Management of Apical Periodontitis: Healing of Post-treatment Periapical Lesions Present 1 Year after Endodontic Treatment

Ming-Ming Zhang, DDS,[*†] *Yu-Hong Liang, DDS, PhD,*[*‡] *Xue-Jun Gao, DDS, PhD,*[*] *Lan Jiang, DDS,*[*] *Luc van der Sluis, DDS, PhD,*[§] *and Min-Kai Wu, MSD, PhD*[*]

Abstract

Introduction: Post-treatment periapical lesions present 1 year after treatment may heal during the second year or later. The aim of this study was to assess second-year volumetric changes in post-treatment periapical radiolucencies detected 1 year after treatment. **Methods:** Post-treatment periapical radiolucencies were detected on cone-beam computed tomographic (CBCT) scans obtained from 93 single-rooted teeth 1 year after endodontic treatment. The outcome of these teeth was evaluated 2 years after treatment. Two examiners independently measured the volume of the radiolucencies on CBCT images twice. A Wilcoxon signed rank test was used to assess the 1- and 2-year post-treatment volumes. **Results:** The intraclass correlation coefficients for the CBCT volumetric measurements were 0.971 and 0.998 for the 2 examiners, and the interexaminer correlation coefficient was 0.998. Of the 93 teeth with post-treatment radiolucencies at 1 year, 61were examined at the second-year evaluation. The overall size of the radiolucencies significantly decreased during the second year (P = .01); the volume decreased in 38 teeth (63%), remained unchanged in 20 (33%), and increased in 2 (3%). **Conclusions:** The volume of post-treatment periapical radiolucencies detected 1 year after treatment was significantly reduced after the second year in 63% of teeth. *(J Endod 2015;41:1020–1025)*

Key Words

Cone-beam computed tomography, healing, post-treatment periapical lesions

From the *Department of Cariology and Endodontology, Peking University School and Hospital of Stomatology, Beijing, China; †National Engineering Laboratory for Digital and Material Technology of Stomatology, Peking University School and Hospital of Stomatology, Beijing, China; ‡Department of Stomatology, Peking University International Hospital, Beijing, China; and §Department of Dentistry and Oral Hygiene, University of Groningen, University Medical Center Groningen, Groningen, the Netherlands.

Address requests for reprints to Dr Yu-Hong Liang, Department of Cariology and Endodontology, Peking University School and Hospital of Stomatology, Beijing, China 100081. E-mail address: leungyuhong@sina.com

0099-2399/$ - see front matter

http://dx.doi.org/10.1016/j.joen.2015.02.019

Post-treatment periapical lesions present 1 year after treatment may heal during the second year. As reported by Ørstavik (1), the success rate of treatment, based on radiographic findings, increased from 44% in the first year to 72% in the second year. Therefore, the post-treatment periapical lesions present 1 year after treatment often do not need further treatment.

Several studies have shown that cone-beam computed tomographic (CBCT) imaging is more accurate than radiography for identifying periapical lesions (2, 3). Furthermore, the volume and volumetric changes of periapical bone lesions can be measured accurately with the help of CBCT scans and the Amira software program (Visage Imaging GmbH, Berlin, Germany) (4).

In 3 recently published studies, teeth with preoperative periapical radiolucencies that were diagnosed on CBCT scans were endodontically treated (5–7), and complete absence of periapical radiolucency 1 year after treatment, as determined by CBCT imaging, was observed in 48%, 19%, and 16% of the teeth in these 3 respective studies. Thus, in 52%–84% of the teeth, post-treatment periapical radiolucency was still present 1 year after treatment. Therefore, it is important to study the volumetric changes of post-treatment radiolucencies in the second year after treatment and beyond. The aim of this study was to assess the volumetric changes of post-treatment periapical radiolucencies detected 1 year after treatment.

Materials and Methods

The study protocol was approved by the Ethics Board of Peking University Health Science Center (no. PKUSSIRB-2013057). In the Department of Operative Dentistry and Endodontics of the Peking University School of Stomatology, Beijing, China, 162 single-rooted maxillary and mandibular incisors, canines, or premolars in 130 patients were endodontically treated between 2010 and 2011, including 105 teeth in 105 patients who had 1 treated tooth per patient and 57 teeth in 25 patients who had multiple treated teeth per patient. One year after treatment, 126 teeth were examined using CBCT scans to analyze the volume of the periapical lesions. Eighty-four of these 126 teeth were from patients who had 1 treated tooth per patient; the 1-year outcome of the 84 teeth was reported in 2013 (6). Forty-two of the 126 teeth were from the patients who had multiple treated teeth, which were not included in the study (6). In the present study, teeth in patients with either 1 or multiple treated teeth were included.

At the 1-year recall assessment, complete absence of periapical radiolucency was observed in 32 treated teeth, and endodontic surgery was performed on 1 tooth. These 33 teeth were excluded. The other 93 treated teeth (81 patients) with post-treatment periapical radiolucency at 1 year were scheduled for an appointment 2 years after the initial treatment (23–32 months), at which time a CBCT scan of the treated teeth was taken and the teeth were clinically tested for the presence of pain, swelling, sinus tracts, and tenderness to percussion.

A standard treatment protocol of shaping, cleaning, and obturation was followed and previously described (6). Briefly, each treated tooth was isolated with a rubber dam. A crown-down preparation technique was performed using nickel-titanium rotary instruments (Race; FKG Dentaire, La Chaux-de-Fonds, Switzerland; #40/.06, #35/.08, #25/.02, and #25/.04 until #25/.06 reached the working length). Apical enlargement

TABLE 1. Percentage of Decrease in the Volume of Periapical Lesions on Cone-beam Computed Tomographic Imaging of All Reviewed Teeth Preoperatively and at 1 and 2 Years

No.	Preoperative lesion volume (mm^3)	1-year lesion volume (mm^3)	2-year lesion volume (mm^3)	Percentage of decrease at 1 year (%)*	Percentage of decrease at 2 years (%)†
1	339.7	10.5	11.8	97	−13
2	323.1	1.7	0.0	99	100
3	231.2	44.4	30.3	81	32
4	215.2	17.7	0.0	92	100
5	201.8	11.3	10.3	94	9
6	181.5	94.3	5.6	48	94
7	179.2	31.0	33.0	83	−6
8	159.5	42.5	24.7	73	42
9	153.9	174.6	116.9	−13	33
10	139.8	19.3	12.6	86	34
11	135.9	20.1	8.9	85	56
12	128.0	15.5	11.9	88	23
13	127.1	18.4	2.4	86	87
14	115.3	12.6	11.2	89	11
15	111.6	164.0	248.0	−47	−51
16	105.5	18.0	14.1	83	22
17	100.4	18.5	11.9	82	36
18	67.5	3.6	0.9	95	76
19	66.0	5.3	0.0	92	100
20	63.9	10.6	8.5	83	20
21	62.9	34.7	36.0	45	−4
22	61.4	2.2	0.0	96	100
23	56.2	32.2	0.0	43	100
24	52.6	36.7	38.2	30	−4
25	47.9	19.3	0.0	60	100
26	47.0	8.5	0.0	82	100
27	45.4	9.9	4.3	78	56
28	37.5	22.1	11.4	41	48
29	36.6	11.0	11.6	70	−6
30	32.2	1.7	1.7	95	1
31	31.8	18.4	14.1	42	24
32	31.4	1.6	0.0	95	100
33	31.4	9.2	7.4	71	19
34	30.9	10.9	6.9	65	37
35	28.5	1.6	0.0	94	100
36	28.4	7.0	1.8	75	74
37	28.0	5.3	5.3	81	0
38	27.3	5.4	5.9	80	−10
39	26.8	23.9	19.2	11	19
40	26.6	4.9	2.4	82	50
41	22.1	2.8	2.0	87	29
42	20.0	4.1	4.0	79	3
43	19.3	19.7	15.6	−2	20
44	18.5	19.2	22.5	−4	−17
45	18.1	2.0	1.2	89	39
46	16.3	7.0	0.0	57	100
47	15.6	1.7	1.9	89	−11
48	15.6	9.2	10.4	41	−13
49	15.5	21.1	17.0	−36	19
50	14.7	3.4	1.8	77	46
51	12.6	4.6	3.5	64	23
52	12.1	14.6	12.8	−20	12
53	11.8	2.4	1.7	80	28
54	10.6	1.0	1.1	90	−5
55	10.5	1.4	0.0	86	100
56	8.4	6.3	0.0	25	100
57	7.8	4.5	5.7	43	−27
58	6.3	0.8	0.0	87	100
59	4.2	3.9	1.9	9	51
60	2.6	1.5	1.7	42	−12

*Percentage of decrease at 1 year (%) = (preoperative lesion volume − 1-year lesion volume)/preoperative lesion volume.

†Percentage of decrease at 2 years (%) = (1-year lesion volume − 2-year lesion volume)/1-year lesion volume.

was finished using S-Apex instruments (FKG Dentaire, La Chaux-de-Fonds, Switzerland) until #40. Irrigation was performed with 5.25% sodium hypochlorite solution after each file was used. Root canals were filled with gutta-percha cones and AH Plus sealer (Dentsply DeTrey GmbH, Konstanz, Germany) using a warm vertical compaction technique (2 in 1; VDW, München, Germany). The CBCT scans (preoperative and at recall) were acquired with a 3DX-Accuitomo scanner (J Morita Mfg Corp, Kyoto, Japan) using a 4×4-cm field of view selection,

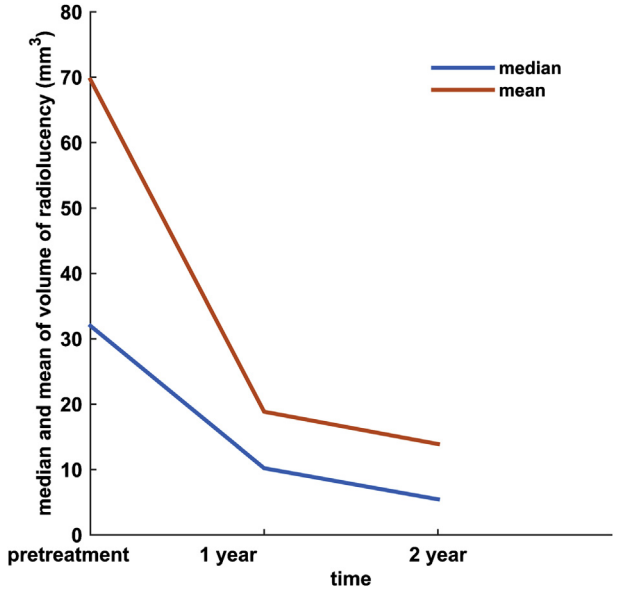

Figure 1. The median and mean volume of periapical radiolucencies showing a decrease in size during the 2-year observation period.

exposure parameters of 80 kVp, 4–5 mA, and 17.5 seconds. The CBCT data were reconstructed with the system's proprietary software.

Two examiners independently measured the volume of the radiolucencies twice on the CBCT scans in Digital Imaging and Communication in Medicine format with the Amira software (version 5.4.3, Visage Imaging GmbH). A periapical lesion was diagnosed when disruption of the lamina dura was detected and the radiolucency associated with the radiographic apex was at least twice the width of the periodontal ligament space (2, 8). A local threshold-determining algorithm (9) with manual tracing was used to plot out the border of the lesion and calculate the volume (3). When a periapical lesion was not diagnosed, the volume was recorded as 0 mm^3.

The volume of each radiolucency at the 2-year recall assessment was compared with that detected 1 year after treatment. The presence of a reduction or increase in volume was determined. Because it has been shown that the percentage of deviation in volumetric measurements with CBCT data is up to 18% (3, 10), the volumetric changes (reduction or increase) of less than 20% were categorized as "unchanged." At the recall examination, the presence of sinus tracts, pain, swelling, and tenderness to percussion were recorded.

Statistical Analysis

Statistical analyses were performed using SPSS software (version 16.0; SPSS Inc, Chicago, IL). The intraclass correlation coefficient (ICC) was used to test the inter- and intraobserver agreement of the volume measurements. The difference in volume of the periapical radiolucency present 1 and 2 years after treatment was analyzed with the Wilcoxon signed rank test. The level of significance was set at $\alpha = 0.05$.

Results

Of the 81 patients (93 teeth) with post-treatment periapical radiolucency at 1 year, 54 (61 teeth) returned for evaluation after the second year. The recall rate was 67% (54/81). One tooth had been extracted for restorative reasons, and 60 teeth were scanned using CBCT imaging. The data are summarized in Table 1.

Twenty-seven patients (32 teeth) dropped out of the study for the following reasons: 1 was deceased, 5 were pregnant, 12 had relocated and could not be reached, and the remaining 9 patients did not respond for unknown reasons.

The ICC values for the CBCT volumetric measurements were 0.971 and 0.998, respectively, for the 2 examiners, and the interexaminer ICC was 0.998. Compared with the volume of the radiolucencies at

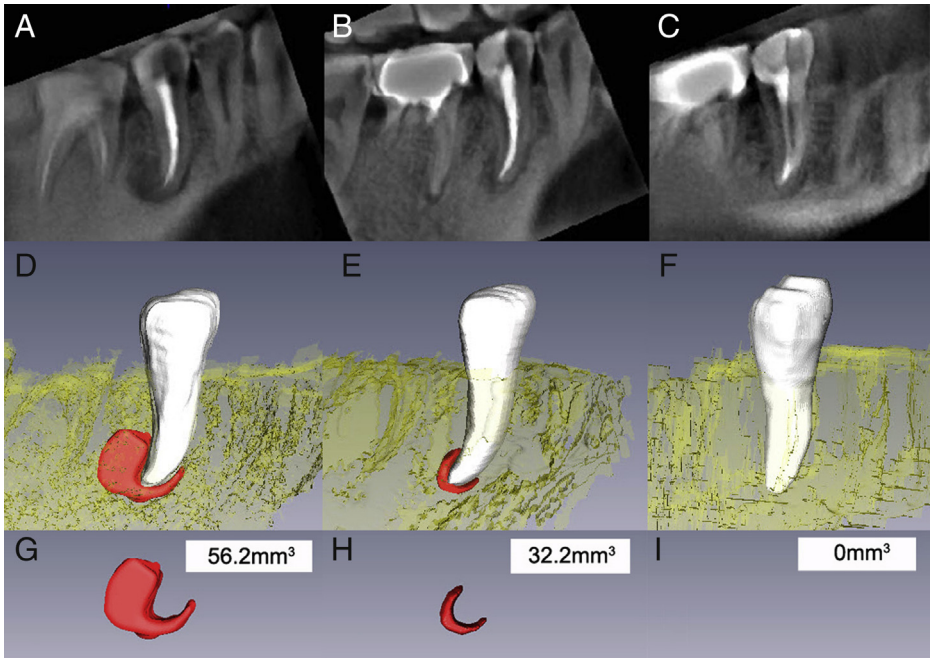

Figure 2. (*A–F*) Multiplanar and 3-dimensional reformatted CBCT images at (*A*, *D*, and *G*) the first visit, (*B*, *E*, and *H*) the 1-year follow-up visit, and (*C*, *F*, and *I*) the 2-year follow-up visit of 35. (*D–I*) The volume measurements of periapical lesions revealed a significant reduction in radiolucency during (*D* and *G*) the first visit, (*E* and *H*) the 1-year follow-up visit, and (*F* and *I*) the 2-year follow-up visit. (*C*, *F*, and *I*) The periapical lesion had completely resolved according to CBCT scans at 2 years after treatment.

the 1-year recall, the volume of the radiolucencies had significantly decreased at the second-year evaluation ($P = .01$) (Fig. 1).

At the second-year recall assessment, the volume of the radiolucencies reduced in 38 teeth (63%) (Table 1), including new complete resolution of the radiolucency in 13 teeth (22%) (Fig. 2*A–I*). In 35 of these 38 teeth, the radiolucencies already reduced 1 year after treatment and further reduced in volume 2 years after treatment; the overall decrease in size was less in the second year than in the first year (Figs. 1 and 3*A–L*). In 13 teeth, the lesion had reduced in size during the second year to less than 10% of the original lesion size. In 20 teeth (33%), the radiolucencies remained unchanged in volume (Fig. 4*A–I*). In 16 of these 20 teeth, the radiolucencies significantly reduced during the first year but remained unchanged at the second-year evaluation. In 2 teeth (3%), the volume of the radiolucencies had increased at the second-year evaluation.

The clinical examination showed that all 60 teeth were asymptomatic at the 2-year recall assessment. Eight teeth showed slight tenderness to percussion, of which 5 had a reduced lesion size and 3 were related to an unchanged lesion. One tooth had recurrent caries but no periapical lesion on CBCT imaging.

Discussion

The ALARA (as low as reasonably achievable) principle should be adhered to when using radiologic examination (11). CBCT scanning is a 3-dimensional imaging method, which is more accurate than periapical radiographs for assessing the periapical lesions and the outcome of treatment (2, 3, 6, 7, 12). In the present study, to reduce the patient dose to the greatest possible extent, the smallest field of view (4 × 4 cm) was selected, and a thyroid collar was used. Under the approval of the ethics board, informed consent was obtained from all patients.

Long-term outcome studies provide indispensable information on the dynamic changes of periapical lesions after endodontic treatment and the development of apical periodontitis (1). In particular, CBCT scans can accurately measure the volume of periapical bone lesions (3), which allows for the careful assessment of volumetric changes of periapical lesions after endodontic treatment (4, 6, 7). CBCT methods represent an improvement over standard 2-dimensional radiographs and provide information on the outcome of endodontic treatment that was previously unavailable (13). To our knowledge, no previous (prospective) clinical studies have compared the volume of periapical lesions, both 1 and 2 years after endodontic treatment, using CBCT analysis. In 2 previous studies, the complete absence of periapical radiolucency on CBCT scans was observed in 19% and 16% of teeth 1 year after treatment (6, 7). In the present study, 22% of the post-treatment periapical lesions that were present at the 1-year recall had completely resolved at the 2-year recall evaluation (Fig. 2). The overall percentage of teeth with complete absence of the periapical radiolucency after the second year was similar to that observed after the first year. Our findings are similar to those reported in a study by Ørstavik (1) in which the success rate at the 2-year recall was noticeably higher than at the 1-year recall.

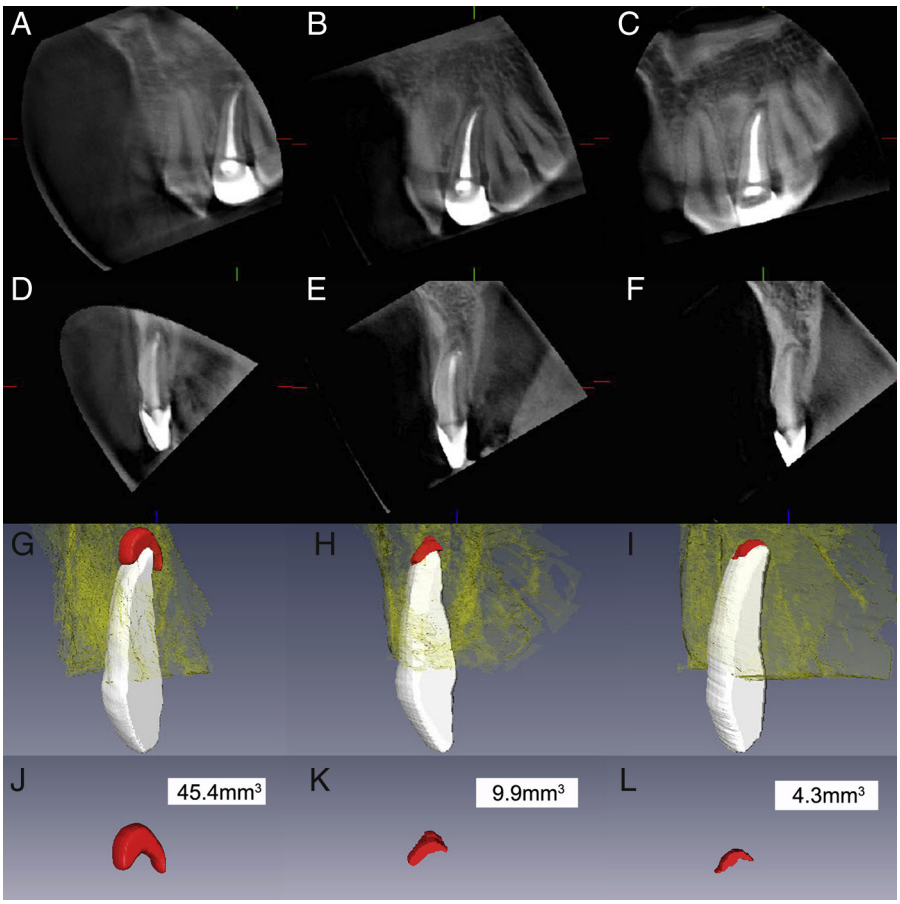

Figure 3. The volume measurements of periapical lesions obtained at preoperative assessment (*G* and *J*), the 1-year follow-up evaluation (*H* and *K*), and the 2-year follow-up evaluation (*I* and *L*). CBCT scans of 22 revealed a continuous, significant reduction in radiolucency. (*A–F*) Multiplanar and (*G–L*) 3-dimensional reformatted CBCT images at (*A*, *D*, *G*, and *J*) the first visit, (*B*, *E*, *H*, and *K*) the 1-year follow-up visit, and (*C*, *F*, *I*, and *L*) the 2-year follow-up visit.

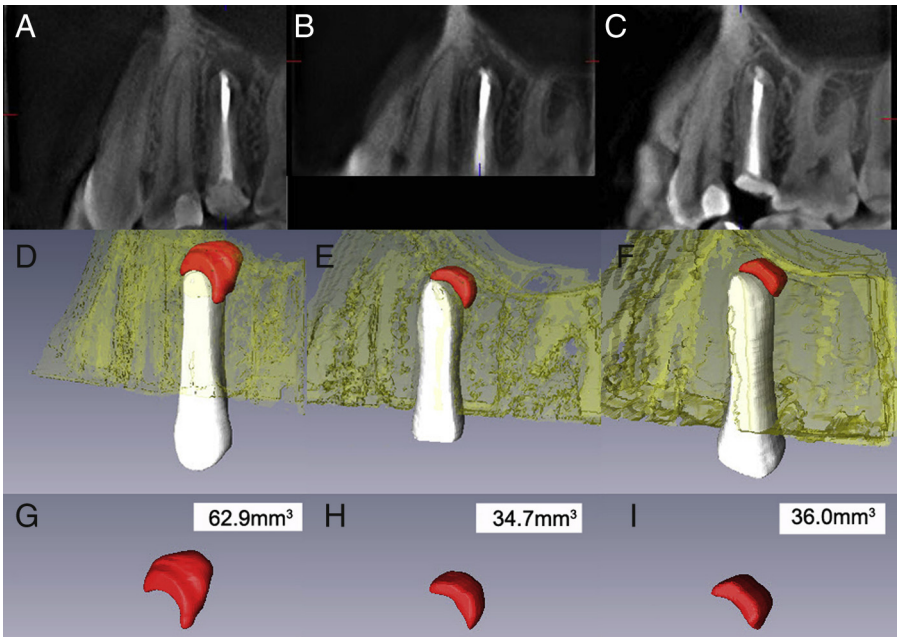

Figure 4. (*A–C*) Multiplanar and (*D–I*) 3-dimensional reformatted CBCT images at (*A*, *D*, and *G*) the first visit, (*B*, *E*, and *H*) the 1-year follow-up visit, and (*C*, *F*, and *I*) the 2-year follow-up visit of 15. (*D–I*) Volume measurements of the periapical lesions revealed a reduction in volume of the radiolucencies 1 year after treatment but no change in size 2 years after treatment.

The terms *success* and *failure* are commonly used in clinical endodontics although there is no consensus on whether *success* is defined as the absence of a periapical radiolucency, a decrease in the size of the periapical radiolucency, or periapical index scores of 1 and 2 (13, 14). In this study, the volume of each lesion was measured 1 and 2 years after treatment, and the volumetric change was calculated (Table 1). The aim of the present study was not to report the success rate at 2 years.

The 13 lesions that had completely resolved at the 2-year follow-up visit were already small at the 1-year follow-up visit, which indicates that the largest reduction in size took place during the first year (Fig. 1). In other periapical radiolucencies, which further reduced in the second year, the reduction speed was less in the second year than in the first year after treatment. Figure 3 shows an example of a case in which the volume decreased from 45.4 mm^3 to 9.9 mm^3 in the first year and from 9.9 mm^3 to 4.3 mm^3 during the second year; this finding may indicate that the initial "healing process" is the most effective.

Similarly, the radiolucencies in 16 teeth significantly decreased in size during the first year but remained unchanged thereafter, which indicates that the greatest decrease occurred immediately after treatment (Table 1) (Fig. 4). In 1 tooth, the volume of the radiolucency reduced by 43% during the first year but increased by 27% during the second year (Table 1). Indeed, regrowth of radiolucencies after complete resolution has been previously reported (15).

The presence of radiolucency on the CBCT scan is correlated with the level of inflammation (12, 16). The percentage of scar tissue of teeth with persistent apical radiolucencies diagnosed on the radiograph is approximately 2% (17, 18), and lesions that are detected on CBCT imaging are likely to be similar. The data presented here confirm that healing of the periapical pathology takes time and involves a dynamic and unpredictable process. This may be because healing depends on the reaction of the host immune system to the remaining biofilm in the root canal system or around the root apex (19, 20), and both are dynamic processes that can fluctuate over time. Complete eradication of the biofilm from the root canal system is impossible because of the intricate anatomy of the root canal, which includes many dentinal tubules (19, 21). Molander et al (22) previously showed that endodontically treated teeth without signs of periapical radiolucency also harbored microorganisms. Furthermore, because of the structure of biofilms, microorganisms can survive harsh environmental conditions (23). Over time, biofilms can regrow, and a renewed reaction of the host can cause reactivation of the inflammatory process. For this reason, it is perhaps more accurate to use the term *management of apical periodontitis* rather than *healing of apical periodontitis* because the term *management* implies follow-up and clinical intervention to prevent any adverse effects on systemic health. Clinically, successful management of apical periodontitis is indicated by complete or partial resolution of the preoperatively existing periapical radiolucency and the absence of symptoms and signs (14, 24).

The teeth treated in this clinical study had a single root canal with a root apex that was completely accessible by instruments and irrigants. The practitioners were also well trained and experienced endodontists. Therefore, the outcome of the endodontic treatments presented here is representative of the standard of care. If during the treatment of infected root canals the root canal anatomy is not completely accessible, the resulting success rate tends to decrease (25).

In previous outcome studies, the median recall rate was 52.7% (14). The recall rate in this study was 67%. The changes of the periapical radiolucencies of the dropouts were unknown, which may result in overestimated or underestimated outcome (5, 26).

The outcome of endodontic treatment could be influenced by the severity of the root infection (19) and the quality of the root filling (27, 28). According to the results of this study, we concluded that the volumes of post-treatment periapical radiolucencies detected 1 year after treatment in 63% of these teeth showed significant decreases in size during the second year, including complete resolution of the radiolucency in 13 teeth (22%). Thus, the healing of apical periodontitis is a dynamic process that takes time.

Acknowledgments

The authors deny any conflicts of interest related to this study.

References

1. Ørstavik D. Time-course and risk analyses of the development and healing of chronic apical periodontitis in man. Int Endod J 1996;29:150–5.
2. Patel S, Dawood A, Mannocci F, et al. Detection of periapical bone defects in human jaws using cone beam computed tomography and intraoral radiography. Int Endod J 2009;42:507–15.
3. Liang YH, Jiang L, Gao XJ, et al. Detection and measurement of artificial periapical lesions by cone-beam computed tomography. Int Endod J 2014;47:332–8.
4. Metska ME, Parsa A, Aartman IH, et al. Volumetric changes in apical radiolucencies of endodontically treated teeth assessed by cone-beam computed tomography 1 year after orthograde retreatment. J Endod 2013;39:1504–9.
5. Patel S, Wilson R, Dawood A, et al. The detection of periapical pathosis using digital periapical radiography and cone beam computed tomography—part 2: a 1-year post-treatment follow-up. Int Endod J 2012;45:711–23.
6. Liang YH, Jiang LM, Jiang L, et al. Radiographic healing after a root canal treatment performed in single-rooted teeth with and without ultrasonic activation of the irrigant: a randomized controlled trial. J Endod 2013;39:1218–25.
7. van der Borden WG, Wang X, Wu MK, Shemesh H. Area and 3-dimensional volumetric changes of periapical lesions after root canal treatments. J Endod 2013;39:1245–9.
8. Bornstein MM, Lauber R, Sendi P, von Arrx T. Comparison of periapical and limited cone-beam computed tomography in mandibular molars for analysis of anatomical landmarks before apical surgery. J Endod 2011;37:151–7.
9. Chang PC, Liang K, Lim JC, et al. A comparison of the thresholding strategies of micro-CT for periodontal bone loss: a pilot study. Dentomaxillofac Radiol 2013;42:1–12.
10. Kamburoğlu K, Kiliç C, Özen T, Horasan S. Accuracy of chemically created periapical lesion measurements using limited cone beam computed tomography. Dentomaxillofac Radiol 2010;39:95–9.
11. Farman AG. ALARA still applies. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;100:395–7.
12. Paula-Silva FW, Wu MK, Leonardo MR, et al. Accuracy of periapical radiography and cone-beam computed tomography scans in diagnosing apical periodontitis using histopathological findings as a gold standard. J Endod 2009;35:1009–12.
13. Wu MK, Shemesh H, Wesselink PR. Limitations of previously published systematic reviews evaluating the outcome of endodontic treatment. Int Endod J 2009;42:656–66.
14. Ng YL, Mann V, Rahbaran S, et al. Outcome of primary root canal treatment: systematic review of the literature—part 1. Effects of study characteristics on probability of success. Int Endod J 2007;40:921–39.
15. Haapasalo M, Udnaes T, Endal U. Persistent, recurrent, and acquired infection of the root canal system post-treatment. Endod Topics 2003;6:29–56.
16. Velvart P, Hecker H, Tillinger G. Detection of the apical lesion and mandibular canal in conventional radiography and computed tomography. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;92:682–8.
17. Bhaskar SN. Periapical lesions: types, incidence, and clinical features. Oral Surg Oral Med Oral Pathol 1966;21:657–71.
18. Love RM, Firth N. Histopathological profile of surgically removed persistent periapical radiolucent lesions of endodontic origin. Int Endod J 2009;42:198–202.
19. Haapasalo M, Shen Y, Ricucci D. Reasons for persistent and emerging post-treatment endodontic disease. Endod Topics 2011;18:31–50.
20. Wang J, Chen W, Jiang Y, Liang J. Imaging of extraradicular biofilm using combined scanning electron microscopy and stereomicroscopy. Microsc Res Tech 2013;76:979–83.
21. Nair PN, Henry S, Cano V, Vera J. Microbial status of apical root canal system of human mandibular first molars with primary apical periodontitis after 'one-visit' endodontic treatment. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005;99:231–52.
22. Molander A, Reit C, Dahlén G, Kvist T. Microbiological status of root-filled teeth with apical periodontitis. Int Endod J 1998;31:1–7.
23. Chávez de Paz L. Redefining the persistent infection in root canals: possible role of biofilm communities. J Endod 2007;33:652–62.
24. Wu MK, Wesselink P, Shemesh H. New terms for categorizing the outcome of root canal treatment. Int Endod J 2011;44:1079–80.
25. Gorni FG, Gagliani MM. The outcome of endodontic retreatment: a 2-yr follow-up. J Endod 2004;30:1–4.
26. Ørstavik D, Qvist V, Stoltze K. A multivariate analysis of the outcome of endodontic treatment. Eur J Oral Sci 2004;112:224–30.
27. Ng YL, Mann V, Rahbaran S, et al. Outcome of primary root canal treatment: systematic review of the literature—part 2. Influence of clinical factors. Int Endod J 2008;41:6–31.
28. Liang YH, Li G, Shemesh H, et al. The association between complete absence of post-treatment periapical lesion and quality of root canal filling. Clin Oral Investig 2012;16:1619–26.