Periradicular Status and Quality of Root Canal Fillings and Coronal Restorations in an Urban Colombian Population

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Abstract

Introduction: This cross-sectional study determined the prevalence of apical periodontitis in 1086 root canal–treated teeth from an urban Colombian population and evaluated the association of several factors with the periradicular status. **Methods:** Periapical radiographs were used for analyses, and teeth were classified as healthy or diseased according to the periradicular status. Other factors were also evaluated for their association with the periradicular conditions, including gender, quality of both endodontic treatment and coronal restoration, apical level of filling, and presence of post restoration. **Results:** Fifty-one percent of the treated teeth were classified as healthy. Only 33% of the teeth had endodontic treatment rated as adequate. The quality of both endodontic treatment and coronal restoration significantly influenced the periradicular conditions ($P < .001$). Combined data revealed that teeth with both adequate endodontic treatment and adequate restorations showed significantly better periradicular status than the other combinations ($P < .01$), except for teeth with adequate treatment and inadequate restoration ($P = .08$). Canals filled up to 0–2 mm short of the apex had a significantly higher number of teeth rated as healthy than overfilled or underfilled cases ($P = .02$). Regression analysis showed that the quality of endodontic treatment was the most significant factor influencing the periradicular status ($P < .001$). Gender and presence of post restoration had no association with the periradicular conditions. **Conclusions:** Data from this Colombian population showed a relatively high prevalence of apical periodontitis in root canal–treated teeth. This was largely due to an equally high prevalence of treatments performed under substandard technical quality. The quality of the endodontic treatment was the most determinant factor for healthy periradicular status. *(J Endod 2013;39:600–604)*

Key Words

Apical periodontitis, coronal restoration, cross-sectional study, endodontic treatment, root canal filling

Longitudinal studies of endodontic treatment outcome performed in university-based or teaching hospital–based settings have shown a very high rate (about 90%–95%) of teeth free of apical periodontitis after 2–5 years of follow-up (1–5). Nonetheless, cross-sectional studies performed in a large number of countries have revealed that the prevalence of apical periodontitis in root canal–treated teeth is relatively high, ranging from 30%–65% (6–11). A systematic review and meta-analysis of cross-sectional studies about the prevalence of apical periodontitis in different countries with high or very high human development indices showed that 36% of 28,881 root canal–treated teeth exhibited periradicular radiolucencies (12). If these teeth are categorized as treatment failures because of persistent or emergent disease, this picture becomes considerably alarming because it reflects the realistic outcome of the root canal treatment in the general population (13). Inadequate treatment is, however, a very frequent observation in most cross-sectional studies and has been regarded as one of the most important factors associated with poor outcome (9, 12, 14–16).

The large majority of cross-sectional studies evaluating the periradicular status of root canal–treated teeth have been performed in Europe, North America, and Asia (6, 7, 14–27). For countries located in the Southern Hemisphere, only limited information is available (9, 28). To the best of our knowledge, there are no studies evaluating the prevalence of apical periodontitis in root canal–treated teeth in Colombia. Therefore, this study was undertaken to assess the prevalence of apical periodontitis in root canal–treated teeth from an urban adult Colombian population and evaluate the association of several factors with the periradicular status of these teeth.

Materials and Methods

Study Population

The sample for this cross-sectional study consisted of 688 adult patients who consecutively presented for the first time seeking routine dental care at the Dental School, Santo Tomas University, Bucaramanga and Floridablanca, Colombia between 2003 and 2010. To be enrolled in the study, the patients had to possess a current full-mouth series of periapical radiographs. Periapical digital radiographs were taken by a dental radiologist who used the radiovisiography system CDR-DICOM (Computerized Dental Radiograph-Digital Imaging and Communications in Medicine; Schick Technologies, Long Island, NY). All root canal–treated teeth from these patients

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were included in the study, except for third molars whose radiographic images could not be conclusively analyzed.

Evaluation Criteria and Radiographic Analysis

The 1086 root canal–treated teeth included in this study were radiographically evaluated for the qualities of the root canal filling and the coronal restoration. The criteria used for evaluation were as described previously (14, 15).

Endodontic Treatment. For adequate treatment, all canals were obturated. No voids were present. Root canal fillings ended from 0–2 mm short of the radiographic apex.

For inadequate treatment, root canal filling ended more than 2 mm short of the radiographic apex or was grossly overfilled. Root canal filling with voids, inadequate density, unfilled canals, and/or poor condensation were also considered inadequate.

In multirooted teeth with similar periradicular status for all roots, the root with the worst treatment quality was used.

Coronal Restoration. Adequate restoration was regarded as any permanent restoration that appeared intact radiographically. Inadequate restoration was any permanent restoration with detectable radiographic signs of overhangs, open margins, or recurrent caries or presence of temporary coronal restoration. (Teeth with no coronal restorations, permanent or temporary, were also included in this group.)

Presence of posts was also recorded. Radiographs were analyzed on the computer screen in a darkened room, and the periradicular status was evaluated according to the criteria of Strindberg (1). Healthy periradicular condition was judged when both the contour and width of the periodontal ligament space were normal, or the periodontal ligament space contour was widened mainly around excess filling. Appearance of the surrounding bone was normal. Diseased teeth presented any discernible apical radiolucency (1, 29). Multirooted teeth were ranked according to the root with the worst evaluation.

Two observers were previously calibrated against a set of 100 reference teeth. Afterwards, they examined all the radiographs independently. Because agreement was moderate (Cohen kappa value = 0.45), a highly experienced endodontist served as the third observer for the cases where disagreement occurred.

TABLE 1. Distribution of Root Canal–treated Teeth According to the Tooth Group (n = 1086)

Covariate	N	%
Gender		
Female	457	66
Male	231	34
Quality of coronal restoration		
Adequate	433	40
Inadequate	480	44
Absent	173	16
Quality of endodontic treatment		
Adequate	360	33
Inadequate	726	67
Apical limit of filling		
0–2 mm short	568	52
>2 mm short	447	41
Overfilling	71	6.5
Post		
Yes	357	33
No	729	67
Periradicular status		
Healthy	555	51
Diseased	531	49

Statistical Analysis

Statistical analyses were performed by using the SPSS software (Statistical Package for the Social Sciences, version 17.0; IBM, Chicago, IL). Initially, a descriptive analysis was performed including the variable healthy treated tooth (dependent variable) and the covariates (independent variables) gender, quality of coronal restoration, quality of endodontic treatment, apical limit of obturation, and presence of post. Descriptive data were obtained as frequencies of the categories within each variable. The χ^2 test was applied to each covariate in relation to the periradicular status of treated teeth to look for significant associations ($P < .05$). A bivariate analysis was also performed to evaluate the combined effects of quality of coronal restoration and endodontic treatment. Next, unadjusted univariate logistic regression was applied between the dependent variable and the covariates to evaluate the association of each one with healthy periradicular conditions through calculation of odds ratio and 95% confidence interval. Finally, adjusted multivariate logistic regression was used to deduce the influence of each covariate on the periradicular conditions. This multiple analysis included only the variables that presented $P < .05$ in the previous analysis. The method used to insert the variables in the logistic model was the backward stepwise, which involved all variables chosen. Furthermore, these variables were gradually excluded until the final model was formed. A probability level of .05 was used as the criterion for statistical significance.

Results

Overall data are displayed in Table 1. Of the 1086 root canal–treated teeth included in this study, 457 (66%) were from female patients and 231 (34%) from male patients. Maxillary teeth corresponded to 77% of the teeth. Maxillary central incisors were the most frequently treated teeth, followed by maxillary premolars, maxillary lateral incisors, and mandibular molars (Table 2).

On the basis of the criteria of Strindberg (1), 555 teeth (51%) were classified as healthy and 531 (49%) as diseased. There was no significant difference in the periradicular status of root canal–treated teeth from male and female patients ($P = .23$). Only 33% of the teeth included in this study had endodontic treatment rated as adequate. Of these, 219 (61%) were ranked as healthy (Table 3). Of the 726 teeth (67%) rated as having inadequate endodontic treatment, only 336 (46%) were classified as healthy. A highly statistically significant difference was observed when comparing teeth with adequate and inadequate treatment ($P < .001$).

Of the 433 teeth (40%) that were found to have adequate coronal restorations, 249 (57.5%) were scored as healthy. The group with inadequate/absent restorations consisted of 653 teeth (60%), of which only 306 (47%) were healthy. Highly significant difference was observed when comparing treatment outcome for teeth with adequate and inadequate/absent restorations ($P < .001$).

Combined data of the quality of both endodontic treatment and coronal restoration were evaluated for periradicular status. The rate

TABLE 2. Distribution of Root Canal–treated Teeth According to the Tooth Group (n = 1086)

Tooth	Maxillary	Mandibular
Central incisor	293 (27%)	29 (3%)
Lateral incisor	152 (14%)	7 (0.6%)
Canine	78 (7%)	13 (1%)
Premolar	245 (23%)	79 (7%)
Molar	71 (6.5%)	119 (11%)
Total	839 (77%)	247 (23%)

TABLE 3. Periradicular Status of Root Canal–treated Teeth Relative to Diverse Factors

Covariate	Periradicular status		*P* value*
	Diseased N (%)	Healthy N (%)	
Gender			.23
Female	222 (49)	235 (51)	
Male	124 (54)	107 (46)	
Quality of coronal restoration			<.001†
Adequate	184 (42.5)	249 (57.5)	
Inadequate/absent	347 (53)	306 (47)	
Quality of endodontic treatment			<.001†
Adequate	141 (39)	219 (61)	
Inadequate	390 (54)	336 (46)	
Apical limit of filling			.007†
0–2 mm short	254 (45)	314 (55)	
>2 mm short	234 (52)	213 (48)	
Overfilling	43 (61)	28 (39)	
Post			.39
Yes	168 (47)	189 (53)	
No	363 (50)	366 (50)	
Combined endodontic treatment and coronal restoration			<.001†
Adequate treatment/adequate restoration	58 (34)	112 (66)	
Adequate treatment/inadequate restoration	83 (44)	107 (56)	
Inadequate treatment/adequate restoration	126 (48)	137 (52)	
Inadequate treatment/inadequate restoration	264 (57)	199 (43)	

*Chi-square test.

†Statistically significant.

of teeth categorized as healthy was 66% for cases with both adequate endodontic treatment and adequate restorations (Table 3). This condition showed significantly better outcome than the others ($P < .01$), except for teeth with adequate treatment and inadequate restoration (56% healthy, $P = .08$). Teeth with both inadequate treatment and inadequate restoration yielded the highest prevalence of disease (57%), which was significantly superior to the other conditions ($P < .05$). No significant difference was observed when comparing teeth with inadequate treatment/adequate restoration and adequate treatment/inadequate restoration ($P = .43$).

Regarding the apical limit of filling, the best results were observed for canals filled up to 0–2 mm short of the apex, with statistically significant superiority over teeth with overfillings or underfillings ($P = .02$). No significant differences were observed between the 2 latter conditions ($P = .24$).

In this study, 357 teeth (33%) were restored with a post. Of these, 189 (53%) were healthy. This showed no significant difference from teeth not restored with posts, half of which were healthy ($P = .39$).

The results of unadjusted (univariate model) and adjusted (multivariate model) logistic regressions are shown in Tables 4 and 5. In the former analysis, quality of the endodontic treatment, quality of the coronal restoration, and apical limit of filling were significantly associated with healthy periradicular status (Table 4). For the quality of endodontic treatment, the chance for adequately treated teeth to exhibit healthy conditions was 80% higher than for inadequate treatments ($P < .001$). For the apical limit of filling, significant association occurred for the category 0–2 mm short ($P = .01$). For the quality of coronal restoration, association was significant for the category adequate restoration ($P = .05$). In the multivariate analysis, only the covariates that exhibited significant associations in the univariate logistic model were included. Gradual exclusion of the variables through the backward stepwise approach led to maintenance of significant association for quality of the endodontic treatment.

TABLE 4. Univariate Logistic Regression for Association of Some Covariates with Periradicular Status

Covariate	β	Standard error	*P* value	Odds ratio (95% confidence interval)
Gender				
Female				1
Male	−0.2	0.16	.21	0.82 (0.59–1.12)
Quality of coronal restoration				
Absent				1
Inadequate	−0.09	0.18	.6	0.91 (0.64–1.29)
Adequate	0.36	0.18	.05*	1.43 (1.01–2.04)
Quality of endodontic treatment				
Inadequate				1
Adequate	0.59	0.13	<.001*	1.80 (1.39–2.33)
Apical limit of filling				
Overfilling				1
0–2 mm short	0.64	0.26	.01*	1.90 (1.15–3.14)
>2 mm short	0.34	0.26	.19	1.40 (0.84–2.33)
Post				
No				1
Yes	0.11	0.13	.39	1.12 (0.87–1.44)

*Statistically significant.

TABLE 5. Multivariate Logistic Regression for Association of Some Covariates with Periradicular Status

Covariate	β	Standard error	*P* value	Odds ratio (95% confidence interval)
Quality of coronal restoration				
Absent				1
Inadequate	−0.1	0.18	.56	0.9 (0.63–1.28)
Adequate	0.3	0.18	.09	1.35 (0.95–1.94)
Quality of endodontic treatment				
Inadequate				1
Adequate	0.55	0.13	.001*	1.74 (1.34–2.25)

*Statistically significant.

Accordingly, the chance for adequately treated teeth to exhibit healthy periradicular status was 74% higher than for teeth with inadequate root canal treatment ($P < .001$).

Discussion

The present study joins a series of other epidemiologic studies evaluating the periradicular status of root canal–treated teeth from several geographic locations and expands the information by including Colombia in this list. Previous information from South America has been limited to Brazil (9, 30). The overall prevalence of apical periodontitis in treated teeth was 49%, which is relatively high considering the potential for successful outcome of endodontic treatment, but it is still within the range reported by most previous cross-sectional studies performed in other countries (6–11, 22, 26).

About two-thirds of the treated teeth had root canals ranked as inadequate in quality. This high prevalence of inadequate treatment has been widely observed in other studies (9, 12, 14–16) and may be considered as the main factor responsible for such a high prevalence of post-treatment apical periodontitis. Actually, regression analysis showed that the quality of endodontic treatment was the most important factor influencing the status of the periradicular tissues.

In inadequately treated teeth, there is increased chance for persistence or emergence of intraradicular infection, which is the prime cause of post-treatment apical periodontitis (31). It is worth pointing out that the quality of treatment was inferred by the quality of filling as determined by radiographic analysis. Although teeth ranked as adequately treated showed significantly better status than inadequately treated teeth, the prevalence of apical periodontitis was still higher than expected (39%). This would translate into a success rate of 61%, which is far below the reported 90%–95% for university-based studies. The reason for this discrepancy is highly likely to be that many of the teeth categorized as adequately treated were not so in fact. This is because of the well-known limitations of radiographs to determine quality of endodontic treatment (32) and because teeth were ranked according to the quality of filling, with no information on the disinfection measures used.

Another factor that may exert some influence on the periradicular status is the quality of coronal restoration (33). In the present study, teeth with adequate coronal restorations had significantly better periradicular conditions than teeth with inadequate/absent restorations. The best outcome was observed for teeth with both adequate endodontic treatment and adequate coronal restoration, with a healthy rate significantly superior when compared with the other combinations, except for teeth with adequate treatment and inadequate/absent restoration. Therefore, the optimum outcome seems to depend on the tooth being adequately treated as a continuum, with both endodontic treatment and coronal restoration following acceptable standards. The role of coronal restoration in the continuum is certainly to help prevent reinfection, but restoration of occlusal function may also influence bone healing and remodeling after endodontic treatment.

Teeth with root canal fillings termini located at 0–2 mm from the root apex showed significantly better periradicular conditions than teeth with either overfillings or underfillings. This is in agreement with other studies showing that the closer the terminus of operative procedures is to the apical foramen (provided it is still intraradicularly), the better the outcome (5, 34). Indeed, finishing the treatment disinfection procedures as close to the foramen as possible increases the possibility of extending the disinfection procedures beyond the apical limit of infection (35).

One-third of the teeth examined in this study were restored with a post. Some studies have previously reported an increased prevalence of apical periodontitis for teeth restored with posts (23, 36). However, the present study is in consonance with many others that found no difference in the periradicular status of teeth with or without a post restoration (3, 15, 37–39). Thus, posts do not seem to influence the endodontic treatment outcome.

One should be aware that the cross-sectional nature of this study has the serious limitation that the design does not permit the evaluators to determine whether a disease is active or healing, and because of that these studies are ranked below longitudinal studies in the hierarchy of evidence level. However, cross-sectional evaluations stand as an important source of information because they permit analyses of the overall health state and the prevalence of both disease and treatment in a given population at a certain point in time. Although most longitudinal studies of endodontic treatment outcome are performed in universities or teaching hospitals, samples used in most cross-sectional studies come from general practice or community settings. Therefore, whereas the former study type provides information on the potential of successful outcome, the latter indicates the realistic scenario in the overall population. Data on the current situation of a given disease or the quality of treatment in a selected population may serve as a basis for establishment of intervention strategies and further improvements in provision of healthcare services. In addition, the cross-sectional design permits inclusion of a very large number of patients, which is difficult to achieve and control in longitudinal studies. Interpretation biases are potentially diluted in studies with large sample size.

It is also salient to point out that the use of radiographic analysis is conceivably of incomplete diagnostic value, especially for categorization of the quality of treatment and restoration and detection of apical periodontitis (32, 40). Cone-beam computed tomography has the potential to circumvent some of the limitations of radiographs, and its high sensitivity for detection of bone changes has comparatively disclosed a higher prevalence of apical periodontitis than radiographs (41–43). However, the latter still remains as the most common method used for routine diagnosis of apical periodontitis, and its use permits comparison with previous studies on this subject. In addition, for many countries, it is not yet possible to gather a large number of patients subjected to cone-beam computed tomography to compose a reasonable sample size for cross-sectional studies.

In conclusion, findings from this Colombian population regrettably agree with those from other countries to show that the prevalence of apical periodontitis is relatively high in root canal–treated teeth from the general population, and the main factor responsible for that is an equally high prevalence of treatments performed under substandard technical quality. Academics and authorities in the field of dentistry and endodontics should be aware of this worldwide problem, and a call for action is necessary. Some possible solutions have been suggested and include review of the curricular structure of undergraduate programs, research for developing user-friendly but still effective treatment techniques, or restricting provision of endodontic care to specialists (44). Obviously, all these require conscientization and extra funding, resources, and manpower. Moreover, the fact that this study confirms that teeth can be saved and maintained in healthy periradicular conditions provided that both endodontic and coronal restorations are of good quality indicates that efforts in that direction are surely worth expending.

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