuing orthodontic studies/¹⁵¹⁷¹ Orthodontic tooth movement affects alveolar bone and other supporting structures, and also affects dental pulp in a way similar to surgical or chemical stimulation. Studies show that the orthodontic force application may cause pulpal changes like alteration in pulpal respiration rate, pulpal obliteration by secondary dentin formation, internal root resorption, cyst formation, pulpal necrosis and also pulpal calcifications/^{13,18*201}

The relationship between orthodontic force and pulp calcifications have been investigated before/²¹¹ However, to our best knowledge, there is no published study that investigate the change of the pulp stone incidence in orthodontic patients with retrospective clinical follow-up study. Therefore, the aim of this study was to determine the incidence of pulp stone formation during orthodontic treatment using pre- and post-treatment panoramic radiographs of orthodontic patients and to report the correlations among the presence of pulp stones and age, gender and dental arch.

Materials and Methods

For the current retrospective study, a sample of 545 patients who had undergone nonextraction orthodontic treatment in the Department of Orthodontics at Selçuk University, Konya, Turkey was selected. There were 334 girls and 211 boys age range; 12-22 years at the beginning of the treatment. The inclusion criteria were the existence of pre-treatment (T1) and post-treatment (T2) panoramic radiographs and patients without poor quality radiographs (overexposed,

underexposed, incorrect patient positioning), any systemic diseases.

The panoramic radiographs of all patients were obtained as a part of the diagnostic records gathered for comprehensive orthodontic treatment; therefore, they were not unnecessarily subjected to additional radiation. Because this study was retrospective study, Ethics Committee approval was not needed. Also as usual protocol all patients or the parents already signed an informed consent form recording their agreement for radiographic exposure.

All panoramic radiographs were taken by using ProMax Dimax 3, (PlanmecaOy, Helsinki-Finland). Post-treatment radiographs of the patients were taken immediately at the end of treatment on the same day, and the average orthodontic treatment duration was lasted 16.48 ± 2.16 months.

The first and second maxillary and mandibular premolars and molars were evaluated from the pre-treatment and post-treatment panoramic radiographs of the patients. Deep carious, restored and endodontically treated teeth and crowns, were excluded from the study group and 8442 teeth (T1) and 8410 teeth (T2) were examined in this study (after fixed orthodontic treatment, the number of examined teeth were diminished due to tooth extractions or consisting deep caries lesion).

One orthodontist (I.V.) and one oral and maxillofacial radiologist (E.E) interpreted all panoramic radiographs. Each observer interpreted each panoramic radiograph individually, followed by a discussion of each radiograph between the two observers. The oral and maxillofacial radiologist with 10 years of experience in image interpretation provided training to familiarize the other observer with the presentation of pulp stones then two the observers discussed and scored a number of teeth for calibration.

Observation conditions were optimized by using the same computer monitor to display all of the images with x 2 magnification. Viewing distance was kept constant, at about 50 cm, for all observers, and the lights were dimmed during the observations.

A definite diagnosis was made when the two observers agreed with the definite radiopaque bodies as dental pulp stones and were noted as present or absent. Twenty percent of all panoramic radiographs were reassessed by each observer together, with a 2-week interval between viewing to eliminate memory bias.

Statistical analysis

The analyses were performed using Statistical Package for Social Sciences software package (SPSS for Windows, version 20.0, SPSS Inc., Chicago, IL, USA). The frequency

of distribution was calculated by descriptive statistics. The Pearson Chi-square test was used to investigate the correlation between the presence of pulp stone and gender, age, tooth type, and dental arches. For all statistical analysis, the level of significance was $P < 0.05$.

Results

From pre- and post-treatment panoramic radiographs of 545 orthodontic patients, a total of 16,852 teeth were analyzed and 257 pulp stones were detected in 3% of the teeth at T1 panoramic radiographs and 437 pulp stones were detected in 5.2% of the teeth at T2 panoramic radiographs. A significant increased (2.2%) pulp stone incidence were found in the pre- and post-treatment radiographs ($P < 0.001$). The incidence of pulp stones increased remarkably during orthodontic treatment.

Based on the number of teeth with new pulp stone formation after orthodontic treatment, of 180 teeth (2.2%), 72 were detected in male patients (2.2%) and 108 were detected in females (2.1%). No relationship was detected between the formation of pulp stones and gender during orthodontic treatment ($P = 0.728$ and $P_{T2} = 0.968$) [Table 1].

Taking into account of the number of patients, 74 patients were detected with new pulp stone formation after orthodontic treatment. Of these 74 patients, 29 were males (13.6%) and 45 were females (13.5%). Formation of pulp stone did not change with gender ($P_{T1} = 0.551$ and $P_{T2} = 0.637$) [Table 2].

The distribution of patients with dental pulp stones during orthodontic treatment according to age was shown in Tables 3 and 4- At the age of 18-20, 52 (3.1%) teeth were detected with new pulp stone formation and highest new pulp stone formation was observed in this age group. At the age of 12-14, the increase of pulp stone was 20 (1.3%) and the least pulp stone formation was examined in this age group. There was a significant difference between the age groups ($P < 0.001$) in tooth size-based comparison [Table 3].

In the maxilla, dental pulp stones were found significantly more than that in the mandible at T1 and T2 panoramic radiographs. There were statistically significant differences between the incidence of dental pulp stone in the maxilla (2.2%) and mandible (2.1%) during the treatment ($P < 0.001$) [Table 5].

Maxillary first molars exhibited dental pulp stones the most frequently, followed by the maxillary second molars and mandibular first molars. The distribution of pulp stones was higher in the first molars than the second molars in

Table 1: Tooth-size based comparison of dental pulp stone formation during orthodontic treatment

	T1		P	T2		P T2-T1
	Male	Female		Male	Female	
Absent	3177	97	3.0% NS	3091	169	5.2% NS
Present	5008	160	3.1%	4882	268	5.2%
Total	8185	257	3.0%	7973	437	5.2%

*** $P < 0.001$; NS: Not significant

Table 2: Patient size-based comparison of dental pulp stone formation in males and females

	T1		P	T2		P T2-T1
	Male	Female		Male	Female	
Absent	159	52	24.6% NS	130	81	38.4% NS
Present	244	90	26.9%	199	135	40.4%
Total	403	142	26.1%	329	216	39.4%

*** $P < 0.001$; NS: Not significant

Table 3: Tooth size-based comparison dental pulp stone formation in terms of age

Age	T1		P	T2		P T2-T1	P
	Absent	Present		Absent	Present		
12-14	1413	30 2.1% ***		1408	50	3.4% ***	1.3% *
14-16	2019	50 2.4%		1974	87	4.2%	1.8% ***
16-18	1532	29 1.9%		1483	63	4.1%	2.2% ***
18-20	1629	75 4.4%		1571	127	7.5%	3.1% ***
20-22	930	54 5.5%		893	75	7.7%	2.2% *
>22	662	19 2.8%		644	35	5.2%	2.4% *

*** $P < 0.001$; * $P < 0.05$

Table 4: Patient size-based comparison of dental pulp stone in terms of age

Age	T1		P	T2		P T2-T1	P
	Absent	Present		Absent	Present		
12-14	72	21 22.6% NS		63	30 32.3% *	1.3%	NS
14-16	101	32 24.1%		84	49 36.8%	1.8%	*
16-18	82	19 18.8%		68	33 32.7%	2.2%	*
18-20	70	39 35.8%		48	61 56.0%	3.1%	**
20-22	45	19 29.7%		39	25 39.1%	2.2%	NS
>22	33	12 26.7%		27	18 40.0%	2.4%	NS

** $P < 0.01$; * $P < 0.05$

each dental arch. The increase in pulp stone incidence of the premolars were found only 0-0.4% in maxilla and 0-0.2% in mandible and the increase in pulp stone incidence of the molars were found 32-51% in maxilla and 37-43% in mandible with a statistically significant difference ($P < 0.001$) [Table 5].

Also, there were no statistically significant differences between the right and the left sides in the maxillary and mandibular arches at T1 and T2 panoramic radiographs [Table 6].

Table 5: Tooth-size based comparison of dental pulp stone formation in terms of tooth type and dental arch during orthodontic treatment.

		T1		P		T2		P	T2-T1	P
	Absent	Present			Absent	Present				
Maxilla										
First premolar	1056	1	0.1%	***	1008	1	0.1%	***	0	NS
Second premolar	1057	2	0.2%		1053	6	0.6%		0.04%	NS
First molar	931	116	11.1%		871	168	16.2%		0.51%	***
Second molar	983	56	5.4%		979	93	8.6%		0.32%	**
Total	4027	175	4.2%		3911	288	6.4%		0.22%	***
Mandibula										
First premolar	1075	2	0.2%	***	1047	2	0.2%	***	0	NS
Second premolar	1065	5	0.5%		1056	7	0.7%		0.02%	NS
First molar	992	54	5.2%		941	99	9.5%		0.43%	***
Second molar	1035	21	2.0%		1018	61	5.7%		0.37%	***
Total	4158	82	1.9%		4062	169	4.0%		0.21%	***

***P<0.001; NS: Not significant

Table 6: Tooth size-based comparison of dental pulp stone formation in terms of side in the jaws

	T1		P		T2		P T2-T1	
	Absent	Present	Absent	Present	Absent	Present		
Maxilla								
Right	2006	93	4.4%	NS	1948	136	6.5%	NS
Left	2021	82	3.9%		1963	132	6.3%	
Mandible								
Right	2084	40	1.9%	NS	2043	80	3.8%	NS
Left	2074	42	2.0%		2019	89	4.2%	

***P<0.001; NS: Not significant

Discussion

The prevalence of pulp stone varies from 8% to 90%, depending on the study type, design, and radiographic technique employed.^[22] This radiologic study was the first to evaluate the change in dental pulp stone incidence during orthodontic treatment with clinical follow-up.

There is conflicting literature on the association of the presence of pulp calcification and systemic disturbance. Although Stafne and Szabo^[23] Edds *et al.*^[18] found a significant relation between pulp stones and the presence of arteriosclerosis, osteitis deformans and cardiovascular diseases, Gulsahi *et al.*^[14] did not show such a correlation between reported systemic diseases and prevalence of pulp stones. Ilgüy *et al.*^[24] investigated the presence of pulp stones among adult insulin-dependent diabetics and nondiabetics, using periapical radiographs and found that Type I diabetics had more pulp stones than nondiabetics in first maxillary molars. To eliminate the confliction, patients with any systemic disease were excluded from this study.

Pulpal calcifications have been investigated by radiographs^[18,25,26] or histological sections.^[27] Dental pulp stones, which are bigger than 200 µm can be observed

by dental radiographs due to this situation radiographic prevalence is less than histologic studies.^[11] On the other hand, radiographs are the only noninvasive way of evaluating dental pulp stones in clinical researches. While the radiological studies tend to underreport the incidence of pulpal calcifications, even histological observations may be incomplete in this respect because of a limited number of investigated tooth sections.^[22]

In general, calcifications of the pulp can be demonstrated more readily by use of bitewing and periapical radiographs. Bite wing radiographs could also be used, but would limit the examination to the crown only. While Baghdady *et al.*^[26] used bitewing radiographs to investigate the prevalence of pulp stones, al-Hadi Hamasha and Darwazeh^[25] assessed both periapical and bitewing radiographs. Tamse *et al.*^[28] examined both periapical, and bitewing radiographs to identify pulp stones and to compare the two radiographic techniques and concluded that no significant difference was found between the projections. We evaluated the occurrence of pulp stone with digital panoramic radiograph so that teeth involved with calcification in both maxilla and mandible can be ruled out.

Some investigators believe that pulp calcification is a pathologic process related to different forms of damage; however, others consider this finding as normal.^[29] A huge variety of fixed orthodontic appliances and techniques exists, and the potential association between type of force/tooth movement and pulp stone formation is still undetermined. In previous histological studies, there were contradictory results in the correlation between orthodontic forces and pulp stones. While Stenvik and Mjör^[30] showed that orthodontic forces can cause pulp stone formation, Ramazanzadeh *et al.*^[21] reported that there was no relationship between pulp stone formation and orthodontic forces. Ramazanzadeh *et al.*^[21] compared the effects of

orthodontic extrusive and intrusive forces on histological changes of the human dental pulp and concluded that there were no significant differences among extrusive, intrusive and control groups for pulp stone formation after force application. In this study, type of orthodontic tooth movement was disregarded.

Uslu *et al.*¹³¹¹ evaluated the prevalence of dental anomalies in different orthodontic malocclusions and found that 4.2% of patients (n = 363) had dental pulp stone, however this was not statistically different among the malocclusion groups. Based on this information, malocclusion type of the patients was ignored.

Review of the literature reveals a wide discrepancy in the prevalence of pulp stones in different populations. Furthermore, the presentations of prevalence were also different in the literature since some investigations presented the prevalence based on person and teeth numbers^{114,321} and the others reported only the prevalence based on teeth number^{25,261}. In the present study, the prevalence based on both person and teeth number were presented.

Gulsahi *et al.*¹⁴¹ assessed the prevalence of pulp stones in a group of Turkish patients using full-mouth periapical radiographs and reported pulp stones in 12% of the subjects and 5% of the teeth. In another study, Çolak *et al.*¹³³¹ investigated the prevalence of pulp stones in a Turkish dental patients, using bitewing radiography and pulp stones were identified in 518 (63.6%) of the subjects and in 2391 (27.8%) of the teeth examined. From pre- and post-treatment panoramic radiographs of 545 orthodontic patients in the present study, 257 pulp stones were detected in 3% of the teeth at T1 panoramic radiographs and 437 pulp stones were detected in 5.2% of the teeth at T2 panoramic radiographs. The present findings were lower than the results of the studies by Gulsahi *et al.*¹⁴¹ and Çolak *et al.*¹³³¹ However, such findings should be compared with caution because of the variations in sampling procedures and the types of radiograph examined.

al-Hadi Hamasha and Darwazeh²⁵¹ examined patient records of 814 Jordanian adults and reported pulp stones on radiographs in 51% of the patients and 22% of the teeth studied. Baghdady *et al.*¹²⁶¹ assessed 515 Iraqi teenage subjects and recorded that 19% of the teeth contained pulp stones. Tamse *et al.*¹²⁸¹ evaluated full-mouth radiograph of 300 patients and reported that 20.7% had pulp stones. These variations in prevalence between different populations may be due to ethnic variations and geographical differences.

In T1 and T2 incidences, there were no significant differences between girls and boys in agreement with previous studies of Ranjitkar *et al.*¹¹¹¹ and Gulsahi *et al.*¹¹⁴¹ Some studies did not find any difference in occurrence between genders^{110,11,251} whereas other studies have found

females to have more pulp stones than males.^{126,28,341} It should be investigated by further studies since the present study is the first incidence study with orthodontic patients.

Pulp stones are reported to increase in frequency with age.¹²⁸¹ However in another study, it was reported that age was not associated with pulp stones.¹²⁵¹ In the present study, the least increase of the incidence was 1.3% at the youngest age group (age of 12-14). Therefore, one reason for dental pulp stone formation, beside orthodontic treatment, may be the age increase as consistent with our findings.¹⁴¹

Maxillary molars exhibited pulp stone more frequently than mandibular molars. This finding is consistent with the studies of Tamse *et al.*¹²⁸¹ and Ranjitkar *et al.*¹¹¹¹ Most authors pointed that molars had a higher prevalence of pulp stones.^{18,11,141} Ranjitkar *et al.*¹¹¹¹ calculated the prevalence of pulp stones in young Australian adults using radiographs and reported that occurrences were rare in premolars (0.4%) but significantly higher in molars (19.7%) and more common in first molars than in second molars and in maxillary first molars than in mandibular first molars. They attributed these results to the fact that molars provide a better blood supply, which may cause calcification. Baratiert *et al.*¹³⁵¹ reported that orthopedic force induced by rapid maxillary expansion and applied to the anchorage molars seemed not to interfere significantly with the pulpal physiologic modification depending upon a high capacity for adaptation of the molar pulp tissue to an aggression, probably because of its greater blood supply, since it is a multi-rooted tooth. On the other hand, there was no formation of pulp stones in the first premolars during treatment in both arches. A difference in blood supplies because of their anatomic dissimilarity may be a possible explanation of different percentages of molar and premolar's pulp stone formation. Also, different percentages between maxillary and mandibular molar teeth may be attributed to larger root surfaces and hence better blood supply.

The limitations of this study were the absence of control group to compare the difference between orthodontically treated and untreated population. Although we observed an increase of pulp stone formation during orthodontic treatment in our study, further studies including control group are also required to determine the relationship between the pulp stone formation and orthodontic treatment.

The following conclusions were drawn from the present study:

1. From pre- and post-treatment panoramic radiographs, pulp stones were detected in 3% of the teeth at T1 panoramic radiographs and 5.2% of the teeth at T2 panoramic radiographs
2. No differences were found in the occurrence of dental pulp stone between genders
3. The least increase in prevalence of pulp stone was 1.3% at the age of 12-14 years

4. There were no statistically significant differences in the prevalence of dental pulp stone formation in the maxilla and mandible
5. Maxillary molars exhibited pulp stone more frequently than the mandibular molars
6. Orthodontic treatment may trigger the formation of dental pulp stones.

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Conflicts of interest

There are no conflicts of interest.

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