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Oral Health Conditions of Older People: Focus on the Balkan Countries

SUMMARY

Oral health plays a pivotal role in general health, especially in older people. Oral diseases may affect the development of systemic conditions, such as diabetes mellitus, cardiovascular disease, stroke and hypertension. The most important oral health conditions that have been recorded in dental literature for older population include tooth loss, dental caries, periodontal diseases, xerostomia (dry mouth) and oral cancer. Edentulism influences social life, either causing aesthetic problems or affecting functional abilities, such as speaking, chewing and eating. Dental caries in older people is similar to that in people in their thirties. Socio-economic status and living area play a key role in the development of dental caries. In addition, the accumulation of several risk factors, such as plaque or systemic diseases, acts synergistically in the onset of periodontal disease in seniors. Furthermore, older people, mainly due to their medications, exhibit a reduced amount of saliva. Xerostomia causes difficulties in chewing, speaking and swallowing, and it has a substantial impact on older people’s lives. The prevalence of oral cancer is 1-10 per 100,000 patients, and several factors (smoking, alcohol, education, economic status) play crucial role. Limited data exists today that evaluates oral health conditions of seniors in the Balkan countries. Aging and socio-economic status of seniors in the Balkans are significantly associated with oral health problems.

Keywords: Oral Health, Aging, Balkan Peninsula, Tooth Loss, Dental Caries, Periodontal Disease, Xerostomia, Oral Cancer

Introduction

Oral health plays a pivotal role in general health, especially in older people. Oral diseases may also affect the onset of systemic conditions such as diabetes mellitus, cardiovascular disease, stroke and hypertension. On the other hand, there is abundant evidence supporting the idea that the improvement of oral health results in controlling systemic diseases such as diabetes mellitus. Periodontal disease is characterized as a multi-factorial inflammatory disease, which may share the same risk factors with various systemic diseases. Not only periodontal disease, but also dental caries and oral cancer, may exhibit an interplay role. The process of growing old increases the risk of chronic conditions that may influence the prevalence of oral conditions in older people.

Demographic transition is a phenomenon of modern society that has appeared in industrialized countries. Life expectancy has increased during the last decades, and birth rate has diminished as well. In the majority of western societies, lifespan increases raise in systemic diseases and oral health issues. Thus, increasing interest has been shown in all medical fields regarding older populations.

Geriatrics or geriatric medicine is the specialty that focuses on older people’s health care. According to the British Geriatrics Society, geriatrics is a branch of general medicine that is concerned with the clinical, preventative, remedial and social aspects of illness in old age. The unique characteristics of the elderly create the need of special care. Prevention and treatment for older adults are the major goals of such a specialty. In dental
medicine, gerodontontology is the field that is specialized in the dental treatment of older people, and it is also engaged in research about geriatric patients.

According to a United Nations’ report in 2013, the ratio of older people globally was 11.7%. A 2.5% increase was observed between 1990 and 2013, while the proportion of people aged 60 years or over will have increased extremely by 2050 (21.1%). In real terms, 841 million older people were recorded in 2013 and the number will be enlarged by 2050: more than 2 billion seniors. As the United Nations has reported, aging causes several significant social and economic problems, which will increase during subsequent years. It is important for dental clinicians to know and understand the risks for oral health problems in senior citizens. The aim of this study is to present the most prevalent oral conditions that affect older people.

Main Oral Health Conditions

The main oral health conditions that have been recorded in the literature for older people include tooth loss, dental caries, periodontal disease, dry mouth and cancer.

Tooth Loss

Tooth loss occurs as a consequence of 2 other oral diseases: periodontal disease or/and dental caries. The complete loss of a tooth is a common condition for older people. More specifically, the World Health Organization (WHO) reports that about 30% of the population aged 65-74 has a complete absence of natural teeth. Edentulism influences social life, either causing aesthetic problems or affecting functional abilities. The latter problem includes speaking, chewing and eating consequences that result in adopting poor diets and a low intake of nutritional ingredients. According to the literature, each person needs 20 teeth in order to have a functional dentition. Chewing using removable dentition reduces the chewing efficiency at least 30% or 40% compared to chewing with natural teeth.

On the other hand, tooth loss may display advantages for patients. Extraction of damaged teeth drops the concentration of bacteria in a human body and offers a full clearance in the oral cavity. Furthermore, the risk of dental or gum pain disappears, and older people have lower dental treatment needs and needs for dental care than in the past when having natural teeth. The option of prosthetic treatment is also a valuable advantage.

Dental Caries

Dental caries is the most common dental problem globally. Worldwide, 100% of adults have experienced dental cavities and been faced with pain and discomfort. As dental caries is an infection of the teeth, an untreated decay may cause pain and tooth loss as well. Generally, dental caries is 1 of the 2 major reasons of tooth loss.

Griffin et al concluded that older people present active formation of dental cavities about 1 surface per year. Similar activity was observed also in people during the early thirties by another group of researchers. In a sample group of 438 older individuals in Chile aged 65-74 years, the prevalence of dental caries was 99.8%. Dental caries and tooth loss are also significantly associated with the education level and living areas (urban/rural) of older people. Individuals living in rural areas exhibited more tooth loss, whereas seniors in urban areas displayed more dental caries. In addition, highly educated individuals demonstrated less dental caries.

Periodontal Disease

Periodontal diseases, or gum diseases, are infections of periodontal tissues. Periodontal tissues support the structures of the teeth and in the case of destruction may lead to tooth loss. The prevalence of periodontal diseases increases with age, as epidemiological studies have shown. Although age is not a risk factor for periodontal diseases, and older people are not susceptible to periodontal diseases, bone destruction or gingival recession are ordinary conditions. The accumulation of several risk factors through the years, such as plaque or systemic diseases, acts synergistically in the onset of periodontal diseases.

In the United States 70.1% of adults aged 65 years and over is estimated to suffer from periodontal diseases. Eke et al also concluded that periodontal disease is observed more frequently in males than in females. Furthermore, Mexican-Americans had the highest likelihood of a diagnosis with such a disease compared to other racial groups. Smoking habits and socio-economic status were also important. Smokers and low educated individuals with low social status exhibited higher percentages of periodontal disease.

Dry Mouth

Saliva is required not only for function, but also for protection of the oral cavity and contiguous gastrointestinal epithelium. According to a systematic review, the prevalence of self-reported xerostomia in population ranged from 0.9% to 64.8%. Another study found that 30% of a sample population aged 65 years and over experienced this disorder. Older people receive a great number of medications that may have an important role in oral health. It is common that 1 of these drugs may affect the salivary glands and reduce the amount of saliva. Tricyclic antidepressants, antihistamines,
antimuscarinic medicines, some anti-epileptic medicines, some antipsychotics, beta-blockers and diuretics may have a key role in causing dry mouth.

Dry mouth has a substantial impact on older people’s lives. The reduction of saliva causes difficulties in chewing, speaking and swallowing as well. Tissue problems, dental caries and problems with dentures constitute consequences of xerostomia. The term xerostomia refers to the subjective feeling, while the term “salivary gland hypofunction” refers to a low salivary flow. This oral condition has an important negative effect on older people’s lives. Therefore, its association with quality of life is clear.

**Oral Cancer**

Oral pre-cancer includes leukoplakia, lichen planus and erythroplakia, while oral cancer mainly refers to oral squamous cell carcinoma. The prevalence of oral cancer, according to WHO, is 1-10 per 100,000 people. Statistically significant differences were recorded in males, seniors, and low-educated individuals with low-income. Also, smoking habits and alcohol consumption play a crucial role in the development of oral cancer. Petersen and Yamamoto concluded that older people were more prone to oral cancer and especially people that lived in less developed countries compared to more developed ones.

Oral cancer demonstrates catastrophic consequences in human life. The death ratio of oral cancer is extremely high, similar to breast cancer, and higher than the generally known melanoma.

**Studies from Some Balkan Countries**

A relatively high number of tooth loss was recorded in a Turkish population aged 65 years and over. Mean tooth loss for 215 patients participating in the study was 17.1 ± 10.1, while females exhibited a higher prevalence of tooth loss. Maxillary posterior teeth were extracted more frequently than the other tooth types. Educational level and age were associated with tooth loss. In the same study, the mean number of carious teeth was 1.7 ± 1.9, where the educational level of the individuals played a crucial role. Both the number of carious teeth and the number of teeth with furcation lesions and infra-bony defects were negatively associated with educational level.

The oral health status of hospitalized psychiatric patients was reported in a Greek study by Kossioni et al. 111 patients were diagnosed with mood disorders, psychotic disorders, dementia and other. The mean age of the individuals was 73 years. 39.6% of the examined patients were completely edentulous, while the dentate seniors exhibited 12.9 teeth on average. 26.7% had fillings, 50.7% had at least one decayed tooth, and 44.8% needed at least 1 extraction. Dental plaque or calculus was recorded in 83.6% of psychiatric patients. Mental disorders did not influence significantly dental conditions. However, the number of remaining teeth was associated with age, and the duration of hospitalisation demonstrated a positive association with the increased rate of caries and need of extractions. In a sample group of the previous population, mean aged 73 years, the same research group showed that the most common complaint of psychiatric patients was xerostomia (44.9%).

In a retrospective study of Baderca et al. in Romania, oral cavity melanomas were found in high incidence (25%). Mucosal melanomas were associated with age and had a poor prognosis. The male/female ratio in this study was 10:6 and the age of the patients included ranges from 53 to 94 years. The most frequent localization of these 17 cases was in the nasal cavity, but also mucosal melanomas were diagnosed in the oropharynx, right mandibular gum, right palatine tonsil, left maxillary mucosa, lower lip, anus, rectum, etc.

316 patients attending 12 randomly selected community centres located in Athens participated in another study. The mean age of the study population was 78 years and the age ranged between 65 and 99 years. The majority of the study patients (79%) were edentulous, while 14.6% of them suffered from dry mouth. Although 27 oral conditions were recorded, no cases were found with malignant lesions. In another study from Greece, 43% of an older institutionalised population, with a mean age of 83.7 years, complained about xerostomia. Almost all of these (95%) suffering from xerostomia were under medication, and the mean number of consumed drugs was 3.3 ± 2.0. 62% of seniors were completely edentulous. Socio-economic status and the presence of various psychiatric disorders (personality disorders, schizophrenia and delusional disorders, depression) influenced significantly the number of remaining teeth. This number was not associated with the functional quality of dentition. The authors deduced that approximately 2 to 4 posterior tooth contacts were adequate for chewing ability. Patients suffering from mental disorders were also included in a study conducted by the same group in Greece. Kossioni et al. discovered that xerostomia and some other complaints, such as burning mouth, dysgeusia, and oral malodour, were more prevalent in seniors diagnosed with mental disorders than older people without mental disease.

231 free-living individuals aged 65 years and over from Bosnia and Herzegovina were included in a study measuring the validity and reliability of the OIDP (oral impacts on daily performance) scale. 19.9% of the
participants demonstrated complete absence of natural teeth, while 10.7% of the dentate sample needed tooth extraction. 20.3% of the total population exhibited 21 teeth and over. Restorative needs of at least 1 filling were exhibited by 27.9%27,52.5% of the participants in another study in Ankara, Turkey, were edentulous, and tooth loss was more frequent in females compared to males28. A possible reason for this observation is that women are more prone to develop osteoporosis, which may have an effect in tooth loss. In addition, a high edentulism rate was observed in patients over 75 years28.

Aging and tooth loss were associated also in another study in Turkey29. Edentulism increased with increasing age, and tooth loss was also correlated with age. In particular, in a study conducted by Dogan and Gokalp29, almost half (48%) of the participants were edentulous. Seniors aged 70-74 years exhibited a significantly higher complete absence of teeth in contrast with the population aged between 65 and 69. DMFT scores were also associated significantly with age and living area: higher DMFT scores were measured in older aged seniors whose residency was in rural areas. The DMFT scores of another older population in Istanbul, Turkey were 19.60 (± 7.56) for individuals aged 55-64 years, and 22.17 (± 6.71) for seniors over 65 years30.

The relationship between oral and systemic diseases of older adults was evaluated in a study conducted by Ozcaka et al31. The older population of the study had a mean age of 62.5 years, and the periodontal measurements were the following: mean CPTIN (community periodontal treatment needs) was 1.62 (± 1.12), PI (plaque index) 1.57 (± 1.48), GI (gingival index) 1.55 (± 1.31). The average tooth loss for this sample was 7.38 teeth, with a range from 0 to 2531.

Discussion

Poor oral health and oral health problems are preventable. However, the huge majority of the older population is characterized by extensive tooth loss, periodontal destruction and untreated caries. One of the main reasons for the higher prevalence of oral diseases in older people is inequalities in dental care access. Apart from the older population, minorities or low-educated individuals with low socio-economic status report rare dental visits.

Older people have difficulties in accessing preventive dental care and dental treatment. A crucial reason is lack of insurance. Dental insurance plays an important role in the selection of the dental treatment that older people select. Each country adopts different coverage for dental procedures. In particular, in Turkey, cavity fillings, periodontal therapy and tooth extractions are free of charge for insured older people. However, 50% of the cost of prosthodontic treatments must be paid by the patients. Another option is private insurance. Both Medicare and Medicaid in the United States offer limited access to dental care. Particularly, Medicare provides older people with only necessary dental procedures. Therefore, the majority of the older population must cover the expenses of their dental treatment by themselves. Unfortunately, a significant proportion of the older population confronts economic problems. According to Eurostat, 22% of the older population in Greece were at risk of depression in 200832.

Treatment needs of an elderly population are high as a result of missing teeth, caries, periodontal diseases, restorations and edentulism. However, this lack of insurance coverage limits the treatment options for some patients. They usually prefer to extract a tooth instead of attending an endodontist and a prosthodontist for performing a root canal therapy and constructing a crown or a bridge respectively. No treatment is also a viable choice for a group of patients who cannot afford any dental treatment under any circumstances.

The ability of chewing, apart from social impacts and oral health problems, is also an important parameter of general health. Older people with increased tooth loss may perforce change their diet. Therefore, a big question arises as far as nutritional intake is concerned, and the possible effects of such dietary choices. Yet studies in Greece have shown that seniors with an increased tooth loss did not avoid food types. Greek individuals reported continuing to eat hard foods even if they had difficulties in chewing. They preferred to change cooking strategies and consume softer food types, such as chicken, grains or dairy commodities. Meat, vegetables and fruits consumption was not related to dental status or to the number of posterior occluding teeth contacts33,34.

Conclusion

Oral health is essential to general health and quality of life. Oral conditions such as tooth loss, dental caries, periodontal diseases, dry mouth or oral cancer limit patients’ ability to smile, chew and speak, which influences their social life. Oral diseases are more prevalent among poor, low-educated individuals and smokers with low socio-economic status. Governments have the responsibility for providing an adequate dental care system for minorities, as well as powerless, disabled and impoverished people. The aim for the future is to diminish oral health problems in geriatric patients by developing community-based projects for oral health promotion and prevention of oral diseases.
Limited data exists today that evaluate oral health conditions of seniors in the Balkan countries. Researchers from Greece and Turkey have mainly studied oral health problems in older population, but the majority were focused on tooth loss and periodontal diseases. There are also studies examining DMFT scores in older Balkan populations. Almost all of the studies concluded that aging and the socio-economic status of seniors are significantly associated with oral health problems. Therefore, the dental community and society should contribute to improve oral health of the older population by retaining more natural teeth in the oral cavity. Further studies are needed to record oral health problems of older populations in Balkan countries, in order to compare them with records from Western countries. Seniors should have equal access to appropriate dental health care with children, adolescents and adults.

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Introduction

Mental diseases in adolescents and young adults are more common than most people believe. These include eating disorders, 2 of which are anorexia nervosa and bulimia nervosa. Nowadays, the connection of a slim figure with the beauty stereotypes, the emotional and the professional success, has enhanced the development of eating disorders, particularly affecting young people. This situation has caused lifestyle changes, even bringing eating disorders in the third most common chronic illnesses among adolescent girls. Eating disorders are associated with the highest morbidity and mortality rates of mental disorders. A dentist may be the first to suspect or diagnose an eating disorder. However, even proper training is required for the treatment of people with eating disorders and studies have shown that hygienists know better than dentists about the clinical signs of anorexia and bulimia nervosa. The purpose of this review is to highlight the main and secondary signs and symptoms of these diseases, giving each clinical general dentist a more global view and a motivation to include eating disorders in everyday clinical practice.

Anorexia Nervosa

The term anorexia nervosa implies that a person has lost his/her appetite due to “neural” or psychological reasons. It is defined as “inability to maintain body weight, through the intentional restriction of food and drink, combined with increased physical activity”. Anorexia appears mainly between the ages of 15 and 19 years, but can affect people of all ages and although it is considered as a female problem, approximately 10% of treated patients are men. Aetiology is complicated and not fully understood. It is believed, that there is a genetic background and a disruption in the serotonin pathways relating to anxiety, behavioural inhibition and body image distortions.

SUMMARY

Rhythms, requirements and standards of modern life have made the anxiety a common feature of most people. Along with stress, several other psychological problems increasingly appear and, unfortunately, critically affect young ages. 2 of the most common chronic mental disorders are anorexia nervosa and bulimia nervosa. Dentists are uniquely positioned because in their area of examination, signs of these diseases can be seen and then their symptoms can be discussed with patients. Nowadays, despite the fact that these diseases are on the rise, dentists do not know enough about them. Often, even if the knowledge is enough to diagnose the disease, they avoid doing it, because they try not to make their patients feel uncomfortable and lose them.

The purpose of this review is to highlight the main and secondary signs and symptoms of these diseases, giving each clinical general dentist a more global view and a motivation to include eating disorders in everyday clinical practice.

Keywords: Adolescents; Anorexia Nervosa; Bulimia; Dental Erosion

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REVIEW PAPER (RP)
Anorexia nervosa is divided into 2 types, the restricting type and the bingeing or purging type. In the first one, the restriction of food intake is the only behaviour, while in the second type this restriction is accompanied by bulimic episodes and/or use of laxatives. Latter category may include self-induced vomiting, strenuous exercise and abuse of laxatives, diuretics or enemas\(^8\). Anorexia nervosa takes an average of 6 years, indicating increased mortality rates (4-20\%) due to drug complications and suicides\(^9\).

**Bulimia Nervosa**

Bulimia nervosa seems to be more common than anorexia nervosa\(^9\). Both have several similar clinical signs but bulimia nervosa often remains undetected for a longer period, as persons suffering from this disease remain in a normal weight and as a result the presence of bulimia is revealed to an average age of about 25 years. But, there is a clinical sign, which is a characteristic of this disease. Its name is Russell’s sign and it is the existence of calluses on the back of hand or fingers, appearing after repeated use of the hand for self-induced vomiting\(^8\). Bulimia nervosa, like anorexia, has a mean duration of 6 years but much less mortality\(^9\).

**Diagnosis**

The diagnosis of eating disorder is often difficult, as people with such a disease tend to be secretive about their problem. If the disease is detected, it is very likely that the patient will deny it, because of guilt, shame or general self-denial or refuse to treat\(^10\). The dentist has a very important position on diagnosis of eating disorders, because lesions of teeth, caused by self-induced vomiting, are a very common sign of these disorders\(^11,12\). So, in the case of presence of the disease, the dentist has a very important and vital position to motivate the patient for psychiatric help and dental care seeking\(^13\). Instead of this, however, there are only a few dentists who take the responsibility of tackling an eating disorder and the most of them are women\(^14\).

Basic clinical signs that can be detected are dental erosion, hypertrophy of parotid and saliva changes\(^15\). There are conflicting elements about dental caries and its correlation with eating disorders\(^15\). Studies have correlated dental erosion with eating disorders, but regarding dental caries the results were statistically non significant\(^16\).

**Dental Erosion**

Dental erosion is the basic dental implication of eating disorders. It is mainly the result of self-induced vomiting, but may be caused by a diet rich in fruits, often used for its laxative properties. Corrosive lesions appear on palatal and labial surfaces of the upper teeth, due to vomiting, regurgitation and reflux. The occlusal surfaces can also be affected. Surprisingly, there is no correlation between the severity of dental erosion and the duration or frequency of vomiting, or the cause of it (frequent vomiting or diet rich in fruits)\(^6\). It is argued, that the distribution of dental erosions in the mouth is the same, whether the cause is gastric acid or diet acid\(^6\). This view has been significantly challenged, when was proved that patients with bulimia nervosa had more areas with erosive enamel and more severe erosive lesions\(^17\). Erosion, associated with repeated vomiting, often leads to thinning and fracture of cutting edges of incisors, reduction of vertical dimension, compensatory teeth over-eruption and increased temperature sensitivity\(^18\). Exposed dentin, due to erosion, can be painful and thus is 1 of the symptoms presented. Moreover, dental erosive lesions are common on dental surfaces without dental plaque\(^19,20\).

**Parotid Hypertrophy**

Parotid hypertrophy is commonly observed in patients with anorexia and bulimia nervosa\(^21\) and can also be used for diagnosis of these diseases in the absence of any other clinical sign\(^22\). Anorexia and bulimia nervosa have also been associated with sialadenitis of the minor salivary glands of the palate, which is presented as a bilateral, symmetrical and painless, mild swelling of the hard palate\(^23\).

**Changes in Saliva**

There are no differences in stimulated salivary flow in patients with eating disorders. However, dry mouth and reduced un-stimulated salivary flow are mentioned as common symptoms and signs in patients with bulimia nervosa. The concentration of bicarbonate ions in saliva is decreased and as a result its buffer capacity is lower. The above was found in individuals with bulimia nervosa with and without erosive lesions, thus was impossible to be part of aetiology. Viscosity of saliva was increased only in patients with bulimia nervosa and could be a part of aetiology\(^8\). In many cases, hypo-salivation and dry mouth is a side effect of some medication, such as antidepressants that are often prescribed in bulimia nervosa\(^24\). Medication for bulimia nervosa seems to reduce both stimulated and un-stimulated salivary flow\(^25\). Results about, bulimic patients which are not under medication and their stimulated salivary flow, are conflicting\(^26-30\). Dynesen et al\(^25\) have shown an increased calcium concentration in saliva, while older studies hadn’t shown any differences\(^31,32\).

**Other Manifestations**

Repeated self-induced vomiting may cause mobility at one or more teeth, as well as orthodontic disorders, the most frequent of which is open bite\(^33\). If the patient...
uses, apart from fingers, other things to induce vomiting, lesions like those caused by intubation in general anaesthesia, can be observed. Eating disorder-patients often experience insomnia, tension and compression, which could cause or enhance bruxism. It is mentioned that bruxism in combination with erosion, due to acids, has a detrimental effect against dental tissues. According to Emodi-Perlman et al., patients suffering from eating disorders are very sensitive to palpation of the masticatory muscles, although facial pain, in general, is a controversial issue. Frequent and repeated vomiting is considered like a micro-trauma, and is accompanied by intense, sudden and abnormal mouth opening. Some people believe that it can be part of aetiology of temporomandibular joint disorders.

Management by the Dentist

Medical history should be taken with great understanding, non-judgemental style and absolute confidentiality, and all these must be very obvious to the patient. Good cooperation between dentist and patient is very important, as a patient with eating disorders has much more dental anxiety compared with general population, explaining why these individuals visit the dentist only when symptoms are there.

When the desired cooperation is achieved, the next target is to maintain the existing teeth and avoid further dental erosion. Regarding the proper time for restorative therapy, there are 2 opinions. The first one supports that this time is when therapy of eating disorder is completed and the patient has a stable prognosis. The opposing view argues that, especially since restorative treatment helps to improve appearance and self-esteem, it must be done immediately, as it may be the motive needed to seek medical help. If restorative therapy is decided, especially in a young patient with severe erosive lesions, an atraumatic restorative therapy with adhesive materials is proposed. Apart from restorative therapy, very important for these patients is preventive therapy, including dietary and dental hygiene advices, rich in fluoride. Regarding time of tooth-brushing, a very common dental advice is: “Avoid brushing your teeth just after an acidic food intake”, or here after vomiting, as it is considered that decalcified dentin is more sensitive to the abrasion caused by a toothbrush. At this point, it is worth mentioning a study, where statistically non-significant difference was found concerning severity of abrasion among individuals brushing immediately after vomiting and those that delay.

However, another survey of 1203 people 15-18 years old showed that 75% of participants with erosions had the habit of brushing their teeth immediately after eating. The use of dental casts and images as well as the implementation of a re-examination system are of critical importance for the monitoring of these patients through the observation of tooth decay, as patients with eating disorders very often tend to recur after cure. Dentists and other health professionals tend to cover suspicions about eating disorders due to their fear of losing their patient, or insufficient reliance on the clinical signs they notice. A dentist, whatever final attitude he/she may decide to have, must offer prevention tips to avoid further damage such as those involving the use of fluoride, xylitol, soda, soft toothbrush and non-abrasive pastes.

Risk Factors

Only 1 study in the literature seems to have dealt with the normal population, the risk factor per person with respect to the occurrence of eating disorders and related oral manifestations. According to BITE (Bulimic Investigatory Test of Edinburgh), 6% of the population showed a high probability to meet the diagnostic criteria for bulimia nervosa, 15% had sub-clinical bulimia, while 20% had abnormal eating habits. Further analysis of the results showed that adolescents with high risk of eating disorder had increased chances of developing dental erosion. Of course, today, the risk of dental erosion is particularly high in the general population because of changing eating habits, which are rich in consumption of products containing acids. Finally, the clinical sign of dental erosion is particularly important because even if it does not lead along with other signs and symptoms to the diagnosis of an eating disorder, it includes the patient in a high risk - list of displaying disturbed nutritional behaviour.

Reported Symptoms by the Patient Himself

According to a survey of eating disorders in a clinic in Sweden, the mentioning of dental problems was more common in patients with eating disorders compared to healthy patients. Also, clinical signs particularly frequent in patients with eating disorders were dry lips and swelling of the parotid, which are results of frequent evoked vomiting and dehydration. It was also found that these patients often reported a burning feeling of the tongue, night thirst and facial pain. It was stressed that particular attention should be given by dentists at the latter signs, because these are the ones indicating whether the disease is active at the time of examination. Otherwise, only the presence of erosive lesions may be a clinical sign of an already cured disease.
Radiographic Findings

There is research relating the width of the cortex of the mandible shown in a panoramic radiography with the measurements of a special radiographic examination DXA (Dual-energy X-ray Absorptiometry)\(^\text{48}\). Another research leads to positive, but weak, correlation between them\(^\text{49}\).

Approaching the Patient

The approach to a patient with an eating disorder could start from the waiting room of a dental practice, with the apparent distribution of leaflets exhibiting in a simple and understandable way these disorders and their management\(^\text{50}\). For a dentist, it is not sufficient to lead only to the diagnosis of the disease, but he/she should be able afterwards to guide for its treatment. To make this possible, he/she should be aware of specialists in his/her area, psychologists, nutritionists, clinics and hospitals able to handle such a case\(^\text{50}\). Typically, a patient suffering from an eating disorder does not immediately admit it. Burkhart et al\(^\text{50}\), concerning the approach of a patient suspected for an eating disorder, propose the following steps:

- **Select the appropriate time for discussion**
  It may be early in the morning or later in the day when both the patient and the dentist will have plenty of time to express their concerns.

- **Select the appropriate location**
  If the dentist and patient have never met outside the practice, then the most appropriate place is the dental practice with the patient sitting on the dental chair and the dentist nearby. It is also very important that they are not visible to other patients present at the clinic. This way, the person suffering from an eating disorder, can possibly not worry that their conversation is heard by third parties.

- **Good knowledge and management of body language**
  It is very important for the dentist to be familiar with his body language. Thus, he can start the conversation in a non-judgmental way, e.g.: “I feel a little uncomfortable to ask you these questions, but I really care about you.” Particular attention is needed so the patient does not feel the pressure for immediate answers. This is enhanced even by the distance kept by the dentist and the patient, which should leave a space of approximately 2.5 to 3.5 feet between them. The posture should be relaxed (e.g. not having his hands crossed) and their visual contact especially comfortable.

- **Slow start**
  The dentist can start saying: “I noticed some changes in your mouth, such as ... (at this point he/she may state exactly what he/she sees). Are you thinking of something that could have caused these injuries?” If the answer is positive, explanation of the patient follows. If the patient answers “No”, the dentist proceeds correspondingly.

  - **Suggestion for possible causes**
    The dentist may suggest some possible causes. “The changes I notice could be caused by many candies, reflux, many soft drinks and juices, strict diet, pregnancy or frequent vomiting. Is any of these connected to you?” If the answer is negative again the next step follows.

  - **Verification of the relationship of the patient with food**
    “One of our mouth’s basic functions is to obtain food. From my experience, today there are many people who have a peculiar relationship with food. Of course, this is something very personal, so we usually have difficulty talking about it. I would like to ask you about your eating habits in order to better understand the changes I see. Are you okay with that? I do not intend to change or judge you. I only want to help with your oral health. Can I?”

  - **Pause and monitoring**
    This is one of the most important stages. The dentist should give the patient the time necessary to respond but at the same time he/she should understand whether the patient is ready to talk about his problem or not. If the dentist feels that he/she can continue, the next step follows.

  - **Verification of the image that the patient has for his body**
    The dentist should start with some informative questions like: “How do you feel about your weight?”, “Do you want to lose weight?”, “Have you ever eaten in secret?” There is the case the patient does not understand his situation yet and there have to follow many more questions.

  - **Verification of the nutritional behaviour of the patient**
    At this stage the dentist can use more direct questions. He/she can start by saying: “I want to make some specific questions about your diet. Your answers will help me understand why these lesions are in your mouth. If at any time you feel uncomfortable, feel free to tell me.”, “Have you ever caused vomiting?”, “Do you use laxatives or other pills or intense exercise to lose weight?”, “Does anybody worry about how you eat? Who and why?”, “Have you ever consulted a nutritionist, dietitian or psychologist?” If at this point the answer is still “No”, another step follows.

  - **Summarizing and asking for the patient’s permission for his monitoring**
    Now it’s the right time for the dentist to appreciate the patient’s willingness to discuss, whatever the result.
And the discussion may follow like: ‘‘I would like your doctor to know about some changes you have in your mouth because they are concerning. May I contact him?’’ If the authorization is given it is advisable to be in written form because confidentiality is very important. The clinician must give the patient some brochures and then ask him if he has any questions or wants to discuss something.

For all the above steps and at any time the patient can become very defensive towards the dentist. However, the dentist must be calm and highly supportive. If at any stage the patient states that they are aware of their condition, the dentist should praise them and point out that any time they are ready to start treatment he/she will be there to advise them. When the diagnosis involves a child, parents have the right to know and the situation must immediately be transferred to them.

Conclusions

In conclusion, it is stated that every patient with tooth abrasion, can be considered a candidate for eating disorders, but there certainly should be a careful investigation of all the possible coexisting factors. Thus, a more complete picture of our patient will lead to a safer conclusion and an appropriate treatment. For extensive and easily detectable tooth abrasions to occur from an eating disorder, it can be deducted that this disorder already existed and even for more than a year. Exploring further signs and symptoms, less obvious but related to eating disorders in daily dental practice, can place the dentist in a special position, making her/him able to offer help and cure to a large part of the young population, in which, as victims of nowadays stereotypes, eating disorders exist.

References


Application of High-Power Diode Laser and Photodynamic Therapy in Endodontic Treatment - Review of the Literature

SUMMARY
Lasers have found important role in clinical application, science and scientific research. *The aim of this review is to focus on using soft tissue laser in endodontic treatments.* The main goal of endodontic treatment is elimination of pathogenic microorganisms from root canal system. Laser light has the ability to reach parts of the tissue and areas where classical techniques and instruments cannot. New approaches to disinfecting root canals have been proposed recently, which include the use of high-power diode lasers, as well as disinfection of the root canal by using photodynamic therapy. *A research is necessary to define a precise protocol for high-power laser and photodynamic therapy in treatment of the root canal system.*

Keywords: Diode Laser; Photodynamic Therapy; Endodontics

Introduction
Miaman\(^1\) was first who introduced lasers in dentistry in the 1960s, and since then it led to the application of lasers in everyday dental practice. Beside clinical, lasers have found important role in science and scientific research. Modern day lasers represent results of years of the research. The first laser designed specifically for dentistry was introduced in 1989\(^2\). The medical community began to incorporate lasers for soft-tissue procedures in the mid-to-late 1970s, and oral surgery added the technology in the early 1980s. On the account of efficiency, specificity, comfort, and cost over the conventional modalities, lasers are indicated for a wide variety of procedures in dental practice\(^3-5\). The aim of this review is to focus on using soft tissue diode laser for disinfection of root canals in endodontic treatments.

Mechanism of Laser
The working of laser light depends on typical properties of electromagnetic radiation. While in nature most of the light is white, laser light is monochromatic, coherent and focused. Monochromatic means that it emits at a specific wavelength or frequency containing 1 or narrow spectral range. Laser light is generated as only 1 colour. Dental lasers may emit visible or invisible light. The waves of laser light are coherent. Each wave is identical in physical size and shape. Coherence means that all photons are in the same phase in time and space, and focus denotes a virtual mutual parallelism of the photons in the beam. Result of orientation is a very small divergence at large distances, which allows the laser beam to be easily controlled and focused.

Working of the laser and its effect on biological tissue is determined by interaction of laser radiation parameters, such as: wavelength, physical characteristics of the illuminated tissue, energy radiation, continuous or pulsed mode, diameter of the laser beam, and the exposure time. Laser beam passing through the tissue can be reflected, absorbed, transmitted and scattered. Proportion of reflection, absorption, transmission and scattering depends on the wavelength of the rays and the absorption capacity of the tissue\(^6-10\).

Illumination by different wavelengths of the laser beam produces different absorption coefficients and...
depends on the tissue the laser beam acts. The target components of the tissue on which the laser beam acts are referred to as chromophores, such as water, protein, melanin, haemoglobin, hydroxyapatite, and other minerals. Knowledge of the composition of the target tissue is necessary in selecting the correct wave length of the laser. In this way we will achieve the desired absorption which is optimal for biological effects of lasers on tissue. The laser parameters - energy, beam diameter, and duration of exposure - must be carefully monitored to produce a successful treatment result.

There are 4 reaction mechanisms associated with the use of lasers in medicine, which depend on the therapeutic aim of laser treatment: photomechanical effect (photo-acoustic) i.e. for laser lithotripsy, removal of tattoos and certain pigmented lesions, photochemical effect i.e. photodynamic therapy (PDT), chemical reaction stimulation, photothermal effect i.e. laser resurfacing, treatment of vascular lesions, laser hair removal, and photobiostimulative effect i.e. low level laser therapy (LLLT), laser acupuncture, collagen remodelling for aged skin, anti-inflammatory treatments, accelerated wound healing11-26.

It is important to note that the commercially available dental instruments all have emission wavelengths ranging from 488 nm to 10,600 nm and are all nonionizing radiation. This is to be distinguished from ionizing radiation, which is mutagenic to cellular DNA components27.

**Types of Lasers**

In dental scientific and professional literature many experimental and clinical studies are described, as well as case reports that use different types of lasers of different wavelengths, such as: Carbon dioxide (CO2) lasers, Nd:YAG lasers (1064nm), Er:YAG (2.94μm) and Er:YSGG lasers, Argon (488, 514nm) and krypton (513nm), and diode laser.

Due to extremely wide range of applications, diode lasers are now the most widely used types of laser devices in dentistry. Results of scientific and clinical studies indicate increasing application of diode lasers as an adjunct therapeutic agent. Diode lasers, depending on the wavelength and power irradiation can be used for incision, haemostasis and coagulation. Depending on the chosen parameters, lasers can have a significant antibacterial effect of direct ablation, thermal denaturation or destruction of bacterial cells. Thermolysis by laser energy achieved significant decrease of pathogenic flora27.

Diode laser can be applied in many branches of dentistry: periodontics, oral medicine, oral surgery, maxillofacial surgery, restorative dentistry, endodontics, prosthetics, and paediatric dentistry.

**Lasers in Endodontics**

The development of new delivery systems, such as thin and flexible fibres, as well as new endodontic tips, allowed this technology to be applied in various endodontic procedures. The application of lasers in endodontics can be for: pulp diagnosis (laser doppler flowmetry), pulp capping and pulpotomy, cleaning and disinfecting the root canal system, sedative and anti-inflammatory treatment, endodontic re-treatment, apical surgery.

**Disinfection of the Root Canal System**

The main goal of endodontic treatment is to complete disinfection and elimination of the pathogenic microorganisms from the root canal system. It has been known that microbial infection plays an important role in the development of necrosis in the dental pulp and formation of periapical lesions19. It is well established that eradication of bacteria from root canals is difficult, and current endodontic techniques are unable to consistently disinfect the canal systems20. Endodontic therapy attempts to eliminate bacteria within the root canal system by utilizing protocols that combine mechanical instrumentation and chemical irrigation of disinfectant agents, such as sodium hypochlorite or hydrogen peroxide, the application of an inter appointment dressing containing an antimicrobial agent, and sealing of the root canal21. New approaches to disinfecting root canals have been proposed recently that include the use of high-power lasers16,22, as well as disinfection of the root canal by using photodynamic therapy16,23-25.

Disadvantages of conventional root canal treatments include their skill-dependent nature, long treatment time, possible weakening of teeth due to widening of the root canal, and use of medicaments such as sodium hypochlorite25. A disadvantage with irrigants might also be their inability to penetrate the deeper parts of dentinal tubules where microorganisms may reside26.

Field of antibacterial chemotherapy is a constant challenge. The current problem of bacterial drug resistance perhaps best illustrates the continuing requirement both for new agents and new approaches to eliminate infection from root canal system.

Ng et al.27 suggested that it would be superior to develop adjunctive antibacterial therapeutic strategies to chemo-mechanical methods to target residual microorganisms and thus enhance the healing rates of teeth with infected root canals.

The bactericidal effects when lasers are used as adjunctive therapy for root canal disinfection depend on the type of laser used. There is still lack of evidence for understanding the exact way of killing microorganism using the laser. The high-power diode laser has been tested in several areas of dentistry, with promising results for the disinfection of root canals22,34-39. It has
been shown that laser light has the ability to reach parts of the tissue and areas where classical techniques and instruments cannot\cite{16,22,29,31}.

Nd:YAG lasers are thought to eradicate microorganism mainly by thermal effects, whereas the suggested bactericidal mechanism of action for Er:YAG lasers is linked to the strong water absorption of the laser output. Lasing parameters such as pulse length, fluency and irradiance are also suggested to be involved in the anti-bacterial effect\cite{25}.

High-power lasers function by dose-dependent heat generation, in addition to killing bacteria. Antibacterial effect is achieved by increasing temperature in root canals. When the transmitted laser light leads to the appearance of the thermal effects care must be taken not to damage the surrounding periapical tissues, anatomical structures (the mental foramen, mandibular canal).

Earlier studies demonstrated that this form of therapy has no advantage over the classical application of sodium hypochlorite\cite{16,32}. High-power laser have the potential to cause collateral damage, such as char dentine, root ankylosis, cementum melting, and root resorption and peri-radicular necrosis if incorrect laser parameters were used\cite{33}. There is a need for new studies about using high-power laser in combination with sodium hypochlorite.

Lasers are also used in techniques that employ photo-activated substances or photosensitizers; however, the mode of action is completely different from the ones described above. This technique is photodynamic therapy (PDT) which was first developed as a cancer therapy. Today, PDT, or photo-chemotherapy is a non-invasive therapeutic modality for treatment of various infections by bacteria, fungi and viruses\cite{40,41}. Mechanism of PDT involves 3 elements: a photosensitizer, a light and tissue oxygen. Antimicrobial photodynamic therapy (aPDT) could be used as an adjunctive therapy in the treatment of periodontitis\cite{41,42}, periimplantitis\cite{41,43}, endodontics and caries\cite{44,46,47}.

**PDT** is defined as an oxygen-dependent reaction that occurs upon light-mediated activation of photo-sensitising compound leading to the generation of cytotoxic reactive oxygen species, predominantly singlet oxygen\cite{49}. Phototoxic substance (photosensitizer) binds to the target cell, and appropriate wave length activates this matter, which causes excitation of phototoxic materials in the presence of oxygen. This process leads to the formation of free radicals (with the largest quantity of free oxygen) that lead to cytotoxicity and death of the target cell\cite{40,41}. Previous studies have shown that Gram-negative bacteria are resistant to the photoactive material, in contrast to Gram-positive bacteria\cite{45}. aPDT is without harmful effects on the surrounding hard and soft tissues\cite{40,45,46,47}.

There are many studies where aPDT is compared with another type of therapy, such as irrigation with different concentration of sodium hypochlorite\cite{6,45,47}, ozone therapy\cite{32} or some another type of laser\cite{16}. It has been shown that aPDT significantly reduces bacteria in root canals, which creates better results than conventional protocols and has much higher efficiency than high power lasers. Most research was done ex vivo; therefore more in vivo experiments are needed.

**Conclusion**

A precise protocol for aPDT or high-power diode laser therapy does not exist. It has not been determined how many sessions or repetitions of therapy are needed to create completely sterile conditions. A research is necessary to define a precise protocol for a PDT and high-power laser in therapy of the root canal. Looking to the future, it is expected that specific laser technologies will become essential components of contemporary dental practice over the next decade.

**References**


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Effective Cell Growth Potential of Mg-Based Bioceramic Scaffolds towards Targeted Dentin Regeneration

SUMMARY

New emerging approaches in tissue engineering include incorporation of metal ions involved in various metabolic processes, such as Cu, Zn, Si into bioceramic scaffolds for enhanced cell growth and differentiation of specific cell types. The aim of the present work was to investigate the attachment, morphology, growth and mineralized tissue formation potential of Dental Pulp Stem Cells (DPSCs) seeded into Mg-based glass-ceramic scaffolds with incorporated Zn and Cu ions. Bioceramic scaffolds containing Si 60%, Ca 30%, Mg 7.5% and either Zn or Cu 2.5%, sintered at different temperatures were synthesized by the foam replica technique and seeded with DPSCs for up to 21 days. Scanning Electron Microscopy with associated Energy Dispersive Spectroscopy (SEM-EDS) was used to evaluate their ability to support the DPSCs’s attachment and proliferation, while the structure of the seeded scaffolds was investigated by X-Ray Diffraction Analysis (XRD). Zn-doped bioceramic scaffolds promoted the attachment and growth of human DPSCs, while identically fabricated scaffolds doped with Cu showed a cytotoxic behaviour, irrespective of the sintering temperature. A mineralized tissue with apatite-like structure was formed on both Cu-doped scaffolds and only on those Zn-doped scaffolds heat-treated at lower temperatures. Sol-gel derived Zn-doped scaffolds sintered at 890°C support DPSC growth and apatite-like tissue formation, which renders them as promising candidates towards dental tissue regeneration.

Keywords: Bioceramic Scaffolds; Dental Pulp Stem Cells; Copper Ions; Zinc Ions; Dentin Regeneration

Introduction

Scaffold-based approach for dental tissue regeneration involves the use of an appropriate scaffolding material where cells, triggered by specific molecular or environmental cues, become able to “create” tissues of the desired architecture. Ceramic scaffolds consisting of calcium/phosphate glasses, such as β-TCP and HA have been applied for tooth or specific dental tissue regeneration due to their compositional resemblance to hydroxyapatite, the mineral phase of enamel, dentin and cementum, while other bioactive glasses and glass ceramic compositions have shown promising results.

Magnesium (Mg) is a key element in human body, as it plays a significant role in cellular processes and skeletal metabolism, while Mg deprivation inhibits cell growth. Despite the effective use of Mg in bone tissue regeneration, Mg-containing glass-ceramics have been only recently proposed for dental tissue regeneration and have been proven effective to induce differentiation of human mesenchymal stem cells (MSCs). The sustained release of Si and Mg during the gradual degradation of the scaffolds can significantly enhance proliferation, differentiation and bio-mineralization of stem cells as well as human dental pulp stem cells (DPSCs) in vitro.
Many trace elements, such as Sr, Cu, Zn or Co that are physiologically present in the human body are known for their contribution effects in bone metabolism\textsuperscript{9,10}, so new emerging approaches exploit the potential introduction of these ions into scaffolding materials for an enhanced therapeutic result. Among those, copper (Cu) has been proposed to modulate the proliferation and differentiation of human MSCs\textsuperscript{11}, while it is known to have a positive effect on angiogenesis\textsuperscript{12}. However, the most dominant property of copper is its antibacterial activity against various Gram-positive and Gram-negative species\textsuperscript{13,14}. Another element of interest is zinc (Zn), as Zn ions show anti-inflammatory effects and stimulate bone formation \textit{in vitro} by activating protein synthesis in osteoblasts\textsuperscript{15,16}. Zinc ions attain further antibacterial properties, that are related to the modulation of membrane-associated enzyme mechanisms\textsuperscript{17} and antimicrobial activity that has been partially attributed to the hydrogen peroxide that is generated from the surface of ZnO crystals\textsuperscript{18}. Furthermore, the release of Zn\textsuperscript{2+} from dental restorative glass-ionomer cements has been reported to provide local antimicrobial resistance and cariostatic protection\textsuperscript{19}.

The ability to support cell growth and differentiation is a prerequisite for a successful scaffold for guided tissue regeneration. However, the strategy of incorporating into the ceramic scaffolds ions with antimicrobial properties and/or proven contribution to specific growth-kinetic mechanisms could be highly beneficial and lead to more efficient tissue regeneration. Consequently, the aim of the present work was to investigate the attachment, morphology, growth and mineralized tissue formation potential of DPSCs seeded into Mg-based glass-ceramic scaffolds with incorporated Zn and Cu.

Materials and Methods

Scaffold Synthesis

Mg-based scaffolds of different compositions (Tab. 1) were synthesized by the foam- replica technique\textsuperscript{20} using sol-gel derived glasses. The sol-gel solution was prepared by the following procedure: \textit{Tetra-ortho-silicate} (TEOS) was added to the mixture of ultra pure H\textsubscript{2}O and HNO\textsubscript{3} (2N) and stirred for approximately 30 min until partial hydrolysis of TEOS occurred. Calcium nitrate tetrahydrate (Ca(NO\textsubscript{3})\textsubscript{2}·4H\textsubscript{2}O), Magnesium nitrate hexahydrate (Mg(NO\textsubscript{3})\textsubscript{2}·6H\textsubscript{2}O) and Zinc nitrate hexahydrate (Zn(NO\textsubscript{3})\textsubscript{2}·6H\textsubscript{2}O) or Cupric nitrate hemipentahydrate (Cu(NO\textsubscript{3})\textsubscript{2}·2.5H\textsubscript{2}O) were added to the mixture, allowing 50 min for the hydrolysis reaction complete at 60°C. After the immersion of the foam in the sol-gel and mechanical stirring for 5 min, the samples (green bodies) were retrieved from the sol-gel and squeezed in order to remove the excess of sol from the pores and then left to dry out for at least 12 h. The thickness of the bioactive glass on the green bodies was adjusted by pouring droplets of sol-gel on them and making sure that the excess of it was removed after centrifuging the green bodies. Following, the synthesized scaffolds were sintered at different temperatures according to the Thermogravimetric (TG) and Differential Scanning Calorimetry (DSC) curves\textsuperscript{21} (Tab. 1).

### Table 1. Composition and sintering temperature of the synthesized scaffolds

<table>
<thead>
<tr>
<th>Abbreviations</th>
<th>Compositions</th>
<th>Sintering Temperature</th>
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<tbody>
<tr>
<td>ZnA2</td>
<td>Si60% Ca30% Mg7.5% Zn2.5%</td>
<td>890°C</td>
</tr>
<tr>
<td>ZnB2</td>
<td>Si60% Ca30% Mg7.5% Zn2.5%</td>
<td>1180°C</td>
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<tr>
<td>CuA2</td>
<td>Si60% Ca30% Mg7.5% Cu2.5%</td>
<td>866°C</td>
</tr>
<tr>
<td>CuB2</td>
<td>Si60% Ca30% Mg7.5% Cu2.5%</td>
<td>1060°C</td>
</tr>
</tbody>
</table>

Evaluation of Cell Attachment and Morphology of DPSCs Seeded into the Scaffolds

DPSC cultures were established from third molars of young healthy donors aged 16-18 years old and extensively characterized for several stem cell markers, as previously published by our group\textsuperscript{22}. The collection of the samples was performed according to the guidelines of the Institutional Review Board and the parents of all donors signed an informed consent form. For the establishment of cell cultures the enzymatic dissociation method was used\textsuperscript{23}. Cells were expanded with a MEM (Minimum Essential Media) culture medium (Invitrogen), supplemented with 15% FBS (EU-tested, Invitrogen), 100 μm of L-ascormic acid phosphate and 1% antibiotics/antimycotics (=complete Culture medium-CCM) and incubated at 37°C in 5% CO\textsubscript{2}. Cultured DPSCs in passage numbers from 3-6 were used for all experiments.

To analyze cell attachment and morphology, DPSCs were spotted at low volume (100 μl) into the scaffolds at 10\textsuperscript{6} cells/scaffold in 24 well-plates and allowed to attach for 45 min before being fully covered with 1200 μl CCM. Medium change was performed every 2-3 days during the entire experimental period. After 3, 7, and 14 days the scaffold/cell constructs were processed for Scanning Electron Microscopy-SEM (Jeol, Japan). Briefly, cell/scaffold complexes were washed twice with PBS and fixed with 3% glutaraldehyde (in 0.1M sodium cacodylate, pH 7.4 containing 0.1M sucrose). The specimens were subsequently dehydrated in a series of increasing concentrations of ethanol, completely dried by exposure to hexamethyldisilazane and carbon-coated for SEM observation.
In a second series of experiments, DPSCs were spotted at $10^6$ cells/scaffold in 24 well-plates, as described previously, and exposed to CCM supplemented additionally with 1.8 mM monopotassium phosphate (KH2PO4) and 5 mM b-glycerophosphate (b-GP), as external phosphate sources to allow mineralized tissue formation. Energy Dispersive X-ray analysis was simultaneously performed on scaffold/cell constructs for the investigation of any compositional alterations of the scaffolds during the cell culture process. X-ray diffraction analysis (XRD) was used in order to exam changes of scaffold’s crystal structure and/or the structural properties of any mineralized tissue. For the XRD analysis a Philips (PW1710) diffractometer with Ni-filtered CuKa wave radiation was used.

### Results

#### Scaffold Morphology

The scaffolds derived from the Cu compositions were very brittle and multiple fractured struts and pores were observed in the respective SEM micro-photographs (Fig. 1, a and b). On the contrary scaffolds with pore size of approximately 200-400 μm and interconnected pore structure were successfully fabricated via the foam replica technique for the Zn compositions (Fig. 1, c and d). Almost all pores remained open while blocked pores were rarely observed. The scaffolds presented a mean porosity around 80%\(^2\). Although scaffolds of both formulations contained traces of Mg and similar amounts of Si, higher amounts of Ca were found in the Cu-doped scaffolds as recorded by the EDS analysis.

<table>
<thead>
<tr>
<th>Element</th>
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<th>CUB2 (b) w.t.%</th>
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<tr>
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<tr>
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</table>
Evaluation of Cell Attachment and Morphology of DPSCs Seeded into the Scaffolds

The SEM micro-photographs of representative scaffolds/cells constructs after 14 days of cell culture are presented in figure 2. It can be observed that cells attachment and growth were mainly favoured inside the struts and the pores of the ZnA2 scaffolds that were almost completely covered with cells after 14 days of culture. In contrast, only few cells were apparent on the surface of CuA2, CuB2 and ZnB2 scaffolds at all time points. Figure 2f reveals the significant attachment and spreading of DPSCs inside the ZnA2 scaffolds.
Figure 2. SEM micro-photographs of representative scaffolds/cells constructs after 14 days of culture. (a) CuA2 at lower and (b) CuA2 at higher magnification, (c) CuB2 at lower and (d) CuB2 at higher magnification, (e) ZnA2 at lower and (f) ZnA2 at higher magnification, (g) ZnB2 at lower and (h) ZnB2 at higher magnification.
Although Si and Ca could be found in the initial scaffold composition, the presence of P as well as a Ca/P ratio of the synthesized tissue ranging from 1.5-2.1, indicated formation of biological non-stoichiometric hydroxyapatite. This is further evidenced by the formation of multiple areas with mineralized aggregates on the surface of a CuA2 scaffold presented in the SEM micro-photograph in figure 5a. At higher magnification of a CuB2 scaffold, a fibrous-like tissue was observed with randomly developed mineralized nodules of apatite (Fig. 5b, spectrums 1,2).

![SEM micro-photographs of Cu scaffolds](image)

<table>
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Figure 3. Scaffolds/cell constructs after 21 days of culture: (a) SEM micro-photograph of a CuA2 scaffold seeded with DPSCs, (b) back-scattered micro-photograph of (a), (c) SEM micro-photograph of a CuB2 scaffold seeded with DPSCs, (d) back-scattered micro-photograph of (c). Frame corresponds to the area of EDS analysis.
Figure 4. Scaffolds/cell constructs after 21 days of culture: (a) SEM micro-photograph of a ZnA2 scaffold seeded with DPSCs, (b) back-scattered micro-photograph of (a), (c) SEM micro-photograph of a ZnB2 scaffold seeded with DPSCs, (d) back-scattered micro-photograph of (c). Frame corresponds to the area of EDS analysis.

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Figure 4. Scaffolds/cell constructs after 21 days of culture: (a) SEM micro-photograph of a ZnA2 scaffold seeded with DPSCs, (b) back-scattered micro-photograph of (a), (c) SEM micro-photograph of a ZnB2 scaffold seeded with DPSCs, (d) back-scattered micro-photograph of (c). Frame corresponds to the area of EDS analysis.
### CuA2 (a) (wt%) and CuB2 (b) (wt%)

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Figure 5. (a) Backscattered microphotographs of a representative CuB2 scaffold, (b) Mineralized aggregates on a CuA2 scaffold.

### ZnA2 (a) (w.t.%) and ZnB2 (b) (w.t.%)

<table>
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Figure 6. Backscattered microphotographs of a representative ZnA2 (a) and ZnB2 (b) scaffolds.
In contrast, only traces of Ca and P were found on the Zn scaffolds, although Ca and P were higher in ZnA2 compared to ZnB2 (Figure 4). Even though no apatitic phases were formed on Zn-doped scaffolds, backscattered micro-photographs revealed formation of a fibrous tissue similar to extracellular matrix that covered the whole surface of both ZnA2 and ZnB2 scaffolds and was well spread even inside their pores (Fig. 6, a and b).

The structure of the synthesized tissues was investigated through XRD and the results are presented in the respective XRD patterns in figure 7. For comparison reasons the XRD pattern of human dentine is apposed in the same figure. The formation of apatite is verified by a broad peak around 31° (2θ), showing the apatitic structure of the tissue formed on CuA2, CuB2 and to a lesser extent on ZnA2, while further, no other calcium phosphate phases were detected. Further, a higher amount of amorphous phase is present on the XRD patterns of both ZnA2 and ZnB2.

![Figure 7](image.png)

Figure 7. XRD patterns of the calcified tissues on the surface of the scaffolds remaining in culture for 21 days: (a) Cu-doped scaffolds, (b) Zn-doped scaffolds. The grey frame indicates the bioapatite main peak area

**Discussion**

This study investigated the efficacy of bioceramic scaffolds of different compositions to support the attachment, growth and mineralized tissue formation of human DPSCs up to 21 days in culture. SEM analysis revealed a much better biological behaviour of ZnA2 compared to all other scaffolds. The cells proliferated over the surface of the scaffold and were densely grown, attaining an elongated, spindle-like morphology, indicative of high viability. In contrast, cells inside the CuA2 and CuB2 scaffolds could not attach, spread and grow and the respective SEM micro-photographs revealed a cytotoxic effect.

The profound differences concerning the biological response of these scaffolds can be attributed to major differences concerning their structure and composition. The effect of zinc incorporation into the structure of various glasses with potential application in tissue engineering has been reported to affect the 2 main properties of such glasses, i.e. bioactivity and biocompatibility. Zinc has been found to drastically reduce the total dissolution rate of various formulations in different media\(^24,25\) and this reduction is concentration-depend\(^24\). Goel et al.\(^23\)
reported on the effect of varying the Zn\(^{2+}/\text{Mg}^{2+}\) ratio on the structure and biodegradation of glasses in an alkali-free system designed in the glass forming region of diopside (CaMg\(_2\)Si\(_2\)O\(_6\))-fluorapatite [Ca\(_3\)(PO\(_4\))\(_2\)F]-TCP (3CaO-P\(_2\)O\(_5\)). They found that the increasing Zn\(^{2+}/\text{Mg}^{2+}\) ratio decreases the chemical degradation of glasses as well as reduces their apatite forming ability. On the other hand, Aina et al.\(^{24}\) after investigating the effect of Zn content in different zinc-doped 45S5-derived systems concluded that only the glass containing 5\% Zn presented at the same time reduced solubility, apatite forming ability and conditions allowing endothelial cell growth over a 6-day period. Unpublished data of our group concerning the apatite forming ability of these scaffolds reveal that both the formation of new more stable crystal phases, such as foshagite (Ca\(_4\)Si\(_3\)O\(_9\)(OH)\(_2\)), calcite CaCO\(_3\), wollastonite (CaSiO\(_3\)) and christobalite (SiO\(_2\)), together with the generation of a glass structure with higher network connectivity, are associated to a lower dissolution process\(^{23}\) and the inhibition of the conversion from amorphous CaP to HA, as has been reported in other studies as well\(^{26,27}\). This low dissolution of Zn-doped scaffolds leading to low amounts of released Zn or other elements may have attributed to the superior biological response of these scaffolds, as high amounts of Zn have been reported to present cytotoxicity\(^{28,29}\).

On the other hand, Cu-doped 45S5 BG scaffolds exhibit high apatite forming ability, as proven by the rapid formation of a carbonated HA layer on their surface (3 days in SBF)\(^{30}\). Hoppe et al.\(^{30}\) reported that Cu\(^{2+}\) addition (up to 2.5\% CuO) had no effect on the reactivity of the un-doped BG, as measured through immersion in SBF. The reason for this difference between Zn- and Cu-doped scaffolds is that Zn ions can act either as network formers or network modifiers depending on their coordination forming less or more stable structures respectively, while Cu ions that are network modifiers generate glass structures less chemically stable and dense than that generated by Zn\(^{2+}\) ions\(^{29}\). However, whether this inferior biological behaviour of CuA2 scaffolds is due to a very high release of cytotoxic concentrations of Cu or any other elements or other underlying molecular mechanisms are responsible needs further investigation.

The formation of a mineralized tissue was evidenced in most of the scaffolds synthesized in this study, although nodules and aggregates of apatite were found on the Cu-doped compositions. Despite this, the inferior cellular response of Cu-doped scaffolds reveals the necessity to modify their composition and/or structure in order to restrict the release of toxic elements without jeopardizing their apatite forming ability. In contrast, the enhanced cell viability on the Zn-doped scaffolds impels further research on their potential ability to induce odontogenic differentiation of DPSCs.

### Conclusions

The present study showed that Mg-based bioceramic scaffolds doped with Zn enhance the attachment, growth and mineralized tissue formation by human DPSCs, while identically fabricated scaffolds doped with Cu are cytotoxic. A mineralized tissue attaining apatite-like structure was formed on both Cu-doped scaffolds and on the Zn-doped scaffolds heat-treated at lower temperatures. Combining these findings it is concluded that sol-gel derived Zn-doped scaffolds with the composition of Si60\%, Ca30\%, Mg7.5\%, Zn2.5\% sintered at 890°C acquire the desired properties and can be further evaluated towards dental tissue regeneration.

### Acknowledgments
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### References


Restoration of Endodontically Treated Anterior Teeth with Cast Metallic Post or Prefabricated Fibre Post Placement: 2 Case Reports and Critical Literature Review

SUMMARY

With a wide variety of post systems and materials available for the restoration of lost tooth structure of endodontically treated teeth, the clinical decision of which to use constitutes a challenge for dental practitioners. Cast metal post and cores are widely used for restoring endodontically treated teeth with extensive loss of coronal tooth structure and to retain metal-ceramic crowns. When dental aesthetics is of primary concern, the selection of the underlying restorative material becomes an important factor to consider. The fibre-reinforced posts combined with all-ceramic crowns offer a highly aesthetic outcome in anterior region restorations, but long-term evaluation is necessary in order to assess their clinical performance and longevity.

The purpose of this paper was to present and compare 2 restorative options with regard to materials (cast metallic post and core versus prefabricated fibre post and composite resin core) for the prosthetic rehabilitation of cases with inadequate aesthetic appearance or fractured maxillary anterior teeth. Furthermore, the article reviews the main indications, advantages, and disadvantages from the use of the 2 post types combined with the final restorations, in order to allow the dental practitioner to make the selection of appropriate restorative materials.

Keywords: Cast Post; Fibre Posts; Metal Ceramic Crowns; All-Ceramic Crowns

Introduction

Endodontically treated teeth (ETT) have been problematic in most cases as a result of dental caries, fractures, previous restorations and endodontic procedures. Several post system techniques and materials are currently used to build up ETT with moderate or severe loss of coronal tooth structure and to retain final restorations1,2.

Following root filling, the custom-made cast metallic post and core with metal-ceramic crowns was the traditional restoration of choice1,3, but this has changed. The patients’ primary motivation for seeking superior dental aesthetics, particularly in the anterior aesthetic zone, has prompted the development of non-metallic restorations4-8. Several new types of polymeric and more aesthetic quartz and glass-fibres posts, combined with direct resin composite cores, provide an aesthetic foundation for an all-ceramic crown and have overcome the aesthetic limitations of metallic posts and cores in the anterior teeth4-8.

Until recently, there has been controversy in the dental community regarding which material or technique is the most favourable for the restoration of ETT5-11. It seems that the amount and retentive capacity of the remaining tooth structure12, the position of the tooth in the dental arch, the functional or para-functional loading on the tooth, and the treatment plan to restore aesthetics and function all influence the selection of the most appropriate post system for each case11-14.

The aim of the present work was to present and discuss 2 restorative options with regard to materials (cast
metallic post and core versus prefabricated fibre post and composite resin core) for the prosthetic rehabilitation of cases with inadequate aesthetic appearance or fractured maxillary anterior teeth. The focus of the discussion was to compare indications, advantages, and disadvantages of the 2 alternative types of posts to aid the clinician in the choice of an appropriate restoration of ETT.

Case Reports

1st Case

A 28-year old female patient presented with a chief complaint of inadequate aesthetic appearance of the maxillary anterior teeth. She had been aware of a gradual aesthetic deterioration of her dental appearance over many years. The anterior teeth #13, #12, #11 and #21 had been restored several years ago but the patient’s aesthetic demands were not satisfied (Fig. 1). Clinical examination revealed metal-ceramic restorations without satisfactory depth of colour, inadequate length, a grey shadow along the gingival margin and uneven occlusal level.

Preliminary diagnostic aids for treatment planning included panoramic radiograph, periapical radiograph of the maxillary teeth, and a diagnostic wax-up of the maxillary teeth on mounted study casts, using an intraoral centric relation registration. After the root canal treatment of the maxillary anterior teeth #13, #12 and #11, the treatment planning for this patient included:

- Indirect technique for fabrication cast metallic post and cores;
- Custom-made posts and cores cementation with zinc phosphate cement in the canal space of the maxillary anterior teeth #13, #12 and #11. Teeth were prepared with a circumferential chamfer including a 1.5 to 2 mm ferrule preparation (Fig. 2);
- Placement of long-term (4 weeks) interim prostheses on the prepared maxillary teeth;
- All -ceramic restorations (single crowns) for the maxillary anterior teeth #22, #21, #11, #12 and a metal-ceramic FPD for teeth #13-(14)-(15)-16 (Figs. 3 and 4).
The all-ceramic crowns for the anterior teeth were fabricated with the e-max ceramic system (Ivoclar Co, Lichtenstein) using high opacity material for the ceramic framework, in order to avoid shimmering of the underlying metal post. The treatment outcome fulfilled the patient’s expectations concerning the aesthetic appearance of the anterior teeth.

2nd Case

A 21-year-old man was presented with a chief complaint of injury to the lip and fractured maxillary right and left central incisors and the right lateral incisor (Fig. 5). The fracture of maxillary incisors, caused by a motorbike accident occurred 1 month earlier. After a thorough intraoral examination, the root canal treatment of the maxillary anterior teeth #21, #11 and #12 was performed. Since an aesthetic outcome was important in this case, the treatment planning included the use of fibre-reinforced posts and resin composite cores combined with the placement of zirconia all-ceramic crowns.

The option was discussed with the patient, and the following treatment plan was carried out:

- The root canals of the maxillary incisors were prepared to receive a glass fibre-reinforced composite post (FRC Dowelec Plus, Ivoclar Vivadent AG, Liechtenstein) of an appropriate diameter and length. Special matching stainless steel reamers were used for the preparation of the recipient site of the post, leaving 4 mm of intact gutta-percha apically;
- A dual-curing composite resin (Variolink II, Ivoclar Vivadent AG, Liechtenstein) was used for luting the fibre posts, according to the manufacturer’s instructions. A composite material (Multicore flow, Ivoclar Vivadent AG, Liechtenstein) was used for building up the core (Fig. 6);
- The zirconia all-ceramic crowns (In-ceram zirconia, Vita, Germany) were tried on the core and checked for marginal fit (Fig. 7);
- Final cementation of all-ceramic crowns was carried out (Fig. 8) using dual-curing composite resin (Variolink II, Ivoclar Vivadent AG, Liechtenstein).

The treatment outcome fulfilled the patient’s requirements concerning the aesthetic appearance of the anterior maxillary teeth.
Discussion

Custom-made metallic posts and cores combined with all-ceramic crowns and metal-ceramic FPD were used in the first clinical case due to the patient’s coronal destruction, extensive loss of anterior teeth structure and the demand for aesthetic and functional rehabilitation. Fibre posts with composite resin cores and zirconia all-ceramic crowns were designed to be used in the second clinical case due to the amount of remaining coronal tooth structure and the high aesthetic demand.

The restoration of ETT with different post and core systems is a topic that is extensively studied and yet remains controversial from many perspectives. The main function of a post is to build up and securely retain a post and core system is necessary. The choice of appropriate post and core restorations is often complicated and should be guided by knowledge of their physical properties, indications, advantages and disadvantages, as well as the amount of coronal structure missing and aesthetic case need.

It generally is agreed that post and core materials should have as many of the following desirable features as possible:

- Adequate post adaptability within the root;
- Maximum retention of a crown;
- Conservation of remaining tooth structure;
- Biocompatibility and compatibility of post material with the core;
- Uniform stress distribution along post length during function. It has been reported that a well-adapted, passively luted, parallel-sided post provides the most retention with the least stress;
- Physical properties, such as compressive strength to resist intraoral forces, modulus of elasticity (stiffness), and coefficient of thermal expansion, similar to those of dentin;
- Rapid setting, dimensionally stable core material, resistant to leakage of oral fluids at the core/tooth interface, that is easy to use with high compressive strength and rigidity;
- Pleasing aesthetics, when indicated;
- Easy removal from the root.

In most cases, the choice of cast metallic post or prefabricated fibre-reinforced composite restorations relies on clinical judgment and experience. Possible indications for use of custom-made metallic cast post and cores include:

- Restorations of ETT with moderate-to-severe loss of coronal tooth structure. 2 retrospective studies of ETT with extensive loss of tooth structure reported success rate of 89-98.5% after at least 7 years, using cast post and cores with single crowns as foundation restorations;
- Restorations of ETT used as abutments of extensive tooth-supported fixed partial dentures. The use of cast post and cores must be particularly considered when multiple abutments are prepared in complicated periodontic and tooth wear prostodontic treatments;
- Restorations of posterior teeth with insufficient tooth structure and root divergence to support a crown, therefore requiring fabrication of separate element, 2-piece cast post and cores with different paths of insertion that link on placement.
- Cast gold or silver-palladium alloy post and core build-up has some advantages over a prefabricated post;
- The cast post and core is customized to fit the root canal space, and both post and core are cast as a single unit with good compressive strength that withstands normal or para-functional occlusal forces and minimizes the possibility of separation;
- The angulation and the design of the core of the cast post can be modified to produce a more convenient shape for the crown of proclined teeth, particularly when multiple anterior abutments are prepared;
- The anti-rotational projection of the shape of the post for anterior wide, single-rooted teeth and the placement of multiple dowels at multi-rooted teeth provides the opportunity to control the design characteristics of a post and core build-up.

However, disadvantages of the cast post and core system are considerable:

- Aesthetic problems in anterior metal-ceramic restorations as their metallic colour leads to a greyish discoloration of the root, thus shadowing at the thin gingival tissue;
- Several aesthetic problems in anterior all-ceramic coronal restorations, as the cast post and core may shine through or at least decrease the depth of translucency of the all-ceramic crown;
- Cast post and core placement procedure requires 2 appointments, dental laboratory fabrication, and additional financial cost;
- Very difficult removal from the root.

The availability of new aesthetic prefabricated fibre post systems has created the need for a systematic evaluation of their physical properties and clinical performance. For direct build up of the coronal tooth structure after luting a fibre post, many types of resin composite materials have been proposed.

There are some possible indications for use of fibre-reinforced posts in combination with composite materials, such as:

- All-ceramic restorations of anterior ETT with mild-to-moderate loss of coronal tooth structure, visible in smile. It has been reported that in ETT restored with fibre dowel-composite core and all-porcelain crowns, the survival rate of the tested posts was high...
Prefabricated fibre post systems have some advantages over cast post and cores:

- Best aesthetics; a white or tooth-coloured dowel prevents the “shine-through” effect that occurs with metal dowel systems and improves the translucency and appearance of all-ceramic crowns;
- Uninterrupted bonding at all interfaces and adhesive integration between 5 components of the fibre-reinforced composite resin system (dentine surface, luting cement, fibre post, core build-up, and crown);
- Fibre posts are also more flexible, require less dentin removal to accommodate a shorter and thinner dowel, and lead to lower susceptibility to root fracture;
- Involve less-time consuming chairside procedure and requires 1 appointment to complete the restoration.

However, there are also some reported disadvantages of these restorations such as:

- Composite resins present volumetric contraction during and after the process of polymerization, resulting in stress concentration at the adhesive interface;
- Composite materials present low wear resistance and microleakage;
- Very few long-term clinical results for their clinical performance and longevity are available.

**Conclusion**

Selection of the most suitable post and core systems is challenging and should be guided by knowledge of their indications, advantages and disadvantages, as well as the amount and quality of remaining tooth structure and aesthetic requirements.

The use of cast metallic posts and cores are recommended to restore severe loss of coronal tooth structure and to retain metal-ceramic crowns. Prefabricated fibre posts and all-ceramic restorations offer a promising alternative to the restoration of anterior ETT with cast metallic posts and porcelain fused to metal crowns. The use of fibre posts with resin composite core is preferred when the hard dental tissue loss is moderate and dental aesthetics is of primary concern. The new fibre posts provide impressive aesthetic results in the anterior aesthetic zone, but long-term clinical trials are necessary in order to assess their mechanical properties and clinical performance.

**References**


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Influence of Prosthetic Crowns on Gingival Fluid

SUMMARY

Purpose: Evaluation of the impact that a foreign body has in the gingival sulcus, expressed in scale to cause significant gingival infection.

Material and Methods: In a sample of 10 clinical cases with fixed prosthetic appliances in the oral cavity, the levels of gingival fluid to bridge anchoring teeth are measured and compared to the same opposite respective teeth in the mandible and in the maxilla. Measurement of gingival fluid was done with the blue coloured absorbent paper, kept in the gingival sulcus for 60 seconds. With the technique of centrifugation the respective values of gingival fluid were found.

Result: Levels of gingival fluid were distinguishably different around the anchor teeth of bridges compared to natural teeth.

Conclusions: Signs of primary infection onset are manifested by an increased gingival fluid. The presence of a foreign body caused an increase of gingival fluid in the sulcus, as a sign of physical harassment, possibly causing an initial stage of gingival inflammation.

Key words: Gingival Fluid, Gingival Inflammation

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Introduction

Most studies have focused on the effects of fixed prosthetic, especially concerning the location of the crown margin in relation to the gingival structures and periodontium. The margin of the crown can be placed supra-gingival or sub-gingival regarding the plan of treatment. This setting may touch the ability of the patient to achieve proper oral hygiene. According Schatzle et al10, after a 26-year long-term study, supported the concept that sub-gingival restorations may be harmful for periodontal health. Although supra-gingival margins do not differ significantly from sub-gingival margins, crowns with sub-gingival margins resulted with recession and bleeding in greater degree compared to the natural teeth of the control group9.

Gingival inflammatory reaction can be evaluated by the assessment of the volume of gingival fluid. Gingival fluid is the fluid that flows through the sulcular epithelium. Its quantity reflects the degree of inflammation in the interior of gingival sulcus. To enumerate its functions: it contains plasma proteins that may increase the adhesion of epithelium to tooth; there are antimicrobial abilities (Ig); it may urge the creation of plaque, due to the presence of calcium ions to gingival margin.

Gingival fluid acts as a defensive barrier in gingival sulcus and protects oral tissues (including junctional epithelium) against the bacterial invasion and trauma from infection7. Gingival fluid contains bacteria, epithelial cells, monocytes and other leukocytes, macrophages and protein derived from bacteria or from the host organism itself. Cytokines, interleukin, that are detected in gingival fluid, serve as possible markers for diagnosis of periodontal diseases17. If there are higher quantities of neutrophils and leucocytes in the sulcus, then it appears the presence of the well. Clinically, quantity of the well we observe by pressing against the wall of the sulcus against the clinical crown. However, clinical presence of the well is not the perfect indicator for inflammation activity.

The purpose of this study was to evaluate the impact that a foreign body in gingival sulcus has, expressed in scale of inflammation it caused to gingiva. It is known
Materials and Methods

Patients taking antibiotics for any kind of treatment or prophylaxis, or any kind of non-steroidal anti-inflammatory drugs or contraceptives were not included into the study. We also excluded patients with systemic inflammatory diseases, diabetes, as well as pregnant women.

The best and simple mode to measure the quantity of fluid is placement of absorbent paper inside in sulcus. We selected to place the absorbent paper, 2x2.5mm in size, only in the orificium of sulcus and to measure, within a certain period of time, the quantity of fluid that has been absorbed. Wet part we measured in mm.

We acted in this way: the analysed areas were isolated with cotton rolls and dried with air. The presence of any type of supra-gingival plaque was carefully removed with cotton rolls prior to the measurement. Absorbent blue letters placed under cervical gingiva, with light stripes on the tail of the absorbent paper, until we felt minimal resistance while keeping it thus positioned for 60 seconds. No attempt was made to track and control for cyclical hormonal circadian changes on the volume of fluid. Gingival fluid volume was measured by weighing the tubes of micro-centrifuge with located dry strips and then with wet strips. Absorbent strips from different areas, placed in plastic tubes centre of the micro-centrifuge, were centrifuged twice at 3000 rotations per minute, after being added to 50μl saline. Micro-centrifuge tubes were prepared by placing the plastic cap on top of which one further fixed tube length at most up to the length of half of the tube. The perforation in the centre of window shutters were made with the aim to secure the entry of absorbent papers.

We collected 20 samples of gingival fluid, 50% from teeth with the prosthetic fixed crowns and 50% from the teeth at the other side of the same jaw. Gingival fluid samples were collected only on the vestibular surface of the teeth. From 10 prosthetic crowns, 9 of them had margins positioned sub-gingival, and 1 was positioned supra-gingival.

Results

The data collected are shown in table 1. For each patient, time of putting the prosthesis in the mouth was recorded, as well as the position of the prosthetic crown margin, Mühlerman index and the amount of gingival fluid at the abutment and natural teeth.

<table>
<thead>
<tr>
<th>The patient</th>
<th>Time of setting the crown</th>
<th>Position of the margin</th>
<th>Mühlerman Index</th>
<th>The tooth with a crown</th>
<th>Gingival fluid (ml)</th>
<th>Antagonist tooth</th>
<th>Gingival fluid</th>
<th>Mühlerman Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>sub-gin.</td>
<td>3</td>
<td>46</td>
<td>0.93</td>
<td>36</td>
<td>0.65</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>sub-gin.</td>
<td>4</td>
<td>21</td>
<td>1.2</td>
<td>11</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>sub-gin.</td>
<td>2</td>
<td>13</td>
<td>1.35</td>
<td>23</td>
<td>0.83</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>6</td>
<td>sub-gin.</td>
<td>4</td>
<td>22</td>
<td>1.75</td>
<td>12</td>
<td>1.23</td>
<td>3</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>sub-gin.</td>
<td>3</td>
<td>41</td>
<td>1.23</td>
<td>31</td>
<td>0.8</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>3</td>
<td>supra-gin.</td>
<td>2</td>
<td>24</td>
<td>0.87</td>
<td>14</td>
<td>0.63</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>7</td>
<td>sub-gin.</td>
<td>4</td>
<td>14</td>
<td>1.23</td>
<td>24</td>
<td>0.7</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>sub-gin.</td>
<td>4</td>
<td>13</td>
<td>1.76</td>
<td>23</td>
<td>1.25</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td>12</td>
<td>sub-gin.</td>
<td>3</td>
<td>13</td>
<td>1.25</td>
<td>23</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>4</td>
<td>sub-gin.</td>
<td>3</td>
<td>21</td>
<td>1.95</td>
<td>12</td>
<td>1.35</td>
<td>2</td>
</tr>
</tbody>
</table>

The data collected only for the fixed prosthetic crowns are summarized in table 2. The p value by unpaired t test was 0.0044. This difference was statistically highly significant. The confidence interval: the average value of the first group minus the second group was 0.468000. 95% of the confidence interval...
for this difference varied from 0.166214 to 0.769786. Standard error of the difference was 0.144.

Table 2. Results of statistical processing of the collected data

<table>
<thead>
<tr>
<th>Teeth with prosthetic crowns</th>
<th>Natural teeth</th>
</tr>
</thead>
<tbody>
<tr>
<td>The average value 1.3520</td>
<td>The average value 0.8840</td>
</tr>
<tr>
<td>SD 0.3584</td>
<td>SD 0.2792</td>
</tr>
<tr>
<td>SEM 0.1133</td>
<td>SEM 0.0883</td>
</tr>
<tr>
<td>N 10</td>
<td>N 10</td>
</tr>
<tr>
<td>Min 0.87</td>
<td>Min 0.63</td>
</tr>
<tr>
<td>Average 1.24</td>
<td>Average 0.75</td>
</tr>
<tr>
<td>Max 1.95</td>
<td>Max 1.35</td>
</tr>
</tbody>
</table>

From the analysis of the data of identifying the possible influence of time of the placement of the denture in the mouth on values of gingival fluid in the sulcus, resulting p value was 0.0005, which was statistically significant.

Discussion

With the aim of increasing the efficiency of fixed prosthetic treatment, we analysed the effect of the prosthetic crown margin on periodontal tissues. We noticed some changes in the gingival fluid characteristics: its quantity, acidity and concentrations of interleukin 1, as the basic indicators of microcirculation in periodontal tissue in contact to artificial crowns. These data can serve to prevent chronic periodontitis.

Gingival sulcus is the ideal space for addition and multiplication of bacteria. Humidity, temperature, pH, the presence of oxygen and carbon dioxide, all this may well become exploited by bacteria. Although gingival fluid may present “food” for bacteria, it also eliminates acids produced during fermentation and serves to wash the cells and remove microorganisms.

In this preliminary study we assessed only the quantity of gingival fluid as the primary signs of gingival inflammation, if this exists. P value extracted from the data indicated the presence of gingival inflammation, which was present in sulci of prosthetic abutments in the same oral cavity, with same plaque index. It was also established by the Mühlerman index, which was 3 at prosthetic abutments in 1 at natural teeth.

It happened that almost all crowns in the study were sub-gingival. Another element of interest was the fact that fluctuations in the amounts of gingival fluid, as to the abutment teeth and to natural teeth, were within the normal values 0.43μl-1.56μl, with rare exceptions. Another fact of importance was data concerning the difference in the amount of gingival fluid around abutment teeth and natural teeth. This difference was, roughly speaking over 0.47μl. Where the local excitation was present due to margin of the prosthetic crown, local reaction was protective - gingival fluid leak washes the sulci, removing bacteria. This was a proof that gingival fluid served as a protective mechanism for gingival sulcus, having well known effects, both positive and negative in this process.

For all prosthetic crowns with margin located in the sub-gingival region, microbial colonization demonstrate increased value at the prosthetic abutment, that interval varying 1 week, 1 month or 2 months after the settlement by the crown. This may affect periodontal health around the prosthetic abutment. Another fact of the data coming from our study is a link between time of putting prosthetic crown in the oral cavity and the amount of gingival fluid. This fact is, generally, supported by other studies, showing a connection that exists between the duration of action of local irritant and intensity of inflammation. Therefore, the longer the influence of a local factor, inflammation is more expressed.

Conclusions

Prosthetic crowns affect the amount of fluid produced in the gingival sulcus, inducing perceptible increase. The amount of gingival fluid varies according to grade of inflammation, and this depends on the plaque index and the presence of specific bacteria in the oral cavity. The amount of gingival fluid is directly proportioned to the time of settlement of prosthetic crowns.

References


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Technical Quality and Associated Iatrogenic Errors of Endodontic Treatments Performed in Extracted Anterior Single-Rooted Teeth by Preclinical Undergraduate Students

SUMMARY

Aim: To evaluate technical quality of root canal treatments performed in extracted anterior single-rooted teeth in an undergraduate dental clinic, and to record the associated iatrogenic errors. Material and Method: 287 root canal treatments performed by 114 preclinical undergraduate students in extracted anterior teeth at the Department of Endodontology were radiographically evaluated, based on the following parameters: access cavity dimensions and direction, root canal instrumentation, and root canal filling quality. Results: The access cavity was found of adequate dimensions in 28.9% and straight in direction in 71.1% of the material. Erroneous position, overextension of the access cavity and non-straight access were noted in 39.7%, 21.6% and 28.9% of the cases, respectively. The frequency of ledged root canals was 10.1%, while 84.7% of the teeth had no instrumentation related iatrogenic errors. Regarding root canal filling, incomplete density apically and technical inadequacies in the middle and cervical thirds were observed in 76.3% and 82.3% of the cases. The percentage of flawless endodontic treatments was 3.1%. Conclusions: Most of the endodontic treatments evaluated were classified unacceptable. Inadequate root canal filling density in the middle and cervical third and ledge formation were the most common faults.

Keywords: Dental Education; Dental Students; Endodontics; Medical Errors

Introduction

Endodontic mishaps or procedural accidents are events that happen during diagnosis, access preparation, cleaning and shaping, obturation and post-space preparation; some due to inattention to detail, while others are totally unpredictable4,13. Iatrogenic errors can be classified according to the stage of endodontic treatment, and they occur as follows: (1) during access cavity preparation; (2) during root canal instrumentation (ledge, root perforation, root transportation, fractured instrument); (3) during root canal obturation (inadequate root canal filling length or density, vertical root fracture); and (4) other accidents during root canal treatment (aspiration or ingestion, extrusion of irrigant, emphysema)7. Iatrogenic complications, by hindering the sequence of root canal treatment steps, thus affect its outcome2.

The technical quality of root canal treatments performed in dental schools or private clinics, and the prevalence of associated iatrogenic errors have been extensively studied on the basis of radiographic criteria1,7. To the best of our knowledge, the present study is the first in peer reviewed journals evaluating each stage of endodontic treatment (access cavity preparation, root canal instrumentation and filling) performed by undergraduate students at a preclinical level, although a similar study evaluated root canal filling length, density and taper only10. The influence of the preclinical teaching approach on the outcome of root canal treatment on patients was examined in another cohort study12.
According to the “Undergraduate Curriculum Guidelines for Endodontology” of the European Society of Endodontology, a graduating European dentist is expected to be competent at performing good quality root canal treatments, and to have knowledge of prevention and management of common procedural errors. The assessment of endodontic treatment during preclinical and clinical training programs is crucial in determining the level of the provided education in Endodontics. Establishing a higher level of training could lead to better qualified graduate students and more effective health services.

The purpose of this study was to evaluate technical quality of root canal treatments and to record the associated iatrogenic errors performed by preclinical undergraduate students in the extracted anterior single-rooted teeth at the Department of Endodontology, School of Dentistry, Aristotle University of Thessaloniki, Greece.

**Materials and Methods**

**Selection of Cases**

The material of this study consisted of 390 root canal treatments performed by 114 fourth semester undergraduate students in extracted anterior teeth during the academic year 2012-2013 at the Department of Endodontology, School of Dentistry, Aristotle University of Thessaloniki, Greece. The fourth semester preclinical curriculum consists of one 1-hour theoretical lecture and one 2-hour practical course per week. During these practical courses, each student has to complete at least 3 root canal fillings in the extracted anterior teeth. The 114 undergraduate students were divided into 3 groups. Supervision was carried out by academic staff, PhD candidates or postgraduate students with an overall student/staff ratio of 8:1.

The extracted tooth roots were embedded in acrylic resin (Vertex-Dental B.V., Zeist, The Netherlands). All teeth were instrumented with the step back technique using stainless steel K-files of 0.02 taper (VDW GmbH, Munich, Germany), and the canals irrigated with tap water. Root canal fillings were performed with gutta-percha (Coltène/Whaledent GmbH, Langenau, Germany) and zinc oxide-eugenol sealer (K600, Dental Corporation of Thessaloniki, Greece) using the lateral condensation technique. 4 digital radiographs (pre-operative, working length radiograph, post-operative) for each tooth were exposed using the paralleling technique (Gendex Dental Systems, Milan).

The evaluation of technical quality of root canal treatments and the detection of iatrogenic errors was based on radiographic criteria. A total of 85 cases were excluded due to missing or poor quality radiographs and 18 cases were excluded due to pre-existing defects, such as crown fractures. As a result, a total of 287 teeth were finally evaluated.

**Evaluation of Technical Quality of Root Canal Treatments**

Strict radiographic criteria were defined regarding: access cavity preparation, root canal instrumentation, root canal filling and the relative iatrogenic errors. The material was evaluated by 2 members of the academic staff of the Department of Endodontology. They were calibrated by discussing some randomly selected cases separately from the main study material. Inter-examiner agreement was determined by examining 30 cases included in the main study. In cases of disagreement, the 2 groups reached a consensus by discussion.

The method of viewing the radiographs was standardized. Radiographs were interpreted on a 15.6-inch LCD monitor with a resolution of 1920 x 1080 pixels (Lenovo, Paris, France) using Windows Photo Viewer software (Microsoft, Redmond, WA, USA). Precise measurements were made where necessary by means of a 0.5 mm resolution digital ruler. The extracted evaluation data were recorded on a specially designed form. Specifically, the form included the serial number of each student, the tooth type, the dimensions and direction of the access cavity, the presence of ledge, root perforation, root transportation, fractured instrument, and the taper and density of root canal fillings.

The radiographic criteria applied were as follows:

1. Access cavity preparation
   a. Access cavity dimensions
      i. Adequate, when the access cavity walls and root canal walls were in a straight line.
      ii. Incorrect
         1. Overextended, when the access cavity wall extension exceeded the root canal walls
         2. Inadequate, when the root canal wall extension exceeded the access cavity wall
         3. Incorrect position, when the access cavity was not prepared over the roof of the pulp chamber
   b. Access cavity direction
      i. Straight, when the K file inserted into the root canal did not interfere with the access cavity walls on the working length radiograph
      ii. Non straight, when the K file inserted into the root canal interfered with the access cavity walls on the working length radiograph

2. Root canal instrumentation
   a. Access cavity preparation
      i. Ledge, when the apical end of the master cone, or the root canal filling, deviated from the root canal...
limits on the master cone or the post-operative radiograph respectively

(ii) Root perforation, when an iatrogenic communication between the root canal space and the extra-radicular space was detected by extrusion of the K file, the master cone or the filling material on the working length, master cone or postoperative radiographs respectively

(iii) Root canal transportation, when the post-instrumentation root canal walls were not the result of uniform preparation of the initial root canal walls

(iv) Fractured instrument, when the whole or part of a separated instrument was detected in the root canal

(3) Root canal fillings

a. Apical third

(i) Adequate both in length and density, when the filling ending was situated 0-2 mm short of the radiographic apex with uniform radiodensity and the adaptation of the filling material to the root canal walls11

(ii) Adequate in length, but inadequate in density, when the filling ending was situated 0-2 mm short of the radiographic apex, but there were radiographically visible voids, either in the mass of the filling material or between the filling and the root canal walls

(iii) Overextension, when the filling ending extruded beyond the radiographic apex, and there were radiographically visible voids in either the filling material mass or between the filling and the root canal walls

(iv) Overfilling, when the filling material was extruded beyond the radiographic apex, but there was uniform radiodensity and adaptation of the filling material to the root canal walls

(v) Under-extension, when the filling material fell more than 2 mm short of the radiographic apex and there were radiographically visible voids either in the mass of the filling material or between the filling and the root canal walls

(vi) Under-filling, when the filling material ended more than 2 mm short from the radiographic apex, but there was uniform radiodensity and adaptation of the filling material to the root canal walls

b. Middle and cervical third

(i) Adequate, when there was uniform radiodensity and adaptation of the filling material to the root canal walls, and progressive taper at the middle and cervical thirds

(ii) Inadequate, when there were some radiographically visible voids, either in the mass of the filling material or between the filling and the root canal walls, or a lack of uniform taper at the middle and cervical thirds.

Statistical Analysis

Inter-examiner agreement was measured using Cohen’s kappa (k) values3,14. The k-statistic was used to assess the intra-examiner agreement of each group by re-evaluating 30 randomly selected radiographs at least 2 months after the first examination. SPSS 17.0 for Windows software (SPSS Inc., Chicago, IL, USA) was used for data processing and statistical analysis.

Results

The k-value for inter-examiner variability was 0.73 for “access cavity direction” and 0.88 for “length of root filling”. The k-values for intra-examiner reproducibility were 0.76 for “access cavity direction” and 0.85 for “length of root filling”.

Technical Quality and Iatrogenic Errors

Access cavity was adequate in 83 cases, while straight line access to the root canal was observed in 204 teeth (Tab. 1). Iatrogenic errors attributed to instrumentation were observed in 44 cases (15.3%). Specifically, the prevalence of ledges, root perforations, root canal transportations, and fractured instruments was 10.1%, 1.4%, 3.1%, and 0.7% respectively (Tab. 2). Root filling length was adequate in 168 of the root canals (58.5%). Acceptable filling density in the apical third was found in 47 of the cases (16.4%). Adequate filling taper and absence of voids in the middle and the coronal thirds was observed in 51 of the root canals - 17.7% (Tab. 3). The percentage of overall “lege artis” endodontic treatments was 3.1%.

Table 1. Evaluation of technical quality and iatrogenic errors of access cavity preparation (results are shown in percentages)

<table>
<thead>
<tr>
<th>Adequate access cavity preparation</th>
<th>28.9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect cavity preparation</td>
<td></td>
</tr>
<tr>
<td>Overextended</td>
<td>21.6</td>
</tr>
<tr>
<td>Inadequate</td>
<td>9.8</td>
</tr>
<tr>
<td>Dimensions</td>
<td></td>
</tr>
<tr>
<td>Incorrect position</td>
<td>39.7</td>
</tr>
<tr>
<td>Direction</td>
<td></td>
</tr>
<tr>
<td>Straight</td>
<td>71.1</td>
</tr>
<tr>
<td>Not straight</td>
<td>28.9</td>
</tr>
</tbody>
</table>

Table 2. Technical quality and iatrogenic errors of root canal instrumentation (results are shown in percentages)

<table>
<thead>
<tr>
<th>Ledge</th>
<th>10.1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Root perforation</td>
<td>1.4</td>
</tr>
<tr>
<td>Root canal transportation</td>
<td>3.1</td>
</tr>
<tr>
<td>Fractured instrument</td>
<td>0.7</td>
</tr>
<tr>
<td>Total</td>
<td>15.3</td>
</tr>
</tbody>
</table>

The k-value for inter-examiner variability was 0.73 for “access cavity direction” and 0.88 for “length of root filling”. The k-values for intra-examiner reproducibility were 0.76 for “access cavity direction” and 0.85 for “length of root filling”.

Technical Quality and Iatrogenic Errors

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heads limited the extent of the potential to simulate clinical conditions.

According to our study, the most common iatrogenic error during access cavity preparation was incorrect position (39.7%), followed by non straight access direction (28.9%), and overextension (21.6%). Regarding root canal instrumentation, the formation of ledges was the most prevalent mishap (10.1%). Finally, root canal fillings were erroneous mainly due to incomplete apical density (76.3%), and technical inadequacies in the middle and cervical thirds (82.3%).

The high frequency of endodontic mishaps assessed in this study could be attributed to several reasons: the study design, the radiographic criteria applied, the inexperience of undergraduate students, the endodontic curriculum, or the lack of proper equipment.

Table 3. Technical quality and iatrogenic errors of root canal fillings (results are shown in percentages)

<table>
<thead>
<tr>
<th>Apical third</th>
<th>Adequate both in length and density</th>
<th>16.4</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adequate in length, but inadequate in density</td>
<td>42.5</td>
</tr>
<tr>
<td></td>
<td>Overextension</td>
<td>0.7</td>
</tr>
<tr>
<td></td>
<td>Overfilling</td>
<td>0.0</td>
</tr>
<tr>
<td></td>
<td>Under-extension</td>
<td>33.8</td>
</tr>
<tr>
<td></td>
<td>Under-filling</td>
<td>6.6</td>
</tr>
<tr>
<td>Middle and cervical thirds</td>
<td>Adequate</td>
<td>17.7</td>
</tr>
<tr>
<td></td>
<td>Inadequate</td>
<td>82.3</td>
</tr>
</tbody>
</table>

Discussion

The material of this study consisted of the radiographs taken during the preclinical training of fourth semester undergraduate students. Extracted anterior single-rooted teeth were selected due to their simple anatomy and limited morphological variety compared to other groups of teeth.

To the best of our knowledge, this is the first study evaluating the technical quality of root canal treatments and recording the associated iatrogenic errors at a preclinical level. Radiographic interpretation of periapical disease is affected by the levels of inter-examiner variability and intra-examiner reproducibility. In our study, the high inter-examiner variability and intra-examiner reproducibility values supported a high level of reliability of the evaluation of the material.

Potential limitations of the used method should be acknowledged. The retrospective study design limits the available information to that coming from the radiographic record base. Moreover, the inherent limitations of radiographic examination and interpretation may have introduced methodological errors. In particular, the radiographs were not taken in a strictly standardized and reproducible manner. Changes in beam and sensor angulation affect the radiographic appearance of the evaluated parameters. Bucco-lingual root canal curvatures, as well as procedural errors, may not always be accurately depicted on periapical radiographs. For example, a short filling may be a result of either a ledge or apically packed dentin chips and debris. Additionally, it has been shown that there is limited correlation between the radiographic appearance of the root canal filling and its adaptation and compaction. Moreover, the acrylic resin used to embed the teeth does not accurately simulate periapical tissue. This may explain the low frequency of apical foramen perforations and overfillings/overextensions in our study. Finally, the lack of phantom heads limited the extent of the potential to simulate clinical conditions.

According to our study, the most common iatrogenic error during access cavity preparation was incorrect position (39.7%), followed by non straight access direction (28.9%), and overextension (21.6%). Regarding root canal instrumentation, the formation of ledges was the most prevalent mishap (10.1%). Finally, root canal fillings were erroneous mainly due to incomplete apical density (76.3%), and technical inadequacies in the middle and cervical thirds (82.3%).

The high frequency of endodontic mishaps assessed in this study could be attributed to several reasons: the study design, the radiographic criteria applied, the inexperience of undergraduate students, the endodontic curriculum, or the lack of proper equipment.

Conclusion

Within the limitations of this study, endodontic treatments performed by undergraduate students at a preclinical level were mostly classified as inadequate. The most common mishaps were the inadequate root canal filling density in the middle and cervical thirds and the formation of ledge. More prospective studies are needed to clarify the deficiencies of the currently applied preclinical endodontic training.

Acknowledgements

The authors would like to thank Prof. Theodoros Lambrianidis, School of Dentistry, Aristotle University of Thessaloniki, Greece, for his vital contribution to the study.

References


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Evaluation of Surface Treatment Methods on the Bond Strength of Zirconia Ceramics Systems, Resin Cements and Tooth Surface

SUMMARY

Objectives: To compare the effects of airborne-particle abrasion (APA) and tribochemical silica coating (TSC) surface treatment methods on the shear bond strength of zirconia ceramics systems, resin cements and tooth surface.

Materials and Methods: Prefabricated Cercon and Zirkonzahn specimens treated with Al₂O₃ APA and TSC (Cojet, 3M ESPE) were luted on a dentin surface with Panavia F 2.0 (Kuraray, Japan) and Multilink Automix (Ivoclar Vivadent, Liechstein). The specimens were immersed in distilled water (37°C) for 30 days and then loaded in a universal test machine with a crosshead speed of 1 mm/min. Shear bond strength at failure was measured and recorded in N. The data were analysed by Mann-Whitney-U test (p<0.005) and by Chi-square test. Results: It’s demonstrated that the surface treatment affected the bond strength of all specimens. The mean bond strength values of the 2 zirconia systems were nearly the same. Shear bond strength of Cercon specimens treated with Cojet System, luted with Panavia 2.0 (242, 77 ± 53, 17 N were found to be significantly higher (p=0.04) than the other specimens. Fractures were observed at the interface between the ceramic surface and the cements or within the cements.

Conclusion: There were no statically significant differences between zirconium systems (Cercon and Zirkonzahn). The specimens luted with Panavia F 2.0 showed higher shear bond strength values than the specimens luted with Multilink Automix. Panavia F 2.0 cement could be used with TSC, when the additive retention was needed.

Key words: Resin Cements; Shear Bond Strength; Zirconia Systems; Tribochemical Silica Coating; Airborne-Particle Abrasion

Introduction

Like many areas of dentistry, aesthetic restorative materials have improved because of their improved biocompatibility and optical properties compared with metal-ceramic restorations. Zirconium restorations are stronger than the other all-ceramic restorative non-metal restorative materials. They are indicated for all-ceramic posterior crowns and bridges and indicated anywhere in the mouth. The superior mechanical properties, and the aesthetic colour, combined with CAD/CAM technology, all make zirconia the core material of choice. CAD-CAM method of fabricating zirconia single copings and frameworks involves manipulation of a 3-D design on the computer screen, followed by the automated production by a computer-controlled milling machine. There are 3 components to the CAD/CAM system: scanning, designing, and milling. MAD-MAM system of a coping or framework is manually fabricated in wax or composite, and then the pattern is placed into the pantographic machine. The copying arm of the machine traces the wax pattern while the cutting arm, which has a carbide cutter, mills a selected “green” or presintered zirconia block. The final shape is 20% to 25% larger.
to account for shrinkage during the sintering step. Besides the lower cost factor for these types of milling machines, this method of milling allows the dental technician to correct any discrepancies found in the tooth preparation by compensating during the waxing of the pattern.

The retention of restoration is a result of a complex phenomenon in which the mechanical and rheological properties of luting agents are of primary importance. Derand and Deraud evaluated different surface treatments and resin cements and found that auto-polymerizing resin cement exhibited the significantly highest bond strength regardless of surface treatment. Hydrofluoric acid etching and the application of a silane coupling agent to silica-based ceramic increases the bond strength between all-ceramic restorations and composite resins. These techniques do not improve the bond strength of zirconium and alumina ceramics because their high crystalline content makes them resistant to acid etching. Some studies have evaluated the effect of silica coating on the bond strength of acid-resistant ceramics bonded to resin luting agents. They found that silica coating “energizes” the substrate surface, which allows the silica to adhere to it. Also, silane improves the bond between the silica adhered to the substrate and the resin matrix. The CoJet System (3M ESPE, Seefeld, Germany) may significantly increase the bond strength for high-alumina and zirconium-oxide ceramics compared to that of airborne-particle abrasion alone in a clinical condition.

Cement selection is prerequisite for ensuring effective bond strength to zirconia. Phosphate monomer-based luting agents have been proposed for cementation. Multistep 10-MDP containing luting systems have been previously investigated recording satisfactory results. It’s found that high and reliable resin bond to alumina and zirconia ceramics was achieved with airborne particle abrasion and by using phosphate monomer (MDP) containing resin composite luting cement. Atsu et al. found that tribiochemical silica coating and the application of a 10-methacryloyloxydecyl dihydrogen phosphate monomer (MDP)-containing bonding/silane coupling agent mixture has been shown to increase the shear bond strength between zirconium-oxide ceramic and resin luting agent.

The purpose of this study was to investigate the effects of APA and clinical TSC surface treatment methods on the bond strength between zirconia ceramics systems, different resin cements and dentin. The following null hypothesis was tested: there is no difference in the shear bond strength of zirconia systems when the surface treatments groups were compared with 2 different resin cements.

Material and Methods

80 recently extracted caries-free mandibular molars of similar sizes were selected and stored in tap water at room temperature (37°C +/-1°C). Teeth were brushed with pumice at 6000 rpm until they were visually clean. The cleaned specimens were inspected by a halogen light for any pre-existing minor cracks. The roots of each tooth were embedded in a plastic cylinder of 2.5 cm diameter, 3.5 cm in height, filled with auto polymerizing acrylic resin (Meliodent, Heraeus Kulzer, Berkshire, USA). The specimens were attached with a sticky wax ( Sticky Wax 772, Giordano Vannini, Firenze, Italy) to a pin fixator vertically. The teeth were embedded in acrylic resin (Meliodent, Heraeus Kulzer, Berkshire, USA) blocks to 1mm below the cemento-enamel junction. The pin fixator was detached after acrylic resin polymerization, and to remove the sticky wax, the specimens were cleaned under hot water. Dentin surface was cut on the occlusal surface of each specimen with a high speed of diamond disc vertically (Norton Diamond Wheel Blade, 10.2 cm x 0.30 mm, Buehler, USA).

80 standardized (10×5×2.5 mm) prefabricated zirconium specimens (Cercon and ZirkonZahn) were used (40 of each). Each zirconium specimen was divided into 4 subgroups according to surface treatment agents and luting cements. 40 zirconium specimens were prepared with Cercon (Degudent GmbH, Frankfurt, Germany) and other 40 samples with ZirkonZahn (GmbH, Italy). The zirconium specimens were divided into 2 groups (20 of each). ZirkonZahn and Cercon samples were sandblasted with APA (110 µm Al2O3 particles). The others were subjected to TSC with CoJet system (3M ESPE GmbH Neuss, Germany) (n=20). 2 of the surface treatment groups were applied perpendicular to the ceramic surface at a distance of 10 mm for 15 seconds and at a pressure of 2 bars according to manufacturer’s direction. Then any residual blast-coating agent was removed with an oil-free air. The surfaces treated with TSC were coated with a silane coupling agent (ESPE-Sil; 3M ESPE), which was allowed to air dry for 5 seconds. 10 samples of each surface conditioning system were cemented with a dual cured resin cement (Panavia F 2.0 (Kuraray Medical Inc, Okayama, Japan), the others were cemented with a chemically cured resin cement, Multilink Automix (Ivoclar Vivadent AG, Schaan, Liechtenstein), according to the manufacturer’s directions. ED Primer A and ED Primer B (Kuraray, Okayama, Japan) and Multilink Primer A and Multilink Primer B (Ivoclar Vivadent AG, Schaan, Liechtenstein) were mixed in a same ratio and were applied only for 30 and 15 seconds respectively on a prepared tooth surface and air dried. A dual-polymerizing resin luting agent - Panavia F 2.0 (Kuraray Medical Inc., Okayama, Japan) and Multilink Automix (Ivoclar, Vivadent, Liechtenstein) was mixed according to the manufacturer’s recommendations, and applied to the treated surface of the zirkonia specimens, and placed on the prepared tooth surfaces. Excess cement was removed with a brush, and the tooth-resin cement-zirconia
complex was then placed in a custom-made alignment apparatus and a weight of 50 N was applied. The alignment apparatus was used to standardize the bonding procedure and consisted of parallel guides, a holder for the specimen and an added weight. The specimens were polymerized 40 seconds with LED (Voco, Almanya) from each aspect, a total of 160 seconds. The groups were summarized in table 1. Manufacturer and composition of each material used in this study were shown in table 2. Following polymerization, specimens were stored in distilled water at 37°C for 30 days. The specimens were loaded axially in a universal test machine (Testometric Micro 500 (Testometric Company Ltd, Lancashire, England) with a crosshead speed of 0.05 mm/min until fracture. Shear bond strength at failure were measured and recorded for each group in Newton.

Table 1. Distribution of specimens

<table>
<thead>
<tr>
<th>Cercon Specimens (n=40)</th>
<th>Zirkonzahn Specimens (n=40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treated with 110 µm Al₂O₃ (n:20)</td>
<td>Treated with Cojet System (n:20)</td>
</tr>
<tr>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
</tr>
<tr>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
</tr>
<tr>
<td>1st group</td>
<td>2nd group</td>
</tr>
<tr>
<td>Treated with Cojet System (n:20)</td>
<td>Treated with Cojet System (n:20)</td>
</tr>
<tr>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
</tr>
<tr>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
</tr>
<tr>
<td>3rd group</td>
<td>4th group</td>
</tr>
<tr>
<td>Treated with Cojet System (n:20)</td>
<td>Treated with Cojet System (n:20)</td>
</tr>
<tr>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
</tr>
<tr>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
</tr>
<tr>
<td>5th group</td>
<td>6th group</td>
</tr>
<tr>
<td>Treated with Cojet System (n:20)</td>
<td>Treated with Cojet System (n:20)</td>
</tr>
<tr>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
<td>Ceramic treated with Panavia 2.0 (n:10)</td>
</tr>
<tr>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
<td>Ceramic treated with Multilink Automix 2.0 (n:10)</td>
</tr>
<tr>
<td>7th group</td>
<td>8th group</td>
</tr>
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</table>

Table 2. Manufacturer, composition and batch number of each material used

<table>
<thead>
<tr>
<th>Material</th>
<th>Composition</th>
<th>Batch Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefabricated zirconium sample</td>
<td>Cercon (DeguDent GmbH, Germany)</td>
<td>YTP2</td>
</tr>
<tr>
<td>Zirkonzahn (Zirkonzahn Italy)</td>
<td>YTP2</td>
<td></td>
</tr>
<tr>
<td>Resin Cement Agent</td>
<td>Panavia F 2.0 (Kuraray Medical Inc., Sakaizu, Kuroshiki, Okayama, Japan)</td>
<td>41191</td>
</tr>
<tr>
<td></td>
<td>Bis-GMA, TEGDMA, silica,</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Bis-GMA, TEGDMA, silica, coumaronein</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EMA, MDP, water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Metakrylate monomer, violet, initiator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Phosphoric acid</td>
<td>3-Methacryloxypropyltrimethoxysilane, MDP, ethanol</td>
</tr>
<tr>
<td></td>
<td>Asetoin, MDP, Triazin Vinyl monomer</td>
<td>Oxygen-barrier agent</td>
</tr>
<tr>
<td></td>
<td>Multilink Automix (Ivoclar Vivadent, Liechtenstein)</td>
<td>K02702</td>
</tr>
<tr>
<td></td>
<td>Multilink Automix Monobond S</td>
<td>3-methacryloxypropyl-trimethoxysilane 31% water/ethanol solution 50%</td>
</tr>
<tr>
<td></td>
<td>Primer A</td>
<td>Initiators</td>
</tr>
<tr>
<td></td>
<td>Primer B</td>
<td>HEMA, Phosphoric acid, acryl acid monomers</td>
</tr>
<tr>
<td></td>
<td>Metal/Zirkonzahn Primer</td>
<td>Phosphoric acid acrylate, organic solution</td>
</tr>
<tr>
<td>Surface Treatment</td>
<td>Metoide Aluminyum Oxide</td>
<td>110µm Al₂O₃</td>
</tr>
<tr>
<td></td>
<td>Cojet System</td>
<td>Silica, Ethanol</td>
</tr>
<tr>
<td></td>
<td>Cojet sand (Cojet Coating agent)</td>
<td>30µm silica sand</td>
</tr>
<tr>
<td></td>
<td>ESPE 81</td>
<td>Bisacrylate, aminoal metal matrix</td>
</tr>
<tr>
<td></td>
<td>Visko Bond</td>
<td>Coporoquin</td>
</tr>
<tr>
<td></td>
<td>Sifonity Opique Powder</td>
<td>Titanium dioxide, organic peroxide</td>
</tr>
<tr>
<td></td>
<td>Sifonity Opique Liquid</td>
<td>Methoxyacrylate, Acrylate, Ammoniumhydroxide</td>
</tr>
</tbody>
</table>
Table 3. Mean (SD) of shear bond strength. Mode of failure according to Chi square test results (p<0.05):
Type I - cohesive failure in teeth; Type II - adhesive failure between teeth and resin cement;
Type III - cohesive failure in resin cement; Type IV - adhesive failure between the resin cement and zirconium surface;
Type V - cohesive failure in ceramic

<table>
<thead>
<tr>
<th>Specimens Groups</th>
<th>Shearbond Strength (N)</th>
<th>Failure Types (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Type I</td>
</tr>
<tr>
<td>Cercon CAP</td>
<td>192.61±38.12</td>
<td>10</td>
</tr>
<tr>
<td>CAM</td>
<td>174.32±39.18</td>
<td>0</td>
</tr>
<tr>
<td>CCP</td>
<td>242.77±53.17</td>
<td>10</td>
</tr>
<tr>
<td>CCM</td>
<td>209.05±36.06</td>
<td>20</td>
</tr>
<tr>
<td>Zirkonzahn ZAP</td>
<td>194±48.45</td>
<td>10</td>
</tr>
<tr>
<td>ZAM</td>
<td>187.98±39.04</td>
<td>10</td>
</tr>
<tr>
<td>ZCP</td>
<td>231.6±44.18</td>
<td>0</td>
</tr>
<tr>
<td>ZCM</td>
<td>214.18±50.03</td>
<td>10</td>
</tr>
</tbody>
</table>

Table 4. Results of the statistical analysis according to the cements

<table>
<thead>
<tr>
<th>Surfaces</th>
<th>Multilink</th>
<th>Panavia</th>
<th>MW</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zirkonzahn Cojet</td>
<td>214.18±50.03</td>
<td>231.6±44.18</td>
<td>44</td>
<td>0.65</td>
</tr>
<tr>
<td>Air-abraded</td>
<td>187.98±39.04</td>
<td>194±48.45</td>
<td>43</td>
<td>0.63</td>
</tr>
<tr>
<td>Cercon Cojet</td>
<td>209.05±36.06</td>
<td>242.77±53.17</td>
<td>22</td>
<td>0.04</td>
</tr>
<tr>
<td>Air-abraded</td>
<td>174.32±39.18</td>
<td>192.61±38.12</td>
<td>36</td>
<td>0.29</td>
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</tbody>
</table>

Mann-Whitney-U test

Table 5. Results of the statistical analysis according to the surface treatments methods

<table>
<thead>
<tr>
<th>Surfaces</th>
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<th>Air-abraded</th>
<th>MW</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zirkonzahn Multilink</td>
<td>214.18±50.03</td>
<td>187.98±39.04</td>
<td>33</td>
<td>0.199</td>
</tr>
<tr>
<td>Panavia</td>
<td>231.6±44.18</td>
<td>194±48.45</td>
<td>29</td>
<td>0.112</td>
</tr>
<tr>
<td>Cercon Multilink</td>
<td>209.05±36.06</td>
<td>174.32±39.18</td>
<td>26</td>
<td>0.070</td>
</tr>
<tr>
<td>Panavia</td>
<td>242.77±53.17</td>
<td>192.61±38.12</td>
<td>17</td>
<td>0.013</td>
</tr>
</tbody>
</table>

Mann-Whitney-U test

Table 6. Results of the statistical analysis according to the zirconium systems

<table>
<thead>
<tr>
<th>Surfaces</th>
<th>Zirkonzahn</th>
<th>Cercon</th>
<th>MW</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cojet Multilink</td>
<td>214.18±50.03</td>
<td>209.05±36.06</td>
<td>43</td>
<td>0.597</td>
</tr>
<tr>
<td>Panavia</td>
<td>231.6±44.18</td>
<td>242.77±53.17</td>
<td>35</td>
<td>0.257</td>
</tr>
<tr>
<td>Air-abraded Multilink</td>
<td>187.98±39.04</td>
<td>174.32±39.18</td>
<td>37</td>
<td>0.353</td>
</tr>
<tr>
<td>Panavia</td>
<td>194±48.45</td>
<td>192.61±38.12</td>
<td>48</td>
<td>0.880</td>
</tr>
</tbody>
</table>

Mann-Whitney-U test
Debonded specimen surfaces were examined using a stereomicroscope (Leica Cambridge Ltd, Cambridge, England) at x25 magnification and a scanning electron microscope (Jeol JSM-5600, England) at x150 and x500 magnification. Location and type of the failure were recorded. The failure modes of the specimens were classified in 5 groups and described in table 3. NCSS 2007 pocket program was used for statistical analysis. Chi-Square test was used to evaluate all the results (mean shear bond strengths values, their standard deviations and failure type - table 3). Multiple comparisons were made with Mann-Whitney-U multiple range analysis (Tabs 4, 5 and 6).

Results

The mean, standard deviation of shear bond strength test results and failure type according to Chi square test results were shown in table 3. Statistical analysis’s results according to the zirconia systems, surface treatments methods and cements were shown in tables 4, 5 and 6, respectively.

Significant difference was found for CCP group. Surface treatment of Cercon specimens treated with TSC resulted in higher mean shear bond strengths for Panavia F 2.0 resin cement (CCP: 242.77 N; p=0.04). No statically significant difference was found between zirconium systems (Cercon and Zirkonzahn) and surface treatment’s groups, APA and TSC.

Mostly adhesive failures at the ceramic-cement interface (Type II) and cohesive failures within the cements (Type III) were observed at the debonded surfaces under x25 magnification with the stereomicroscope (Figs. 1-6). Adhesive failures at the teeth-cement interface were exhibited 10% in CAP, CCM, ZCP and ZAP groups, and 20% in CCP and ZAM groups. Cohesive failures in ceramic were not observed (Type V). Cohesive failures in teeth (Type I) were not observed also in CAM and ZCM groups (Tab. 3).
Figure 3. Type 3 failure image

Figure 4. Type 4 failure image

Figures 5. Cercon Stereomicroscope and SEM Images

Figure 5 a. Cercon Specimens without surface treatment

Figure 5 b. Cercon Specimens treated with 110 µm Al2O3

Figure 5 c. Cercon Specimens treated with Cäjet System
Figures 5. CCM group Type 3 failure surface x25 stereomicroscope and Type 3 failure x150 SEM images.

Figure 5 g-1. CCM group Type 3 failure surface x25 stereomicroscope
Figure 5 g-2. CCM group Type 3 failure x150 SEM images

Figures 6. Zirkonzahn Stereomicroscope and SEM Images

Figure 6 a. Zirkonzahn specimens without surface treatment
Figure 6 b. Zirkonzahn specimens treated with 110 µm Al2O3
Figure 6 c. Zirkonzahn specimens treated with Cofet System
Figure 6 d-1. ZAP group Type 3 failure surface x25 stereomicroscope

Figure 6 d-2. ZAP group Type 3 failure x150 SEM images

Figure 6 e-1. ZAM group Type 3 failure surface x25 stereomicroscope

Figure 6 e-2. ZAM group Type 3 failure x150 SEM images

Figure 6 f-1. ZCP group Type 3 failure surface x25 stereomicroscope

Figure 6 f-2. ZCP group Type 2 failure x150 SEM images
In SEM micrographs (Figs. 5 and 6), the machined zirconia surfaces were characterized by regularly and evenly distributed crystal grains. After APA, the smooth surface of Cercon and Zirkonzahn specimens were roughened and crystal grains were no longer observable. The topographic pattern of the specimens abraded with airborne APA and TSC specimens was different. TSC specimen’s surface topography was more roughened and porosities were observed. On the debonded areas, the porosities were filled with the silane coupling agent, so that the surfaces of all samples were smoother.

**Discussion**

One of the null hypotheses, that there is no difference in the shear bond strength of zirconia systems when two surface treatments group were compared with two different resin cements, was proved for the first part of the hypotheses. No difference in the shear bond strength of zirconia ceramic systems and surface treatments groups was defined, but the second part was rejected: the difference was defined in tested resin cements results.

Bonding of ceramic to tooth substance is based on the adhesion of luting cement and its bonding resin to the ceramic substrate together with the adhesion of luting cement to enamel and dentin. Most of the studies in the literature showed the bond strengths of zirconium samples to the composite. There are few studies in the literature that used tooth structure (enamel or dentin) as the bonding area. Many studies reported that airborne abrasion may increase the surface area, resulting in acceptable micrometre scale facilitating resin-ceramic micromechanical interlocks formation. Tribochemical silica coating technique is supposed to provide ultrafine mechanical retention embedding treated surfaces with silica particles. In the presented study, treated zirconia-reinforced ceramic surfaces with APA and TSC, and silane application evidently enhanced the bond between luting cement and ceramic surfaces. The silica layer left by silica coating on the ceramic surface provides a basis for silane to react. In the ceramic-resin bond, silane functions as a coupling agent, which adsorbs onto and alters the surface of the ceramic, thereby facilitating chemical interaction. The other reason for lower results obtained after APA could be due to the weak bond between Al-Si-O, as reported by Ozcan.

Resin bonding of ceramic restorations to the supporting tooth structure increases retention, marginal adaptation, and fracture resistance of the restored tooth and the restoration. Therefore adhesive cementation may be beneficial for high-strength ceramic full-coverage restorations, especially in situations of compromised retention or high occlusal load. Burke et al strongly suggested to use of resin as a luting material for ceramic restorations. Madani et al reported that the use of Panavia Ex/Panavia 21 on sandblasted In-Ceram can produce tensile bond strengths up to 35 MPa. The adhesive monomer (MDP)-containing resin cement was found to have higher bond strength to the sandblasted-only ceramic surface than the value achieved with the use of a conventional Bis-GMA resin.

The results of this study showed that the bonding could be increased by the application of silica coating/phosphate monomer-based luting agents and silica coating/MDP-containing bonding/silane coupling agent mixture in similar degree. The bond strength was found to be significantly higher in silica coating/phosphate monomer-based luting agents group; CCP (242.77 ± 53.17 N). There were no significant differences between other groups. Secondary highest bond strength value were obtained with silica coating/MDP-containing bonding/silane coupling agent mixture group; CCM (209.05 ± 36.06 N). No differences were found among the other groups. In
the present study, the bond strength values obtained with using airborne particle abrasion/MDP-containing bonding/silane coupling agent mixture were lower than that of the silica coated group’s. The silica coating treatment method was seen more effective than the airborne particle abrasion treatment method, but the results were statistically insignificant. In the presented study, the shear bond strength values obtained from the Cercon and Zirkon-Zahn systems’ specimens were nearly the same, except for CCP group as mentioned before. The results of the presented study are not consistent with those of the Bottino et al36 study, who reported that the tribochemical systems increased the bond strength between Panavia F and In-Ceram Zirconia. The reason for this disagreement may be that Bottino et al luted zirconia specimens to the composite surface, but in the related study tooth surface was used as a luting surface.

According to manufacturers’ instructions, no tooth conditioning is required prior to cementation with self-etching adhesive cements. Hitika et al25 found a negative influence on the bond strength of a self-etching luting cement (RelyX Unicem, 3M ESPE) to enamel where no phosphoric etching was performed prior to cementation, but in the related study as a luting agents MultilinkAutomix and Panavia resin cement were used and before the cementation procedure, the tooth surface were conditioned with their primer agents.

Fracture surfaces were examined using light and scanning electron microscopy. SEM analysis provided more detailed information on the fracture events than the optical microscopy. It can be observed that the failure type for all groups was similar. Adhesive fracture occurred within the adhesive zone at the resin luting agent-ceramic interface and cohesive fracture within the resin cement. According to SEM results, in the presented study, while type II failures (adhesive failures at the ceramic-cement interface) were seen in CAM, CAP, ZCP groups, Type III failures (cohesive failures within the cements) were seen in CCM, CCP, ZAM, ZAP, ZCM groups. In SEM images, the machined zirconia surface was characterized by regularly and evenly distributed crystal grains (Figs. 5 and 6); SEM evaluation of the specimens showed morphological changes after surface treatment, such as pores and grooves. Irregular surface of treated zirconium are important for the increase of the bonding surface area. SEM results of ceramic fracture surfaces were examined and it was observed that the surface porosities of the zirconium specimens were filled with resin cement and there were resin tags between the zirconium and cement. Phark et al6 determined that the resin cement is able to flow into the micro porosities of the modified surface, by filling the micro spaces with composite resin matrix. The result of this study confirmed that.

The purpose of the present study was to evaluate the bond strength of resin luting agent to tooth structure and also to treated zirconium surface. Thermal cycling and long-term storage are the factors that can have effects on the durability of the resin bond strength to zirconium, and they are important parameters to simulate oral conditions17. In the present study, the specimens were kept only 30 days in distilled water after cementation protocols as in Dunnn et al38 study, to provide the water absorption of the resin cement. Further studies are needed to evaluate the effect of thermal cycling on the bond strength values for the tested materials.

**Conclusion**

There were no statically significant differences between zirconium systems (Cercon and Zirkonzahn). The specimens luted with Panavia F 2.0 showed higher shear bond strengths values than the specimens luted with Multilink Automix. Panavia F 2.0 cement could be used with TSC, when the additive retention was needed.

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Immediate Implant Placement: Report of Case Series

SUMMARY

Objective: The aim of this study was to evaluate the outcome of immediate postextraction implant placement. Immediate placement of dental implants have been claimed of the potential advantages such as reductions in the number of surgical interventions, a shorter treatment time, an ideal 3-dimensional implant positioning, the presumptive preservation of alveolar bone at the site of the tooth extraction and soft tissue aesthetics.

Method: In this case series we reported to extract 15 teeth in 12 patients (8 males; 4 females, mean age: 46.08 years) and replace the teeth with implants immediately.

Results: There were no signs of inflammation or infection and none of the patients had complaints subsequently. All implants were osseointegrated at the time of abutment connection. Postoperative healing was uneventful in all of the patients. No complications were observed.

Conclusion: Within the limits of the present study, immediate implant placement was a predictable treatment.

Keywords: immediate implant placement

Introduction

Immediate postextraction implant placement is a well accepted protocol due to the preservation of aesthetics, shorter total treatment time, maintenance of socket walls, reduced surgical time, and better actual implant placement. Advanced periodontitis, non-restorable caries, fractures, and traumatic injuries are the most common reasons for missing anterior teeth. Nowadays, patients and clinicians expect shortening the overall treatment period and minimizing the number of surgical interventions in implant dentistry. Simultaneous guided bone regeneration procedures, using bone grafts and barrier membranes, are usually necessary in such a situation to correct peri-implant defects and/or to augment surrounding tissues. This approach can also achieve successful treatment outcomes with high predictability and a low risk of complications, both from functional and aesthetic points of view.

Teeth replacement using dental implants has proven to be a successful and predictable treatment procedure; different placement and loading protocols have evolved from the first protocols in order to achieve quicker and easier treatment time. The original protocol of a dental implant was to place the implant into a healed alveolar socket. However, that protocol requires time to allow healing of the extraction socket. Schulte and Heimke initially described immediate placement of a dental implant in an extraction socket more than 30 years ago, in 1976. Reduction in number of surgical interventions, a shorter treatment time, an ideal 3-dimensional implant positioning, the presumptive preservation of alveolar bone at the site of the tooth extraction and soft tissue aesthetics have been claimed as potential advantages of this treatment approach. Additional benefit, which is also valued by patients, is the avoidance of a second surgical intervention. On the other hand, the morphology of the site, the presence of periapical pathology, the absence of keratinized tissue, thin tissue biotype and lack of complete soft tissue closure over the extraction socket have been reported to adversely affect the immediately placed implants. The purpose of this paper was to evaluate the outcome of immediate postextraction implant placement.
Material and Methods

The present study was performed within the guidelines of the Helsinki Declaration for Biomedical research involving human subjects. The study was conducted at the Department of Oral Surgery and Oral Medicine, Faculty of Dentistry, Istanbul University.

All patients were given emphasis-placed detailed explanations of the study protocol and were asked to sign surgical consent forms. 15 teeth in 12 patients (8 males; 4 females, mean age: 46.08) were evaluated for this case series and were scheduled for tooth extraction and immediate implant placement. Patients with ongoing inflammatory, exacerbating processes were excluded from the study. A 2-stage surgical procedure was planned to optimize marginal bone healing. The patients were initiated on a daily dose of 1.5 g amoxicillin, or 0.9 g clindamycin in penicillin-sensitive patients, 3 days prior to the surgical procedure and maintained on it for 2 days postoperatively.

Under local anaesthesia, a full-thickness mucoperiosteal flap was reflected at the surgical site and the involved teeth were extracted with minimal trauma to the cortical plates, and implant placement was made into the tooth extraction sites. The resultant sockets were then prepared by the standard implant placement protocol, and were extended apically 3 to 4 mm to achieve primary stability for the implants. In 6 of the cases, membranes and bovine bone graft materials were used. The flaps were subsequently replaced and secured with sutures in such a way that the healing cap of the implant was exposed to the oral environment. The implants were evaluated clinically and radiographically, and the follow-up period was 8-72 month (mean: 20.75 months).

Results

Immediate implant placement demonstrated acceptable clinical and radiographic outcome over a 8 months period in all 12 patients with 15 implants. There were no signs of inflammation or infection and none of the patients had subsequent complaints. All implants were osseointegrated at the time of abutment connection. Postoperative healing was uneventful in all of the patients. No complications were observed. None of the implants were lost or demonstrated progressive bone loss beyond acceptable levels.

Discussion

Immediate implantation has predictable results, with several advantages over delayed implant placement. Dental implants have become a predictable treatment option for the completely or partially edentulous patient. A 3- to 6-month healing period is usually recommended to achieve osseointegration before loading implants with prosthesis. The first reported case was described by Schulte and Heimke in 1976 using a polycrystalline aluminium surface. Since then, numerous clinical case reports have been published, and, at various times, review papers have appeared to update this surgical technique with contemporary findings. Clinical indications for replacing teeth with immediate implants include retained deciduous teeth, vertically and horizontally fractured teeth, teeth lost due to non-restorable dental caries, periodontal disease, endodontic failure, and poor aesthetics. Primary stability, defined as the biometric stability immediately after implant insertion, is a critical factor that determines the long-term success of dental implants. In our case series, all implants had primer stability.

Lindeboom et al reported the cumulative implant survival rate for immediate-placed implants 92% versus 100% in the delay-placed implants for replacement of teeth with periapical lesions. They concluded that immediate implant placement may be indicated. Corbella et al also reported a high survival rate for the delay-placed implants for replacement of teeth with periapical lesions, in the literature review that included 10 studies. Although Chen S et al reported the presence of periapical pathology to be a criterion to affect immediately placed implants adversely, findings of Casap et al reported that 29 of 30 immediately placed implants were osseointegrated in debrided infected dentoalveolar sockets in 20 patients, and they were functional when followed up from 12 to 72 months. 1 implant was mobile after its immediate restoration and was removed. They concluded that successful immediate implantation in debrided infected alveolar sockets depends on the complete removal of all contaminated tissue and the controlled regeneration of the alveolar defect. This treatment may be considered in patients presenting dentoalveolar infections by experienced clinicians. Our results were also successful because we excluded inflammatory teeth from our study and prescribed prophylactic antibiotic before the surgery.
before the surgery. We confirmed that immediate implant placement is a treatment with multiple benefits, as reduction in the number of surgical interventions, a shorter treatment time, an ideal 3-dimensional implant positioning, the presumptive preservation of alveolar bone at the site of the tooth extraction and soft tissue aesthetics were potential advantages of this treatment approach. Additional benefit, which is also valued by patients, is the avoidance of a second surgical intervention.

In patients with endodontic or periodontal lesions we presume more controlled clinical trials and it requires longer follow-up period to confirm this procedure as a safe treatment.

In conclusion, the results of this study were satisfying and showed that immediate implant placement could be an alternative choice to delayed implant placement. When compared to other studies, we had a high survival rate of 100%. Within the limits of this approach, we suggest that immediate implant placement is a choice of treatment in patients with a healthy alveolar bone.

References


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Oral Ulceration Due to Methotrexate Treatment: A Report of 3 Cases and Literature Review

Introduction

Methotrexate (MTX) is an antimetabolite, acting as a DHP reductase inhibitor, resulting in blocking intracellular DNA synthesis\(^1,2\). It is used for the treatment of both benign conditions (rheumatoid arthritis\(^1,3-11\), psoriasis\(^1,2,3,5,8,12\), atopic dermatitis\(^2\), psoriatic arthritis\(^2,12\), collagen vascular disease\(^2\) and malignancies (leukemia\(^3\), non-Hodgkin’s lymphoma\(^5,9\), cutaneous T cell lymphoma\(^3\), choriocarcinoma\(^3\)). MTX was approved as an antirheumatic drug in 1999\(^4,10\). The efficacy of MTX against rheumatic diseases was first noticed in the early 1950s, when aminopterine, a precursor of MTX, was used for rheumatoid arthritis (RA)\(^3,8\). The use of MTX in psoriasis was increased during the 1970s. In the 1980s, randomized clinical trials proved its efficacy against RA. Since then, rheumatologists have extensively used long-term low-dose methotrexate (LDMTX), especially in North America\(^3\).

LDMTX may also be administered to children; MTX is the only effective DMARD (disease-modifying antirheumatic medication) in juvenile RA. The long-term positive results, along with the fact that medication tolerance in children seems to be of a good level, have made MTX the most commonly used second-line agent after NSAIDs (non-steroidal anti-inflammatory drugs)\(^3\). In non-malignant conditions the weekly dosage is up to 25 mg (low dose)\(^3,5\).

Adverse effects to MTX include gastrointestinal toxicity\(^3,4,6,8,10\), hepatotoxicity\(^1,5,6,7,10\), myelosupression\(^1-5,10,12\) and oral manifestations (oral ulceration and oral mucositis)\(^5,10,12,13\). Severe oral manifestations are common in high-dose MTX therapy, especially for the treatment of malignancies.

The aim of this paper was to present 3 cases of oral ulcerations due to MTX treatment, along with a brief review of the literature.

Case Reports

The following cases were all presented and cured in Apostolos Matiakis (second author) private practice. All figures belong to his personal archive.

Case 1

A 38-year-old woman presented with ulcerative lesions at the labial mucosa (especially at the lower labial mucosa) and the floor of the mouth (Figs. 1 and 2). The above lesions were painful. She indicated that oral ulcerations developed for the first time and there was no history of recurrent aphae. Her medical history revealed that the patient suffered from psoriatic arthritis and was under MTX treatment.
A 78-year-old man, edentulous, was referred by his dentist, due to an insisting ulcer, (3mm x 7mm) at the left buccal mucosa (Fig. 3), causing a suspicion of malignancy. The patient reported severe topical pain, which increased during mastication. Patients’ history revealed that he was under MTX treatment, due to RA. In cooperation with his rheumatologist, we decided to discontinue MTX treatment, which improved the clinical symptoms.

**Case 3**

A 52-year-old woman presented with aphthous-like ulcers, located on the left side of the tongue (Fig. 4). Due to the fact that she suffered from RA, the patient was under MTX treatment. Her rheumatologist accepted the interruption of the MTX administration, while methyl-prednizolone treatment was prescribed, leading to complete remission of the ulcerative lesions.

The previous information, as well as clinical examination, lead us to the conclusion that oral ulcers presented due to MTX administration. In cooperation with her rheumatologist, we decided to discontinue MTX treatment. In a few days, ulcers were significantly reduced.

**Case 2**

In our report, 3 cases of patients who presented oral ulcers due to MTX treatment are described. MTX is an effective antiproliferative, antineoplastic and anti-inflammatory medication. In a high dosage, it is used as a chemotherapeutic agent in treating malignant diseases, including leukemia, non-Hodgkin’s lymphoma and a number of solid tumors. Lower dosage of MTX, is used in controlling chronic inflammatory disorders, such as rheumatoid arthritis and psoriasis.

Nevertheless, MTX does not lack side effects. The frequency and severity of MTX toxicity depends on dosage, although tolerance in MTX may vary among patients. Renal and hepatic dysfunction may influence the MTX metabolism and clinical tolerance. Adverse effects of LDMTX have been classified in 3 major groups. The first group includes direct gastrointestinal and bone marrow toxicity. They are dose-dependent effects, though a clear correlation between plasma concentration and this effect.

**Discussion**

In our report, 3 cases of patients who presented oral ulcers due to MTX treatment are described. MTX is an effective antiproliferative, antineoplastic and anti-inflammatory medication. In a high dosage, it is used as a chemotherapeutic agent in treating malignant diseases, including leukemia, non-Hodgkin’s lymphoma and a number of solid tumors. Lower dosage of MTX, is used in controlling chronic inflammatory disorders, such as rheumatoid arthritis and psoriasis.

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has not been established. These effects are mediated by folate antagonism and are the most common. The second group includes idiosyncratic or allergic reactions such as pneumonitis. The third one includes effects of long-term treatment in diseases such as liver or cardiovascular diseases, caused mainly by hyper-homocysteinaemia. General adverse effects include gastrointestinal toxicity (nausea, vomiting, abdominal discomfort, anorexia, dyspepsia, diarrhea), hepatotoxicity (hepatitis, fibrosis, cirrhosis), myelosuppression, (leukocytopenia, thrombocytopenia, pancytopenia), hyperhomocysteinemia, hypersensitivity causing pulmonary toxicity, renal insufficiency, central nervous system events (headaches, depression) and osteoporosis. Oral lesions are less common, appearing as oral ulcers and mucocititis. The above is considered to be a dose-dependent effect. Oral ulcerations may be related to medication overdose or folate deficiency. Attention ought to be given when prescribing to patients who present with oral ulcerations whilst being under MTX. Although oral manifestations are not life threatening, they have, however, a negative impact on patient’s quality of life.

<table>
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<tr>
<th>Researchers</th>
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<th>Sex</th>
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Interacting drugs can also affect serum MTX levels, despite a correctly administered low-dose MTX. Drugs that interact with renal and hepatic function such as aspirin and ibuprofen, antibiotics, sedatives and anticonvulsants should only be prescribed to patients on low-dose MTX treatment at limited doses and under meticulous supervision. MTX excretion is reduced by aspirin and other NSAIDs and penicillin, increasing the risk of toxicity. Nitrous oxide increases the antifolate effects of MTX and their concurrent use, such as in inhalational sedation, should be avoided.

Further interest should be paid to the fact that some patients do not develop oral mucositis under a high-dose MTX regimen. Genetic polymorphism has been implicated as a predictive factor for MTX toxicity. The pharmacologic mechanism of MTX action involves inhibition of the synthesis of purines and pyrimidines by inhibiting the key enzymes dihydrofolate reductase (DHFR) and thymidylate synthase. Rapidly proliferating cells are susceptible to MTX because most cells are in the S-phase, where this medication exerts its effects. Gastrointestinal mucosa, hair and bone marrow are very susceptible to MTX, due to the high rate of cellular turnover. Therefore, these tissues are among the first to be affected and disrupted by the side effects of cytotoxic medication, such as MTX.

Several mechanisms are considered for the development of erosions and ulcerations. One of them attributes ulcerations to shortening the time between doses of MTX. According to the weekly dosing schedule used by dermatologists and rheumatologists, medication is either taken as a single dose once per week or divided into 2 to 3 doses, usually taken in 12-hour intervals; patients are told to always take their medication on the same day(s) of the week. If a patient were to accidentally...
take a MTX dose before the next scheduled time, the additional dose would theoretically stop proliferation of the small percentage of cells that escaped the initial MTX dose, thereby increasing the total number of cells affected by medication. Other mechanisms that may contribute to MTX-induced ulcerations include renal dysfunction, which leads to elevated MTX levels due to decreased renal clearance and concomitant administration of medication such as NSAIDs, sulfonamides, and salicylates, which increase soluble MTX levels by displacing the protein-bound fraction.

MTX toxicity can be treated and reversed by the substitution of folate or folic acid (leucovorin). Leucovorin, the reduced form of folate, bypasses the target of MTX, the enzyme dihydrofolate reductase, and can therefore restore the cell’s ability to produce DNA bases despite MTX treatment. A current market shortage of leucovorin may complicate MTX management and increase the incidence of patients suffering from MTX side effects.

Other possible solutions to oral toxicity of LDMTX are:
- topical treatment (analgesics, antiseptics, steroids) which only provide symptomatic relief;
- excision of lesions (it can be effective in some cases, especially when biopsy is required);
- cessation of LDMTX (relapse of the disease that MTX was prescribed);
- MTX dosage reduction (less effective than cessation);
- interruption of MTX for 2-3 weeks (may cause relapse of the disease, requiring higher doses subsequently);
- fortnightly (instead of weekly) MTX dosing (may be appropriate for well-controlled patients);
- switching to another drug (azathioprine, sulphasalazine) - less effective and more likely to cause adverse effects;
- combination of MTX and other medication (may allow dose reduction of all, and consequently reduce toxicity);
- combination or substitution with newer biological agents (lefumonide, etanercept, infliximab) - high cost and unproven long-term safety (further research required).

Gobbo et al (2013) reported the use of LLLT (low-level laser therapy) as an effective treatment of low-dose MTX related oral mucositis in patients affected by rheumatoid arthritis. The previous treatment is safe, atraumatic and rapid, whilst being free of side effects and easy to apply. Also, it does not interfere with other therapies and can help in avoiding a dangerous discontinuation of MTX therapy. As LLLT reduces pain, even if a fibrous scar remains visible after treatment, this new technique is believed to be useful in the management of such lesions. Nevertheless, further investigation is needed to evaluate this innovative technique.

If a medication is suspected to be the cause of an oral ulceration, cooperation is essential with the prescribing doctor in order to discuss the possibility of alternative medication or dosage reduction. After cessation, change, or dosage reduction, ulcerations may decrease in 1-2 weeks. In cancer patients, the combination of radiotherapy and chemotherapy can cause mouth ulcers, which are due to either MTX or to the radiation. Radiation may cause xerostomia, fact that leads to more painful ulcers.

Ulcers are common symptoms observed in the oral cavity and some of the above are induced by medication (such MTX). Ulcers presenting with typical clinical findings, may be differentially diagnosed, but the final diagnosis is often difficult and histopathological examination may be needed.

In the case of immunosuppression with agents such as MTX or by cytotoxic chemotherapy, Epstein-Barr virus can be the cause of mucocutaneous ulcers (EBV positive biopsy) in patients with various types of immunosuppression, EBV has long been associated with B-cell lymphoproliferative disorders. In 2010 Dojcinov et al were the first to propose EBVMCU (Epstein-Barr virus-positive mucocutaneous ulcer) as a newly recognized clinical-pathological entity after describing a series of EBV-positive circumscribed, ulcerative lesions with Hodgkin-like histological features associated with various types of immunosuppression. Typically, these ulcers present as isolated, circumscribed, cutaneous and mucosal lesions with a benign and self-limited clinical course.

Dental practitioners are very likely to encounter patients under MTX treatment and so ought to be aware of clinical and histopathological oral manifestations. Since it is a widely prescribed medication by rheumatologists, dermatologists and oncologists, cooperation is required between the previous and dental practitioners as well as oral pathologists.

In conclusion, MTX is a non-rare prescribed medication by many medical specialists. Oral ulcers stand among MTX’s main side effects. Dental practitioners should be well informed about MTX prescription, in order to be able to estimate the potential adverse effects in their patients.

References


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Text. The complete title should precede the text (but without authors and institution names). Headings should be appropriate to the nature of the paper. Normally, only two categories of headings should be used: major ones should be typed in capital letters in the centre of the page and bolded; minor ones should be typed in lower case (with an initial capital letter) at the left hand margin and bolded.

All illustrations, labeled as figures (such as photographs, line drawings, charts or tracings) should be submitted as high-contrast prints, black and white, suitable for publications. They must be marked on the back with the title of the paper, numbered with Arabic numerals in the same order as they are cited in the text, and the top edge indicated with an arrow. Photomicrographs should have the magnifications and details of staining techniques shown. Short explanatory captions of all illustrations should be typed on a separate sheet.

Tables should be typed on a separated sheet. Each table should have a short heading (title) above and any footnotes, suitably identified, below. Tables should be numbered consecutively with Arabic numerals. Do not submit tables as photographs. Ensure that each table is cited in the text. Abbreviations are not desirable.

References. References in the text should use superscript numerals as they appear in the list of references, with or without the name(s) of the author(s). The list of references at the end of the paper should be typed on a separate sheet, arranged alphabetically and numbered, and should include all references cited in the text. For review papers, references can be arranged consecutively and numbered (by Arabic numerals) as they are cited. The accuracy of references is the responsibility of the author.

Titles of journals should be abbreviated as used by Index Medicus. The format for references should be: year-volume-first and last page. References to monographs should also include place and the name of the publisher, and the page(s) referred to.

Examples: