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Effects of Coronal Restorations and Root Canal Filling Quality on Periapical Status in A Turkish Population

Koronal Restorasyonların ve Kök Kanal Dolgularının Kalitesinin Periapikal Sağlığa Türk Popülasyonundaki Etkileri

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Abstract

Objective: This study aimed to evaluate the prevalence of apical periodontitis in endodontically treated teeth and to assess the effects of coronal restorations and root canal filling quality on periapical status in a Turkish population.

Material-Method: A total of 901 adult patients and 1,709 endodontically treated teeth were assessed. Their digital panoramic radiographs were examined by three independent observers. The quality of the coronal restorations and root canal fillings was classified by radiographic examination, and the teeth were classified as healthy / success or diseased according to periapical status. The Cohen kappa calculated to assess inter-observer agreement for the quality of the restorations and root canal fillings and for periapical status. The results were analyzed using a chi-squared test and Fisher's exact test.

Results: According to the periapical index scoring system (PAI), 750 (43.9%) teeth were classified as healthy, and 959 (56.1%) teeth were classified as diseased. The adequate coronal restoration and adequate root canal filling group showed the highest success rate. The adequate root canal filling and inadequate coronal restoration group had a significantly higher success rate than the inadequate root canal filling and adequate coronal restoration group ($p<0.001$). The inadequate coronal restoration and inadequate root canal filling group had the lowest success rate. The most frequently treated teeth were maxillary premolars, mandibular molars and maxillary molars, respectively. The Cohen's kappa values were 0.82, 0.83 and 0.89 in the categories of periapical status, root canal filling and coronal restoration, respectively, thus test results showed that the inter-observers were in close agreement.

Conclusion: The quality of coronal restorations influenced the periapical health. The quality of root canal fillings may be the most effective factor in periapical health.

Keywords: Apical Periodontitis, Coronal Restoration, Endodontic Treatment, Periapical Status, Radiographic Evaluation.

Özet

Amaç: Bu çalışmanın amacı Türk popülasyonunda endodontik tedavili dişlerdeki apikal periodontitis prevalansını belirlemek, koronal restorasyon ve kök kanal dolgu kalitesinin periapikal sağlık üzerindeki etkilerini değerlendirmektir.

Materyal-Metot: Toplam 901 hastaya ait 1709 endodontik tedavi görmüş diş değerlendirildi. Dijital panoramik radyografler üç bağımsız araştırmacı tarafından incelendi. Değerlendirilen dişler koronal restorasyonlarının ve kök kanal dolgularının kalitelerine göre sınıflandırıldı. Dişler ayrıca periapikal duruma göre sağlıklı / başarılı veya hastalıklı olarak değerlendirildi. Araştırmacıların birbirleri arasındaki koronal restorasyon kalitesi, kök kanal dolgu kalitesi ve periapikal durum değerlendirme ölçümlerinin uyumunu karşılaştırmak için Cohen'in Kappa (κ) katsayısından yararlanıldı. Elde edilen sonuçlar ki-kare ve Fisher's exact testi kullanılarak analiz edildi.

Bulgular: Toplamda 750 (%43,9) diş sağlıklı, 959 (%56,1) diş hastalıklı olarak PAI skorla-masına göre sınıflandırıldı. Yeterli koronal restorasyon ve yeterli kök kanal dolgusuna sahip dişler en yüksek başarı oranını gösterdi. Yeterli kök kanal dolgusu ve yetersiz koronal restorasyona sahip dişler, yetersiz kök kanal dolgusu ve yeterli koronal restorasyona sahip dişlerden istatistiksel olarak anlamlı derecede daha yüksek başarı oranına sahipti ($p<0,001$). Yetersiz koronal restorasyon ve yetersiz kök kanal dolgusuna sahip dişler en düşük başarı oranı gösterdi. En sık tedavi edilen dişler sırasıyla maksiller premolar, mandibular molar ve maksiller molar dişlerdi. Cohen'in Kappa değerleri periapikal durum, kök kanal dolgusu ve koronal restorasyon kategorilerinde sırasıyla 0,82, 0,83 ve 0,89 olarak hesaplandı ve bu sonuçlara göre farklı araştırmacılar tarafından yapılan ölçümlerin uyumunun yüksek olduğu görüldü.

Sonuç: Koronal restorasyonun kalitesi periapikal sağlık üzerinde etkili bir faktördür. Kök kanal dolgusunun kalitesi periapikal sağlık üzerindeki en etkili faktör olabilir.

Anahtar kelimeler: Apikal Periodontitis, Koronal Restorasyon, Endodontik Tedavi, Periapikal Durum, Radyografik Değerlendirme.

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Introduction

Apical periodontitis is defined as destruction and inflammation in the periapical area because of a root canal infection and is observed as a radiolucency around the root apex (1). Many factors, primarily bacteria, can cause apical periodontitis (2). Bacteria and their products can progress to the dental pulp tissue through dental caries, operating procedures or dental trauma and can reach to the periapical tissues (3). The quality of root canal obturation, effectiveness of the chemomechanical preparation, pulpal and periradicular status, and root canal anatomy can influence the success of endodontic treatment (4).

Longitudinal studies have shown that endodontic treatment success rates can reach up to 95% when treatment is performed under controlled clinical conditions (5, 6). However, different results have been demonstrated in cross-sectional studies evaluating the outcomes of endodontic treatment, which have reported only 35% to 60% success rates for teeth with endodontic treatment (7-14).

The majority of the studies revealed that the success of endodontic treatment can be positively associated with the quality of the root canal filling (9, 12, 15, 16). However, according to Ray and Trope's study (17), the quality of the coronal restoration has more effect on the periapical tissues when compared with the quality of the root canal filling. Georgopoulou et al. (18) supported these results, reporting that the quality of the coronal restoration was a more significant factor than the quality of the root canal filling on periapical status. On the other hand, Siqueira et al. (9) showed that the quality of coronal restoration is significant to the success of the treatment only for teeth with inadequate root canal fillings (IRCFs). Tronstad et al. (15) observed that the quality of root canal filling is a more crucial factor than the quality of coronal restoration, and that the quality of coronal restoration is important only when associated with adequate root canal filling (ARCF). On the other hand, Song et al. (19) and Thampibul et al. (20) observed that the quality of root canal filling and coronal restoration share equal importance to periapical health.

Ørstavik et al. (21) defined a method for the evaluation of periapical lesions in 1986, the periapical index scoring system (PAI), which classifies periapical lesions. Currently, this system is widely used in epidemiologic studies for evaluating the success of endodontic treatment (22).

This cross-sectional study aimed to evaluate the prevalence of apical periodontitis in endodontically treated teeth and to assess the effect of coronal restorations and root canal filling quality on periapical status in a selected Turkish population. The null hypothesis tested was that there is no difference between the effect of coronal restoration and root canal filling quality on periapical status in a selected Turkish population.

Material and Methods

This study was approved by the Ethics Committee of Dumlupinar University (ref. no.: 2017- 7/7). The sample used for this study consisted of 901 randomly selected adult patients, 462 men and 439 women, seeking routine dental care at the Department of Oral Diagnosis and Radiology, Faculty of Dentistry, Dumlupinar University, Kutahya, Turkey. Digital panoramic radiographs were randomly selected, and those damaged in any way or of poor quality were excluded. All radiographs were taken by a Veraviewepocs 2D X-550 panoramic X-ray unit (J. Morita Mfg. Corporation, Kyoto, Japan). They were taken by a dental radiologist using an X-ray viewer (Mediadent v8 dental imaging software; ImageLevel, Kruibeke, Belgium) on a high-resolution 19.5-inch LED monitor (A4320; Asustek Computer Inc., Taipei, Taiwan). The radiographs were examined by two independent observers (observer 1: an endodontist, observer 2: a restorative dentist). A third observer (observer 3: an endodontist) was consulted and determined the final score or classification of coronal restoration or endodontic treatment when a disagreement between observers 1 and 2 occurred (23).

The quality of coronal restoration and root canal filling were classified according to the radiographic evaluation. The criteria used for evaluation were slightly modified from those described by Tronstad et al. (15) and Tavares et al. (16), as follows:

Classification of Root Canal Filling

(1) Adequate root canal filling (ARCF): All root canals are obturated. Root canal fillings end at 0–2 mm short of the radiographic apex, and no voids are present in any area of the root fillings.

(2) Inadequate root canal filling (IRCF): Root canal fillings are grossly overfilled or end more than 2 mm short of the radiographic apex. Voids in the root canal fillings or unfilled canals are present. Poor condensation and/or inadequate density of the root canal filling is observed.

Classification of Coronal Restoration

(1) Adequate coronal restoration (ACR): Any permanent intact restoration of the teeth, with no recurrent caries and good margin adaptation.

(2) Inadequate coronal restoration (ICR): Any permanent restoration with recurrent caries, open margins or overhangs, and teeth with no coronal restoration or the presence of temporary coronal restoration.

Classification of Periapical Status

Periapical status was evaluated using the PAI score (21). The teeth were classified according to healthy/success (PAI 1 or PAI 2) or diseased (PAI 3, PAI 4 or PAI 5) (21, 24). The root with the highest PAI score was selected for multirooted teeth (25).

Statistical Analysis

Cohen's kappa statistics were performed for the evaluation of inter-observer agreement of the quality of coronal restoration, quality of root canal filling and periapical status. The data were analyzed with the SPSS statistical package software (SPSS, Inc, Chicago, IL). The data obtained were statistically analyzed using a chi-squared test with Fisher's exact test. The significant level was established at 5% ($p<0.05$).

Results

The Cohen's kappa values were 0.82, 0.83 and 0.89 in the categories of periapical status, root canal filling and coronal restoration, respectively, thus showing that the inter-observers were in close agreement.

Of the 1,709 root canal treated teeth, 891 (52.1%) were from males and 818 (47.9%) from females (Table 1). There was no statistically significant difference between the genders in terms of the number of teeth with root canal treatment (p>0.05). The most frequently treated teeth were maxillary premolars, mandibular molars and maxillary molars, respectively (Table 2), and there was a statistically significant difference between the tooth types in terms of the number of the teeth with root canal treatment (p<0.001).

According to the PAI scoring system, 750 (43.9%) teeth were classified as healthy, and 959 (56.1%) teeth were classified as diseased. Therefore, the prevalence of apical periodontitis was determined as 56.1% in this study.

The number of teeth with ARCF was 642 of 1,709 (37.6%) (Table 3). According to these results, when teeth classified as PAI 1 and PAI 2 were examined, the proportion of teeth classified as PAI 1 was higher in teeth with ARCF compared to teeth with IRCF (p<0.001). In cases of ARCF, the ratio of healthy teeth was 76.8%, whereas in cases of IRCF the ratio was 24.0%. Teeth with ARCF had a significantly reduced prevalence of diseased teeth when compared to teeth with IRCF (p<0.001).

Table 2. Distribution of root canal treated teeth according to the tooth group (n=1,709)

Tooth	Maxillary	Mandibular	P
Central incisor	131 (7.7%)	18 (1.1%)	<0.001
Lateral incisor	104 (6.1%)	21 (1.2%)	
Canine	106 (6.2%)	34 (2.0%)	
Premolar	407 (23.8%)	236 (13.8%)	
Molar	301 (17.6%)	351 (20.5%)	
Total	1049 (61.4%)	660 (38.6%)	

P: Pearson's chi-squared test

Table 1. Distribution of root filled teeth according to gender

Gender	N	Teeth with ET †	Healthy teeth with ET †	Diseased teeth with ET †	P
Male	462/901	891/1709	388/750	503/959	>0.05
	(51.3 %)	(52.1 %)	(51.7 %)	(52.5 %)	
Female	439 /901	818/ 1709	362/750	456/959	
	(48.7 %)	(47.9 %)	(48.3 %)	(47.5%)	

P: Pearson's chi-squared test, † Endodontic treatment

Table 3. Periapical health of root canal treated teeth in relation to the quality of root canal filling

	PAI	Adequate root canal filling (n=642)	Inadequate root canal filling (n=1067)	Total (n=1709)	P
Healthy teeth	1	312 (48.6%)	57 (5.3%)	369 (21.6%)	<0.001
	2	181 (28.2%)	200 (18.7%)	381 (22.3%)	
Total healthy teeth	1&2	493 (76.8%)^{a}	257 (24.0%)^{b}	750 (43.9%)	
Diseased teeth	3	87 (13.5%)	373 (35.0%)	460 (26.9%)	
	4	60 (9.4%)	412 (38.7%)	472 (27.6%)	
	5	2 (0.3%)	25 (2.3%)	27 (1.6%)	
Total diseased teeth	3,4 & 5	149 (23,2%)$^{\alpha}$	810 (76.0%)$^{\beta}$	959 (56.1%)	

P: Pearson's chi-squared test; different letters indicate statistically significant difference, p<0.001

Table 4. Periapical health of root canal treated teeth in relation to the quality of coronal restoration

	PAI	Adequate root canal filling (n=1135)	Inadequate root canal filling (n= 574)	Total (n=1709)	P
Healthy teeth	1	334 (29.4%)	35 (6.1%)	369 (21.6%)	<0.05
	2	250 (22.1%)	131 (22.8%)	381 (22.3%)	
Total healthy teeth	1&2	584 (51.5%)^{a}	166 (28.9%)^{b}	750 (43.9%)	
Diseased teeth	3	264 (23.2%)	196 (34.1%)	460 (26.9%)	
	4	270 (23.8%)	202 (35.3%)	472 (27.6%)	
	5	17 (1.5%)	10 (1.7%)	27 (1.6%)	
Total diseased teeth	3,4 & 5	551 (48.5%)$^{\alpha}$	408 (71.1%)$^{\beta}$	959 (56.1%)	

P: Pearson's chi-squared test; different letters indicate statistically significant difference, p<0.05

Table 5. Periapical health of root canal treated teeth in combined groups (n=1,709)

Combined Groups	PAI 1	PAI 2	PAI 3	PAI 4	PAI 5	Healthy (PAI 1&2)	Diseased (PAI 3,4 & 5)
Group A (ARCF† /ACR‡)	287/522 (55.0%)	133/522 (25.5%)	62/522 (11.8%)	39/522 (7.5%)	1 /522 (0.2%)	420/522 (80.5%)	102/522 (19.5%)
Group B (ARCF†/ICR§)	25/120 (20.0%)	48/120 (40.0%)	25/120 (20.8%)	21/120 (17.5%)	1/120 (0.8%)	73/120 (60.8%)	47/120 (39.2%)
Group C (IRCF¶/ACR‡)	47/613 (7.6%)	117/613 (19.1%)	202/613 (33.0%)	231/613 (37.7%)	16/613 (2.6%)	164/613 (26.7%)	449/613 (73.3%)
Group D (IRCF¶/ICR§)	10/454 (2.2%)	83/454 (18.3%)	171/454 (37.6%)	181/454 (39.9%)	9/454 (2.0%)	93/454 (20.5%)	361/454 (79.5%)
Total	369/1709 (21.6%)	381/1709 (22.3%)	460/1709 (26.9%)	472/1709 (27.6%)	27/1709 (1.6%)	750/1709 (43.9%)	959/1709 (56.1%)

P: Pearson's chi-squared test; different letters indicate statistically significant difference, $p<0.001$ for groups A-B and B-C, $p<0.05$ for groups C-D.
† Adequate root canal filling, ‡ Adequate coronal restoration, § Inadequate coronal restoration, ¶ Inadequate root canal filling.

The percentage of healthy teeth for cases with ACR was 51.5% (Table 4), whereas for cases with ICR it was 28.9%. The difference was statistically significant when comparing the prevalence of healthy teeth between ACR and ICR ($p<0.05$).

In group A (ARCF/ACR), the healthy teeth ratio was 80.5% (420/522), while in group B (ARCF/ICR) it was 60.8% (73/120) (Table 5). The difference between the two groups was statistically significant ($p<0.001$). Statistical analysis revealed the ARCF outcome was influenced by the quality of coronal restoration.

A statistically significant difference was observed between group C (IRCF/ACR) and group D (IRCF/ICR) ($p<0.05$); the lowest success rate in this study was observed in Group D (IRCF/ICR) (Table 5). The statistical analysis indicated that the success rate of IRCF was influenced significantly by the quality of coronal restoration ($p<0.05$).

The statistical analysis revealed that the quality of the root canal filling was the factor with the greatest influence on the periapical status of the teeth. The healthy teeth ratio was 60.8% (73/120) in group B (ARCF/ICR), whereas in group C (IRCF/ACR) the ratio was only 26.8% (164/613) (Table 5). The statistically significant difference between these groups demonstrated that the quality of root canal filling was the most influential factor in the success of treatment ($p<0.001$).

Discussion

Cross-sectional studies have some limitations because of the analyzed data being limited to the available information. For instance, when the radiographs were examined, there was no in-formation about how much time had elapsed after root canal treatment. Therefore, some radiolucencies associated with endodontically treated teeth which were defined as having periapical lesions might have been in the process of healing (9). However, cross-sectional study results remain meaningful because misinterpretations and misdiagnoses are fairly equally distributed in these studies (26). Furthermore, large sample size and random selection of cases can be achieved more easily in a cross-sectional study compared to longitudinal studies (27).

Microbiologic situations of the root canal, cracks in restorations and leaky occlusal margins cannot be observed completely in radiographs. For these reasons, the present study and other studies with similar methodologies have limitations. More sensitive techniques for evaluating coronal restorations, both clinically and radiographically or using cone beam computed tomography (CBCT), might minimize these limitations (16). Furthermore, panoramic radiographs have some disadvantages, such as the superimposition and distortion of important structures that commonly mask lesions (28). It has also been reported that extensive bone resorption may be present in some cases even if there is no radiographic evidence (29).

Today, the use of CBCT has made it possible to visualize teeth and their surrounding tissues in three dimensions with higher resolution (30). Additionally, previous studies have shown that CBCT imaging can better detect periradicular changes than can conventional radiography. In a study on this subject, Estrela et al. (31) examined 1,425 root canal treated teeth with three different imaging techniques (panoramic radiographs, periapical radiographs and CBCT); they reported that the CBCT imaging technique had a higher sensitivity for identifying periapical lesions than the other methods. In Velvart et al.'s study (32), endodontic lesions in 50 patients were assessed with conventional radiographs and CBCT scans; the researchers diagnosed all 78 lesions with CBCT scans whereas only 61 lesions were detected by conventional radiographs. However, CBCT images are associated with a higher radiation dose than other radiographic techniques, and panoramic radiographs are more routinely used for dental records than other radiographs (33). Moreover, digital panoramic radiographs have some advantages such as both jaws and all teeth can be examined at the same time, with low dose radiation and low cost. In addition, high-quality images can be obtained with modern panoramic devices, and the evaluation of the tooth and periapical status with panoramic radiography is reliable (34). Therefore, panoramic radiographs were preferred in this study, both because of these advantages and in order to access more patient records for evaluating more teeth at the same time.

In this study, the apical periodontitis rate of root canal treated teeth was 56.1%. This high rate is generally associated with the high frequency of IRCF and ICR. Of the 1,709 root-filled

teeth, 642 (37.6%) had ARCF, and only 522 (30.5%) teeth had both ARCF and ACR. The apical periodontitis rate has been reported with different ratios by several epidemiologic studies conducted in different countries. De Moor et al. (10) reported it as 40.4% in a Belgian population, while Siqueira et al. (9) reported 51% in the Brazilian population. In two Canadian populations, this ratio was observed by Dugas et al. (35) to be 44% and 51%. In Danish, Greek and Spanish populations, the rates were 52% (24), 60% (18) and 64.5% (7), respectively. In studies conducted at different times in Turkey, Kayahan et al. (13), Alkis and Kustarci (12), Sunay et al. (11) and Gündüz et al. (14) evaluated apical periodontitis prevalence with panoramic radiographs in root canal treated teeth; they reported this rate as 40.5%, 40.5%, 53.5% and 67.9%, respectively. In another study conducted in Turkey, researchers evaluated 522 endodontically treated teeth with CBCT scans and found apical periodontitis in 45.6% of the root canal treated teeth (36). Our results agreed with these studies.

Cross-sectional research has been widely used to assess which factor is more influential on the success of treatment. Georgopoulou et al. (18) and Ray and Trope (17) claimed that the quality of the coronal restoration was a more significant factor than the quality of the root canal filling on the periapical tissues. Other studies (19, 24, 37) suggest that the quality of coronal restoration and quality of root canal filling have equal importance in periradicular health. However, most studies (7, 9, 15, 16, 35, 38) emphasize that endodontic treatment quality is more important than coronal restoration. In a cross-sectional study, Gomes et al. evaluated 1,290 root canal treated teeth with CBCT scans and observed that the quality of root canal treatment was the most important determinant of periapical health (39). In a recent study, Gambarini et al. (40) examined 1,011 endodontically treated teeth with CBCT scans and reported that the combination of both high-quality coronal restoration and root canal fillings increases the success of root canal treatment outcomes. However, they observed that the quality of the coronal restoration had a lesser impact on root canal treatment outcome than the quality of the root canal filling.

In our study, it appeared that the quality of the root canal filling was a more significant factor in the success of treatment than the quality of the coronal restoration. The ARCF/ICR group showed a significantly higher success rate than the IRCF/ACT group (Table 5). Therefore, the study's null hypothesis was rejected. Moreover, our study showed that if the root canal filling was inadequate, with either adequate or inadequate coronal restoration, the tooth would have a poorer prognosis than a tooth with ARCF. These results demonstrated that the quality of the root canal filling is the most important factor regarding the status of periapical tissues. Our findings are consistent with the previous studies.

The results of the present study demonstrated that the highest rate of healthy teeth was observed for cases with ARCF and ACR. A significant difference was observed when teeth with ARCF/ACR were compared with ARCF/ICR teeth in terms of a healthy teeth rate. Additionally, teeth with IRCF/ACR showed a higher success rate than teeth with IRCF/ICR. The difference between the two groups was also significant. These results showed that higher success rates were always observed in teeth with ACR. Our results are in agreement with the Tavares et al. (16) study that reported coronal restoration quality also influences periapical health.

Approximately 20% of the teeth with ARCF/ACR showed periapical radiolucencies. Some of these cases might have still been in the process of healing at the time of evaluation. The quality of coronal restoration and root canal filling are not the only factors to influence periapical health. Although cases are radiographically classified as adequate root canal filling or coronal restorations in this study, the radiographs might be misleading about whether a three-dimensional sealing was completed successfully (9). Furthermore, microorganisms are a major factor in endodontic failures, and the disinfection of the root canal cannot be observed radiographically (41-44). Cases with ARCF/ACR which are classified as diseased teeth in our study could be attributed to these factors.

Many factors have been associated with the long-term success of root canal treatment. Age, tooth type, rubber dam usage, presence of pre-operative periapical lesions, presence of mesial/ distal contacts and post-treatment type of coronal restoration may affect the outcome of endodontic treatment (45-48). Therefore, the survival of root canal treatment is multifactorial, and the results of our study may have been affected by these conditions. The success of root canal treatment is also related to the training of the provider. Alley et al. (49) found that root canal treatment performed by endodontists was 10% more successful than treatment performed by general dentists. Similarly, Burry et al. (50) observed that after 10 years molar teeth treated by endodontists have higher survival rates than molars treated by non-endodontists. One of the main possible reasons for this may be that general dentists do not in their routine treatments use most of the endodontic principles and techniques taught in dental schools. Another reason may be that general dentists do not stay up to date on the innovations in endodontics and do not improve themselves in this regard (51). It was also reported that the quality of the root canal fillings is related with higher professional standards and better technique, undergraduate and postgraduate training, and better equipment (36). The majority of root canal treatment in Turkey is performed by general dentists (52). For these reasons, the prevalence of apical periodontitis may be high in our study.

Using panoramic radiography instead of CBCT is a limitation of this study. Therefore, different results could be obtained if the evaluations were performed with CBCT scans in our study.

Conclusion

Within the limits of this study, the highest success rate was observed for cases with ARCF/ACR. The quality of root canal filling may be the most influential factor in treatment outcome, but the treatment success rate may also influenced by the quality of the coronal restoration.

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