Diagnosing Tooth Root Resorption with Cone Beam Computed Tomography after Six Months of Fixed Appliance Orthodontic Treatment and Its Relationship with Risk Factors

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Abstract

Objective: This study was conducted with the aim of diagnosing tooth root resorption with cone beam computed tomography after six months of orthodontic treatment with a fixed appliance and its relationship with risk factors.

Materials and methods: 121 patients (11-58 years old) with class I malocclusion and irregular teeth who were treated with fixed appliance and premolar extraction method participated in this research. Patients were evaluated using CBCT before and 6 months after active orthodontic treatment. This evaluation included all teeth from the right first molar to the left first molar in both jaws. Malmgren's index was used to evaluate root analysis. Irregularity of the root contour (grade 1 root analysis) was seen in most teeth before active treatment, and therefore in this study, root analysis related to orthodontic treatment, grade 2 analyses (minor analysis or root analysis to the extent of < 2 mm) or higher grades were considered.

Results: Minor resorption was observed in 20% of patients and severe root resorption (grade 3 resorption or root resorption <2 mm) was observed in 2 patients. Root resorption was more frequent in the upper jaw, especially in the incisors. The root because analysis did not show a statistically significant correlation with the investigated risk factors.

Conclusion: Six months after active orthodontic treatment, clinically significant root resorption was detected in 9% of patients. In other words, in 91% of patients, evaluation by CBCT did not show significant information. The factors that were considered as possible risk factors in this study did not show a significant effect on the amount of root resorption six months after active orthodontic treatment.

Keywords: Diagnosing Tooth Root, Cone Beam, Orthodontic Treatment, Risk Factors

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Introduction

Many studies have identified orthodontic treatment as the cause of root external analysis. Among patients undergoing orthodontic treatment, the incidence of root resorption related to orthodontic treatment or OIRR has been reported from 1% to 100%. This wide variation depends on several factors including the examination methods, the definition used to determine the root analysis, the type of device and the forces used. In various studies, several factors have been introduced as significant risk factors in creating OIRR:

- Sucking nails and chewing nails;
- Abnormalities of root formation;
- Traumatic teeth [1-3].

Radiography is the most common diagnostic tool for root canal analysis, and periapical intraoral radiography has been used in most clinical studies. This technique has disadvantages that are difficult to overcome. In addition, root resorption must be higher than certain values to be detected by radiography [4-6]. Panoramic radiography is another technique that has been used to investigate root canals. As one of the disadvantages, this technique is sensitive to the position of the patient, which is relatively narrow due to the sharp-layer and the shape of the central channel [7].

Even under favorable conditions and placing the patient in the correct position, panoramic radiographs are accompanied by lack of clarity, especially in the anterior regions. The use of a lateral radiograph along with a panoramic image is suggested to overcome the lack of clarity in the anterior regions [8-10]. Of course, the difficulty of distinguishing teeth in the lateral photo is considered a problem. It was released in the late 1990s. The CBCT technique was introduced in the late 1990s. Studies have shown that CBCT radiation dose is lower than conventional CT. Of course, the dose of radiation varies according to the brand of the device, the size of the examined area, and the radiation parameters [11-13]. After the invention of CBCT, this technique has been widely used in different branches of dentistry in addition to orthodontics [14].

Even under favorable conditions and placing the patient in the correct position, panoramic radiographs are accompanied by lack of clarity, especially in the anterior regions. The use of a lateral radiograph along with a panoramic image is suggested to overcome the lack of clarity in the anterior regions [15]. Of course, the difficulty of distinguishing teeth in the lateral photo is considered a problem. It was released in the late 1990s. The CBCT technique was introduced in the late 1990s. Studies have shown that CBCT radiation dose is lower than conventional CT. Of course, the dose of radiation varies according to the brand of the device, the size of the examined area, and the radiation parameters (Figure 1). After the invention of CBCT, this technique has been widely used in different branches of dentistry in addition to orthodontics [16-18].

Dadik et al. compared the accuracy of panoramic radiography and CBCT to detect OIRR and showed that root apical analysis could be detected using panoramic photo in 44% of teeth, but using CBCT in 69% of teeth. The CBCT technique is also superior to pre-apical radiography in terms of providing images in all three planes and showing analysis at levels that cannot be identified by conventional radiography [19].

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Figure 1. Root Resorption: What Is It, and What Can Be Done?

The most important advantage of CBCT compared to conventional radiography is the high reproducibility in the treatment process, because despite the changes in the position of the teeth during orthodontic treatment, this technique can provide a favorable view of the teeth by presenting images in multiples regardless of the change in the position of the teeth. Studies have shown that there is a significant correlation between the presence of minor root resorption in the early stages of treatment (3 to 9 months) and severe resorption at the end of treatment [20]. Levander et al reported that 3 months after the start of treatment, apical root resorption was detected in only a few teeth, but 6 months after the start of treatment, the number of these teeth increased significantly [21]. It has been reported that compared to patients without root resorption, patients who have resorption during the first six months of active treatment are more likely to undergo root resorption in the next six months [22].
Mohandsan et al observed clinically significant root resorption in 74% of upper centrals and 82% of upper centrals during a 12-month treatment period [23].

Everything about imaging procedures in orthodontics

Imaging procedures in orthodontics are one of the key tools in installing brackets. These images provide a complete view of the mouth and jaw structures before, during and after treatment for dentists and orthodontists. Radiographic treatment planning can well evaluate the angles, goals and beauty of the face [24-26].
Imaging in orthodontics is very important for correct diagnosis and providing accurate treatment, and the types of imaging are different based on the patient's age, medical records, gum health, etc. In fact, the orthodontist is based on the fact that he can design and implement the treatment of straightening the teeth [27].

X-rays and brackets

As we mentioned above, imaging in orthodontics is very important to get a favorable result. When you begin the process of straightening your teeth, you may not be sure what to expect. Whether you or your child will undergo this treatment, it will be scary [28]. There is no way to know how long it will take to straighten your teeth or what the best treatment option is until the orthodontist gives an opinion. This is where the role of imaging steps in orthodontics becomes prominent. Imaging procedures in orthodontics are an important part of this treatment before, during and after installing brackets. The types of X-rays also depend on your treatment plan. The first stage of imaging identifies the problems that must be solved before installing the brackets [29-31].

These steps allow the orthodontist to consider the health and location of tooth roots, soft tissues, nerves, and bone structures, all of which play a role in your treatment plan. Some of the things that the specialist should check in orthodontic treatment are:

- Malformed or misplaced teeth or roots;
- Abnormal length of teeth or roots;
- Jaw bones that are irregular and asymmetrical or have the wrong size and spacing [32].

Imaging steps in orthodontics in different treatment schedules can control the way of re-advancement, how the roots and jaw react. In addition, these steps allow the orthodontist to evaluate the outcome of the treatment and, if necessary, offer other options to advance the treatment (Figure 2). He will also use the obtained images to make retainers [33].

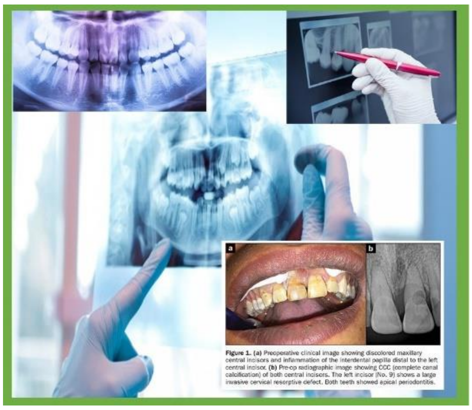

Figure 2. X-rays and brackets

What type of imaging is used in orthodontics?

Orthodontists use both intraoral and extra-oral imaging technology to achieve the best results. The digital images created by the scanners enable orthodontists to pinpoint small structural problems and plan more effective treatment compared to traditional molds [34].

The types of imaging in orthodontics are:

- **True Definition 3D scanner**

True Definition scanners can download and store hundreds of images digitally. This type of imaging in orthodontics makes the patient more comfortable and increases the precision of orthodontic specialists. These types of scanners provide accurate images of upper and lower teeth without bothering the patient with previous traditional methods. In addition, the obtained images are important for subsequent treatments, except for the initial stages [35].

- **iTero scanner**

Another imaging procedure in orthodontics that evaluates the inside of the mouth is the iTero scanner. Using a radiation-free laser, this device provides 3D digital images of teeth and soft oral structures within minutes. In addition, the orthodontist can make sure that the treatment is progressing according to the plan by following the scans [36].

- **Cone-Beam Computed Tomography or CBCT**

CBCT is an extra-oral x-ray that provides a three-dimensional computer model of your teeth, allowing the dentist to accurately analyze the orientation of the teeth and roots. This type of imaging in orthodontics also allows the specialist to analyze more complex procedures and thus correct more serious problems [37].

What is the use of dental radiography?

Dental radiography is used in many cases and with its help, dental problems can be checked. It can be said that a dentist cannot diagnose the severity of tooth decay without radiographs or dental imaging. Among its other uses, the following can be mentioned:

1- Diagnosis of problems such as cyst, tumor and abscess.

2- Helping the dentist to plan the appropriate treatment plan for cases such as extensive caries, denervation surgery, dental implant and tooth extraction.

3- Planning a suitable treatment plan for orthodontics and aligning teeth [38].

4- Diagnosis of oral problems such as tooth decay, hidden dental structures and...

5- Detect and check teeth that are not in place or do not fit properly in the gums [39].

When does the dentist suggest the need for dental x-rays to the patient?

When x-rays are taken and what type of x-rays the dentist recommends depends on the dentist's responsibility to perform a thorough examination and to ensure that dental problems are detected early to cause less damage to tooth and gum tissue. It also depends on the condition of the patient's mouth, what degree of problems are visible in your mouth and what part of your mouth the dentist wants to see. One of the reasons why the dentist may suggest you to do a dental x-ray is to detect early caries between the teeth, which may be hidden from the dentist's view during clinical examinations. In some cases, the appearance of the tooth looks healthy, but the dentist can detect cavities using radiographs.

Also, diagnosing the condition of the bone supporting the tooth, the root of the tooth, and the hidden teeth are among the cases that require radiography of the tooth [40].

Radiation hazards in dental radiography

The question that arises for many patients is whether the radiation used in dental photographs is harmful or not. The answer to this question is both yes and no. If we want to check from a scientific point of view, the answer is yes, the radiation used in dental radiography is X-ray and can be harmful and ionizing radiation [41]. (Of course, it has not been proven harmful in the doses used in dentistry) but we should know that walking under the sun, air travel, living next to volcanoes, living at high altitudes, cosmic rays around us, low energy lamps that they are used in homes and... all of them can expose us to ionizing radiation! All these rays are harmful in turn, but they do not seriously threaten our health (Table 1). We are exposed to radiation with cosmic rays and ionizing rays around us, without any apparent health complications [42].

Table 1. Summarizes the initial (pretreatment) mean and standard deviations before placing the Forsus Device and final values after treatment (post-treatment), showing the significance of Student's t-tests for related data.

	Pre		Post		pvalue
SNAR	129.87	7.34	129.3	6.45	0.618
Co-A	82.97	5.57	84.06	4.69	0.434
SNA	81.36	3.51	80.38	3.29	0.438
A-NPerp	3.16	3.3	1.9	2.81	0.057
Co-Gn	104.21	6.6	108.25	6.86	0.019*
SNB	76.47	2.99	77.81	2.89	0.002*
Pg-NPerp	0.09	4.68	1.2	4.03	0.253
Gonial Ang	123.58	4.34	123.21	4.48	0.878
Wits	3.08	2.11	-0.07	2.67	0.002*
Mx-Md diff	21.3	18.20-24.35	25.1	20.80-26.45	0.005*
ANB	4.89	2.06	3.03	2.47	0.011*
L1-MP	20.58	3.36	20.06	3.86	0.296
ANS-Me	59.95	4.01	61.24	5.36	0.148
Overjet	6	5.20-6.45	3.4	3.25-3.95	<0.001*
Overbite	0.9	2.75	1.79	0.75	0.223
Molar Rel	2.1	-0.65 - 3.45	-1.3	-2.00 - -0.7	0.003*
U1-SN	104.29	10.61	103.01	7.67	0.624
L1-MP	97.66	5.21	97.66	5.21	0.213
Nasolab Ang	116.7	109.72-120.40	114.8	110.10-125.35	57
U lip-Eplane	-3.43	1.85	-5.46	1.87	0.002*
L lip-Eplane	-3.18	2.09	-4.26	2.65	0.001*

What is the difference between dental x-rays and those used in medicine?

X-ray radiation has a single nature in dental and medical sciences, but the dose of this radiation in dentistry is very small and is not comparable to medical radiographs at all, and it is not very dangerous. In fact, the amount (dose) of different diagnostic and therapeutic rays differs from each other. For example, it should be said that a CT scan introduces a lot of radiation into the patient's body compared to a simple dental x-ray. In the comparison between the types of dental radiographs, digital dental radiography creates the lowest level of radiation and is the best method for performing dental radiography [43].

What is the dose used in dental radiography?

The dose used in dental x-rays is very small. Four typical bitewing (or periapical) x-rays have a radiation dose of about 0.005 millisieverts, which is equivalent to one day's worth of cosmic rays you normally receive each day. You will receive the same amount of harmful radiation if you take even a short flight of one to two hours. Panoramic radiography requires twice this amount (that is, two days of normal cosmic radiation) of X-rays. This dose of radiation is not comparable to medical radiographs and CT scan, gamma, etc. and is very insignificant compared to them [44].

Are dental x-rays dangerous for pregnant women?

Radiography up to four units per visit is safe for pregnant women, but considering that the fetus is in a very sensitive stage of its development in the first trimester of pregnancy, radiography should be avoided as much as possible in the first trimester of pregnancy, except in cases in which the dentist deems it necessary to perform radiography. In these cases, with the consultation of the obstetrician and gynecologist, the dentist can protect the fetus from radiation by using two-layer lead coatings [45].

Ways to reduce the risks of radiography and protect the patient against X-rays

Most clients who receive radiation for a limited number of radiographs per year do not need special protection against X-rays, especially digital radiographs that have become popular in our country today. These types of radiographs have a much lower radiation dose than the previous ones. However, in the case of children and pregnant women (on the recommendation of the attending physician), protective measures may be used with a lead cover and thyroid band. It is recommended to go to places that do not use old radiography devices for radiography to reduce the risks of radiation [46].

Materials and methods

A total of 200 patients (referring to the orthodontic department of the dental clinic) participated in this study. As a criterion for entering the study, the patients had to have class I malocclusion with crowding and overjet < 5 mm. Also, the intensity of crowding of patients should be such that the extraction of one premolar in each quadrant was part of the treatment plan. Consent was obtained from the parents of the patients. Treatment was performed identically using a preadapted BMT device (3M Unitek, Monrovia, CA) with 0.022-inch slots. Initial leveling and adjustment was done by thermal nickel-titanium trend wires and closing the space by stainless steel wires with a rectangular cross-section of 0.019 x 0.021 inches. Risk factors were recorded for each patient [47].

Radiographic examination

CBCT scans before the start of treatment for all patients and scans six months after treatment for 97 patients (57 girls, 40 boys) who were randomly selected were analyzed. The average age of the patients was 24.7 years with a standard deviation of 1.5. For the random selection of 121 patients, the list of random numbers created in the Excel sheet was used. Scans were taken using Accuitomo 3D FPD (J Morita Mfg Corp, Kyoto, Japan) [48]. The radiation parameters were 4.5-5.4 mA (75 kV depending on the size of the patient and the volume of 60 mm × 60 mm with the time of a complete rotation of 17.5 seconds). All patients were positioned identically using a standard method, and the position of the X-rays was adjusted so that all teeth of both jaws, from the incisors to the first molar, were included in the same imaging space [49].

Discuss

Dental implants and teeth treated with endodontics have been widely studied and reviewed. However, there is still a serious debate about preserving the natural tooth and when to extract it for dental implants. In the past, doctors used fibrous-osseous implant designs. Modern dental implants are screw, rooted and with bone graft (Osseo integration), (by directly placing bones on titanium surfaces). These implants are useful for patients who have lost all or part of their teeth. Modern dental implants are one of the greatest advances in dentistry [50]. However, can they be useful in all clinical situations?

Back teeth can be good candidates for implants, and partial dentures are not necessary. Partial dentures are less popular today because their use requires the preparation of adjacent teeth and healthy tooth structure. Although historically very successful, FDPs have a lower survival rate than single implants, especially when posterior teeth have been endodontics treated. Therefore, the proper use of dental implants creates benefits that were not imagined in the past.

Success and survival of implants and endodontics

The term "survival" was never used to evaluate endodontic results until implants came along. Basically, the resolution of apical periodontitis, along with asymptomatic reactions, is considered one of the successes of endodontics. For implants, bone grafting of an implant (with or without pre-implant), or bone resorption, is considered survival and not success. Therefore, comparing implants and endodontics treated teeth based on endodontic outcome is a difficult endeavor. Strindberg and Ørstavik criteria (PAI index) are almost widely accepted for non-surgical endodontics. The result of surgery is usually evaluated (Figure 3) by the criteria of Rud et al or Molven et al. In the field of implants, there is no brief definition for implant success [51].

Figure 3. Success and survival of implants and endodontics

The latest guidelines of the Academy of Bone Transplantation define a "successful implant" as "achieving the therapeutic goal of a stable tooth replacement, and providing good function and esthetics to the patient. Implant failure includes the following: loosening or falling out of the implant, disability in implant repair, persistent pain, neuropathy and/or loss of function, persistent pre-implant radiolucency, bone resorption, increased probing depth, uncontrolled gingivitis or infection, prosthetic instability, fracture or loosening of occlusal materials or prosthetic components, and Implant fracture. Implant survival has been frequently used for evaluation. An implant meta-analysis, for example, included studies that used the Albertson or Smith and Bowser criteria as "useful criteria" or "well-defined criteria for failure or survival" [52].

A systematic review and qualitative analysis of implant articles over a 20-year period showed that the majority of studies used the survival criterion to evaluate success. This is important because there is a difference between the results of success analysis and the results of survival analysis.

For 1022 implants observed over 7 years, overall survival was 92.2%, but overall success was only 83.4%. The overall survival/success rate of implants supporting single-tooth prostheses was 95.6%, and 75.6%, and 76.3% and 94.4% for cantilever fixed partial prostheses, and 96.1% and 73.8% for fixed partial prostheses, and for fixed complete prostheses are 100%/63.8%, respectively, and for implant/tooth supported prostheses 6.6%/70.6% and for overdenture 7.95%/78.6%. Therefore, it is difficult to compare endodontics results (with strict criteria for success) to implant results based on survival [53].

If we define the success of endodontics as the preservation of teeth without symptoms, regardless of the periapical condition, the survival of teeth treated with endodontics is similar to implants. If survival is used as a measure, we have a good benchmark for comparison. Based on insurance data, 1,462,936 teeth with primary endodontic treatment were followed up for 8 years. Of these teeth, 97.0% were still in place with primary endodontic treatment and 3.0% of them underwent retreatment (surgical or non-surgical) received or removed [54].

Similarly, 1,557,547 endodontics treated teeth were reviewed for 5 years and the survival rate was 92.9%. In a meta-analysis, there was no significant difference between single implants (95%) and endodontics treated teeth (94%) over 6 years. In the results of implant studies, success rates of over 95% have been reported. In conventional analyses, the success rate for single tooth restorations was 96.7% to 97.5% and for fixed partial restorations was 92.5% to 93.6% (over 6 to 7 years). Extensive studies have shown that the overall survival rate for 13,494 two-stage implants over 15 years was 92% and for 5,515 one-stage implants over 10 years, it was 85% (including initial failures). Again, it should be noted that "success" may often mean "survival" and sometimes even "defective" or "failed" implants appear to be successful [55].

Don Hartog and colleagues reported a survival rate of 95.5% after one year of follow-up. However, these authors also noted that aesthetics, soft tissue aspects, and patient satisfaction were less considered [56]. Often in dental implant-ology, complications are not considered. Pre-implant (inflammatory disease of tissue around the implant) in 9.7% of single implants, bone loss of more than 2 mm in 3.6% of implants and screw loosening in 12.7% of implants (after 5 years) was observed. During the short-term follow-up of 5 years, the frequency of pre-implant and severe bone resorption question the long-term stability [57].

According to these data, 16 to 28% of implants were affected by pre-implant. Pre-implant is a type of late failure. In advanced stages, it may be accompanied by pain or bleeding in the probe. Although a pre-implant is clinically comparable to progressive periodontal disease in a tooth, the tooth will become loose, whereas an implant with bone grafting areas will not. When the implant has to be removed, a traumatic intervention with bone resorption may be required. A second or even a third implant replacement is performed under much more difficult conditions. Implants may need to be replaced during the patient's lifetime. The lifespan of natural teeth is longer than implants (at ten-year observation points), and teeth that have undergone endodontic or periodontal treatment. Although there is good follow-up data for implants, the issue of success and/or survival remains to be resolved [58].

The results from the study of the general population will be significantly lower. Pairs of endodontics treated teeth and single implants were compared at the University of Minnesota. This university-based study, without industry support, provides additional information that is objective and unbiased. Positive results after 7 to 9 years were 74% for implants and 84% for endodontics treated teeth. The rate of complications and necessary interventions was significantly higher in the implant group and the time to reach adaptation was longer for the implant group. However, similar satisfaction levels have been reported for implant or endodontics treated teeth. The survival of teeth treated with endodontics (83.34%) and implant (80.8%) was not significantly different after 8 years. However, success/survival reports do not provide a good prognosis based on individual clinical circumstances. The decision for endodontics or implants should not be made based on the analysis of the results [59].

Endodontic microsurgery - an endodontic method to save teeth

Failure of primary endodontic treatment leaves 3 options: Extraction and retreatment with or without surgery. For nonsurgical retreatment, data are retrospective. In data from 1961 to 2005, a success rate of 27.2% was reported. Retreatment of failed endodontics with apical periodontitis and altered canal morphology showed only 40% success. For these conditions, surgical retreatment may be considered a less invasive option, although nonsurgical retreatment is generally preferred. A systematic review of the results of surgical endodontics reported a success rate of 37% to 91%. However, these results include historical information with traditional techniques as well as modern studies [60].

The success rate of traditional epichoectomy is reported to be 59.0%. Modern microsurgical techniques include: ultrasonic devices to prepare cavities along the longitudinal axis of the root and an operating microscope to identify the complexity of canal anatomy on the surface of excised roots at high magnification. Biocompatible fillers such as mineral trioxide (MTA) have made significant improvements. Two meta-analyses that focused on contemporary microsurgical techniques on teeth with endodontics (but with good periodontal support using ultrasonic cavity preparation and modern filling materials) reported overall success rates ranging from 91.4% to 93.5% reported after at least one year of follow-up [61].

In order to correctly evaluate the OIRR value and minimize the error in radiographic evaluation, tooth root resorption was evaluated in patients using CBCT before treatment, six months after the start of treatment, and at the end of treatment. The radiation dose in the CBCT technique is relatively lower compared to other advanced radiography methods, and the amount of radiation in this technique is similar to the radiation dose from eight panoramic radiographs. The Malmgrem index was first used for pre-apical intraoral radiography. The advantage of this index is the use of a kind of grading to show the intensity of the root analysis. Reformatting was done according to the descriptive method of Lund et al. Reframing was done along the longitudinal axis of the tooth/root, and therefore a favorable view of the tooth/root was obtained in the axial, coronal and sagittal planes. The correctness and accuracy of this method is described in the study of Lund et al. To determine the severity of the analysis, changes in root length between before and six months after treatment were converted into Malmgren index. This index was originally designed for intraoral radiography by Malmgren et al [61].

This classification consists of four different grades:

Grade 1 = irregular root contour,

Grade 2 = Root apical dissection less than ~ 2 mm (minor dissection),

Grade 3 = Root apical dissection from 2 mm to one third primary root length (severe analysis) and Grade 4 = Analysis of more than one third of the initial root length (very severe analysis). All evaluations were done by one person [60].

Statistical analysis

The condition of the root was grouped into two states of presence of analysis and absence of analysis. The occurrence of root analysis and the presence of risk factors were checked using Fisher's exact test. $P < 0.05$ cases were considered as significance level [59-61].

Results

Irregular root contour was present in most of the teeth before the start of active treatment. Therefore, cases were considered as root analysis related to orthodontic treatment, which analysis was identified as grade 2 or higher. Grade 2 analysis was seen in 10 patients and grade 3 analysis was seen in four patients. In one of these two patients, root resorption was not observed in the maxillary teeth, but in the other patient, in addition to the lower jaw, root resorption was also observed in the laterals and upper left canine. It is clinically useful and in addition, it can be easily used in daily treatments [60].

In the current study, the CBCT technique showed that almost all teeth had some irregularity in the apical contour of the root even before the start of treatment (level 1 analysis). Therefore, this degree of analysis was not calculated as a treatment complication. If the 1st degree analysis was considered, the existence of OIRR would be overestimated. Probably, root contour irregularity has no clinical significance. Grade 2 resection (<2 mm), although mild, is detectable and can be used clinically as a useful criterion to determine root resection. So far, few studies have been published regarding the investigation of OIRR in all teeth of both jaws during the initial stages of orthodontic treatment. In agreement with Pithsin studies that examined the upper incisors, the present study revealed that some patients show signs of OIRR during the early stages of treatment with fixed appliances [61].

Of course, at this stage, the number of patients with high levels of analysis is small. Among the 97 patients, in the present study, 96% of the patients did not show a change in the root length that was clinically apparent during the first phase of orthodontic treatment. According to this finding, X-ray examinations of patients within 3 to 6 months after treatment are doubtful. Therefore, the benefits of radiography in the middle stages of treatment need more investigations [62-64].

Conclusion

However, a recent study has provided a wealth of information (over 20 years) on rough-surfaced, microporous implants in situations involving partial edentulous ness; that 72 of the original 145 implants remained for follow-up (after removing patients who died and those lost to follow-up). Of these implants, 68% were without technical complications. The success/survival rate was 75.8%/89.5%. However, these long-term data are scarce. Even after craniofacial growth is complete, implant placement in young adults may be cautious, as restoration in areas where implants have already been lost still needs to be evaluated with higher evidence.

Based on a critical evaluation of published data and methods used in clinical studies, the success rate of implants may be unrealistically high. In addition, implant companies support these studies. A systematic review of industry-sponsored implant trials found that 63% of studies did not disclose the sponsor, 66% of trials had a risk of bias, and studies with unknown funding or industry support had lower annual failure rates than those without. Non-industrial have reported. Strict entry and exit criteria for participants in implant trials are common. Six months after the treatment, clinically significant root resorption was diagnosed in 9% of patients. In other words, the radiographic examination did not show important clinical information in 91% of patients. The risk factors examined in this study had no effect on the amount of root resorption after six months of active orthodontic treatment.

Four people had grade 3 analysis. In one of these patients, root resorption was detected in the first premolars of the upper jaw. Usually, during orthodontic treatment or in scientific studies regarding the early stages of root resorption, the first premolars are not subjected to radiographic examination. In the present study, root resorption was seen in almost all cases in the upper jaw, however, one patient showed grade 3 resorption in the root of the lower jaw. The root analysis in the present study was less severe than the study of Small et al. In the study of Small et al., after 3 to 9 months from the start of treatment, 8.5% of patients showed at least one upper incisor with grade 3 analysis. In our study, grade 3 analyses in the roots of upper incisors showed a frequency of 3.1%. Regarding milder degrees of root resorption, two studies reported different results.

So that Small et al observed 2nd degree analysis of incisor roots in 40% of patients, but in the present study this phenomenon was seen in 9.3% of patients. Levander and Malmgren investigated during the early stages of orthodontic treatment (in their study, root resorption was not evaluated based on patients, but based on teeth). One of their results was the higher frequency of grade 2 analysis compared to the present study. Evaluation based on teeth is not an accurate method for presenting clinical findings due to the influence of individual differences, but based on this method, it was observed that the percentage of teeth with grade 3 analysis in the present study was similar to the study by Small et al. and the study by Levander and Malmgren. Of course, the root analysis calculation based on the present teeth was less than the study by Small et al. and the study by Levander and Malmgren, which is probably due to the difference in radiographic techniques.

Projection error is a fundamental problem in intraoral radiography. This error exists in orthodontics due to the displacement of the teeth and their angle change during the treatment period. CBCT technique can control the projection geometry for each tooth, so that the projection errors are less (up to 2 mm in tooth length measurement). It is possible to attribute the low frequency of 2nd degree analysis in the present study to this error rate. However, root analysis with higher intensities does not have technical sensitivity and these findings were more similar in all three studies. In the present study, no significant correlation was found between OIRR and the investigated risk factors, which is probably due to the small number of patients with root resorption. In a systematic review study, Weltman et al. reported that tooth morphology and history of trauma are not risk factors for OIRR, which is in agreement with the findings of our study. The findings of the present study showed that approximately 50% of patients with grade 3 analysis (>2 mm) had abnormally shaped roots, but no statistically significant correlation was found. Levamder et al also reported higher degrees of OIRR in teeth with blunt roots or pipette-like roots. These findings have been reported in other studies.

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