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The Impact of Orthodontic Forces on the Occurrence of Iatrogenic Tooth Root Resorption

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Abstract

Modern orthodontic treatment ensures optimal functional and aesthetic results but does not exclude the risk of various complications, including external or internal resorption of tooth roots. One of the causes of root resorption is the impact of orthodontic forces during treatment with both non-removable (brace-system) and removable (aligners) appliances. The aforementioned complication of the treatment of occlusal anomalies, which occurs with a fairly high frequency, potentially threatens not only the patient's health but also complicates the treatment outcomes and worsens the prognosis. The lack of pathognomonic symptoms of root resorption increases the difficulty of an accurate diagnosis. According to the literature, the issue of root resorption is very relevant in clinical dentistry but has not been studied in detail, and contradictory opinions can be found.

Keywords: Orthodontic forces, tooth root resorption, non-removable appliances (brace-system), removable devices (aligners)

Introduction

Root resorption (RR) in deciduous teeth is a normal physiologic response, resulting in exfoliation of the deciduous teeth with replacement by permanent dentition. However, the process of root resorption in permanent dentition has a pathologic basis. However, in permanent dentition, root resorption has a pathologic basis, and the etiology requires two phases: an injury and a stimulus. Types of root resorption in permanent teeth may be broadly categorized into internal and external resorption. The RR process may be self-limiting and go undetected clinically; however, once initiated and with the initial injury and stimulus sustained, destruction of hard dental tissue will continue, and tooth tissue loss may occur. External RR has various causes and is more prevalent than internal RR, which is relatively rare. Several classifications have been proposed, with distinctive terms and categories used to describe tooth root resorption (Henrique et al., 2018). Modern orthodontic treatment ensures optimal functional and aesthetic results but does not exclude the risk of various complications, including external or internal resorption of tooth roots (Yuan et al.,(2020), Jianru et at., 2018, Joãoet al., (2018), Caroline et al., (2015), Ahu et al., (2012)). Caroline The aforementioned complication of the treatment of occlusal anomalies, which occurs with a fairly high frequency, potentially threatens not only the patient's health but also complicates the treatment outcomes and worsens the prognosis (Caroline et al., (2015). The trauma received before orthodontic treatment, bone density and morphotype, the shape of tooth roots, patient's age, duration of treatment, mechanism of orthodontic treatment, equal distribution of forces on teeth, metabolic disorders, and others are considered to be the determining factors of root resorption.

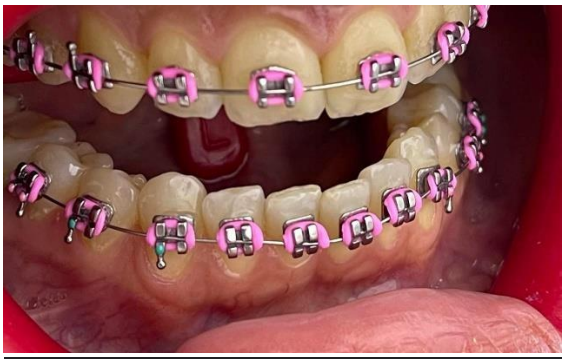

Fig.1. Treatment with Brace system (Dr. Natia Natsvlishvili)

Fig.2. Teeth straightening with Clear Aligners (Dr. Natia Natsvlishvili)

Classification of root resorption

Several classifications have been proposed, with distinctive terms and categories used to describe RR. Amongst all classifications, the Andreasen classification is fundamental and the most widespread, as all subsequent classifications have cited it, and comparisons amongst classifications are always made using this one. Moreover, the authors consider the Kanas classification to be the most complete with full descriptions and categorizations (Henrique et al., 2018). (Table.4).

Table.1. Classification of root resorption

Andreasen J.	1970	Localization, type, and trauma	I. Internal resorption-Replacement, Inflammatory II. External resorption-Surface, Replacement, Inflammatory
Kanas and Kanas	2011	Localization, aetiology and Type	1. Dental Origin -Internal resorption-Infective, inflammatory, trauma: a) Radial pulp enlargement resorption; b) Metaplastic (replacement) pulp resorption 2. Dental Original- External resorption-a) Physiological apical resorption: External surface resorption, TAR; b) Infective/Inflammatory resorption: Apical (pulp) inflammatory resorption, Cervical (periodontal) inflammatory resorption; c) Trauma (avulsed/luxated/fractured): TAB, Periapical replacement resorption (PARR) with ankylosis, Infective/inflammatory (apical or cervical); d) Pressure: Orthodontic (TAB, PARR without ankylosis), Impacted teeth, Occlusal forces; e) Idiopathic: Localized apical resorption (PARR without ankylosis), Multiple apical resorption (PARR without ankylosis); Multiple cervical resorption; f) Surgical: Bone grafts of alveolar clefts. Nondental Origin 1. Internal resorption - Herpes zoster infection. 2. External resorption - Neoplasia/cysts of the jaws, Systemic disorders.

Diagnosis

The relevance of the problem was first voiced by Ottolengui R in 1914 (Jacob et al.,(2020)) since then many studies have been devoted to determining the cause-and-effect relationship between orthodontic treatment and root resorption, and the main research methods include radiological studies (Panoramic radiography, CBCT), the most informative of which is cone-beam computed tomography (CBCT) (Neeta et al, (2017), Jian-Hong et al.,(2013) that can enhance the diagnosis of resorptive lesions in earlier stages. The detailed visualization afforded by CBCT is also associated with an improvement in outcomes.

The lack of pathognomonic symptoms of root resorption increases the difficulty of an accurate diagnosis. **An early diagnosis** is a crucial factor in the management of this pathology because the earlier the treatment is initiated, the less severe the resorption consequences will be.

Sensibility tests might be useful for RR recognition (Jian-Hong et al., (2013), Topkara et al., (2012)) and are mandatory for differential diagnosis. Full extra- and intraoral clinical examination must be implemented as a first step.

The issue of root resorption is very relevant in clinical dentistry. There is a lack of methodological approaches to studying the etiology, spread, diagnosis, treatment, and prevention of the mentioned pathology. Researchers mainly look at the issue of resorption from the individual aspects of endodontics, orthodontics, and periodontology.

Based on the aforementioned, we decided to study the occurrence of iatrogenic tooth root resorption in orthodontic practice thoroughly. Since June 2022 the research investigation was being conducted at the training-research and clinical center of Grigol Robakidze University “GRuniverse”.

The study aim is to evaluate the prevalence and peculiarities of the manifestation of root resorption caused by orthodontic treatment using non-removable (brace-system) and removable (aligners, orthodontic plate) devices for the treatment of malocclusion in children, adolescents, and adult patients (Figure 1, 2).

The objectives of the planned research are the following:

- The study of the prevalence of internal and external root resorption of different groups of teeth in orthodontic patients at different stages of treatment (6- and 12 months after treatment) through Orthopantomography.

Exclusion Criteria are the following: Patients with systemic diseases or the use of any prescription drugs that might have an impact on the bone

metabolism processes; patients with odontogenic acute or chronic apical periodontitis.

Materials and methods

The study was conducted on 56 patients of different age groups:

1. Study groups: A - 12- to 17-years-old patients with non-removable orthodontic appliances (Brace-system), Subgroup B - 18- to 35-years-old patients with non-removable orthodontic appliances (Brace-system);
2. Control groups: A1 - 12- to 17-years-old patients with removable orthodontic appliances (orthodontic plate), subgroup B1 - 18- to 35-years-old patients with removable orthodontic appliances (Aligners) (**Table.2**);

In order to achieve the goal of the study, patients of both the research and control groups were subjected to orthopantomographic studies; Statistical processing and comparative analysis of the obtained results were carried out.

Table 2. Characterization of Study and Control Groups

	Group A (12-17 years)	**Control Group A1 (12-17 years)**
n=	14	14
Sex		
Male	7 (50%)	7 (50%)
Female	7 (50%)	7 (50%)
Mean Age ± SD, years	15.3 ± 1.6	15.3 ± 1.6
Follow up		
6 months	7 (50%)	6 (50%)
12 months	7 (50%)	8 (50%)

	Group B (18-35 years)	**Control Group B1 (18-35 years)**
n=	14	14
Sex		
Male	7 (50%)	7 (50%)
Female	7 (50%)	7 (50%)
Mean Age ± SD, years	26.3 ± 5.6	26.4 ± 5.2
Follow up		
6 months	3 (21.4%)	4 (28.6%)
12 months	11 (78.6%)	10 (71.4%)

Results

This study comprised 56 patients including 28 patients with non-removable orthodontic appliances of different age groups:14 patients from Group A (12- to 17) and 14 patients from Group B (18- to 35) and 28 patients

with removable orthodontic appliances of different age groups: 14 patients from Group A1 (12- to 17) and 14 patients from Group B1 (18- to 35).

Regarding the gender distribution, there were 14 males and 14 females from Group A, A1 (50%/50%), and the same pattern is observed in Groups B, and B1.

The study of different groups of teeth in orthodontic patients at different stages of treatment (6- and 12 months after starting treatment) through Orthopantomography shows the prevalence of internal and external root resorption (Figures 3, 4, 5, 6). Complications due to orthodontic forces occur only in 12 patients in total.

The frequency of tooth roots resorption according to age group, sex, and a group of teeth, as well as the type of resorption was revealed as follows:

Study Group A: 4 patients (consisting of 3 females and 1 male patient) out of 14: Females: *apical root resorption* on a tooth 1.1-one case, tooth 1.2-one case, tooth 1.3-one case, tooth 3.1 three cases, tooth 3,2 -two cases, tooth 4.1-three cases, tooth 4.2-three cases.

Males: teeth 4.2,4.1,3.1,3.2, -one case.

Study Group B: 5 patients (consisting of 3 females and 2 male patients) out of 14: Females: *apical root resorption* on a tooth 1.1-one case, tooth 1.2-two cases, tooth 2.1-one case, tooth 2.2-one case, tooth 3.1-one case, tooth 3.2-one case, tooth 4.1-one case, tooth 4.2-one case, teeth 4.4, 4.5, 4.6, 3.4, 3.5, 3.6 –one case, *internal root resorption* tooth 1.2-one case.

Males: apical resorption on teeth 3.2,3.1,4.1,4.2- two cases, tooth 3.3-one case (**Figures 3,4,5,6)**

Control Group A1: 3 patients (females) out of 14: apical root resorption on a tooth 1.1-one case, tooth 2.1-one case, tooth 3.1- one case.

Control Group B1: No case of tooth root resorption was found. The data are given in **Tables 3 and 4.**

Table 3. The prevalence of root resorption due to orthodontic forces according to age group, gender, and a group of teeth

	Study Group A (12-17 Years)			**Study Group B (18-35 Years)**			**Study Group Total**	**Control Group A1 (12-17 Years)**		
Tooth No.	**Female**	**Male**	**Age Group Total**	**Female**	**Male**	**Age Group Total**		**Female**	**Male**	**Group Total**
1.1	1		1	1		2	3	1		1
1.2	1		1	3		2	4			0
1.3	1		1			0	1			0
Age Group Subtotal			**3**	**Age Group Subtotal**		**4**		**Control Group Subtotal**		**1**
Subtotal							**7**			
2.1				1		1	1	1		1
2.2				1		1	1			0

Age Group Subtotal			**0**	**Age Group Subtotal**		**2**		**Control Group Subtotal**		**1**
Subtotal							**2**			
3.1	3	1	4	1	2	3	7	1		1
3.2	2	1	3	1	2	3	6			0
3.3					1	1	1			0
3.4				1		1	1			0
3.5				1		1	1			0
3.6				1		1	1			0
Age Group Subtotal			**7**	**Age Group Subtotal**		**10**		**Control Group Subtotal**		**1**
Subtotal							**17**			
4.1		1	1	1	2	3	4		0	1
4.2		1	1	1	2	2	3			0
4.4				1		1	1			
4.5				1		1	1			
4.6				1		1	1			
Age Group Subtotal			**2**	**Age Group Subtotal**		**8**		**Control Group Subtotal**		**1**
Subtotal							**11**			
Total										
	Female	**Male**	**Age Group Total**	**Female**	**Male**	**Age Group Total**	**Study Group Total**	**Female**	**Male**	**Group Total**
	8	**4**	**12**	**16**	**9**	**25**		**3**	**0**	**3**
Age Group total			**12**	**Age Group total**		**25**		**Control Group total**		**3**
Study Group Total							**37**	**Control Group total**		**3**

Table 4. The results of Statistical Treatment of the Root Resorption cases in the Study and Control Groups

	Study Group	**Control Group**
n=	28	28
Root Resorption cases, n(%)	9 (32.1%)	2 (7.1%)
RR (95% CI)	**4.5 (1.07 – 18.99)**	
P	**0.041**	
	Group A (12-17 years)	**Control Group A1 (12-17 years)**
n=	14	14
Root Resorption cases, n(%)	4 (28.6%)	2 (14.3%)
RR (95% CI)	2.0 (0.43 – 9.21)	
P	0.374 (NS – No significant)	
	Group A (18-35 years)	**Control Group A1 (18-35 years)**
n=	14	14
Root Resorption cases, n(%)	5 (35.7%)	0 (0.0%)

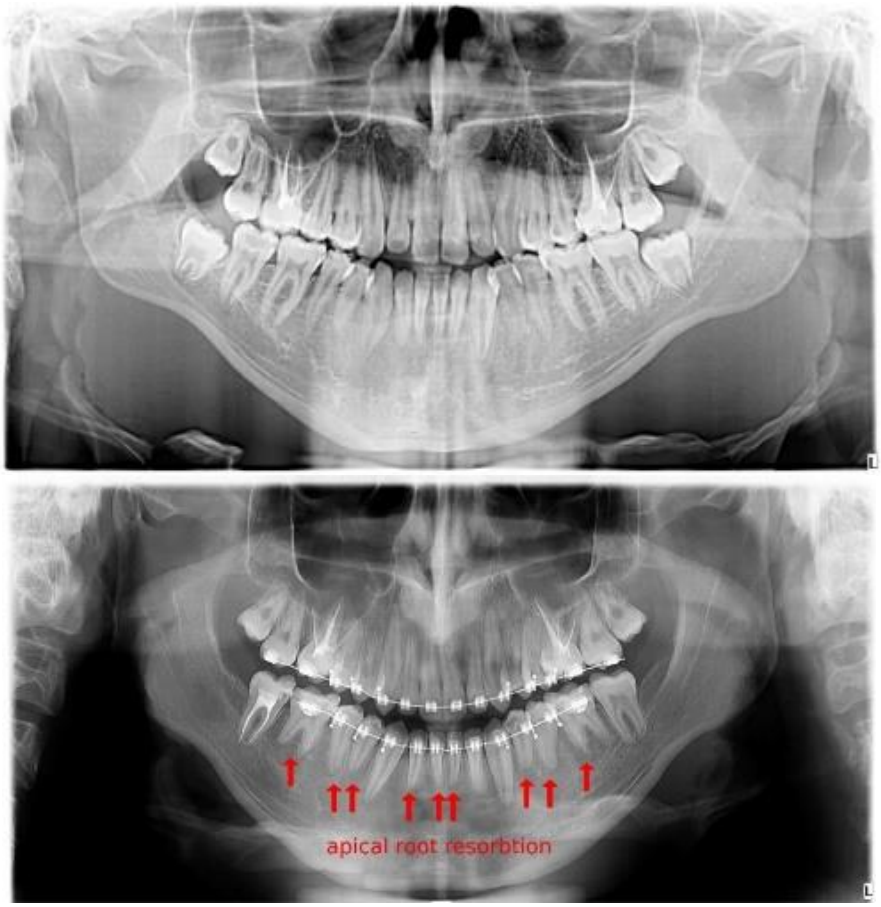

Figure 3. Apical root resorption in a patient (Group B) with brace-system before and after 12 months from the treatment.

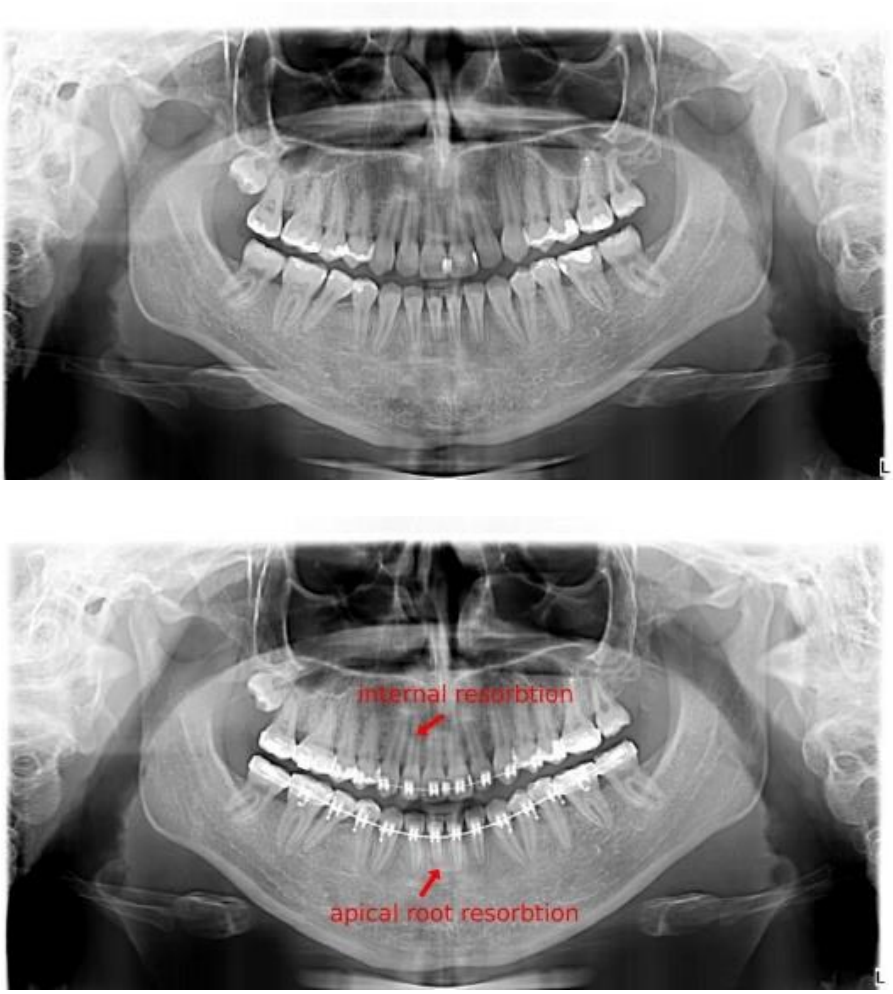

Figure 4. Apical and internal root resorption in a patient (Group A) with brace-system before and after 6 months from the treatment.

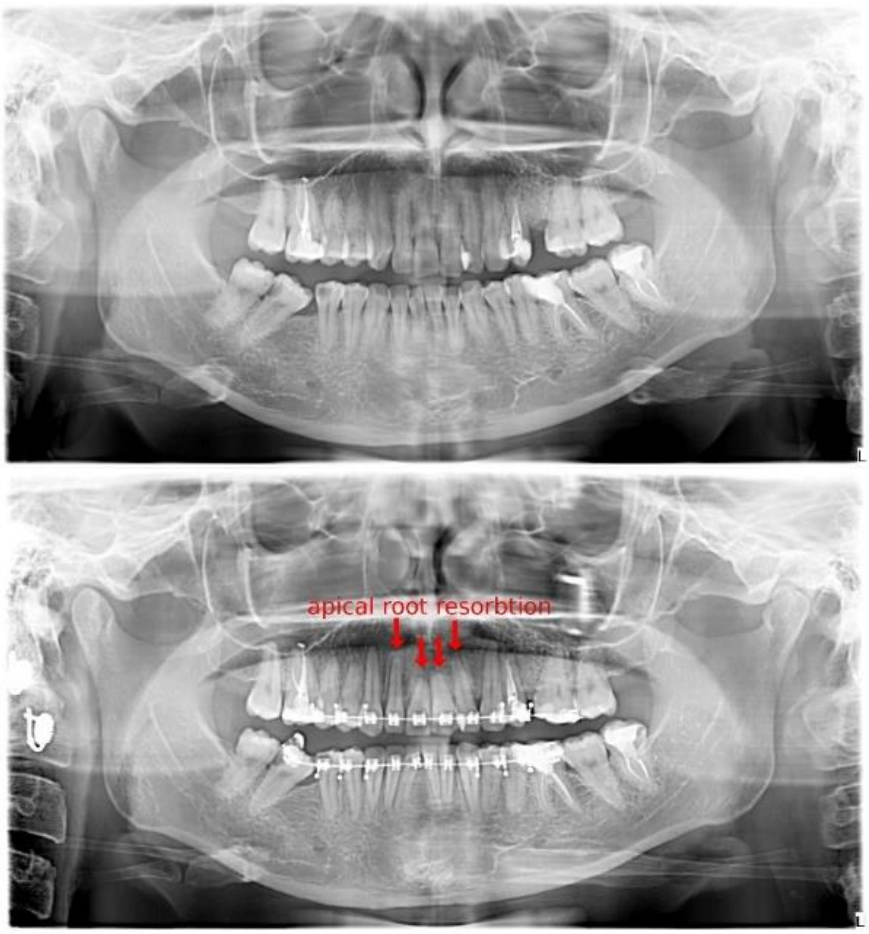

Figure 5. Apical root resorption in a patient (Group B) with brace-system before and after 12 months from the treatment

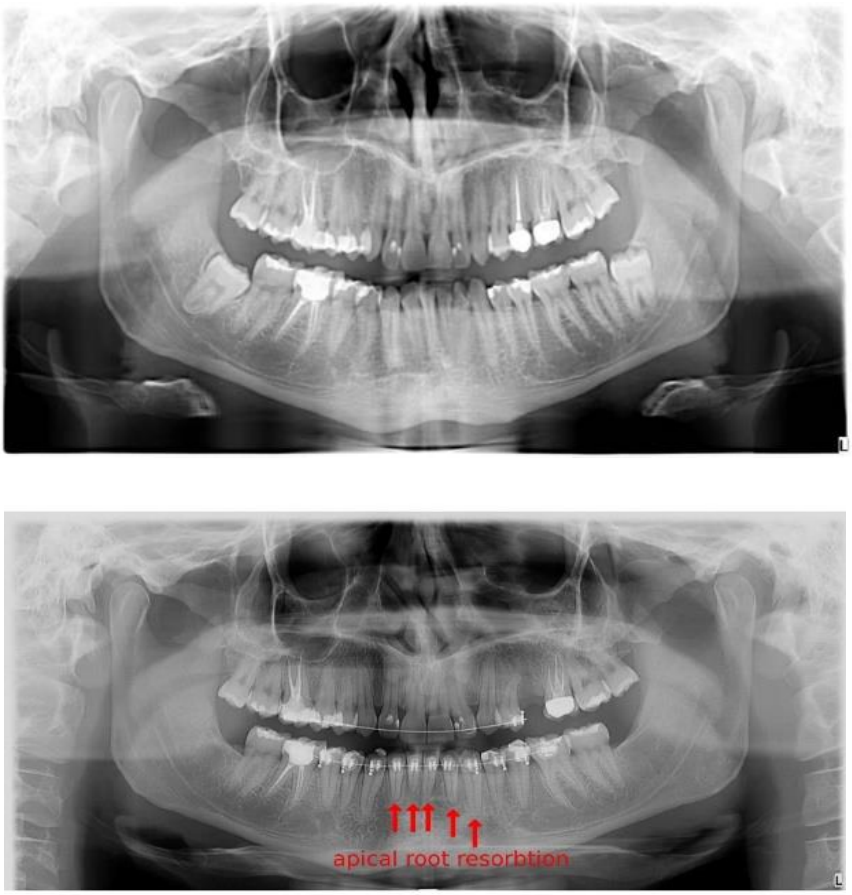

Figure 6. Apical root resorption in a patient (Group B) with brace-system before and after 6 months from the treatment.

Discussion

Today, the genetic and molecular aspects of this problem are actively researched. However, despite this, the issue has not been studied in detail, and contradictory opinions can be found (Krishnan et al., (2017)). Although most studies do not confirm the correlation between the patient's age and the incidence of root resorption, according to Sameshima and Sinclair, the majority of cases occur in older patients and there is a statistically insignificant increase in the incidence of resorption in men. Geraldo and co-authors associate the mentioned tendency in men with the morphological peculiarities of the root and explain this by the pipette-like shape of the roots of the central incisors. Kathryn and Begole studied the roots of patients from four ethnic groups (Asians, Caucasians, Spanish, and African Americans) before orthodontic treatment. According to these authors, women in all four ethnic groups had significantly shorter roots compared to men, and when it came to ethnic differences, Caucasians and Spanish had longer roots

compared to Asians and African Americans. According to their data, Asians are less prone to root resorption compared to Caucasians and Spanish. According to Kathryn and Begole, short roots (Asians, African Americans, and females) are more likely to be resorbed by orthodontic forces than roots with long or atypical roots (Sameshima et al., (2001)). According to the literature, root resorption is the second most common complication of orthodontic treatment after enamel white spots. The majority of authors believe that resorption is most often observed on the roots of upper incisors, although it is not clear which incisor root is resorbed more often - central or lateral ((Krishnan et al., (2017), Jairo (2013), Al-Qawasmi RA et al., (2004)). In the frequency of detection of this pathology on the upper jaw, the incisors are followed by the molars, and then the incisors, as for the lower jaw, resorption is manifested more in the incisors, followed by the central and lateral incisors.

According to other data, we find opposite results - resorption on the lower jaw is most often seen in the central and lateral incisors, while in the molars of the lower jaw, resorption of the distal root is more marked. Following the same authors, the molars of the lower jaw are followed by the molars of the upper jaw and the premolars of the lower jaw, and finally, the lowest rate of resorption is found in the premolars of the upper jaw (Krishnan et al., 2017).

Several authors focus on the root apex shape abnormally and its relationship with resorption (Jairo et al (2013), Sherrard et al (2017)). In roots with different apex shapes (single apex, blunted, bifurcated, pointed, immature) the lowest frequency of resorption was observed in roots with blunted apex. Compared to roots with a single apex, resorption is more marked in the roots with an apical bifurcation, and much less in immature teeth. According to the data of Levander E, Bajka R, and Malmgren O, blunt roots are more inclined to resorption (Al-Qawasmi RA et al., (2004)). A positive correlation was found between root length and resorption—longer roots were more disposed to resorption than shorter ones (Mah Jet al., (2004)). Data concerning the resorption of endodontically treated teeth are noteworthy (Jairo et al., (2013., Wickwire (2007), Pustułka et al., (2021)). According to the data of S. W. Spurrier et al., compared to vital teeth, dentin hardening after endodontic treatment provides increased resistance to root resorption, However, this hypothesis is contradicted by the studies of N.A. Wickwire (Wickwire, 2007), where no statistically significant difference was found in terms of resorption between vital and nonvital teeth, although it was noted that compared to intact teeth, resorption is more evident in endodontically treated teeth according to reports, root resorption is more common in adult orthodontic patients than in adolescents, and it is more common in women

than in men, and resorption is characterized by a sluggish course in repeat orthodontic patients than in primary patients (Elif Dilara Seker et al ., (2021)). The relationship between 1, 25-DHCC (Vit. D3), parathyroid hormone (PTH), Ca imbalance and root resorption has been determined, and endocrine disorders such as Hyperparathyroidism, Paget's disease, Hypophosphatemia, Hypothyroidism, Hypopituitarism, Hyperpituitarism has been considered as a cause of dental maldevelopment (Jacob et al., (2020)). Thus, according to the literature, the issue of root resorption is very relevant in clinical dentistry. There is a lack of methodological approaches to studying the etiology, spread, diagnosis, treatment, and prevention of the mentioned pathology. Researchers mainly look at the issue of resorption from the individual aspects of endodontics, orthodontics, and periodontology.

Conclusion

According to data of recent research the most commonly affected age group was 18-35 treated with non-removable orthodontic appliances (brace system). The occurrence of tooth root apical and internal resorption was revealed mostly in women. The frequency of the abovementioned complication of orthodontic treatment was observed primarily in cases of the lower incisors - 3.1,3.2, 4.1,4.2. Regarding the type of resorption - from 100% of the identified cases it was observed only 1 case of internal root resorption. External root resorption was revealed in the remaining 99%.

As for the control group, results-resorption due to orthodontic forces was detected in the control group B1 (12-17) in 3 patients with removable orthodontic appliances (orthodontic plate) and gender affiliation was the same. Regarding the results of treatment with Aligners (control group B2), no case of tooth root resorption was found.

Based on the relevance of the problem further research is needed to determine the correlation between the manifestation of root hard tissue resorption caused by orthodontic forces and the shape of the apex and the length of the root, teeth vitality/devitality, and the duration of orthodontic treatment. We consider the detailed study should significantly simplify treatment planning by taking into account the individual peculiarities of the patient and choosing an orthodontic appliance in order to prevent complications due to orthodontics, they will also make the results of treatment more predictable, and contribute to its stable and safe outcome.

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