Coronal Restoration as a Predictor of Periapical Disease in Non-Endodontically Treated Teeth

Koronarna restauracija kao predskazatelj periapikalne bolesti u endodontski neliječenim zubima

Introduction

Apical periodontitis (AP) is a common inflammatory disease affecting periapical tissues due to microbial infection of root canals. The incidence of AP varies greatly among countries considering the differences in sampling methods and diagnostic criteria (1). A study on the prevalence of AP in Croatian adults reported the presence of periapical disease in 8.5% of the examined teeth (2). Several risk indicators specific for the occurrence of AP have been identified. A significantly increased risk for the presence of AP was reported for teeth restored with coronal fillings or crowns, teeth with primary caries, endodontically treated teeth, and molars (3). A longitudinal epidemiologic study reported an association of

Uvod

Apikalni parodontitis (AP) česta je upalna bolest koja za-hvaća periapikalna tkiva, a nastaje zbog mikrobine infekcije korijenskih kanala. Njegova se incidencija uvelike razlikuje između zemalja zbog različitih metoda uzorkovanja i dijagno-stičkih kriterija (1). U istraživanju u kojemu su autori istraživali pojavnost AP-a na uzorku odraslih Hrvata, utvrđena je periapikalna bolest na 8,5 % pregledanih zuba (2). Prepoznato je nekoliko rizičnih čimbenika specifičnih za pojavu AP-a. Značajno povećani rizik za tu bolest imali su zubi opskrbljeni koronarnim ispunima ili krunicama, zubi s primarnim karijesom, endodontski liječeni zubi i kutnjaci (3). U longitudinalnoj epidemiološkoj studiji uočena je povezanost AP-a
periapically diseased non-endodontically treated teeth with the presence of coronal restoration of poor quality or carious lesion (4). However, limited data on the association of AP and type of coronal restoration in non-endodontically treated teeth are available.

Despite recommendations for a global phase-down, amalgam is still widely applied material for restoration of posterior teeth in certain countries due to its low cost and effectiveness (Minamata Convention on Mercury). In Croatia, amalgam is mostly utilized in dental settings because it provides dental care through the health insurance system. Alternatively, resin composite restorations require highly demanding adhesive procedure that can be challenging in oral environment. Furthermore, polymerization shrinkage, stress, debonding and marginal leakage as the main causes of adhesive restorations failure can lead to pulpal breakdown, and subsequently to AP (5). Low-quality evidence suggested a higher failure rate in resin composite restorations and an increased risk of recurrent caries in contrast to amalgam restorations (6). An in vitro study found that microleakage was significantly higher in composite than amalgam restorations (7). A cross-sectional study conducted in Sweden hypothesized that teeth restored with composite resin restorations exhibit AP more frequently than teeth restored with amalgam restorations, yet no significant differences in the frequency of periapical pathology regarding these materials were found (8).

Several studies reported higher prevalence rates of AP in teeth restored with crowns (8, 9). However, long-term follow-up studies reported low incidence of radiographically detectable periapical lesions in crowned teeth (10, 11). A study investigating factors related to pulpal breakdown in vital teeth restored with metal-ceramic crowns suggested a significantly higher survival of the pulp vitality in single crowned teeth than in teeth that served as abutments of a fixed bridge (12).

The hypothesis for the present study was that the periapical status of non-endodontically treated teeth does not vary with regards to the type of permanent coronal restorations. The purpose was to compare the frequency of AP in non-endodontically treated teeth restored with full coverage crowns, amalgam and resin composite fillings, as well as to disclose the association of type and quality of coronal restoration with the presence of AP.

Material and methods

This cross-sectional study received ethical approval from the Institutional Ethical Committee (003-05/13-01/03). The sample that formed the basis for the study consisted of 1072 patients older than 18 years, who attended Dental Clinic of the Clinical Hospital Centre, Rijeka, Croatia for the first time and who presented consecutively within two years. The patients were not included if they refused to participate, had seven or less remaining teeth, received endodontic therapy within two years, and were unwilling or unable to attend the radiographic diagnostics. The implementation of these criteria provided the sample of 597 subjects (Figure 1). All participants accepted to take part by signing an informed consent.

Material i metode

Ovo presječno istraživanje odobrilo je lokalno etičko po- veterenstvo (003-05/13-01/03). Uzorak se sastojao od 1072 pacijenta starija od 18 godina koji su, u razdoblju od dvije godine, prvi put posjetili Kliniku za dentalnu medicinu Kli- ničkoga bolničkog centra Rijeka. Pacijenti nisu bili uključeni u istraživanje ako su odbili sudjelovati, imali su sedam ili manje preostalih zuba, bili su podvrgnuti endodontskom liječenju u prethodne dvije godine te su odbili radiološku dijagno- stiku ili su joj bili u nemogućnosti pristupiti. Primjenom tih kriterija dobiven je uzorak od 597 ispitanika (slanka 1.). Svi su potpisišali informirani pristanak. Istraživanje je provedeno u skladu sa načelima Helsinške deklaracije Svjetskoga medicin-
Figure 1 Flowchart demonstrating patient enrollment in the study
Slika 1. Dijagram koji pokazuje uključivanje pacijenata u istraživanje
Figure 2 Flowchart demonstrating teeth enrollment in the analysis of apical periodontitis presence regarding the type of restoration
Slika 2. Dijagram koji pokazuje uključivanje zuba u analizi prisutnosti apikalnog parodontitisa s obzirom na vrstu restauracije
The study was conducted in accordance with the World Medical Association Declaration of Helsinki principles.

Data were collected by means of a clinical and radiographic survey. The radiographic survey included digital panoramic radiographs and 4 bitewings (revealing the distal surface of canine to mesial surface of the last molar). Panoramic images were obtained utilizing a panoramic digital radiography device (J. Morita Corporation, Veraviewepocs 6716, Kyoto, Japan) with exposure parameters following the manufacturer’s recommendation depending on the patient’s size and weight (70 - 90 kV, 10-15 mA, and 14 s of exposure). Images were processed using software (Mediadent V4, Image Level, Nieuwerkerkenwaas, Belgium). Bitewings were taken using an X-ray unit (Trophy Elitys, Trophy Radiologie, Marne-la-Vallee, France) and an intraoral sensor (One, Owandy Radiology, Roslyn, NY, USA). The exposure parameters used were 60 kV, 7 mA and 0.32 s. Panoramic and bitewing images were analyzed on a 19-inch liquid crystal monitor (P1914S; Dell, Austin, TX, USA; resolution:1,280 x 1,024 32-bit color; graphic card: HD Graphic; Intel, Santa Clara, CA, USA).

The following data were recorded for all present teeth, apart from third molars and impacted teeth: coronal status (intact tooth, primary caries, temporary restoration, permanent restoration), the presence of endodontic treatment and periapical status. For diagnosis of dental caries, the WHO diagnostic thresholds were used (World Health Organization 1997; 13). The total number of teeth present in the sample was 14,852. The analyses of AP presence regarding the quality and type of coronal restoration were performed on 5,298 permanently restored non-endodontically treated teeth. All endodontically treated teeth and 8,063 non-endodontically treated teeth (intact teeth, teeth with primary caries or temporary restoration) were omitted from further analysis (Figure 2).

Assessment of restorations

Using the recordings from clinical examination and interpretation of radiographic images (panoramic radiographs and bitewings), following data for all non-endodontically treated teeth with permanent restorations were noted: type (filling or crown), material (amalgam or resin composite) and quality of restoration according to clinical and radiological criteria for marginal integrity and recurrent caries presence. The clinical quality of coronal restorations was evaluated in accordance with modified United States Public Health Service/Ryge (USPHS/Ryge) criteria for marginal integrity and recurrent caries as reported by Merdad et al. (14). Radiographically, marginal integrity of the restoration was defined as adequate (radiographically sealed) or inadequate (signs of open margins or overhangs) according to previously described criteria (15). Recurrent caries was noted as absent or present (clearly visible reduction in mineral content of a proximal tooth surface contiguous with a restoration; 16).

Assessment of periapical status and marginal bone loss

Analysis of the marginal bone loss and periapical status was accomplished using digital panoramic radiographs. The loss of the marginal bone was designated as less or more than skog uduženja (engl. World Medical Association Declaration of Helsinki principles).

Podatci su prikupljeni kliničkim i radiološkim pregledom. Radiološki pregled obuhvaćao je analizu digitalne panoramske snimke i četiri snimke s ugrizom u traku (područja od distalne plohe očnjaka do mežijalne plohe zadnjeg kutnjaka). Panoramske snimke izrađene su s pomoću uređaja za digitalnu radiografiju (J. Morita Corporation, Veraviewepocs 6716, Kyoto, Japan). Parametri izloženosti prilagođeni su prema uputama proizvodaca s obzirom na veličinu i težinu pacijenta (70 – 90 kV, 10 – 15 mA i 14 s izloženosti). Snimke su obradene u računalnom programu (Mediadent V4, Image Level, Nieuwerkerkenwaas, Belgija). Iz izradi snimki s ugrizom u traku korišten je rendgenski uređaj (Trophy Elitys, Trophy Radiologie, Marne-la-Vallee, Francuska) s intraoralnim senzorom (One, Owandy Radiology, Roslyn, NY, SAD). Primijenjeni parametri izlaganja bili su 60 kV, 7 mA i 0,32 s. Rendgenske snimke analizirane su na 19-inčnom monitoru na temelju tehnologije tekućih kristala (P1914S; Dell, Austin, TX, SAD; rezolucija:1,280 x 1,024 32-bit boja; grafička kartica: HD Graphic; Intel, Santa Clara, CA, SAD).

Osim impaktiranih zuba i trećih kutnjaka pregledani su svi zubi te su zabilježeni sljedeći podaci: koronarni status (intaktni zub, primarni karijes, privremena restauracija, trajna restauracija), endodontsko liječenje i periapikalni status. U dijagnozi dentalnog karijesa korišteni su dijagnostički kriteriji Svjetske zdravstvene organizacije (SZO 1997.; 13). Ukupan broj pregledanih zuba u ovom istraživanju bio je 14 852. Kod 5,298 trajno restauriranih endodontski neliješenih zuba analizirana je prisutnost AP-a s obzirom na kvalitet i vrstu koronarnih restauracija. Svi endodontski liječeni zubi te 8,063 neliješena zuba (koji su bili intaktni, imali primarni karijes ili privremenu restauraciju) isključeni su iz daljnje analize (slika 2.).

Procjena restauracija

Kliničkim i radiološkim pregledom prikupljeni su sljedeći podaci za sve endodontski neliješene trajno restaurirane zube: vrsta (ispun ili krunica), materijal (amalgam ili kompozit) i kvaliteta restauracije s obzirom na kliničke i radiološke kriterije marginalnog integriteta i pojave rekurentnog karijesa. Klinički je kvalитет koronarnih restauracije procijenjena prema modificiranim Rygovevim USPHS kriterijima (engl. United States Public Health Service) za rubnu cjelovitost restauracije i rekurentni karijes (14). Radiološki je rubna cjelovitost restauracije definirana prema već opisanim kriterijima kao odgovarajuća (radiološki vidljivo brtvljenje rubova) ili neodgovarajuća (radiološki vidljivi otvoreni rubovi restauracije ili previs) (15). Rekurentni karijes zabilježen je kao odsutan ili prisutan (jasno vidljivo smanjenje mineralnog sadržaja aproksimalne površine zuba u dodiru s restauracijom; 16).

Procjena periapikalnog statusa i gubitka marginalne kosti

Gubitak marginalne kosti i periapikalni status određeni su analizom digitalnih panoramskih snimki. Određen je kao gubitak više ili manje od trećine dužine korištena (9). Peria-
one third of the root length (9). The periapical status was analyzed using the periapical index system (PAI; 17). Each tooth was scored using visual references for the full-scale PAI. To define the periapical status in multirooted teeth, the highest PAI value of all roots was used. The full-scale scores were dichotomized, and periapical status was registered as healthy (PAI scores 1 and 2) or AP (PAI scores 3, 4 and 5).

Calibration procedures

The PAI calibration was accomplished by evaluation of periapical status in 100 reference teeth (17). After each tooth was given one of the five PAI scores, a comparison to gold standard scores was made, and a Cohen’s Kappa was calculated (0.70). Calibrations for diagnosis of dental caries, coronal restoration quality and marginal bone loss were performed according to WHO recommendations (13). Diagnostic intra-examiner agreement was analyzed by double scoring of the 30 randomly selected individuals’ clinical and radiographic surveys. Intra-examiner agreement was determined by calculating Cohen's Kappa for clinical and radiographic diagnosis of recurrent caries (0.85 and 0.92, respectively), clinical and radiographic assessment of marginal integrity (0.81 and 0.85, respectively), PAI (0.75) and marginal bone loss (0.89).

Statistical analysis

For statistical analysis, a software (Statistica 13.0, Statsoft, Tulsa, OK, USA) was used, at level of statistical significance P<0.05. To test data for distribution normality Lilliefors test was used. As the distribution of data was not normal, medi-

*p<0.05. To test data for distribution normality Lilliefors test, at level of statistical significance (Tulsa, OK, USA) was used, at level of statistical significance P<0.05. To test data for distribution normality (13). Diagnostic intra-examiner agreement was analyzed by double scoring of the 30 randomly selected individuals’ clinical and radiographic surveys. Intra-examiner agreement was determined by calculating Cohen's Kappa for clinical and radiographic diagnosis of recurrent caries (0.85 and 0.92, respectively), clinical and radiographic assessment of marginal integrity (0.81 and 0.85, respectively), PAI (0.75) and marginal bone loss (0.89).

Table 1

| Type of restoration | Vrsta restauracije |
|---------------------|---------------------|
| Amalgam filling     | Amalžamski ispun     |
| Composite resin filling | Kompozitni smolasti ispun |
| Crown               | Krunica              |

| Marginal integrity of restoration (clinically and radiographically) | Rubna cjelovitost restauracije (klinički i radiološki) |
|---------------------------------------------------------------------|--------------------------------------------------------|
| Adequate                | Njega, nema defektnih rubova restauracije              |
| Inadequate              | Defektivne margin, Defektivan rubov restauracije       |

| Recurrent caries (clinically and radiographically) | Rekurentni karijes (klinički i radiološki) |
|----------------------------------------------------|--------------------------------------------|
| No        | Nema vidljivih karijesa u dodiru s restauracijom  |
| Yes       | Vidljiv karijes u dodiru s restauracijom         |

| Tooth type | Grupa zuba |
|------------|------------|
| Incisors and canines | Sjekutići i očnjaci |
| Premolars     | Pretkutnjaci |
| Molars        | Kutnjaci |

| Marginal bone loss (radiographically) | Gubitak marginalne kosti (radiološki) |
|---------------------------------------|---------------------------------------|
| No Marginal bone loss                 | Nema gubitak marginalne kosti         |
| Marginal bone loss                    | Gubitak marginalne kosti              |

*First category was used as reference category • Prva kategorija korištena je kao referentna kategorija
analysis was used to assess the effect of explanatory tooth-specific variables (type of restoration, marginal integrity, recurrent caries, tooth type and marginal bone loss) on periapical status. All explanatory variables are provided in table 1. The outcome variable was defined as the presence versus absence of AP in the tooth.

**Results**

The final sample involved 190 male (31.8%) and 407 female participants (68.2%). The median age of participant was 34 years (interquartile range 24 - 46). No difference in age was detected regarding participants’ sex (Mann-Whitney U test; P=0.534). The median number of remaining teeth ranged from 27 in the youngest age group to 22 in the oldest age group. On the average, an examined individual had 1 non-endodontically treated tooth with AP (interquartile range 0-1). The presence of AP in 1 or more non-endodontically treated teeth was recorded in 54.3% of the examined participants (Table 2). AP was diagnosed in 286 (5.4%) permanently restored non-endodontically treated teeth. The frequency of AP in relation to restoration and restoration quality were calculated in the examined population (Table 3).

Ukupan uzorak činilo je 190 muškaraca (31,8 %) i 407 žena (68,2 %). Medijan dobi sudionika iznosio je 34 (interkvartilni raspon 24 – 46). Nije uočena razlika u godinama sudionika s obzirom na spol (Mann-Whitneyjev U-test; P = 0,534). Medijan broja preostalih zuba bio je u rasponu od 27 u najmlađoj dobi, do 22 zuba u najstarijoj. U projektu su ispitanici imali jedan endodontski neliječeni zub s AP-om (interkvartilni raspon 0 – 1). Kod 54,3 % ispitanika uočen je AP na jednom ili više endodontski neliječenih zuba (tablica 2.).

AP je dijagnosticiran na 286 (5,4 %) trajno restauriranih endodontski neliječenih zuba. U tablici 3. prikazana je učestalost AP-a s obzirom na vrstu i kvalitetu koronarne restauracije.
lation to the type and quality of coronal restorations is demonstrated in Table 3. A significant difference in the prevalence of teeth with AP according to the type of coronal restoration was present ($\chi^2=35.344, P<0.001$). The frequency of AP in teeth restored with crowns was significantly higher than in the teeth restored with amalgam (12.0% vs 5.1%; P<0.001) or those restored with composite fillings (12.0% vs 4.8%; P<0.001). If the overall quality of restoration was adequate, there were no significant differences in the proportion of AP with regards to type of coronal restoration ($\chi^2=5.000, P=0.082$; Table 3).

Table 4 demonstrates the distribution of teeth with AP in relation to the tooth group, quality and type of coronal restoration. Significant differences in the proportion of teeth diagnosed with AP regardless of the quality of coronal restoration were detected in the group of premolars ($\chi^2=12.872; P=0.002$) and molars ($\chi^2=34.468; P<0.001$). In the premolar group, AP was more commonly detected in crowned teeth than in teeth restored with amalgam (13.4% vs 4.3%; P=0.002) or composite fillings (13.4% vs 5.9%; P=0.003). Molars restored with crowns were also more often diagnosed with AP than molars restored with amalgam (19.0 vs 5.4%; P<0.001) or composite fillings (19.0 vs 4.1%; P<0.001). However, only the group of premolars demonstrated significant differences regarding the type of coronal restoration ($\chi^2=19.786; P<0.001$) in teeth with adequate quality of coronal restoration. AP was more common in premolars restored with crowns, than those restored with amalgam or composite fillings (11.9% vs 1.9% and 3%, respectively; both P<0.001; Table 4).

Uočena je značajna razlika u učestalosti zuba s AP-om s obzirom na vrstu koronarne restauracije ($\chi^2=35,344, P<0.001$). AP je bio češći u zubima koji su restaurirani krunicama u usporedbi s amalgamskim (12,0% vs. 5,1%; P<0,001) ili kompozitnim ispunima (12,0% vs. 4,8%; P<0,001). Ako je kvaliteta restauracije bila primjerena, nije pro- nađena značajna razlika u učestalosti AP-a s obzirom na vrstu koronarne restauracije ($\chi^2=5,000, P=0,082$; tablica 3.).

U tablici 4. prikazana je raspodjela zuba s AP-om u odno- su prema skupini zuba, kvaliteti i vrsti koronarne restauracije. U grupi pretkutnjaka ($\chi^2=12,872; P=0,002$) i kutnjaka ($\chi^2=34,468; P<0,001$) utvrđena je značajna razlika u udje- lu zuba s dijagnozo AP-a neovisno o kvaliteti koronarne re- stauracije. U grupi pretkutnjaka AP je češće otkriven u zubi- ma restauriranim krunicama negoli u onima restauriranim amalgamskim (13,4 vs. 4,3; P = 0,002) ili kompozitnim is- punima (13,4 vs. 5,9; P = 0,003). Grupa kutnjaka također je imala češću dijagnozu AP-a u zubima restauriranim kruni- cama u usporedbi s amalgamskim (19,0 vs. 5,4; P<0,001) ili kompozitnim ispunima (19,0 vs. 4,1; P<0,001). No u slu- čaju koronarne restauracije primjerene kvalitete, samo je u grupi pretkutnjaka uočena značajna razlika s obzirom na vr- stu koronarne restauracije ($\chi^2 = 19,786; P<0,001$). AP je bio češći u pretkutnjacima opskrbljenima krunicama u usporedbi s amalgamskim ili kompozitnim ispunima (11,9 % vs 1,9 %, odnosno 3 %; oba P < 0,001; tablica 4.).

U tablici 5. su rezultati multivarijantne logističke regresijske analize sa svim opisnim varijablama uključenima u mo-

| Table 4 | Type and quality of coronal restoration in relation to AP and tooth type Tablica 4. Vrsta i kvaliteta koronarne restauracije s obzirom na AP i vrstu zuba |
|-----------------------------------------------|
| **Incisors and canines** • Sjekutići i očnjaci | **Amalgam** | 5 0 (0) | $\chi^2=477,777$ P=0.092† | 5 0 (0) | 540 30 (5.6) | $\chi^2=23,388$ P=0.001* |
| **Composite** • Kompozit | 1024 45 (4.4) | 484 15 (3.1) | 50 (0.0) | 65 15 (23.3) |
| **Crown** • Krunica | 186 15 (8.1) | 121 0 (0) | 605 45 (7.4) |
| **Total** • Ukupno | 1215 60 (4.9) | 610 15 (2.5) |
| **Pre molars • Pretkutnjaci** | **Amalgam** | 323 14 (4.3) | $\chi^2=12.872$ P=0.002* | 213 4 (1.9) | 110 10 (9.1) | $\chi^2=2.046$ P=0.360† |
| **Composite** • Kompozit | 1179 70 (5.9) | 674 20 (3.0) | 505 50 (9.9) |
| **Crown** • Krunica | 119 16 (13.4) ‡ | 84 10 (11.9) ‡ | 35 6 (17.1) |
| **Total** • Ukupno | 1621 100 (6.2) | 971 34 (3.5) | 650 66 (10.2) |
| **Molars • Kutnjaci** | **Amalgam** | 1035 56 (5.4) | $\chi^2=34.468$ P=0.001* | 550 10 (1.8) | 485 46 (9.5) | $\chi^2=29.324$ P=0.001* |
| **Composite** • Kompozit | 1348 55 (4.1) | 745 5 (0.7) | 594 50 (8.4) |
| **Crown** • Krunica | 79 15 (19.0) ‡ | 34 0 (0) | 45 15 (33.3) ‡ |
| **Total** • Ukupno | 2462 126 (5.1) | 1338 15 (1.1) | 1124 111 (9.9) |

*Significant differences in frequency of teeth with AP according to type of coronal restoration • Značajne razlike u učestalosti zuba s AP-om s obzirom na vrstu koronarne restauracije
†No significant difference in frequency of teeth with AP according to type of coronal restoration • Nema značajne razlike u učestalosti zuba s AP-om s obzirom na vrstu koronarne restauracije
‡Significant differences vs both other types of coronal restoration • Značajne razlike vs. obje druge vrste koronarne restauracije
Table 5 demonstrates the results of a multivariate logistic regression analysis with all considered explanatory variables included in the model. A significant positive association was found between the outcome variable, AP and crowns (OR = 3.39; 95% CI 2.181 to 5.269; P < 0.001), recurrent caries (OR = 4.67; 95% CI 2.8 to 7.8; P < 0.001) and premolars (OR = 1.73; 95%CI 1.2-2.4; P = 0.002; Table 4). The highest association was determined for the presence of recurrent caries. Conversely, it was found that teeth with inadequate marginal integrity of restorations have a slightly increased, but not statistically significant risk for AP presence than teeth with an adequate marginal integrity. Marginal bone loss >1/3 root length was not statistically associated with an increased risk of AP presence (Table 5).

Discussion

As in previously conducted surveys (18, 26), the present study sample was mainly composed of female subjects (68.2%). The median number of remaining teeth in the study sample was 26 (interquartile range 24-28), which is also comparable to the previous research (8). Periapical disease was diagnosed in 5.4% of permanently restored non-endodontically treated teeth. Of the 597 examined participants, 54.3% had AP in one or more non-endodontically treated teeth. A high prevalence of AP may be attributable to the sampling method. It was found that teeth with inadequate marginal integrity of restorations have a slightly increased, but not statistically significant risk for AP presence than teeth with an adequate marginal integrity. Marginal bone loss >1/3 root length was not statistically associated with an increased risk of AP presence (Table 5).

Rasprava

Kao i u dosadašnjim studijama (18, 26) većinu ispitanika činile su žene (68,2 %). Medijan broja preostalih zuba u uzorku bio je 26 (interkvartili raspon 24 – 28), što je također u skladu s dosadašnjim istraživanjem (8). Periapikalna bolest dijagnosticirana je u 5,4 % trajno restauriranih endodontski neliječenih zuba. U uzorku od 597 pregledanih ispitanika, 54,3 % imalo je AP jednoga ili više endodontski neliječenih zuba. Visoka učestalost AP-a može biti pripisana metodi uzorkovanja. U ovom slučaju bila je riječ o kliničkom istraživanju u kojemu je uzorak dobio iz populacije pacijenata upućenih na dentalnu kliniku. Ovo istraživanje bilo je usporedno s dosadašnjim istraživanjima, ali je analiza slična za identifikaciju rizik od AP-a u usporedbi sa zubima s najčešćim kvalitetom restauracije. Gubitak marginalne kosti >1/3 dužine korijena nije bio statistički značajan za prisutnost AP-a (tablica 5.).
The hypothesis was that there is no significant difference in the periapical status of non-endodontically treated teeth regarding the type or material of permanent coronal restoration. Indeed, the analysis of teeth with adequate quality of coronal restoration did not find any significant difference in the frequency of AP regarding the type of coronal restoration. Although some experimental studies have revealed some harmful effects of resin composite on pulpal cells, this does not seem to be the case when it is used for restorations in clinical conditions (8, 22, 23). Our study demonstrated that there are no differences in the prevalence of AP between teeth restored with amalgam and resin composite, irrelevant of their quality, which is consistent with the results of the previously cited study (8).

When periapical status was analyzed according to the tooth type, only the group of premolars demonstrated a significant difference regarding the type of coronal restoration. AP was more frequent in premolars restored with crowns, than in those restored with amalgam or composite fillings. An interesting observation was that frontal and molar teeth restored with crowns of adequate quality had no periapical diseases. In contrast, almost 12% of premolars with adequate crowns had AP. Arguably, cumulative insults on dental pulp, such as caries, restorative treatments, periodontal disease and trauma may have diminished a long-term prognosis for pulp vitality in these teeth (12). They had possibly impaired the pulp ability to recover from further trauma that resulted from preparation to receive crowns. Furthermore, tooth preparation for full coverage crowns necessitates more extensive tooth structure removal than for other restoration types. The integrity and vitality of the pulp may also be impaired due to desiccation of dentin and development of frictional heat or exothermic reactions during setting of impression materials, acrylic resins and luting cements (24). While certain studies found no variation in incidence of the pulp necrosis regarding the tooth type, Cheung et al. reported that majority of pulpal necroses developed in the maxillary anterior teeth that served as bridge abutments (12, 25).

The results regarding the differences in periapical status according to the type and quality of coronal restoration, as well as tooth type, were obtained using a bivariate analysis (chi-square test). Since more than one variable affects the course of disease, multivariate models are better approximation to reality, allowing for judgement of the relative importance of each predictor variable. There are variables that could have influenced the results but could not have been controlled due to the cross-sectional nature of the study, such as time of restoration placement, and pulpal and periapical status that preceded the restoration placement. Therefore, this study could only identify risk indicators for AP presence in restored teeth. A variable is designated as a risk indicator when its presence increases the individual’s risk of exhibiting periapical disease. However, risk indicators may, but need not, be directly associated with the disease (3, 21). Bearing in mind the previously mentioned limitations, logistic regression was used to analyze the simultaneous influence of predictor variables on AP presence. This analysis disclosed several possible risk indicators for AP presence. An increased risk for AP presence was nom statusu endodontski neliječenih zuba s obzirom na vrstu i materijal trajne restauracije. U analizi zuba s koronarnim restauracijama odgovarajuće kvalitete nije uočena značajna razlika u učestalosti AP-a s obzirom na vrstu koronarnih restauracija. Iako su neka eksperimentalna istraživanja upućivala na štetan učinak smolastih kompozitnih materijala na stanice zubne pulpe, čini se da to nije slučaj ako se ti materijali upotrebljavaju u kliničkim uvjetima (8, 22, 23). U skladu s nalažima prije navedenog istraživanja, i naše je pokazalo da nema razlike u učestalosti AP-a između zuba restauriranih amalgamom i kompozitom, neovisno o kvaliteti ispunama (8).

U analizi periapikalnog statusa s obzirom na skupinu zuba, samo je na prektunjsacima uočena značajna razlika u odnosu prema vrsti koronarnih restauracija. AP je bio češći na prektunjsacima koji su restaurirani krunicama negoli na onima s amalgamskim ili kompozitnim ispunima. Zanimljivo, na prektunjsacima i kutnjacima restauriranim krunicama odgovarajuće kvalitete nije zabilježena periapikalna bolest. S druge strane, gotovo 12% prektujutnjaka restauriranih krunicama odgovarajuće kvalitete imalo je AP. Moguće je da su skupni štetni učinci na dentalnu pulpu, poput karijesa, restaurativnog liječenja, parodontne bolesti i traume, mogli umanjiti dugoročnu prognozu vitalnosti pulpe u tim zubima (12), Vjerojatno je da su ti zubi imali smanjenu regenerativnu sposobnost zubne pulpe potrebnu za oporavak nakon daljnjih traume učinjene preparacijom za krunice. Nadalje, preparacija zuba za potpune krunice zahtijeva opasnosti povećane uklanjanje zbog štetne strukture u usporedbi s ostalim vrstama restauracija. Integritet i vitalitet pulpe također mogu biti ugroženi zbog isušivanja dentina, nastanka fiksacijske topline ili egzotermne reakcije tijekom stvarndavanja materijala za otiske, akrilatne smole ili cemenata (24). U određenim studijama autori nisu našli razlike u incidenciji nekroze pulpe s obzirom na skupinu zuba, ali je u istraživanju Cheungu i suradnika uočeno da se nekroza pulpe najčešće pojavljava na prektunjsacima uočena značajna razlika u odnosu na onima s amalgamskim ili kompozitnim ispunama. Zanimljivo, na prektunjsacima uočena značajna razlika u odnosu na onima s amalgamskim ili kompozitnim ispunama. Samo je na prektunjsacima uočena značajna razlika u odnosu na onima s amalgamskim ili kompozitnim ispunama. Samo je na prektunjsacima uočena značajna razlika u odnosu na onima s amalgamskim ili kompozitnim ispunama.
found for premolars, crowned teeth and teeth with clinical or radiological diagnosis of recurrent caries. Compared to group of incisors and canines, premolars were 1.7 times more likely to have AP. Teeth restored with crowns were 3.4 times more likely to have AP than teeth restored with amalgam fillings. Interestingly, teeth with inadequate marginal integrity of restorations had a slightly increased, but not statistically significant risk for AP presence. In turn, the presence of recurrent caries demonstrated the highest association and increased the risk for radiologic diagnosis of AP 4.7 times. Contrary to the previously conducted studies, marginal bone loss was not associated with the presence of periapical disease (3, 8). While full coverage crowns seemed to have a positive effect on periapical health in endodontically treated teeth (26), the present results indicated crowns as a risk indicator for poor periapical status in non-endodontically treated teeth. A possible explanation for this finding may be that the teeth that were restored with crowns were originally more compromised due to caries or fractures, than the teeth that were restored with direct restorations and therefore more prone to develop AP. In such a case, the AP would not be related to crowns but to the pre-existing compromised tooth structure.

A study by Hommez et al. demonstrated that the evaluation of coronal restoration quality based merely on radiographic images analysis did not provide adequate data; hence their study emphasized the importance of supplementation of radiographic information with clinical data (27). In the present research, the assessment of the quality of the coronal restorations was based on both clinical and radiographic recordings.

This survey has several issues that might have led to underestimation of periapical pathosis. First, the cross-sectional design of the study precludes the follow-up of the periapical disease dynamics, while the frequency of AP depends on a period for the disease progress or regress. In the present study, PAI was used for AP diagnosis. A strict calibration procedure of observers and the use of visual references with verified histologic diagnoses enable higher reproducibility of the radiographic scores (17, 28). However, as in other studies of similar design, the present survey did not involve clinical criteria for AP diagnosis, and this might inevitably lead to underestimation of periapical pathosis (2-4, 19-21). Since histological studies demonstrated that periapical inflammation may be associated with absence of radiographic signs (29), it is important to use the most sensitive diagnostic tool to identify AP. Cone beam computed tomography (CBCT) has excellent accuracy in AP diagnostics when compared to conventional radiographs (30). However, as it results in a higher radiation dose, CBCT use in endodontics should be limited to cases when conventional radiographic techniques do not provide sufficient information for confident diagnosis and treatment planning (31, 32). Due to lower radiation dose compared with a full-mouth survey, panoramic radiographs were chosen for the evaluation of periapical status in the present study. It has been shown that the prevalence of AP may be underestimated when compared to periapical radiography. However, when compared to cone beam computed tomography, both panoramic and periapical radiographs correctly identify AP in advanced stages (33).

radiološkom dijagnozom rekurentnog karijesa. U usporedbi sa skupinom sjekutića i očnjaka, pretkutnjaci su imali 1,7 puta veću vjerojatnost za nalaz AP-a. Zubi restaurirani krunicama imali su 3,4 puta veću vjerojatnost za pojavu AP-a negoli oni s amalgamskim ispunima. Zanimljivo, zubi s neadekvatnom rubnom cjeloštću restauracije imali su malo povećan, ali statistički neznačajan rizik od pojave AP-a. No pokazalo se da nalaz rekurentnog karijesa ima najveću povezanost te 4,7 puta povećava rizik za radiološku dijagnozu AP-a. Suprotno prije provedenim istraživanjima, gubitak marginalne kosti nije bio povezan s nalazom periapikalne bolesti (3, 8). Iako je u prethodnoj studiji istaknuto da potpune krunice pozitivno utječu na zdravlje periapikalnih tkiva endodontski lijećenih zuba (26), u ovom su istraživanju krunice prepoznate kao indikator rizika za loš periapikalni status endodontski neliječenih zuba. Moguće objašnjenje za taj nalaz mogla bi biti veća preoperativna oštećenja karijesom ili frakturama zuba koji su zatim restaurirani krunicama i slijedom toga skloniji pojavi AP-a. U tom slučaju AP ne bi bio povezan s krunicama, nego s postojećim oštećenjima zubne strukture.

U istraživanju Hommeza i suradnika procjena kvalitetne koronarne restauracije temeljila se isključivo na radiološkoj analizi snimaka. Takvo istraživanje ne daje dovoljno podataka za istaknuta važnost prikupljavanja kliničkih informacija uz radiološke snimke (27).

Ovo istraživanje ima nekoliko ograničenja koja su mogla prouzročiti podcjenjivanje periapikalne patologije. Istaknuto je da prešječni dizajn studije onemogućuje praćenje dinamike periapikalne bolesti, a frekvencija AP-a ovisi o razdoblju napredovanja ili regressije bolesti. PAI je korišten u dijagnozi AP-a. Dosljedan postupak kalibracije i korištenje vizualnih referencija s površinim histološkim dijagnozama omogućuju veću reproducirivost radioloških nalaza (17, 28). Ipak, u sadašnjoj studiji, kao i u druge slične, nisu uključeni klinički kriteriji za dijagnozu AP-a, što bi moglo voditi u podcjenjivanju učestalosti periapikalne patologije (2 – 4, 19 – 21). S obzirom na to da je u histološkim istraživanjima utvrđena mogućnost nalaza periapikalne upale bez radioloških znakova (29), važno je koristiti se osjetljivim dijagnostičkim sredstvima na otkrivanje AP-a. Kompjutorska 3D tomografija (CBCT) zbog preciznosti je izvršna u dijagnostici AP-a u usporedbi s konvencionalnim radiogramima (30). Ipak, CBCT dijagnostika uključuje i veću količinu zračenja te bi njezina upotreba trebala biti ograničena na slučajeve kada konvencionalne radiološke tehnike ne pružaju pouzdane informacije za postavljanje dijagnoze i planiranje liječenja (31, 32). U ovom istraživanju su panoramske snimke korišteni u analizi periapikalnog statusa zbog manejg zračenja u usporedbi s izradom periapikalnih snimki svih zuba. Analizom panoramskih snimki učestalost AP-a može biti podcijenjena u usporedbi s panoramskim snimkama. Ipak, u usporedbi s CBCT-om, panoramske i periapikalne snimke točno su utvrđene AP u napredovim stadijima bolesti (33).

U nekoliko opsežnih istraživanja o oralnim zdravlju autori su se koristili panoramskim snimkama kao metodom izbora za procjenu periapikalnog statusa (8, 34, 35). Panoramski radiogrami omogućuju pregled svih zuba na jedinstvenoj radiološkoj snimci uz nižu dozu zračenja u usporedbi s izra-
Several comprehensive studies regarding oral health that preceded our research utilized the panoramic radiographs as a radiographic technique of choice for periapical status evaluation (8, 34, 35). Panoramic radiographs allow the examination of all teeth in a single radiographic image under low radiation doses when compared to full mouth periapical radiography, and therefore are acceptable and frequently used for the evaluation of AP in epidemiological studies (2, 26, 34-36).

Although the data reported in the present study suggested that crowns may be a risk indicator for the presence of AP in non-endodontically treated teeth, the fact that the pulpal and periapical status at the time of restoration placement were unknown makes impossible to know if the AP was pre-existing or developed after the restoration was inserted. Therefore, to determine a causal-effective relationship between the type of coronal restoration and periapical disease, a prospective design of study should be applied, preferably by using a limited cone beam computed tomography for AP diagnosis.

Conclusion

The results of this research supported our hypothesis. If the quality of restorations is adequate, there is no difference in the periapical status of non-endodontically treated teeth regarding the type and material of coronal restoration.

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Disclosure

Authors deny any conflict of interest.

Author's contribution: R. P. B. - performed a radiological analysis of periapical status and marginal bone loss, statistical analysis, interpretation of data, and she drafted the manuscript; E. P. - performed clinical data acquisition and drafted the manuscript; S. P. R. - co-designed the concept and methodology of the study and edited the manuscript; I. B. P. - co-designed the concept and methodology of the study and reviewed the manuscript.

Zaključak

Rezultati ovog istraživanja potvrdili su našu hipotezu. Ako je kvaliteta restauracije odgovarajuća, nema razlike u periapikalnom statusu endodontski neliječenih zuba s obzirom na vrstu i materijal koronarnog restauracije.

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Sukob interesa

Autori izjavljuju da nisu u bili sukobu interesa.
Sažetak
Cilj: Svrha studije bila je usporediti učestalost apikalnog parodontitis (AP) u endodontski neliječenim zubima (EAP) i endodontijalno restauriranim krunicama (ER) i smolarima kompozitnim ispunivima. Također je istraživana povezanost vrste, kvalitete krunica te prisutnošću periapikalnih bolesti.

Materijali i postupci: Presječno istraživanje obuhvatio je 597 ispitanika koji su prvi put posjetili Kliniku za dentalnu medicinu Kliničkog bolničkog centra Rijeka. Podatci su prikupljeni kliničkim i radioškim pregledom. Za sve trajno restaurirane endodontski neliječene zube analizirani su vrsta, kvaliteta koronarne restauracije prema kliničkim i radioškim kriterijumima za rubnu cjelovitost restauracije i prisutnost rekurentnog karijesa, periapikalni status te gubitak marginalne kosti.

Iskustva testovanih promijenjeni su u analizi razlike periapikalnog statusa sa obzirom na vrstu i kvalitetu restauracije. Multivarijantna logistička regresijska analiza obavljena je u procjeni utjecaja preddiktorskih dentalnih varijabli na periapikalni status. Rezultati: Nije dokazana značajna razlika u proporciji AP-a sa obzirom na vrstu i materijal restauracije odgovarajuće kvalitete (χ² = 5,000, P = 0,082 ). Regresijskom analizom otkrivena je značajna pozitivna povezanost s ishodišnom varijablim (AP) za krunice (OR = 3,39; P < 0,001), rekurentni karijes (OR = 4,67; P < 0,001) i pretkutnjaka (OR = 1,73; P = 0,002).

Zaključak: Ako su restauracije primjerene kvaliteti, nema razlike u periapikalnom statusu endodontskih neliječenih zuba sa obzirom na vrstu i materijal korišten za koronarne restauracije.

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