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Retrospective Investigation of The Relationship Between Coronal Restoration and Quality of Root Canal Fillings and Apical Periodontitis in a Specific Turkish Population

Belirli Bir Türk Popülasyonunda Koronal Restorasyon ve Kök Kanal Dolgularının Kalitesi ile Apikal Periodontitis İlişkisinin Retrospektif Olarak İncelenmesi

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ABSTRACT

Objective: The purpose of this study was to retrospectively assess the prevalence and efficacy of endodontic treatments in Turkish subpopulations, as well as the relationship between the type of coronal restorations, procedural errors, and their association with the periapical status of treated teeth.

Methods: Cone beam computed tomography (CBCT) images of 500 patients were analyzed. A total of 10500 teeth were evaluated and 1185 of those had received root canal therapy. Periapical condition, coronal restoration, and root canal quality of these teeth were evaluated. Periapical status was evaluated by two observers regarding to CBCT periapical index scoring system. The chi-square test was used to evaluate all data for statistical analysis.

Results: Healthy periapical status was seen in 44.9% of endodontically treated teeth. Teeth with procedural errors (broken instrument, untreated canal, perforation, ledge formation, short or overfilled canals, inadequate filling) showed more periapical pathosis than teeth with good endodontic treatment ($p<0.05$). Additionally, it was found that teeth with sufficient coronal restoration had lower prevalence of apical periodontitis. However, existence of post did not effect periapical status ($p<0.05$).

Conclusion: The effectiveness of the root canal treatment and the periapical status were considerably influenced by the quality of coronal restoration.

Keywords: Apical periodontitis, cone beam computed tomography, coronal restoration, epidemiology, root canal treatment

ÖZ

Amaç: Bu çalışmanın amacı, belirli bir Türk popülasyonunda yapılmış endodontik tedavilerin kalitesinin yanı sıra, yapılmış işlemsel hatalar ve dişlerin periapikal durumu ile koronal restorasyonların başarısının retrospektif olarak değerlendirilmesidir.

Yöntemler: Bu çalışma için, 500 hastanın konik ışınlı bilgisayarlı tomografi (KIBT) görüntüleri incelenmiştir. Bu hastalara ait 10500 diş radyografik görüntü incelenmiş ve toplam 1185 dişte kanal tedavisi yapılmış olduğu görülmüştür. Kök kanal tedavilerinin ve koronal restorasyonların kalitesi ile bu dişlerin periapikal durumu tek tek incelenmiştir. Periapikal durum KIBT uyarlanmış peiapikal indeks skorlama sistemine göre iki gözlemci tarafından değerlendirilmiş ve elde edilen tüm veriler, istatistiksel olarak ki-kare testi kullanılarak analiz edilmiştir.

Bulgular: İncelenen dişlerin %44,9'unda periapikal bölgede lezyon olmadığı görülmüştür. İşlemsel hata (kırık alet, bulunamamış kanal varlığı, perforasyon oluşumu, basamak oluşumu, kısa veya taşkın kanal dolumu) yapılmış dişlerde, daha yüksek oranda periapikal lezyon varlığı tespit edilmiştir ($p<0,05$). Ayrıca, yeterli koronal restorasyona sahip dişlerde apikal periodontitis insidansının daha düşük olduğu bulunmuştur ($p<0,05$). Bunun yanı sıra post varlığının periapikal durumu etkilemediği görülmüştür.

Sonuç: Koronal restorasyonun kalitesinin, kök kanal tedavisinin başarısını ve dişin periapikal durumunu önemli ölçüde etkilediği görülmüştür.

Anahtar Sözcükler: Apikal periodontitis, konik ışınlı bilgisayarlı tomografi, koronal restorasyon, epidemiyoloji, kök kanal tedavisi

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Introduction

Inflammation of the periapical periodontium results in a condition known as AP, and its toxins have an impact on the root canal system (1). Apical periodontitis (AP) in root canal of treated teeth is an important public health problem (2).

Epidemiologic studies are usefull to give information about incidence and prevalence of disease and related factors. Since root canal treatment (RCT) is the most frequent treatment done by endodontist, the prevalance and quality of the treatment inform dentist not only the incidence but also risk factors and reasons for failure of endodontic treatments.

Numerious epidemiological studies investigated the prevalance of the AP in all over the world. Tibúrcio-Machado et al. (3) found high prevalence (52%) of AP in their systemic review. However, Al-Omari et al. (4) (83.7%) and Marotta et al. (5) (87%) found much higher prevalance of AP. The rate of prevalence varies according to age (6), level of education, access to dental care (7) and radiographic techniques used during diagnosis (8).

RCT is indicated in patients with irreversible pulpitis and/or AP to keep the tooth functional in the patient's mouth in long term (9). Since high percentage of AP prevalence has been detected in studies (3), prevalence of RCT is expected to be high. However, the frequency of prevalence RCT was found in a very wide range of 0.7-97.3 % in different countries (10).

The difference could be because of needs and availabilty of RCT depending on the countries. Also, preventive dentistry management, using new technology or equipment and materials, or treatment procedure of deep cavity or pulp exposure may affect the results. Meantime, León-López et al. (10) indicated that global prevalence of people with at least one RCT was % 55.7 in their systemic review.

Conventional radiographs are the most common used method for detecting AP and quality of root canal filling. While radiographs show 2 dimensional images, recently introduced cone beam tomography, shows 3 dimensional images. So cone beam computed tomography (CBCT) images can be used for diagnosis of AP, detecting root canal morphology, quality of the fillings, procedural errors and healing outcomes.

Limited studies have been reported on the prevalence of AP and quality of RCT in selected population of Turkish people mostly done by detecting conventional radiographs (11-14). Also, recently introduced new technology in endodontics might improve the outcome of endodontic therapy.

The aim of the present study was to examine quality of endodontic treatments with coronal restorations and analyse the relationship of various factors with AP in a Turkish subpopulation based on radiographic examination. The null hypothesis to be tested was that there was a difference in the prevalence of periapical lesions in each specific root with regard to procedural errors.

Methods

Marmara University Clinical Research Ethical Committe was approved this study by no: 2021/07 and dated 07.10.2021.

In the present study, all CBCT images which were taken from patients refferred to University of Marmara Department of Radiology for different reasons between 2017 and 2021 were investigated. A total of 14623 teeth were examined; 500 patients with 1185 teeth who had undergone RCT were included in the study.

The CBCT images were included according to the following criteria; patients between 18-70 years old with full arch scans and also had at least one endodontically treated teeth (except 3rd molar) and signed informed consent form. Additionally, deciduous teeth and unrestorable root fragments were excluded. Images that could not be examined due to artifacts were excluded.

Evaluation Criteria and Radiographic Analysis

The CBCT images were taken using Planmeca ProMax (Helsinki, Finland, 96 kVp, 10 mA) device in accordance with the manufacturer's instructions and with a voltage of 96 kVp, a tube current of 10 mA. Voxel size for the scans was 0.200, 0.200, and 0.200 mm, and 15 bits. Images were evaluated by two experienced endodontists. Images were examined with a Dell brand monitor (China). The monitor with a screen size of 22 inches had a resolution of 1920*1080.

Teeth were evaluated with the multiplanar reconstruction view of the software Planmeca Romexis viewer (Helsinki, Finland).

All images were evaluated 40-50 cm away from the image and using the same monitor, in a reduced light room. Observers were able to adjust the contrast, density and magnification, settings as they wished. Reviewers assessed all images to get a consensus for the interpretation of the radiographic data. Both examiners reached consensus on each image examination.

The CBCT- periapical index (PAI) scores, created by Estrela et al. (15), were used to determine the score based on the location, size of the lesion and relationship with the roots of the tooth (Table 1).

Total number of RCT, root canal obturation quality, type and coronal restoration quality, periapical status, and total number of teeth were recorded. All spatial planes (sagittal, axial, coronal and cross-sectional) were used to evaluate each tooth.

Table 1. Cone beam computed tomography periapical index scores

Score	Quantitative Bone Alterations in Mineral Structures
0	Intact periapical bone structures
1	Diameter of periapical radiolucency > 0.5-1 mm
2	Diameter of periapical radiolucency > 1-2 mm
3	Diameter of periapical radiolucency > 2-4 mm
4	Diameter of periapical radiolucency > 4-8 mm
5	Diameter of periapical radiolucency > 8 mm
Score (n) + E* Expansion of periapical cortical bone Score (n) + D* Destruction of periapical cortical bone	

Assessment of Endodontic Tretament

When all root canals were adequately filled, with homogenous appearance without voids of the canal fillings and obturation lenght from coronal the root apex was regarded acceptable endodontic therapy (16).

When the root canal fillings extruded over the radiographic apex or shorter more than 2 millimeters of apex, the treatment was regarded unacceptable. Root canal filling with voids, insufficient density, empty canals or poor condensation, broken instrument, ledge formation and perforation also considered as unacceptable.

Apical filling extension was classified into 3 groups according to the lenght of the filling: 0-2 mm short, >2 mm short, and beyond the radiographic apex. These parameters were evaluated for each single root canal.

Assessment of Periapical Status

Each single root was evaluated according to Table 1 for periapical status.

Assessment of Coronal Restoration

Also all endodontically treated teeth were evaluated according to the type of the coronal restoration (direct or indirect). The quality of restoration was classified as insufficient if it was partially or completely missing with open edges, overhangs, or secondary cavities. Meantime, presence of post was recorded.

Statistical Analysis

The data were analysed with IBM SPSS (Statistical Package for Social Sciences) 23 software. Calculated values for frequency and percentages were used to create descriptive statistics for categorical variables. The chi-squared test was used to compare the qualitative data. P values under 0.05 were considered significant.

Result

Six hundred eighty nine (58,14%) teeth were from females and 496 (41,86%) from males. The distribution of teeth with endodontic treatment and its relation to sex and age is represented in Table 2. The mean age of patients with periapical lesions and teeth without lesions were found to be significantly different. The mean age of patients with periapical lesions was lower than without lesions (Table 2).

The CBCT-PAI was used to examine the apical status of endodontically treated teeth; scores of 0 indicated no apical lesions, whereas scores of 1-5 indicated apical lesions. Among these teeth, the prevalance of AP was 55.1% (653 teeth) (Table 2). According to sex, woman (52.8%) was found to have lower prevalance of AP than men (58.3%), but the difference was not significant (p>0.05) (Table 2). The periapical lesions was most found between the ages of 18 and 24 years (Table 2).

Maxillary premolars were the most frequently treated teeth (19.9%), followed by mandibular molars (17.9%), maxillary molars (17.3%), and mandibular premolars (16.9%). Mandibular incisors were found to be the least frequently endodontically treated teeth (Table 3). The distribution of RCT according to the type of tooth is detailed in Table 3.

Table 4 presents a summary of all data displayed. Of 1185 endodontically treated teeth, no procedural error was found in 324 teeth (27%) (Table 5). The prevalence AP was found to be 39% (128 teeth) in teeth without procedural errors (Table 4). Of them 73% (861 teeth) had at least one procedural errors (Table 5). The prevalence of AP was found to be 61% in teeth with procedural errors (Table 4). According to this data, statistically difference was found amoung the quality of root canal filling and AP. In teeth with inadaquate root canal filling with at least one procedural error had statistically higher incidence of periapical lesion compared to teeth with adequate root canal fillings with no periapical lesion (p<0.05).

The number of adequate coronal restoration was 569 (Table 5), and 54.5% (Table 4) of them were healthy. The number of inadequate coronal restoration was 616 (Table 5) and 36% (Table 4) of them were healthy.

When lenght of the root canal was investigated, 318 (47.2%) of 673 teeth with adequate root canal fillings, 285 (65.8%) of 433 teeth with short root canal fillings, 50 (63.2%) of 79 teeth with overfilling had periapical lesions (Table 4).

The quality of endodontic treatment and coronal restoration is also summarized in Table 4. Apical lesion was detected in

Table 2. Distribution of root canal treated teeth according to age and gender

Age/gender	Apical periodontitis		Total
	Healthy periapex	Periapex with pathosis	
Female (n=689)	325 (47.2%)	364 (52.8%)	689 (100%)
Male (n=496)	207 (41.7%)	289 (58.3%)	496 (100%)
18-24 yrs (n=123)	32 (26.0%)	91 (74.0%)	123 (100%)
25-34 yrs (n=230)	86 (37.4%)	144 (62.6%)	230 (100%)
35-44 yrs (n=296)	120 (40.5%)	176 (59.5%)	296 (100%)
45-54 yrs (n=331)	174 (52.6%)	157 (47.4 %)	331 (100%)
55 yrs > (n=205)	120 (58.5%)	85 (41.5%)	205 (100%)
Total	**532 (44.9%)**	**653 (55.1%)**	**1185 (100%)**

Table 3. Distrubution of root canal treated teeth according to the tooth group (n=1185)

Tooth	Maxillary	Mandibular
Central incisor	90 (7.6%)	12 (1%)
Lateral incisor	76 (6.4%)	13 (1%)
Canine	89 (7.5%)	49 (4.1%)
Premolar	236 (19.9%)	201 (16.9%)
Molar	206 (17.3%)	213 (17.9%)
Total	697 (58.8%)	488 (41.2%)

48 (29.3%) of 164 teeth with adequate RCT and coronal restoration. However apical lesion was detected in 211 (52.1%) of 405 teeth with inadequate root canal filling but adequate coronal restoration. Statistically significant difference was found in teeth with adequate coronal restoration between quality of root canal filling and incidence of apical lesions (Table 4).

In case of inadequate obturation with inadequate coronal restorations, 314 (68.9%) of 456 teeth had periapical lesions. However, 50% of teeth with adequate obturation and inadequate coronal restorations showed apical lesions. In case of inadequate coronal restoration, statistically significant difference was found between qualtiy of root canal fillings and incidence of AP ($p<0.05$) (Table 4).

Mostly indirect restoration was found in teeth with endodontic post ($p<0.05$). Also, presence of post statistically did not effect AP incidence ($p>0.05$) (Table 4).

Periapical lesion was detected in 31 (65%) of 47 teeth with broken instrument, 123 (78.8%) of 156 teeth with missed canal, 57 (60.6%) of 94 teeth with perforation, 139 (72.3%) of 192 teeth with ledge formation. AP was found in 440 (67.4%) of 702 teeth with nonhomogeneous root canal filling (presenting voids and poor density) (Table 6). The presence of ledge formation, missed canal and non-homogenous root canal filling in endodontically treated teeth had statistically significantly effect on the incidence of AP ($p<0.05$). The presence of perforation and instrument fracture did not demonstrate a statistically significant difference in terms of the distribution of AP ($p>0.05$).

Table 4. Periradicular status of root canal treated teeth relative to diverse factors

Covariate	Healthy periapex	Periapex with pathosis	p-value
Sex			
Female (n=689)	325 (47.2%)	364 (52.8%)	
Male (n=496)	207 (41.7%)	289 (58.3%)	
Quality of coronal restoration			
Inadequate	222 (36.0%)	394 (64.0%)	**0.0001****
Adequate	310 (54.5%)	259 (45.5%)	
Quality of endodontic treatment			
Inadequate	336 (39%)	525 (61%)	**0.0001****
Adequate	196 (60.5%)	128 (39.5%)	
Apical limit of filling			
0-2 mm short	355 (66.7%)	318 (48.7%)	
>2 mm short	318 (48.7%)	285 (43.6%)	**0.0001****
Overfilling	29 (5.5%)	50 (7.7%)	
Post			
Yes	48 (9.0%)	42 (6.4%)	0.094
No	484 (91.0%)	611 (93.6%)	
Combined endodontic treatment and coronal restoration			
Adequate RCT/ adequate restoration	116 (70.7%)	48 (29.3%)	**0.0001****
Adequate RCT/ inadequate restoration	80 (50.0%)	80 (50.0%)	
Inadequate RCT/ adequate restoration	194 (47.9%)	211 (52.1%)	
Inadequate RCT/ inadequate restoration	142 (31.1%)	314 (68.9%)	

Discussion

Epidemiologic studies related to endodontics give information about frequency of AP and prevalance of endodontically treated teeth. Also, the quality of endodontic treatment and errors can be estimated to improve treatment procedures in health care system or universities in the population. With this study, useful

Table 5. Distribution of evaluated variables with root canal filled teeth

Covariate	n	%
Gender		
Female	689	58.15
Male	496	41.85
Quality of coronal restoration		
Adequate	569	48
Inadequate	616	52
Quality of endodontic treatment		
Adequate	324	27
Inadequate	861	73
Apical limit of filling		
0-2 mm short	673	56.8
>2 mm short	433	36.5
Overfilling	79	6.7
Post		
Yes	90	7.6
No	1095	92.4
Periapical status		
Healthy	532	44.9
Diseased	653	55.1

Table 6. Distribution of endodontic technical errors in cases of teeth and its association with periapical status

Endodontic technical errors	Total	Healthy periapex	Periapex with pathosis	p-value
Non-homogeneous filling	702	262 (49.2%)	440 (67.4%)	0.0001**
Non-filled canal	156	33 (6.2%)	123 (18.8%)	0.0001**
Instrument fracture	47	16 (3.0%)	31 (4.7%)	0.127
Perforation	94	37 (7.0%)	57 (8.7%)	0.261
Ledge formation	192	53 (10.0%)	139 (21.3%)	0.0001**

information was provided for the prevalence of AP as well as endodontic treatment outcome in a large subpopulation who were living in urban area of İstanbul, Türkiye.

Although conventional and digital radiographic techniques either panoromic or periapical X-ray has been used for along time to assess the quality of RCT and periapical status of the teeth, some periapical pathosis may be overlooked or misinterpretered by these technique (15). According to Estrela et al., (15) mineral bone loss should be 30-50% for a lesion detected in conventional radiographs. However, studies indicated that CBCT images had higher performance to indentify periapical lesions compared to conventional periapical and panaromic radiograph without superposition of adjacent structures (17,18). Also, the quality of RCT can be evaluated more accurately with 3 D than 2 D analyses of conventional methods (19).

While Orstavik et al. (20) used the periapical index to define AP in two dimensions, Estrela et al. (15) recently developed CBCT-PAI scoring method to analyse periapical lesions three dimensionally. By this method the lesions can be evaluated mesiodistally, buccopalatinally and diagonally with more precisely. Therefore, CBCT PAI scoring method was used in the present study.

The prevalence of AP in endodontically treated teeth was found to be very high in different population (25-64.5%) (21-25). When the studies were evaluated by continents, the highest prevalence of RCT was found in Europe and South America populations. However, African population had the lowest prevalance of RCT. The differences in the age of population, the different level of economic development, and the different access to dental health services may result from the differences between continents (10). Not only in the same continent but also in the same country, different results were declared (19.4-70.1%) depending on socioeconomic factors such as location (urban or rural area) or education level of patient in Türkiye (11-14). In the present study, 1185 of all evaluated teeth received endodontic treatment. Also, 55.1% of the endodontically treated teeth had AP.

Beside geographic and socieconomic factors, age is also found to be an important factor in epidemiologic studies. Higher prevalance of RCT in older population was reported compared to younger population (10). In the present study also, the age group of 45-54 years showed the highest prevalence of RCT. However, the age group of 18-24 years had higher incidence of AP in endodontically treated teeth may be due to decreasing size of the pulp and calcification of ramifications, MB2 canal or lateral canals by the age.

Regarding sex, this study sample consisted of more women than men which might indicate women were more interested in taking dental care in Türkiye. Although less incidence of periapical pathosis was found in women compared to men, the difference was not significant. Other study results collabarated our findings which indicated statistically no relation between gender and periapical pathosis (26).

In literature, high positive correlation was found between prevalence of AP and poor quality of endodontic treatment (2,7,11-14). In the present study of 1185 teeth, 72.7 % of teeth had inadequate RCT. This finding showed that the quality of root canal was low in this subpopulation and found to be much lower than other studies which were performed in Türkiye (11-14). Also, teeth with inadequate RCT showed statistically higher AP prevalance. Furthermore, homogeneity of root canal, canal length, canal errors such as ledge formation or presence of unfilled canal had significant effect on AP prevalence (11-14).

The lenght of the root canal is an important factor on the quality of the root canal. Inadequate root canal debriment with short of filling with no apical closure may lead to bacterial accumualation and this may increase the AP prevalence (27). In the present study, teeth with short fillings showed higher AP prevalence which collobareted other study results (27-29). Also, of 1185 teeth, 79 teeth (6.7%) showed overfillings and 63.2% of these teeth had AP. Overfilling also causes irritation of periapical tissue which may increse the AP incidence (13). Studies related to epidemology or prognosis of endodontology showed that ideal root canal length should be approximately 0.5-2 mm short of apex for healing of periapical tissue (15,30).

Lee et al. (31) indicated that beside apical extent, homogeneity of root canal had also significant impact on periapical healing. Stoll et al. (32) demonstrated higher survival rates in root canal treated teeth with corrected length and homogenous root canal fillings. Related to this finding, in the present study, teeth with non-homogenous fillings had significantly more incidence of AP (62.6%) than teeth with homogenous fillings.

During instrumentation, every error such as zip, perforation, ledge formation, loss of working length will decrease the success of endodontic treatment (27-29,33). Chugal et al. (33) indicated that loss of working lenght with ledge formation would increase the failure of treatment specially in teeth with AP. They found that a millimeter loss of working length increased the chance of failure by 14%. In the present study, 192 teeth had ledge formation and AP was observed in 72.3% of these teeth. Significant correlation was found between ledge formation and AP ($p<0.05$).

Missed canals and inadequate prepared canals always contain microorganisms and this will increase the AP incidence (34). Incidence of missed canal was found to be 42% by Hoen and Pink (35), 23% by Karabucak et al. (36), 12% by Costa et al. (37) and Baruwa et al. (38). In the present study, 13.2% of teeth had missed canal. Also these investigators reported that, 82.8-82.6% of teeth with missed canals had AP (35-38). In parallel to this findings, in the present study, 78.8% of teeth with missed canals had AP. Also, the relationship between missed canal and AP was found to be significant ($p<0.05$).

Broken instrument is a complication which occurs during instrumentation (39) and affects the success of endodontic tretment. The location and the type of the broken instument and maintenance apical patency are all important factors on the

failure of the endodontic treatment (40). In the present study, the prevalance of AP was found to be 65.9% in teeth with broken instrument.

The size and the location of the perforation is important factor on the success of endodontic treatment (41). Also, high incidence of AP (60.6%) was found in teeth with perforation which was similar to findings of de Chevigny et al. (42).

The quality of coronal restoration is also found to be important factor as well as apical sealing in long term of endodontic treatment (43). Ray and Trope (44) emphasized that the technical quality of the coronal restoration might be more important for periapical health than the technical quality of the root filling. However, Kirkevang et al. (45) and Hommez et al. (46) claimed that both coronal and root filling quality was equally important for periapical healing. Tavares et al. (47) found the highest success rate (93.5%) in teeth with both good coronal and apical sealing. Meantime, Cheung and Chan (48) decleared that crown restoration was increased the longevity of endodontically treated teeth.

Stenhagen et al. (49) found that the type of coronal restoration (direct or indirect) did not have a significant effect on the success of RCT in their retrospective study. In the present study also, the type of the restoration was found to have no effect on AP prevalence. Also, presence of post was not found to be significantly related to AP incidence. These findings were in line with the findings of the studies of De Moor et al. (28) and Estrela et al. (15). Unfortunately, it is difficult to assess the quality of crown restoration by CBCT images due to artefacts. Clinical and oral examinations are much reliable methods to examine the quality of coronal restoration.

Study Limitations

Among the limitations of this study was its cross-sectional design. The main disadvantage of a cross-sectional study was the difficulty in determining whether a periapical lesion was healing or not. A radiograph provides only static information about a dynamic process and at the time the radiograph is taken, the size of a periapical lesion may be increasing or healing.

Another disadvantage of a cross-sectional study was the lack information about when endodontic treatments or restorations were performed, the level of education of the clinician performing the procedure and the time elapsed between treatment and the observation period. It was unknown whether endodontic treatments were performed in a similar manner. However, obtaining a large sample size and random selection are among the most significant advantages of this method.

In our study, intraoral examination of coronal restorations was not conducted. Therefore, the type of indirect restoration was unknown. Restorations were evaluated solely based on radiographs. This was among the limitations of our study. Clinical examination would lead to more accurate results in this regard.

Conclusion

This study's results showed that high prevalence of AP with endodontically treated teeth indicated poor technical quality of endodontic treatment. So, continued education and training of general dentists by Health Ministry, Dental Associations and universities is essential.

Ethics

Ethics Committee Approval: Marmara University Clinical Research Ethical Committe was approved this study by no: 2021/07 and dated 07.10.2021.

Informed Consent: Obtained.

Authorship Contributions

Concept: M.G., N.G., Design: M.G., N.G., Data Collection or Processing: M.G., Analysis or Interpretation: M.G., Literature Search: M.G., Writing: M.G., N.G.

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