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Periodontal and Periapical Effects of Severity of Fremitus Due to Chronic Occlusal Trauma on Mandibular Incisors

Kronik Okluzal Travmaya Bağlı Fremitus Şiddetinin Mandibular Kesiciler Üzerindeki Periodontal ve Periapikal Etkileri

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Abstract

Objective: Excessive occlusal force is defined as the force that exceeds the repair capacity of periodontal attachment and causes occlusal trauma. Fremitus is an important clinical sign of the tooth exposed to occlusal trauma, defined as functional mobility that can be seen or palpated when subjected to occlusal forces. The aim of this study was to determine the effect of fremitus on the periapical and periodontal tissues of the mandibular incisors.

Materials and Methods: This study evaluated 1,004 mandibular incisors of 251 healthy individuals between the ages of 18–65. The presence or absence of fremitus was determined using the fremitus test by dividing individuals into 3 study groups (severe-fremitus, mild-fremitus, and absence-fremitus). Clinical and radiographic parameters such as gingival recession, tooth mobility, attrition, percussion, thermal hypersensitivity, crowded teeth, deep overbite, indication of root canal treatment, disruption in the lamina dura, periodontal ligament anomalies, and triangulation were recorded. Relationships between these parameters and fremitus groups were compared.

Results: Age and gender distribution, the need for root canal treatment, teeth with percussion, thermal hypersensitivity, mobility, deep overbite, crowded teeth, number of teeth whose periodontal ligament space could not be seen normally, and lamina-dura disruption were significantly higher in the severe-fremitus group compared to the non-fremitus ($p<0.05$) and mild-fremitus ($p<0.05$) groups. All three groups were significantly different in terms of triangulation, attrition, the presence of gingival recession, and the amount of gingival recession in mm ($p<0.05$).

Conclusion: Periodontal, pulpal, and periapical tissues are negatively affected by severe fremitus. Excessive occlusal forces on the mandibular incisors increased the incidence of clinical and radiographic anomalies and pathological findings.

Keywords: Fremitus, occlusal trauma, diagnosis, mandibular incisor

Öz

Amaç: Aşırı oklüzal kuvvetler, periodontal ataçmanın tamir kapasitesini aşan ve oklüzal travmaya neden olan kuvvetlerdir. Fremitus, okluzal travmaya maruz kalan dişin gözle görülebilen veya palpe edilebilen fonksiyonel hareketliliği olarak tanımlanan önemli bir klinik belirtisidir. Bu çalışmanın amacı mandibular kesici dişlerin periapikal ve periodontal dokularına fremitusun etkisini belirlemekti.

Gereç ve Yöntemler: Bu çalışmada 18-65 yaş arasındaki 251 sağlıklı bireyin 1.004 mandibular kesici dişi değerlendirildi. Fremitus testi ile fremitusun varlığı veya yokluğu üç grubuna ayrılarak belirlendi (şiddetli fremitus, hafif fremitus ve fremitus yok). Dişeti çekilmesi, diş mobilitesi, atrizyon, perküsyon, termal aşırı hassasiyet, çapraşıklık, şiddetli derin kapanış, kök kanal tedavisi ihtiyacı, lamina durada bozulma, periodontal ligament anomalileri ve triangulasyon gibi kaydedilen klinik ve radyografik parametreler ile fremitus grupları arasındaki ilişki kıyaslandı.

Bulgular: Yaş ve cinsiyet dağılımı, kanal tedavisi ihtiyacı, perküsyon, termal aşırı hassasiyet, diş mobilitesi, şiddetli derin kapanış, çapraşıklık, periodontal ligament aralığı normal görülemeyen ve lamina dura bozulması olan dişlerin sayısı şiddetli fremitus grubunda

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fremitus olmayan (p<0,05) ve hafif fremitusu (p<0,05) olan gruplara göre anlamlı olarak daha yüksekti. Üç grup da triangülasyon, atrizyon, dişeti çekilmesi varlığı ve dişeti çekilmesinin miktarı (mm) açısından anlamlı düzeyde farklıydı (p<0,05).

Sonuç: Periodontal, pulpa ve periapikal dokular şiddetli fremitustan olumsuz etkilendi. Mandibular kesici dişler üzerindeki aşırı oklüzal kuvvetler klinik ve radyografik anomalilerin ve patolojik bulguların insidansını artırdı.

Anahtar Kelimeler: Fremitus, oklüzal travma, tanı, mandibuler kesici

Introduction

Excessive occlusal force is defined as the force that exceeds the repairing capacity of periodontal attachment and causes occlusal trauma (1). The injury that causes tissue changes in the attachment supporting the periodontal ligament, alveolar bone and cementum is referred to as occlusal trauma. Some clinical and radiographic indicators used for the diagnosis of occlusal trauma are: Progressive tooth mobility, fremitus, occlusal disharmonies, gingival recession, wear facets, tooth migration, tooth fracture, thermal hypersensitivity, root resorption, and widening of periodontal ligament space (2). It is important to identify these findings with differential diagnoses. For example, pulp vitality tests, tooth brushing habit, severity of periodontal disease and other parafunctional habits should be evaluated.

Fremitus is an important clinical sign of the tooth exposed to occlusal trauma, defined as functional mobility that can be seen or palpated when subjected to occlusal forces (3). As a result of continuous occlusal trauma that exceeds the adaptive capacity of the periodontium, such as the presence of fremitus in a tooth, the density of the alveolar bone decreases while the width of the periodontal ligament space increases. This expansion occurs either in the form of triangulation at the top of the alveolar crest or along the entire width of the periodontal ligament space, in that connection dental mobility also increases (4).

Due to the limitations of the clinical diagnosis and ethical concerns of occlusal trauma, many clinical studies have focused on teeth with occlusal dysharmonies, as in our study. The relationship between the cusps is an important factor in the transmission of occlusal forces to the periodontium (5). In patients with periodontitis who had obvious occlusal trauma symptoms, including fremitus and widening of the periodontal ligament space, it showed greater probing depth, clinical attachment loss and bone loss, (2) and worsening prognosis over time (6). Extreme functional stress can initiate inflammatory changes in the periodontium, thereby increasing destructive bacterial processes (7). Occlusal therapy slows down the progression of periodontitis and can improve prognosis.

There is a consensus that trauma from occlusion may be a co-destructive factor to periodontal destruction, particularly the destruction of the supportive alveolar bone (8). However, its role in influencing marginal gingival tissues is controversial. Gingival recession increases with age (9) and the mandibular anterior region is a frequently affected area. This problem often promotes root caries, poor aesthetics and increases dentin hypersensitivity (10). Tissue trauma caused by strong toothbrushing, dental malpositions, high muscle attachment, frenum pull, restorative-periodontal treatment procedures, incisor teeth inclination, orthodontic treatments, calculus and iatrogenic factors have been associated with recession of the gingiva (11). Stillman (1) was the first to describe the narrow triangular shaped gingival recession on the facial surface of the tooth. It has been suggested that excessive occlusal forces have been a causal factor in the development of abraction and gingival recession for a long time (1,12,13).

The anatomical and functional presence of the teeth on the arch is important for normal occlusion and healthy dentition. Occlusal trauma leads to changes in the pulp and dentin tissues. The reaction of the pulp to traumatic forces is generally in the form of classical inflammatory responses, similar to the reaction of other connective tissues in the body such as inflammation and fibrous calcification (14). Depending on the intensity and duration of the applied forces and the immune response capacity of each individual, pathological modifications may occur in the pulp tissue or the tissue may be forced to protect itself (14). Nunn and Harrel (6) reported that dentin exposure, dentin hyperhypersensitivity, pulp hyperemia, or pulp necrosis may occur due to abrasions caused by occlusal interferences and paraffunctions. Abnormal occlusal forces accumulate in the apical region of the teeth and cause interruption in circulation of the pulp that leads to pulp necrosis and periapical lesions called sink-like (14-16).

In the present study, it was thought that the mandibular incisors with the lowest root surface areas could be negatively affected under increasing occlusal loads. Therefore, our aim in this clinical study was to investigate the effect of fremitus due to chronic occlusal trauma in the periapical and periodontal tissues of the mandibular incisors.

Materials and Methods

This study was carried out in accordance with the 2002 Helsinki Declaration and "Good Clinical Practices Guide". The purpose of the study and clinical applications were explained to all volunteers. Informed consent forms were signed. The study protocol was approved by the Clinical Research Ethics Committee of Zekai Tahir Burak Women's Health Education and Research Hospital (decision no: 95/2019, date: 25.06.2019). The individuals who participated in the study were selected from among individuals who applied to the Periodontology Clinic of Ankara Yıldırım Beyazıt University Faculty of Dentistry, Tepebasi Oral and Dental Health Hospital between June 2019 and February 2020, taking into account the participation criteria detailed below.

Study Population And Design

This cross-sectional study included 251 healthy individuals of both genders (n=126 male, n=125 female), between the ages of 18-65, who had at least 24 teeth. Individuals with periodontitis, treated periodontitis and teeth with reduced attachment level, generalized gingivitis, missing/decayed/restored tooth in the eight incisor teeth, periodontal and orthodontic treatment or occlusal adjustment history and smokers were not included in the study. The individuals included in the study were patients with a dental relationship of class I and II. Class III was not included in the study. Patients with systemic disease affecting periodontal tissues (diabetes, rheumatoid arthritis, cardiovascular), patients using drugs (antibiotics, anti-inflammatory, calcium channel blockers, etc.) that have an effect on the gingiva in the last six months, patients with active infectious diseases (AIDS, HBV, tuberculosis) and pregnant women were also excluded from the study. In this study, all individuals had good oral hygiene, regular brushing habits and were defined as healthy according to the new periodontal disease classification published in 2018 (17).

Clinical Measurements

Examination of the mandibular incisors of each individual was performed. Clinical and radiographic parameters were measured and recorded. To prevent inter-observer deviation, recordings were made by a single, well-calibrated periodontologist (M.A.T.) (≥85% agreement between recurrent clinical evaluations on non-study patients).

Gingival recession (the distance between the cemento-enamel junction and gingival margin) was measured in mm from the midbuccal region of the teeth using a Williams periodontal probe (LM Dental AB, Nynäshamn, Sweden). Dental mobility was recorded for each tooth using Miller's mobility classification (18). Attrition (wear at the enamel or dentin level on the incisal surface of the tooth) and percussion were recorded as present/absent. Dentin hypersensitivity assessment was determined as present/absent by squeezing cold air spray on the tooth and rubbing the polishing tire. The cold and hot hypersensitivity tests were applied until the patient reacted and for a maximum of 5 seconds. If the pain disappeared immediately after the stimulus was removed, the tested tooth was considered hypersensitive and vital. If the pain persisted after the stimulus disappeared, percussion test, electric pulp test and radiography were evaluated together, and non-vital teeth were referred for root canal treatment.

Presence or absence of fremitus by fremitus test (functional mobility): the index finger was placed on the facial surfaces of the mandibular incisors and the mobility during repeated centric and eccentric occlusion was monitored visually. According to this: there was 0: non-fremitus in the teeth without mobility, 1: mild-fremitus, which is felt slightly with the finger but not visible with the eye, 2: severe-fremitus, that can be felt and visible with the eye. The diagnosis of occlusal trauma was also supported by articulation paper testing. The markings assigning non-functional occlusion were accepted as occlusal trauma. Representative radiograph and photographs are given in Figure 1.

Periapical films of patients taken with parallel technique were evaluated for radiographic examination. The lamina dura degradation (can be observed interrupted, discontinuous or invisible) was recorded as present/absent. A complete and continuous radiopaque line surrounding the tooth socket and separating the periodontal ligament space from the alveolar bone was evaluated as normal lamina dura imaging. Periodontal ligament anomalies (widening or the disappearance of the periodontal ligament space) were recorded. The physiological periodontal ligament space (approximately 0.2 mm) was defined and expressed as normal. Triangulation, crowded teeth, percussion sensitivity and deep overbite parameters were recorded as present/absent. Vertical defects occur adjacent to a tooth and usually in the form of a triangular area of missing interproximal alveolar bone is defined as triangulation (the base is coronally and the top is apically). The range of 3-4 according to Geiger's classification (19) was determined as deep overbite. The point of contact was from the apical crest of the cingulum, including the palatal mucosa.

Root canal treatment was indicated and performed by an experienced endodontist (E.S.) in non-vital teeth, which responded negatively to electric pulp testing (Gentle Pulse; Parkell Inc., New York, USA), and pathology was detected in the periapical region radiographically. The electric pulp test was measured by placing the electrode of the device perpendicular to the 1/3 incisal of the tooth after the each tooth was isolated and dried.

Statistical Analysis

Data analysis was carried out using the SPSS program (ver 26.0; SPSS Inc., Chicago, IL, USA). Significance was

Figure 1. Number of teeth 31 and 41 have severe fremitus, 42 has mild fremitus, 32 has non-fremitus

defined as $p<0.05$. Distribution of variables was measured by Kolmogorov-Simirnov test. Analysis of quantitative independent data was carried out with independent sample t-test, Kruskal-Wallis and Mann-Whitney U test. In the analysis of dependent quantitative data, paired sample t-test was used. Qualitative independent data were analyzed by chi-square test. GPower 3.1 program was used in this study for the calculation of the statistical power at 95% confidence interval (CI) (α=0.05) and 90% CI (1-β= 90). The results of this analysis suggested that a total of 984 teeth should be adequate for this study.

Results

Comparing the Non-, Mild- and Severe-fremitus Groups

Table 1 and Figure 2 show the relationship between clinical, radiographic and demographic data between teeth with fremitus (non-fremitus, mild-fremitus and severe-fremitus). The severe-fremitus group was significantly different from the mild-fremitus and non-fremitus groups in terms of age and gender distribution ($p<0.05$). Severe-fremitus group was significantly different from the other groups ($p<0.05$) for the need for root canal treatment; however no significant difference was found between the non-fremitus and the mild-fremitus groups ($p<0.05$). The teeth with percussion, hypersensitivity, mobility, deep overbite and crowded teeth were statistically significantly higher in severe-fremitus group compared to the other groups ($p<0.05$). The number of the teeth whose periodontal ligament space and lamina-dura disruption could not be seen normally were also statistically significantly higher in severe-fremitus group compared to other groups ($p<0.05$). No significant difference was observed between the non-fremitus and mild-fremitus groups in terms of these parameters ($p>0.05$). The number of the teeth with gingival recession, attrition and triangulation was the highest in the severe-fremitus group and the lowest in the non-fremitus group ($p<0.05$). All three groups were significantly different in terms of triangulation, attrition, the presence of gingival recession and the amount of gingival recession in mm ($p<0.05$).

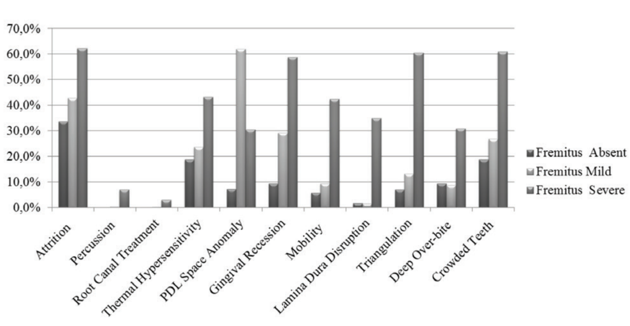

Figure 2. The relationship between clinical, radiographic and demographic data between teeth with fremitus (non-fremitus, mild-fremitus and severe-fremitus)

Comparing with and Without Anomalies Groups

Age, gender distribution, and attrition rates of patients did not differ significantly between percussion and non-percussion groups ($p>0.05$). In the percussion group, the rates of root canal treatment, tooth hypersensitivity, gingival recession, tooth mobility, periodontal ligament anomaly, lamina dura disruption, triangulation, deep overbite and crowded teeth were significantly higher than the non-percussion group ($p<0.05$) (Table 2). Age, gender distribution, attrition and tooth hypersensitivity rate of the patients were not statistically significant between the groups with and without root canal treatment indications ($p>0.05$). In the group with root canal treatment indication, gingival recession, tooth mobility, periodontal ligament anomaly, lamina dura disruption, triangulation, deep overbite and crowded teeth rate were significantly higher than in the group without root canal treatment indication ($p<0.05$) (Table 3). The gender distribution and gingival recession millimeter of individuals were not statistically significant between the groups with and without attrition ($p>0.05$). In the attrition group, patient age, hypersensitivity, gingival recession, tooth mobility, periodontal ligament anomaly, lamina dura disruption, triangulation, deep overbite and crowded teeth rate were significantly higher than the group without attrition ($p<0.05$) (Table 4). In the group with gingival recession; patient age, female patient ratio, hypersensitivity, mobility, periodontal ligament anomaly, lamina dura disruption, triangulation, deep overbite and crowded teeth rate were significantly higher than the group without gingival recession ($p<0.05$) (Table 5). In the group with and without dental mobility, the gender distribution of patients did not differ significantly ($p>0.05$). Age, hypersensitivity, periodontal ligament anomaly, lamina dura disruption, triangulation, deepbite and crowded teeth rates were significantly higher in the mobility group than the non-mobility group ($p<0.05$) (Table 5).

The parameters in the group with periodontal ligament anomaly compared to the non-anomaly group were as follows: the age of the patients (40.4±10.9-33.6±9.9), non-normal lamina dura disruption (33.1-1.3%), triangulation (58.5-11.2%), deep overbite (30.2-8.6%) and crowded teeth (56.9-25.5%). These parameters were significantly higher than in the non-anomaly group ($p<0.05$).

Discussion

In this study, clinical and radiographic data of individuals in mandibular incisors were examined and the effects of fremitus on teeth and related tissues were investigated. Accordingly, all evaluated clinical and radiographic parameters were found to be significantly higher in teeth with severe-fremitus.

Dental mobility has been described as one of the common clinical signs of occlusal trauma (1,20). However, increased mobility may be due to inflammation and/or bone loss or connective tissue loss (21). Mobile teeth with widening of periodontal ligament space has increased probing pocket

Table 1. The relationship between clinical, radiographic, demographic data and fremitus (non-fremitus, mild fremitus and severe fremitus)

Fremitus				Absent (n=169, 16.8%)		Mild (n=609, 60.7%)		Severe (n=226, 22.5%)		p-value
Age	Median (min-max)			33 (18-63)^{A}		34 (18-63)^{A}		38 (18-65)^{B}		0.000^{K}
Gingival recession (mm)	Median (min-max)			1 mm (1-3)^{A}		1 mm (1-4)^{B}		2 mm (2-6)^{C}		0.000^{K}
		n	%	n	%	n	%	n	%	p
Gender	Female	500	49.8	72	42.6	295	48.4	133	58.8	0.003$^{\chi^2}$
	Male	504	50.2	97	57.4^{A}	314	51.6^{A}	93	41.2^{B}	
Attrition	(-)	544	54.2	112	66.3	347	57.0	85	37.6	0.000$^{\chi^2}$
	(+)	460	45.8	57	33.7^{A}	262	43.0^{B}	141	62.4^{C}	
Percussion	(-)	985	98.1	169	100	606	99.5	210	92.9	0.00$^{\chi^2}$
	(+)	19	1.9	0	0.0^{A}	3	0.5^{A}	16	7.1^{B}	
Root canal treatment	(-)	995	99.1	169	100	607	99.7	219	96.9	0.000$^{\chi^2}$
	(+)	9	0.9	0	0.0^{A}	2	0.3^{A}	7	3.1^{B}	
Hypersensitivity (cold-hot)	(-)	729	72.6	137	81.1	464	76.2	128	56.6	0.000$^{\chi^2}$
	(+)	275	27.4	32	18.9^{A}	145	23.8^{A}	98	43.4^{B}	
Gingival recession	(-)	676	67.3	153	90.5	430	70.6	93	41.2	0.000$^{\chi^2}$
	(+)	328	32.7	16	9.5^{A}	179	29.4^{B}	133	58.8^{C}	
Mobility	(-)	840	83.7	159	94.1	551	90.5	130	57.5	0.000$^{\chi^2}$
	(+)	164	16.3	10	5.9^{A}	58	9.5^{A}	96	42.5^{B}	
Mobility	I	147	14.6	10	5.9	57	9.4	80	35.4	
	II	13	1.3	0	0.0	1	0.2	12	5.3	
	III	4	0.4	0	0.0	0	0.0	4	1.8	
Periodontal ligament Space	Normal	756	75.3	151	89.3^{A}	509	83.6^{A}	96	55.8^{B}	0.000$^{\chi^2}$
	Narrow-disappear	123	12.3	15	8.9	76	12.5	34	19.8	
	Wide	121	12.1	3	1.8	78	12.8	42	24.4	
Lamina dura	Normal	912	90.8	166	98.2	599	98.4	147	65.0	0.000$^{\chi^2}$
	Disruption	92	9.2	3	1.8^{A}	10	1.6^{A}	79	35.0^{B}	
Triangulation	(-)	774	77.1	157	92.9	528	86.7	89	39.4	0.000$^{\chi^2}$
	(+)	230	22.9	12	7.1^{A}	81	13.3^{B}	137	60.6^{C}	
Deep overbite	(-)	864	86.1	153	90.5	555	91.1	156	69.0	0.000$^{\chi^2}$
	(+)	140	13.9	16	9.5^{A}	54	8.9^{A}	70	31.0^{B}	
Crowded teeth	(-)	669	66.6	137	81.1	445	73.1	88	38.9	0.000$^{\chi^2}$
	(+)	334	33.3	32	18.9^{A}	164	26.9^{A}	138	61.1^{B}	

^{K}Kruskal-Wallis (Mann-Whitney U test), $^{\chi^2}$Chi-square test. ^{A,B,C}Different uppercase means significant difference within same line, min-max: Minimum-maximum

Table 2. The relationship between clinical, radiographic, demographic data and groups with and without percussion

		Percussion (-)		Percussion (+)		p-value
Age	Median (min-max)	34	(18-65)	36	(18-52)	0.596^m
Gingival recession (mm)	Median (min-max)	2 mm	(1-5)	3 mm	(1-6)	0.000^m
		n	%	n	%	p
Gender	Female	490	49.7	10	52.6	0.803$^{\chi^2}$
	Male	495	50.3	9	47.4	
Attrition	(-)	537	54.5	7	36.8	0.126$^{\chi^2}$
	(+)	448	45.5	12	63.2	
Root canal treatment	(-)	985	100.0	10	52.6	0.000$^{\chi^2}$
	(+)	0	0.0	9	47.4	
Hypersensitivity (cold-hot)	(-)	724	73.5	5	26.3	0.000$^{\chi^2}$
	(+)	261	26.5	14	73.7	
Gingival recession	(-)	672	68.2	4	21.1	0.000$^{\chi^2}$
	(+)	313	31.8	15	78.9	
Mobility	(-)	836	84.9	4	21.1	0.000$^{\chi^2}$
	(+)	149	15.1	15	78.9	
Mobility	I	137	13.9	10	52.6	
	II	11	1.1	2	10.5	
	III	1	0.1	3	15.8	
Periodontal ligament space	Normal	753	76.4	3	15.8	0.000$^{\chi^2}$
	Narrow-disappear	127	12.9	0	0.0	
	Wide	105	10.7	16	84.2	
Lamina dura	Normal	907	92.1	5	26.3	0.000$^{\chi^2}$
	Disruption	78	7.9	14	73.7	
Triangulation	(-)	771	78.3	3	15.8	0.000$^{\chi^2}$
	(+)	214	21.7	16	84.2	
Deep overbite	(-)	857	87.0	7	36.8	0.000$^{\chi^2}$
	(+)	128	13.0	12	63.2	
Crowded teeth	(-)	665	67.5	5	26.3	0.000$^{\chi^2}$
	(+)	320	32.5	14	73.7	

^{m}Mann-Whitney U test, $^{\chi^2}$Chi-square test, min-max: Minimum-maximum

depth, clinical attachment loss and bone loss compared to teeth without mobility (2). There are also studies that could not find a relationship between mobility and occlusal forces (22). In our study, mobility was detected in teeth with severe-fremitus at 35.4% first degree, 5.3% 2nd degree, and 1.8% 3rd degree according to the classification of Miller (18). In the teeth with mild-fremitus and non-fremitus, only 1st degree mobility was determined as 5.9% and 9.4%, respectively. Thus, dental mobility was found to be significantly increased in teeth with traumatic occlusal forces. The researchers also found a strong correlation between the quantitative values of the periotest and Miller's original mobility index (23).

Many types of occlusion including premature contacts or parafunctional habits in centric relation or centric occlusion are significantly associated with deeper probing pocket

Table 3. The relationship between clinical radiographic demographic data and groups with and without root canal treatment

		Root canal treatment (-)		Root canal treatment (+)		p-value
Age	Median (min-max)	35	(18-65)	38	(18-52)	0.590^{m}
Gingival recession (mm)	Median (min-max)	2 mm	(1-5)	4 mm	(1-6)	0.008^{m}
		n	%	n	%	p-value
Gender	Female	496	49.8	4	44.4	0.747$^{\chi^2}$
	Male	499	50.2	5	55.6	
Attrition	(-)	542	54.5	2	22.2	0.053$^{\chi^2}$
	(+)	453	45.5	7	77.8	
Hypersensitivity (cold-hot)	(-)	725	72.9	4	44.4	0.057$^{\chi^2}$
	(+)	270	27.1	5	55.6	
Gingival recession	(-)	673	67.6	3	33.3	0.029$^{\chi^2}$
	(+)	322	32.4	6	66.7	
Mobility	(-)	839	84.3	1	11.1	0.000$^{\chi^2}$
	(+)	156	15.7	8	88.9	
Mobility	I	143	14.4	4	44.4	
	II	12	1.2	1	11.1	
	III	1	0.1	3	33.3	
Periodontal ligament space	Normal	755	75.9	1	11.1	0.000$^{\chi^2}$
	Narrow-disappear	127	12.8	0	0.0	
	Wide	113	11.4	8	88.9	
Lamina dura	Normal	910	91.5	2	22.2	0.000$^{\chi^2}$
	Disruption	85	8.5	7	77.8	
Triangulation	(-)	772	77.6	2	22.2	0.000$^{\chi^2}$
	(+)	223	22.4	7	77.8	
Deep overbite	(-)	861	86.5	3	33.3	0.000$^{\chi^2}$
	(+)	134	13.5	6	66.7	
Crowded teeth	(-)	667	67.0	3	33.3	0.033$^{\chi^2}$
	(+)	328	33.0	6	66.7	

^{m}Mann-Whitney U test, $^{\chi^2}$Chi-square test

depth, clinical attachment loss, increased mobility and poor prognosis in individuals with periodontitis, and their elimination can improve clinical periodontal conditions (24,25). According to the results of our study, the width of the periodontal ligament space increased significantly depending on the severity of fremitus. Similarly, deterioration in the radiographic image of the lamina dura and triangulation findings were significantly increased in individuals in the severe-fremitus group. According to the results of this study, the rate of triangulation detected radiographically in individuals with severe-fremitus was 60%, which was significantly higher than the other groups. These findings are supported by previous studies as findings of traumatic occlusal forces (4,20). In this study, only mandibular incisors under fremitus were evaluated. The root surface area was the smallest in these teeth group, and it was thought that these teeth could be more affected under occlusal forces rather than maxillary incisors. Furthermore,

Table 4. Relationship between clinical, radiographic, demographic data and groups with and without attrition

		Attrition (-)		Attrition (+)		p-value
Age	Median (min-max)	30	(18-59)	41	(18-65)	0.000[m]
Gingival recession (mm)	Median (min-max)	2 mm	(1-5)	2 mm	(1-6)	0.990[m]
		n	%	n	%	p-value
Gender	Female	261	48.0	239	52.0	0.209^{χ^2}
	Male	283	52.0	221	48.0	
Hypersensitivity (cold-hot)	(-)	431	79.2	298	64.8	0.000^{χ^2}
	(+)	113	20.8	162	35.2	
Gingival recession	(-)	451	82.9	225	48.9	0.000^{χ^2}
	(+)	93	17.1	235	51.1	
Mobility	(-)	491	90.3	349	75.9	0.000^{χ^2}
	(+)	53	9.7	111	24.1	
Mobility	I	53	9.7	94	20.4	
	II	0	0.0	13	2.8	
	III	0	0.0	4	0.9	
Periodontal ligament space	Normal	470	86.4	286	62.2	0.000^{χ^2}
	Narrow-disappear	44	8.1	83	18.0	
	Wide	30	5.5	91	19.8	
Lamina dura	Normal	513	94.3	399	86.7	0.000^{χ^2}
	Disruption	31	5.7	61	13.3	
Triangulation	(-)	457	84.0	317	68.9	0.000^{χ^2}
	(+)	87	16.0	143	31.1	
Deep overbite	(-)	502	92.3	362	78.7	0.000^{χ^2}
	(+)	42	7.7	98	21.3	
Crowded teeth	(-)	423	77.8	247	53.7	0.000^{χ^2}
	(+)	121	22.2	213	46.3	

[m]Mann-Whitney U test, $^{\chi^2}$Chi-square test, min-max: Minimum-maximum

the four incisors of a patient could have different results on examination, therefore, the teeth were evaluated regardless of the patients.

Nine of 251 patients that had symptoms of fremitus received root canal treatment indication for any mandibular incisors. None of these teeth had caries or restorations that would require root canal treatment. However, individuals who needed root canal treatment also had a significantly increased level of crowded teeth and deep overbite. The absence of a classification that reveals the severity of crowded teeth can be expressed as the limitation of this study. All of the teeth received root canal treatment after being diagnosed as non-vital. 88.9% of the teeth were accompanied by a periapical lesion and all had percussion sensitivity. In addition, 77.8% of the lamina dura was disrupted and 77.8% had severe-fremitus. Root canal treatment was indicated in 9 (47.4%) of 19 teeth with percussion sensitivity. In a finite element analysis study, it has been reported that hyperfunctional occlusal forces accumulate in the alveolar bone and mostly in the periapical region (26). Therefore, teeth exposed to abnormal occlusal stresses due to deep-bite and crowding may experience pulp necrosis by interrupting pulpal circulation in the apical foramen (14,15). These findings increased with age.

Excessive occlusal loads are supported by finite element analysis studies (12,27) which can demonstrate cervical stress and induce the formation of non-carious cervical lesions (such as abfraction) (28). However, these studies

Table 5. The relationship between clinical, radiographic, demographic data and groups with and without gingival recession and mobility

		Gingival recession (-)		Gingival recession (+)		p-value
Age	**Median (min-max)**	**32**	**(18-63)**	**42**	**(18-65)**	**0.000m**
		n	%	n	%	p-value
Gender	Female	306	45.3	194	59.1	0.000^{χ^2}
	Male	370	54.7	134	40.9	
Hypersensitivity (cold-hot)	(-)	567	83.9	162	49.4	0.000^{χ^2}
	(+)	109	16.1	166	50.6	
Mobility	(-)	628	92.9	212	64.6	0.000^{χ^2}
	(+)	48	7.1	116	35.4	
Mobility	I	46	6.8	101	30.8	
	II	0	0.0	13	4.0	
	III	2	0.3	2	0.6	
Periodontal ligament space	Normal	584	86.4	172	52.4	0.000^{χ^2}
	Narrow-Disappear	63	9.3	64	19.5	
	Wide	29	4.3	92	28.0	
Lamina dura	Normal	650	96.2	262	79.9	0.000^{χ^2}
	Disruption	26	3.8	66	20.1	
Triangulation	(-)	610	90.2	164	50.0	0.000^{χ^2}
	(+)	66	9.8	164	50.0	
Deep overbite	(-)	623	92.2	241	73.5	0.000^{χ^2}
	(+)	53	7.8	87	26.5	
Crowded teeth	(-)	536	79.3	134	40.9	0.000^{χ^2}
	(+)	140	20.7	194	59.1	
		Mobility (-)		**Mobility (+)**		**p-value**
Age	Median (min-max)		33.5 (18-63)		39 (18-65)	0.000m
		n	**%**	**n**	**%**	**p-value**
Gender	Female	412	49.0	88	53.7	0.280^{χ^2}
	Male	428	51.0	76	46.3	
Hypersensitivity (cold-hot)	(-)	646	76.9	83	50.6	0.000^{χ^2}
	(+)	194	23.1	81	49.4	
Periodontal ligament space	Normal	702	83.6	54	32.9	0.000^{χ^2}
	Narrow-disappear	119	14.2	8	4.9	
	Wide	18	2.1	103	62.8	
Lamina dura	Normal	825	98.2	87	53.0	0.000^{χ^2}
	Disruption	15	1.8	77	47.0	
Triangulation	(-)	733	87.3	41	25.0	0.000^{χ^2}
	(+)	107	12.7	123	75.0	
Deep overbite	(-)	752	89.5	112	68.3	0.000^{χ^2}
	(+)	88	10.5	52	31.7	
Crowded teeth	(-)	596	71.0	74	45.1	0.000^{χ^2}
	(+)	244	29.0	90	54.9	

mMann-Whitney U test, χ^2Chi-square test, min-max: Minimum-maximum did not reflect a clinical situation. The relationships between bruxism and the presence of occlusal wear facets has been shown, however, the causal relationship has not been confirmed (29). Although there are studies that did not find a correlation between non-carious cervical lesions and the degree of occlusal abrasions (30), there are also studies that found an increase in the frequency of non-carious cervical lesions related to the presence of occlusal wear facets (attrition) (31) and bruxism (32). In this study, fremitus-induced occlusal forces were significantly associated with attrition and facial marginal gingival recession.

It has been suggested that excessive occlusal forces may be an etiological factor in gingival recession, facial clefts such as "Stillman's cleft" and gingival loss (1). Supportingly, in our study, gingival recession was observed in 58.8% of teeth with severe-fremitus and severity of gingival recession was significantly associated with fremitus-induced occlusal trauma. In a study that examined patients with gingival recession, there was no significant relationship between fremitus test and gingival recession (33). In another study, labial gingival recession of mandibular incisors was found to be associated with linguoversion (34) Stillman (1), Box (35) and Miller (18) argued that gingival recession can be caused by heavy occlusal contacts. Harrel and Nunn (36) reported that more than 70% of teeth with dysfunction are associated with gingival recession. However, Gorman (37) could not associate the presence of gingival recession with occlusal trauma. The available data provide contradictory results regarding the effects of occlusal forces on gingival recession (36-38) Jin and Cao (2) also reported more clinical attachment loss and less bone support in teeth with obvious fremitus. Teeth with significant occlusal wear facets also had less clinical attachment levels. In this current study, the age of patients in the group with gingival recession also increased significantly compared to the group without gingival recession, as stated in previous studies (9).

Most researchers have concluded that the prevalence of dentin hypersensitivity ranges from 3% to 57% (39). In one review, dentin hypersensitivity was reported to affect a quarter of the adult population (40). In our study, individuals with hypersensitivity were 27.4%. In an other study, the prevalence of dentin hypersensitivity was about 25-30%, regardless of age (41). Dentin hypersensitivity is mostly associated with dentin on the buccal surface of permanent teeth (42). Addy and Pearce (43) attributed this to powerful tooth brushing, and this etiology was confirmed by another review (44). The cervical dentin tubules exposed by erosion or gingival recession are thought to cause pain by inducing thermal or tactile stimuli (45). The combination of erosion and abrasion are ideal etiological risk factors for dentin hypersensitivity (46). In our study, only teeth with severe-fremitus had significantly higher hypersensitivity (43.4%) than teeth with mild-femitus and non-fremitus. At the same time, significantly increased attrition, gingival recession and mobility were detected in teeth with thermal hypersensitivity. However, as a limitation of our study, we did not detect gingival recession and thermal hypersensitivity because of powerful brushing.

Researchers reported that excessive occlusal forces cause periodontitis (1) and should be controlled to treat periodontitis successfully (20). According to the results of animal studies (47) occlusal trauma does not cause irreversible bone loss or connective tissue loss without plaque-induced inflammation, and an increase in mobility and a decrease in bone density are reversible. In addition, the researchers created experimental periodontitis using rat models and combined inflammation with occlusal trauma. These studies have demonstrated that connective tissue loss and bone loss due to periodontitis were increased (48). Consequently, occlusal trauma is considered as a cofactor that accelerates periodontitis and loss of attachment has not been associated with trauma on a healthy tooth. However, in terms of the short-term use of extreme forces in animal studies, it could not mimic human tissues in all aspects.

In this current study, individuals diagnosed with periodontitis were excluded from the study. It may be considered as a limitation of our study to exclude periodontal disease and related clinical and radiographic symptoms and not to investigate the combined effects of occlusal trauma with periodontal disease. The whole analysis in this study does not take into account how long has this overload already existed and this can be considered as the limitation of the study as well. In addition, this study only examined the clinical and radiographic findings of mandibular incisors. Further studies are needed to examine the maxillary incisors and posterior teeth, to develop treatment methods against traumatic occlusal forces and to determine the effectiveness of these methods.

Conclusion

Periodontal, pulpal and periapical tissues are negatively affected by severe-fremitus. Excessive occlusal forces on the mandibular incisors increased the incidence of clinical and radiographic anomalies and pathological findings, thus worsening the prognosis of the teeth. Fremitus was also found to be associated with deep overbite and crowded teeth. It is necessary to diagnose and correct problems caused by damaging occlusion in order to maintain oral and dental health.

Ethics

Ethics Committee Approval: The study protocol was approved by the Clinical Research Ethics Committee of Zekai Tahir Burak Women's Health Education and Research Hospital (decision no: 95/2019, date: 25.06.2019).

Informed Consent: Informed consent forms were signed.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.A.T., E.S., Concept: M.A.T., E.S., Design: M.A.T., E.S., Data Collection or Processing: M.A.T., E.S., Analysis or Interpretation: M.A.T., E.S., Literature Search: M.A.T., Writing: M.A.T.

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