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ORIGINAL ARTICLE

Influence of the coronal restoration on the outcome of endodontically treated teeth

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ABSTRACT

Objective: The tooth weakens due to removal of hard tissue during an endodontic procedure. Many dentists find it difficult to choose between different coronal restorations after root canal treatment (RCT). Studies show that the coronal restoration may affect the endodontic prognosis. This student-based study had three aims. (1) Examine the choice of coronal restoration of endodontically treated teeth at a Scandinavian dental school, (2) examine the survival of these restorations and (3) evaluate the influence of the coronal restoration on the outcome of the RCT.

Material and methods: Radiographic and clinical examination was performed on 127 posterior teeth. The quality of the root canal treatment and the periapical status (PAI-index) were evaluated.

Results: 43.8% of the teeth were restored with an indirect coronal restoration and 47.2% with a direct coronal restoration. The period from finished root canal treatment until placement of a permanent coronal restoration was significantly longer for an indirect restoration than a direct restoration. The teeth treated with a PAI score of 1 and 2 following pulpectomy, necrotic pulp treatment and endodontic retreatment was 93.8%, 82.6% and 69.4%, respectively.

Conclusion: There was no significant association between choice of coronal restoration and PAI-score.

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Introduction

The prognosis of root canal treatment (RCT) is influenced by several factors, among them are preoperative diagnoses and quality of the RCT [1]. Completion of the RCT is followed by placement of a coronal restoration (CR), which should prevent bacterial leakage and restore aesthetics and function [2]. Some studies find the quality of the CR as the most important factor regarding the outcome of RCT, while other studies show no correlation between these factors [3–8].

Coronal restorations are usually divided into direct and indirect restorations. Direct restorations consist of fillings placed in the patient's mouth during one single appointment. Indirect restorations are made outside the oral cavity, usually by a dental technician or by the dentist using CAD-CAM techniques. The preparation, impression and placement of the restorations normally require more than one appointment.

Studies have shown that endodontically treated teeth (ETT) have a higher risk of fractures than sound, unrestored teeth [9–11]. This may be due to the loss of tooth substance or due to dehydration of the remaining dentine as a consequence of devitalization of the tooth [12–14]. Placement of a cuspal covering restoration may reduce the risk of fractures [15–17], and this can be accomplished by both a cast or milled restoration or by a direct composite restoration. The preparation for a complete crown leads to a more extensive loss of tooth substance compared to placement of an adhesive restoration [18].

Previous studies have concluded that ETT should be restored with an indirect crown, while others have shown no difference between different types of CRs [19,20]. Due to the disconfirming results of several studies, there are still no official guidelines or consensus regarding the choice of CRs [21].

Thus, the aims of this study were to (1) examine the choice of CR of ETT at a Scandinavian dental school, (2) examine the survival of these restorations and (3) evaluate the influence of the CR on the outcome of the RCT.

The null-hypothesis (H0) was that the CR has no effect on the outcome of the RCT.

Methods

In this retrospective study, patients were recruited from the Department of Clinical Dentistry, University of Bergen, Norway. Patients who had received an RCT in the student clinic by undergraduate students from 2007 until 2010 were systematically identified and assessed according to the following criteria:

Inclusion criteria:

- Premolars and molars that had received RCT from 2007 until 2010.

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- Preoperative radiographs available.

Exclusion criteria:

- Insufficient personal information.
- Insufficient information regarding the current tooth.
- Patients that frequently did not make payments.
- Patients with a high frequency of not meeting to agreed appointments.
- Patients that had moved, died or for other reasons could not participate in the project.

Patients that met the inclusion criteria were offered an appointment for clinical and radiographic examination of the root canal treated tooth. Written consent to participate in the study was collected from each included patient.

In the period from 2007 until 2010, the main technique for root canal instrumentation at University of Bergen was hand-files, mainly Flexofiles and NiTi-flex. The students were also introduced to a machine-driven file system (ProTaper Universal System, Dentsply Sirona, Charlotte, NC). Rubberdam was used routinely. Irrigation for primary endodontic treatment was 0.5% buffered NaOCl and 17% EDTA. Obturation of the root canals was done by cold lateral condensation with gutta-percha master cones and a resin-based sealer, AH^{+} (Dentsply DeTrey GmbH, Konstanz, Germany).

Regarding indirect CRs, mainly porcelain-fused-to-metal crowns/abutments were used. Posts were mainly produced by a dental technician and made of a noble metal. Cementation was done with water-based cements such as zinc phosphate or glass ionomer cement.

Direct CRs were made of nano-hybrid composite materials by using a three-step total-etch adhesive technique. Moisture control was mainly accomplished using a rubber dam.

Clinical and radiographic examination

The CRs were divided into two groups: (1) indirect and (2) direct restorations.

The success of the CR was assessed by clinical inspection and screening of the patient's records. Success was defined as an intact, not revised or repaired, CR.

The quality of the RCT was scored using the criteria shown in Table 1 [4].

Apical pathology was assessed on pre- and postoperative intraoral radiographs. The assessment of the periapical pathology was performed using the periapical index (PAI) [22]. Before radiographic evaluation, the observers participated in a calibration course for the PAI-scoring distributed by the inventor of the index. The calibration material consisted of 100 radiographic images of teeth, some root-filled and some not. Each tooth had to be assigned to one of the five PAI-scores using visual references for the five categories within the scale. After scoring the teeth, the results were compared to a 'silver standard atlas'. A Cohen's Kappa was calculated for intra-observer and inter-observer values, and against the Silver-standard, according to Orstavik et al. [22]. The radiographic assessments were performed by two pre-calibrated observers (SS, HS), and in case of doubt or disagreement, an endodontist was consulted. The preoperative radiographs were taken analogously and therefore examined at a lightboard with loupes. The postoperative radiographs were taken with indirect sensors (Digora) and were examined digitally. In this study, teeth with PAI-score 1–2 were considered healthy and those with a score of 3–5 were considered diseased.

Statistical analysis

Statistical analyses were performed by using SPSS Version 22.0 (IBM Corporation, Armonk, NY). Frequency distributions and chi-square analysis were calculated with relevant values. The Mann–Whitney test was used for calculation of possible non-parametric significances.

Ethical considerations

The Regional Committee for Medical and Health Research Ethics (Rek-Vest) approved the protocol of this study (2014/1624).

Results

The Kappa values for the calibration of the observers were as follows: observers against the silver-standard: 0.68/0.71, intra-observer: 0.72/0.86 and inter-observer (between observer 1 and 2): 0.92.

Based on the inclusion criteria and patient consent, 127 out of 894 identified ETT were included in this study. There was an even distribution between premolars (47.2%) and molars (52.8%). In total, 87 individuals participated in the study (57.7% males). Figure 1 presents the process of exclusion and inclusion of teeth.

Mean age for the participants was 63 years (range 32–95 years) at control. The time from RCT to the examination in this study was calculated from the median date during the examination period. The mean observation time was 87 months (range 42–104 months).

The distribution of CR between the three major groups indirect (43.8%), direct (47.2%) and others (8.7%) is presented in Table 2.

Four teeth had been extracted due to failure during the observation period (two teeth with direct composite restorations, one with an indirect crown and one abutment tooth for a bridge).

The survival of the included CR is shown in Table 2. The indirect restorations had significantly higher survival rates, $p < .001$ than the direct restorations.

The mean treatment time from RCT to final CR was 158 days (0–723) for all examined teeth. For the failed restorations, the mean treatment time was 480 days (365–599), and for the teeth with periapical pathology (PAI-score between 3 and 5) at control 163.5 days (0–694). The total treatment time from RCT to final indirect restoration (229.2 days) was significantly longer than a direct CR (85.9 days), $p = .0001$.

Table 1. Criteria for density, adaptation and length of the root filling.

	Score	Criteria
Density and adaptation of the root filling	(A) Adequate	A smooth adherence to the walls of the root canal with no signs of airpockets, shortages of root filling material or other roughness
	(B) Inadequate	If the root filling did not fulfill criteria 'A', it was considered as criteria B
Length of the root filling	(A) Adequate	The root filling was between 0 and 2 mm from the radiological apex of the tooth
	(B) Short	The root filling was more than 2 mm coronal for the radiological apex of the tooth
	(C) Sealer surplus	Sealer surplus outside the radiological apex of the tooth
	(D) Overfilling	Root filling material (gutta-percha) apically for the radiological apex of the tooth

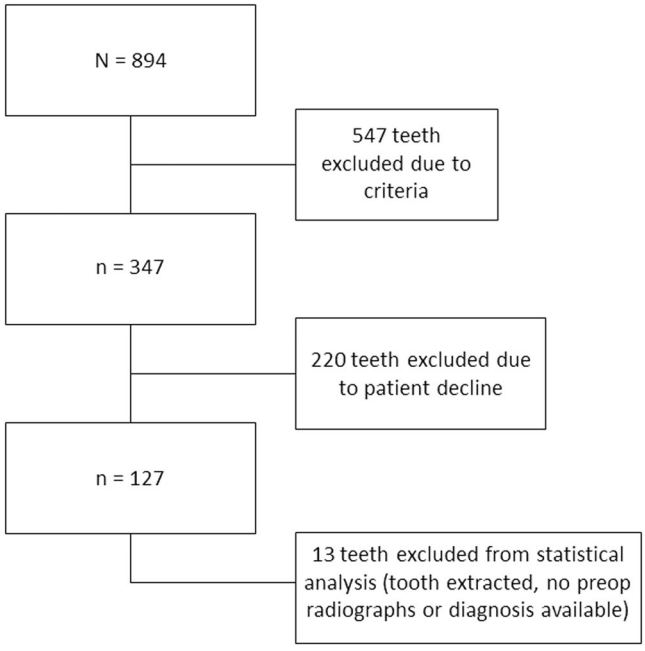

Figure 1. Flowchart showing the process of including and excluding teeth in the study.

Table 2. The distribution of the coronal restorations according to type of restoration and the survival of the coronal restorations during the observation period, $n = 127$.

Coronal restoration		*n*	%	Survival (*n*)	%
Indirect	PFM-crowna	15	11.8	14	93.3
	PFM-crown with post	25	19.7	22	88.0
	Gold crown	2	1.6	2	100.0
	Gold crown with post	1	0.8	1	100.0
	Tooth abutment	6	4.7	5	83.3
	Tooth abutment with post	7	5.5	7	100.0
Direct	Composite	44	34.6	29	65.9
	Composite with cuspal coverage	16	12.6	9	56.3
Other	GIC[b]	2	1.6	1	50.0
	Composite/crown[c]	5	3.9	3	60.0
	Combinations	1	0.8	0	0
	Missing coronal restoration	3	2.4	3	100.0
Total		127	100		100

[a]PFM-crown: porcelain-fused-to-metal crown.
[b]GIC: glass ionomer cement.
[c]Composite restoration placed in the access cavity after doing endodontic treatment through an existing crown.

No significant correlations were found between type of CR and PAI-score at control (Table 3). Further, there was no association between the type of CR, quality of endodontic treatment and the outcome of RCT (healthy being healthy and diseased being healthy versus healthy becoming diseased and diseased still diseased at control). However, there was a significant effect of endodontic treatment on the outcome measured by PAI-score, where retreatments showed the lowest healing rate (Table 3).

Table 4 shows a cross tabulation between pre-operative PAI-score and the PAI-score at last control. Number in bold face show the unchanged cases. For cases with a preoperative PAI-score of 1–2 (considered healthy), only one case ended up with a negative change to PAI score 3 at last control. Cases with a preoperative PAI-score of 3 showed improvement for 38 of 48 cases and only one case had a negative change (PAI-score 5) at last control. The group with a pre-operative PAI-score 4 showed improvement for 13 cases and two cases was unchanged. An interesting finding is that all six cases with pre-operative PAI-score 5 showed PAI-score 1 at final control.

Discussion

All Kappa values showed very good to excellent agreement [23–25]. PAI has been shown to give reliable data for both intra- and inter-observer examination [26].

This study did not identify patients with high caries risk, which might have affected the overall survival rate. Another possible bias includes situations where a patient had multiple ETT (29 of 87 patients had more than one ETT).

The study was based on radiographic and clinical examination of the ETT. Previous studies have mainly conducted a radiographic examination [6,8]. Hommez et al. found a weak correlation between the two examination methods, and argued that this might be due to the difficulty of determining a proof coronal seal from a two-dimensional radiographic image [4]. Dugas et al. argued that the most important aspect of the clinical examination was the ability to conduct an interview with the patients and therefore receive vital information about the course of the RCT and the years following the treatment [27]. This type of interview was also conducted in this study. By doing this, the authors were able to receive a more thorough and complete history of the patients' treatment. At the same time, this may have introduced possible misinformation.

The choice of CRs was evenly distributed among indirect and direct restorations. Among the indirect restorations, the majority was porcelain-fused-to-metal based restorations

Table 3. Coronal restorations and PAI-score at control, $n = 114$.

		PAI 1–2 (%)	PAI 3–5	*p* Value
Coronal restoration	Direct	42 (77.8)	12	.812
	Indirect	43 (86.0)	7	
	Other	8 (80.0)	2	
Endodontic treatment	Pulpectomy	30 (93.8)	2	.035
	Endodontic treatment of necrotic pulp	38 (82.6)	8	
	Retreatment[a]	25 (69.4)	11	
Length	Adequate	57 (83.8)	11	.452
	Inadequate	36 (78.3)	10	
Density	Adequate	60 (81.1)	14	.0852
	Inadequate	33 (82.5)	7	

[a]Retreatments – included both technical and pathological retreatments.

Table 4. Crosstabulation of pre-operative PAI-score and PAI-score at last control.

		PAI-score at last control					
		1	2	3	4	5	Total
Pre-operative PAI-score	1	**28**	1	1	0	0	30
	2	12	**3**	0	0	0	15
	3	31	6	**10**	0	1	48
	4	4	2	7	**2**	0	15
	5	6	0	0	0	**0**	6
Total		81	12	18	2	1	114

Bold face shows the number of unchanged teeth, and the dark blue columns shows improvement from pre-operative PAI-score to PAI-score at last control. The light blue shows number of teeth with negative changes.

(PFMs). Being an academic institution and an educational platform, a dental school must teach the students to use materials and techniques that are scientifically verified and clinically well-tested. This might lead to a conservative restorative approach, and could explain the fact that nearly all of the indirect restorations consisted of cast metal crowns or PFMs. At the same time, a recent study has shown that Norwegian dentists are traditional and conservative in their choice of restorative materials, and that PFMs are still widely used, especially in the posterior segment [28].

Endodontically retreated teeth were significantly more likely to receive an indirect CR. Although not verified in this study, this might be due to the fact that technical retreatments are often considered when planning placement of a post.

Indirect restorations were more likely to survive the observation period than direct restorations. The failures of the direct restorations consisted of both large, catastrophically failures leading to extraction and smaller fractures and defect that were easily repaired. This may challenge to question the definition of survival used in this study, where the major part of failures was repaired by simple and economically reasonable solutions. A systematic criteria system related to survival was not used in this study, mainly because of the retrospective design and lack of baseline data of the restorations. The review article of Stavropoulou and Koidis showed that 63% of direct restorations and 82% of indirect restorations survived a 10-year observation period [20]. These results correlate well to the findings of this study. An *in vitro* study by Xie et al. concluded that ETT restored with a crown (no posts) or an indirect onlay showed a higher fracture resistance compared with direct restorations [29]. The study also showed that fractures of an ETT treated with a cuspal covering CR (i.e. cast crowns, indirect onlays) were more likely unrepairable than fractures of non-cuspal covering restorations (i.e. direct fillings). The Cochrane review by Sequeira-Byron, included only one randomized study of 117 premolars [21], and the authors did not find any significant difference between direct and indirect restorations.

In the present study, cuspal covering composite restorations were more likely to have failed during the observation period than those without cuspal coverage. This is in contrast to results of other similar studies [16,17,29]. These studies based their results on a given preparation (i.e. 2 mm height reduction or 3.5 mm remaining height of the respective cusp). Many of the included restorations in this study had cuspal coverage replacing the total height of the cusps. This includes a large restoration with a small amount of remaining tooth substance. Studies have shown that the probability of fracture increases with increasing size of the composite restoration and decreasing amount of remaining tooth substance [30,31].

ETT restored with a direct restoration were more likely to have a higher PAI score than indirect restorations. Many of these teeth had an uncertain prognosis originally, and the decision regarding choice of restoration, could be explained by the lower costs of direct treatment. Frisk et al. used the same arguments to explain an increased probability of apical periodontitis in teeth restored with a composite or an amalgam filling, compared with an indirect solution [32]. This might show that dentists are more likely to use composites in cases where the periapical prognosis is uncertain.

The period from finished RCT to placement of a permanent CR was significantly longer for an indirect restoration than a direct restoration. Economic considerations may explain the need for longer observation time. Pratt et al. showed a decreased probability of tooth survival when the CR had been placed more than 4 months after the completion of the RCT[33]. There might also be a biased selection of cases as teeth with uncertain or poor prognosis of the endodontic treatment may not be referred for indirect restorations.

The PAI-scores of the different endodontic treatments are shown in Table 3. Sjögren et al. published a similar study in 1990, where 356 patients treated at the University of Umea were included [34]. The authors concluded that 96%, 86% and 62% of pulpectomies, necrotic treatments with apical pathology and retreatments with apical pathology were successful, respectively. The results are similar to those found in this study. Sjögren et al. used the Strindberg criteria to grade success of the endodontic treatment, while the PAI-score

was used in this study. Other studies used increased periodontal space and loss of lamina dura as definition of apical periodontitis, and might have led to an overregistration of apical pathology [35,36].

Table 3 shows a greater mean change regarding the PAI-score for treatment of a necrotic pulp and endodontically retreatment than pulpectomy. When treating pulpitis, radiographic changes preoperatively are uncommon [37]. A successful treatment will therefore not reduce the PAI-score, but rather stay unchanged. This explanation is emphasized in Table 3, where a larger proportion of teeth treated with a pulpectomy had no sign of periapical pathology (PAI 1–2) compared with teeth treated with an endodontic treatment of a necrotic pulp and endodontic retreatment. Some teeth diagnosed with pulpitis were given PAI-score 3. A possible explanation could be partial necrotic pulp tissue, where a root canal or the pulp tissue is partially necrotic and therefore give rise to periapical pathology.

There are some controversies regarding the impact of CR on the outcome of RCT. Some studies have shown that quality of the CR may have an effect on endodontic outcome [5,6,38,39]. On the other side, some authors show that adequate root canal fillings resist bacterial penetration even after long exposure to the oral cavity [40]. Although this study included a small number of teeth, the results support the latter.

In summary, the study showed an even distribution between the choice of indirect and direct CR of endodontically treated posterior teeth at a dental school. Indirect restorations were more likely to have survived the observation period. There was no significant association between choice of CR and PAI-score, hence our null-hypothesis could not be rejected. The period from finished RCT until placement of a permanent CR, was significantly longer for an indirect restoration than a direct restoration. Teeth treated with pulpectomy had a statistically significant lower PAI-score compared with endodontic treatment of necrotic pulp and endodontic retreatment at time of last control.

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References

[1] Ng YL, Mann V, Gulabivala K. A prospective study of the factors affecting outcomes of nonsurgical root canal treatment: part 1: periapical health. Int Endod J. 2011;44:583–609.
[2] Varlan C, Dimitriu B, Varlan V, et al. Current opinions concerning the restoration of endodontically treated teeth: basic principles. J Med Life. 2009;2:165–172.
[3] Kayahan MB, Malkondu O, Canpolat C, et al. Periapical health related to the type of coronal restorations and quality of root canal fillings in a Turkish subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2008;105:e58–e62.
[4] Hommez GM, Coppens CR, De Moor RJ. Periapical health related to the quality of coronal restorations and root fillings. Int Endod J. 2002;35:680–689.
[5] Kirkevang LL, Orstavik D, Horsted-Bindslev P, et al. Periapical status and quality of root fillings and coronal restorations in a Danish population. Int Endod J. 2000;33:509–515.
[6] Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J. 1995;28:12–18.
[7] Sidaravicius B, Aleksejuniene J, Eriksen HM. Endodontic treatment and prevalence of apical periodontitis in an adult population of Vilnius. Dent Traumatol. 1999;15:210.
[8] Tronstad L, Asbjørnsen K, Doving L, et al. Influence of coronal restorations on the periapical health of endodontically treated teeth. Endod Dent Traumatol. 2000;16:218–221.
[9] Adolphi G, Zehnder M, Bachmann LM, et al. Direct resin composite restorations in vital versus root-filled posterior teeth: a controlled comparative long-term follow-up. Oper Dent. 2007;32:437–442.
[10] Pierrisnard L, Bohin F, Renault P, et al. Corono-radicular reconstruction of pulpless teeth: a mechanical study using finite element analysis. J Prosthet Dent. 2002;88:442–448.
[11] Vire DE. Failure of endodontically treated teeth: classification and evaluation. J Endod. 1991;17:338–342.
[12] Helfer AR, Melnick S, Schilder H. Determination of the moisture content of vital and pulpless teeth. Oral Surg Oral Med Oral Pathol. 1972;34:661–670.
[13] Gutmann JL. The dentin–root complex: anatomic and biologic considerations in restoring endodontically treated teeth. J Prosthet Dent. 1992;67:458–467.
[14] Sornkul E, Stannard JG. Strength of roots before and after endodontic treatment and restoration. J Endod. 1992;18:440–443.
[15] Sørensen JA, Martinoff JT. Intracoronal reinforcement and coronal coverage: a study of endodontically treated teeth. J Prosthet Dent. 1984;51:780–784.
[16] ElAyouti A, Serry MI, Geis-Gerstorfer J, et al. Influence of cusp coverage on the fracture resistance of premolars with endodontic access cavities. Int Endod J. 2011;44:543–549.
[17] Mondelli RFL, Ishikiriama SK, de Oliveira O, et al. Fracture resistance of weakened teeth restored with condensable resin with and without cusp coverage. J Appl Oral Sci. 2009;17:161–165.
[18] Edelhoff D, Sorensen JA. Tooth structure removal associated with various preparation designs for posterior teeth. Int J Periodontics Restorative Dent. 2002;22:241–249.
[19] Mannocci F, Bertelli E, Sherriff M, et al. Three-year clinical comparison of survival of endodontically treated teeth restored with either full cast coverage or with direct composite restoration. J Prosthet Dent. 2002;88:297–301.
[20] Stavropoulou AF, Koidis PT. A systematic review of single crowns on endodontically treated teeth. J Dent. 2007;35:761–767.
[21] Sequeira-Byron P, Fedorowicz Z, Carter B, et al. Single crowns versus conventional fillings for the restoration of root-filled teeth. Cochrane Database Syst Rev. 2015;9:CD009109.
[22] Orstavik D, Kerekes K, Eriksen HM. The periapical index: a scoring system for radiographic assessment of apical periodontitis. Dent Traumatol. 1986;2:20–34.

[23] Hunt RJ. Percent agreement, Pearson's correlation, and kappa as measures of inter-examiner reliability. J Dent Res. 1986;65: 128–130.
[24] Valachovic RW, Douglass CW, Berkey CS, et al. Examiner reliability in dental radiography. J Dent Res. 1986;65:432–436.
[25] Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics. 1977;33:159–174.
[26] Orstavik D. Reliability of the periapical index scoring system. Scand J Dent Res. 1988;96:108–111.
[27] Dugas NN, Lawrence HP, Teplitsky PE, et al. Periapical health and treatment quality assessment of root-filled teeth in two Canadian populations. Int Endod J. 2003;36:181–192.
[28] Laegreid T, Gjerdet NR, Johansson A, et al. Clinical decision making on extensive molar restorations. Oper Dent. 2014;39:E231–E240.
[29] Xie KX, Wang XY, Gao XJ, et al. Fracture resistance of root filled premolar teeth restored with direct composite resin with or without cusp coverage. Int Endod J. 2012;45:524–529.
[30] Van Nieuwenhuysen JP, D'Hoore W, Carvalho J, et al. Long-term evaluation of extensive restorations in permanent teeth. J Dent. 2003;31:395–405.
[31] Opdam NJM, Bronkhorst EM, Roeters JM, et al. A retrospective clinical study on longevity of posterior composite and amalgam restorations. Dent Mater. 2007;23:2–8.
[32] Frisk F, Hugosson A, Kvist T. Is apical periodontitis in root filled teeth associated with the type of restoration? Acta Odontol Scand. 2015;73:169–175.
[33] Pratt, I, Aminoshariae, A, Montagnese, T A, et al. Eight-year retrospective study of the critical time lapse between root canal Ccmpletion and crown placement: Its influence on the survival of endodontically treated teeth. J Endod. 2016;42:1598–1603.
[34] Sjögren U, Hagglund B, Sundqvist G, et al. Factors affecting the long-term results of endodontic treatment. J Endod. 1990;16:498–504.
[35] De Cleen MJ, Schuurs AH, Wesselink PR, et al. Periapical status and prevalence of endodontic treatment in an adult Dutch population. Int Endod J. 1993;26:112–119.
[36] Buckley M, Spangberg L. The prevalence and technical quality of endodontic treatment in an American subpopulation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995;79:92–100.
[37] Abbott PV, Yu C. A clinical classification of the status of the pulp and the root canal system. Aust Dent J. 2007;52:17–31.
[38] Kalender A, Orhan K, Aksoy U, et al. Influence of the quality of endodontic treatment and coronal restorations on the prevalence of apical periodontitis in a Turkish Cypriot population. Med Princ Pract. 2013;22:173–177.
[39] Kielbassa AM, Frank W, Madaus T. Radiologic assessment of quality of root canal fillings and periapical status in an Austrian subpopulation – an observational study. PLoS One. 2017;12: e0176724.
[40] Ricucci D, Bergenholtz G. Bacterial status in root-filled teeth exposed to the oral environment by loss of restoration and fracture or caries—a histobacteriological study of treated cases. Int Endod J. 2003;36:787–802.