

Periapical status and quality of root canal fillings and coronal restorations in a Greek population

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Objective: To investigate the quality of root canal fillings and coronal restorations in relation to periapical status in a Greek population. **Method and Materials:** A total of 320 patients who required full-mouth radiographic examination were included. The quality of root canal fillings and the periapical status, as well as the quality of coronal restorations, were assessed by radiographic criteria. Results were analyzed using random effects logistic regression models. **Results:** Root canals with adequate filling length had a lower incidence of apical periodontitis than root canals with inadequate filling length (51.7% versus 63.4%, $P = .002$). Root-filled canals with adequate coronal restorations showed a lower incidence of apical periodontitis than those with inadequate restorations (47.3% versus 67.4%, $P < .001$). When both root filling and coronal restoration were assessed, the incidence of apical periodontitis ranged from 39.2% to 67.6%. **Conclusion:** Quality of root canal treatment, as well as quality of coronal restoration, are strongly associated with the incidence of apical periodontitis. (*Quintessence Int* 2008;39:180.e85–92)

Key words: apical periodontitis, coronal restoration, epidemiologic study, Greek population, radiographic criteria, root canal filling

Several epidemiologic studies have reported a high prevalence of apical periodontitis (AP) associated with endodontically treated teeth, as well as an impact of the quality of root canal filling on the prognosis of root canal treatment. There is a consistent association in the cross-sectional studies between periapical radiolucency and root fillings of poor quality.¹ Poor quality of coronal restoration has been considered a possible additional pathway for bacterial penetration and apical infection, adding to the problems associated

with poor quality of the root filling itself. Although it is extensively documented from experimental studies that microbiologic infection represents the etiology of AP and controlled clinical studies show success rates of endodontic treatment of around 90%, dental treatment as it is performed in the societies investigated is not able to effectively prevent or cure AP.²

The aim of the present study was to investigate quality of root canal fillings and quality of coronal restorations in relation to periapical bone status in a Greek population.

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METHOD AND MATERIALS

The sample consisted of 320 randomly selected full-mouth series of periapical radiographs. The series of radiographs were collected from private dental offices in and around Athens from 1999 to 2001. In all cases, full-mouth periapical radiographic

examination was part of diagnostic and planning procedures. The exact conditions under which the radiographs were taken and processed were not known; however, the quality of radiographs was high, since in most cases, the patients had been referred to an experienced radiologist for radiographic examination.

Two observers, one experienced endodontist (M.G.) and one recently graduated general dentist (A.S.-V.) evaluated the radiographs under standardized conditions using a uniformly illuminated viewing box masked to obtain an illuminated area the same size as the radiograph to be read and a two-fold magnifier. Each radiograph was examined individually through a cardboard slit to block off the ambient light emanating from the viewing box. Apart from data pertaining to periapical status, presence of root canal filling, and presence of coronal restoration as discussed previously,³ further data about the quality of root canal fillings and the quality of coronal restorations was surveyed. Every root in multirooted teeth was assessed separately.

Seven full-mouth radiographic series (112 periapical radiographs) were assessed to calibrate the 2 examiners. Interexaminer agreement with regard to the classification of periapical status was determined by computing Cohen's kappa; the intraexaminer agreement with a 6-month interval was also determined. All kappa values were between 0.76 and 0.82. Because of the high interexaminer agreement, the teeth selected were scored on each occasion by one of the examiners. The data were then pooled.

The radiographic criteria for categorization were as follows:

Periapical status

- *Normal*: No periapical radiolucency and normal width of periodontal ligament space
- *Abnormal*: Distinct periapical radiolucency or break in the lamina dura continuity together with widening of the periodontal ligament space exceeding 2 times the normal width
- *Not evaluable*: Periapical status of at least 1 root (in multirooted teeth) not clear

Endodontically treated teeth

- *Pulpotomy*: Tooth with radiopaque material only in the pulp chamber
- *Root canal filling*: Tooth with radiopaque material in the root canal(s)
- *Surgically treated*: Tooth with apicoectomy or apicoectomy and retrograde filling

Length of the root filling

- Root filling terminating 0 to 2 mm from the radiographic apex
- Root filling terminating at least 2 mm from the radiographic apex
- Root filling extending beyond the radiographic apex
- Unfilled root canal in a treated multirooted tooth

Quality of root canal filling

- *Adequate*: Root fillings ending 0 to 2 mm from the radiographic apex
- *Inadequate*: All other length categories

The lateral seal was not evaluated in the present study.

Coronal status

- *Intact*: Intact tooth with no radiographic signs of caries or any restoration
- *Caries*: Tooth with caries without restoration
- *Intracoronary restoration*: Tooth with restoration, independent of the presence of caries
- *Extracoronary restoration*: Tooth with crown, independent of the presence of caries
- *No restoration*: Tooth with cavity or crown preparation but without any restoration

Quality of coronal restoration

- *Adequate restoration*: Intact restoration with good margin adaptation and no signs of recurrent caries
- *Inadequate restoration*: Restoration with overhangs, open margins, or recurrent caries; or no restoration at all

Combined categories of quality of root canal filling and quality of coronal restoration

- *Category A:* Both parameters scored adequately
- *Category B:* Both parameters scored inadequately
- *Category C:* Adequate root canal filling and inadequate coronal restoration
- *Category D:* Inadequate root canal filling and adequate coronal restoration

Coronal restoration was assessed for every tooth separately. In multirrooted teeth, each root was classified by the category of the tooth to which the root belonged.

Statistical evaluation of differences in proportions among groups was performed using random effects logistic regression models. These models are suitable for multivariate analysis and provide estimates of the magnitude of such differences via the odds ratio. The random effects model was used to take into account the hierarchical structure of the data, where teeth are clustered within subjects ($P < .05$).

RESULTS

Of the 7,664 teeth included in the study, 286 (3.7%) were excluded because the apex and periapical area of one or more roots in multirrooted teeth were not visible on the radiograph. The remaining 7,378 teeth had a total of 11,329 roots, of which 1,199 (10.6%) were endodontically treated. Of the endodontically treated roots, 706 (58.9%) were assessed with abnormal periapical status. The majority (96.7%) of the endodontically treated roots were root-filled, while only 2.1% of the treated roots were pulpotomized and 1.2% surgically treated.

Since the number of surgically treated and pulpotomized roots was low and quality of treatment in those categories could not be radiographically evaluated, these roots were excluded from further analysis.

Of the 1,159 root-filled canals, 132 (11.4%) roots were filled with silver points, 993 (85.7%) roots were filled with other materials that, in most cases, appeared to be gutta-percha, and the remaining 34 (2.9%) roots were

unfilled. The distribution of apical periodontitis among these groups was comparable, ranging from 58.1% in roots filled with gutta-percha-like material to 59.9% in roots filled with silver points and 64.7% in unfilled roots.

Most frequently, underfilled root canals were recorded (48.6%), while the percentage of overfilled canals was low (6.6%).

A total of 486 (41.9%) of the root fillings were assessed as adequate; 51.7% of these had abnormal periapical status. The remaining 58.1% of the root fillings were inadequate, and 63.4% had abnormal periapical status. The difference between these groups was statistically significant (adequate versus inadequate, $P = .002$; odds ratio, 0.61).

Of the total 11,329 roots included in this study, 72 roots (55 teeth) were excluded because of missing data about coronal status. The data related to coronal status of the remaining 11,257 roots were divided into 2 categories: good coronal status, including intact teeth or adequate restoration, and bad coronal status, including caries or inadequate restoration.

Of the total remaining roots, 2,926 (25.9%) were assessed as having bad coronal status. Of these roots, 34.2% exhibited AP, while only 9.4% of roots in the group with good coronal status had AP. A statistically significant difference between the 2 groups was found (good versus bad, $P < .001$; odds ratio, 0.19).

An adequate restoration was present in 60.2% of the roots with restorations, independent of being root-filled or not. Radiographic signs of AP were detected in 17.5% of roots with adequate restorations and in 38% of roots with inadequate restorations. The difference was statistically significant ($P < .001$).

When the coronal status only of teeth with root-filled canals was evaluated, of the 1,120 roots with available data, 611 (54.6%) roots had inadequate coronal restorations, of which 412 (67.4%) were associated with abnormal periapical status, while only 47.3% of root-filled canals with adequate coronal status were associated with AP. The prevalence of AP between adequate and inadequate coronal restorations in teeth with root-

Table 1 Prevalence of apical periodontitis in relation to quality of root filling and coronal restoration combined			
Combined categories	Normal	Abnormal	Total
A: Both parameters adequate	161 (60.8%)	104 (39.2%)	265 (23.7%)
B: Both parameters inadequate	130 (32.4%)	271 (67.6%)	401 (35.8%)
C: Adequate root filling and inadequate coronal restoration	69 (32.9%)	141 (67.1%)	210 (18.7%)
D: Inadequate root filling and adequate coronal restoration	107 (43.9%)	137 (56.1%)	244 (21.8%)
Total roots	467 (41.7%)	653 (58.3%)	1,120

Table 2 Odds ratio (OR) of prevalence of apical periodontitis in combined categories of quality of root filling and coronal restoration			
Combined categories	OR	P	95% Confidence interval
D / B	0.50	.002	0.32–0.78
C / B	1.16	.527	0.73–1.83
A / B	0.21	< .001	0.13–0.33
A / C	0.18	< .001	0.10–0.30
A / D	0.42	< .001	0.26–0.67

See Table 1 for explanation of categories.

filled canals was significantly different ($P < .001$; odds ratio, 0.31).

Finally, the combinations of quality of root filling and quality of coronal restoration were checked in relation to AP. Table 1 shows the possible combinations of quality of root filling and coronal restoration in relation to periapical status. Analysis by logistic regression identified that both quality of root treatment and quality of coronal restoration were significantly correlated with the presence of AP. These relationships remained significant after their adjustment to assimilate the potential interactions between variables.

As shown in Table 2, when both parameters are inadequate, improvement of the quality of coronal restoration would reduce the possibility of AP by 50% ($P = .002$). Improvement of the quality of root filling would not significantly affect the prevalence of AP ($P = .527$), whereas improvement of both parameters would reduce the possibility of AP by 79% ($P < .001$). In case of inadequate root canal filling and adequate coronal restoration, improvement of the quality of root filling would reduce the possibility of AP by 58% ($P < .001$).

DISCUSSION

This study is a subsequence of a cross-sectional study conducted in a Greek population.³ Sampling procedures, evaluation of radiographs, agreement of examiners, and statistical methods used in the present study have been described previously in detail. In the present study, quality of root canal treatment, as well as quality of coronal restoration, were evaluated in relation to periapical status.

The root, not the tooth, was assigned as the unit of evaluation and statistical analysis in this study. It seems that consideration of individual roots as the evaluated subjects, rather than whole teeth, facilitates comparison among studies.¹

Endodontic treatment

Pulpotomized and surgically treated roots were excluded from further evaluation because technical quality of treatment in these categories cannot be reliably determined by radiographic evaluation alone. The

percentage of such performed treatments was very low in the present sample, thus suggesting that root canal filling is the acceptable and most often performed endodontic procedure. Although there were no details available about the exact obturation technique used, the percentage of roots obturated with silver points could be radiographically recorded, indicating that silver points may still be adapted by some clinicians as the obturation material of choice in selected cases.

The technical standard of root canal fillings performed by Greek clinicians was poor, even though only length of root fillings was evaluated in the present study. Of the roots with inadequate root fillings, 427 were associated with AP. This means that at least 36.8% of the treated roots need to be retreated.

Several studies have reported the association of quality of root canal filling with periapical status.^{4–30} The criteria according to which a root filling is categorized as adequate or inadequate differ greatly among studies.²³ In most of the aforementioned studies, both length of the root filling and lateral seal are evaluated to assess quality of root filling, but in some of them,^{13,18,22,28} only length of root filling was evaluated. Agreement exists in the literature that the length of the root filling is an important factor in endodontic treatment success.^{26,31} However, there is still some disagreement about the effect of the homogeneity of the root filling on the periapical status.²⁶ On a radiograph, one can view only the proximal walls of the root canal, and, therefore, voids on the buccal and lingual walls would be missed. Because of that, the possibility of having false-negative readings in the assessment of voids in the obturations is considerable.¹⁴ With regard to these limitations, lateral seals were not evaluated in the present study.

In the present study, 58.1% of the root fillings were classified as inadequate, whereas the percentage of inadequate root fillings in the other studies ranged from 14%¹⁵ to 79.2%.²⁵ Due to methodological variations among different studies, it is difficult to directly compare percentages. Whenever possible from the given results, the percentages were calculated only considering length cate-

gories. Studies^{7,8,10,14,18} with similar methodology to the present study—that is, evaluation of periapical radiographs, the same categorization for length of root filling, and considering the root as the unit—were selected for further comparisons. The percentage of inadequate root fillings in these studies ranged from 32.1%¹⁴ to 58.6%,¹⁰ which is comparable to the present findings. In agreement with the present study, Saunders et al¹⁸ and Ödesjö et al¹⁰ concluded that there was a significant difference in the presence of periapical lesions between adequate and inadequate length categories, while Buckley and Spangberg¹⁴ found a statistically significant difference only between underfilled and overfilled root canals.

Coronal restoration

The quality of coronal status of the total sample could be roughly compared with the results of De Moor et al.²² The percentage of teeth associated with caries or coronal restoration with caries as detected on panoramic radiographs was 13.9% versus 26.0% on periapical radiographs in the present study. Apart from differences in oral health status in populations, the higher percentage in the present study can be justified by the higher sensitivity of periapical radiographs versus panoramic radiographs in detecting caries.³²

Quality of coronal restorations of root-treated teeth/roots in different populations is presented in Table 3. The percentage of inadequate coronal restorations of endodontically treated teeth ranges from 21.9%²⁶ to 80.6%.²¹ On the basis of the present data, the respective percentage (54.6%) was comparable. Despite differences in populations and methodologies, all investigators agree that the prevalence of AP is significantly related to the quality of coronal restoration of treated teeth.

Combinations of quality of root filling and coronal restoration

Previous studies^{16,23,24,26,29,30} evaluated quality of root canal filling combined with quality of coronal restoration to assess the impact on periapical health. The distribution of teeth/roots in different categories as revealed in different studies is presented in Table 4, and the

Table 3		Quality of coronal restoration of root-filled teeth/roots in different countries			
Country	Author	Total teeth (T)/ roots (R)	Inadequate/ RF (%)	Adequate with AP/Adequate (%)	Inadequate with AP/Inadequate (%)
Greece	Georgopoulou et al	1,120 R	54.6	47.3	67.4
Canada	Dugas et al, 2003 ²⁹	383 T	57.7	38.3	50.7
Belgium	Hommez et al, 2002 ²⁶	745 T	21.9	27.8	49.1
Norway	Tronstad et al, 2000 ²⁴	1,001 T	33.8	30.3	37.3
USA	Ray and Trope, 1995 ¹⁶	985.5 T	35.8	20.0	69.8
Denmark	Kirkevang et al, 2000 ²³	773 T	26.5	48.1	63.9
Lithuania	Sidaravicius et al, 1999 ²¹	320 T	80.6	31.1	36.8
Germany	Weiger et al, 1997 ¹⁹	215 T	34.4	—	—

(RF) Root filling; (AP) apical periodontitis.

Table 4		Distribution of teeth/roots in combined categories of quality of root filling with quality of coronal restoration in different countries				
Country	Author	Total teeth (T)/ roots (R)	Combined categories (%)			
			A	B	C	D
Greece	Georgopoulou et al	1,120 R	23.7	35.8	18.7	21.8
Canada	Dugas et al, 2003 ²⁹	383 T	18.3	37.1	20.6	24.0
Belgium	Hommez et al, 2002 ²⁶	745 T	28.4	16.0	5.9	49.7
Norway	Tronstad et al, 2000 ²⁴	1,001 T	36.3	19.6	14.2	29.9
USA	Ray and Trope, 1995 ¹⁶	985.5 T	33.5	19.1	16.7	30.7
Denmark	Kirkevang et al, 2000 ²³	773 T	19.9	8.9	—	—

See Table 1 for explanation of categories.

Table 5		Prevalence of apical periodontitis in combined categories of quality of root filling with quality of coronal restoration in different countries				
Country	Author	Total teeth (T)/ roots (R)	Combined categories (%)			
			A	B	C	D
Greece	Georgopoulou et al	1,120 R	39.2	67.6	67.1	56.1
Canada	Dugas et al, 2003 ²⁹	383 T	18.6	57.0	39.2	53.3
Belgium	Hommez et al, 2002 ²⁶	745 T	20.8	54.6	34.1	31.9
Norway	Tronstad et al, 2000 ²⁴	1,001 T	19.2	43.4	28.9	43.8
USA	Ray and Trope, 1995 ¹⁶	985.5 T	8.6	81.9	55.9	32.4
Denmark	Kirkevang et al, 2000 ²³	773 T	31.2	78.3	—	—

See Table 1 for explanation of categories.

prevalence of abnormal periapical status in different categories in Table 5. In the present study, both root filling and coronal restoration were inadequate (category B) for most roots (35.8%). This was the case in the Dugas et al²⁹ study, as well. On the contrary, Ray and Trope¹⁶ and Tronstad et al²⁴ assessed most teeth with both parameters adequate (category A), while Hommez et al²⁶ found that most teeth had inadequate root fillings and adequate coronal restoration (category D).

Tronstad et al²⁴ and Dugas et al²⁹ concluded that quality of root filling has a more decisive impact on the outcome of treatment than quality of restoration. Segura-Egea et al³⁰ demonstrated that quality of root filling affected significantly the periapical status, but quality of coronal restoration had no effect, while Hommez et al²⁶ found that both parameters are of equal importance. On the other hand, the present results are in agreement with Ray and Trope¹⁶ and suggest that quality of coronal restoration is significantly

more important than the technical quality of root filling for apical periodontal health. According to the present results, when both parameters are inadequate, improvement of root filling would not significantly affect the prevalence of AP. However, when interpreting these results, there are some alterations of the present study that must be kept in mind. First of all, the root, not the tooth was used as the unit of evaluation and statistical analysis, while in the other studies,^{16,23,24,26,29,30} the tooth was used as the unit. Furthermore, in all the aforementioned studies, the lateral seal was also evaluated in quality of root filling, which was not the case in the present study.

CONCLUSIONS

The results of the present study indicate poor technical standard of both root fillings and coronal restorations of root-treated teeth.

Within the constraints of this study, periapical health of root-treated roots depends on both quality of root filling and quality of coronal restoration. Quality of coronal restoration has a greater impact on periapical status.

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