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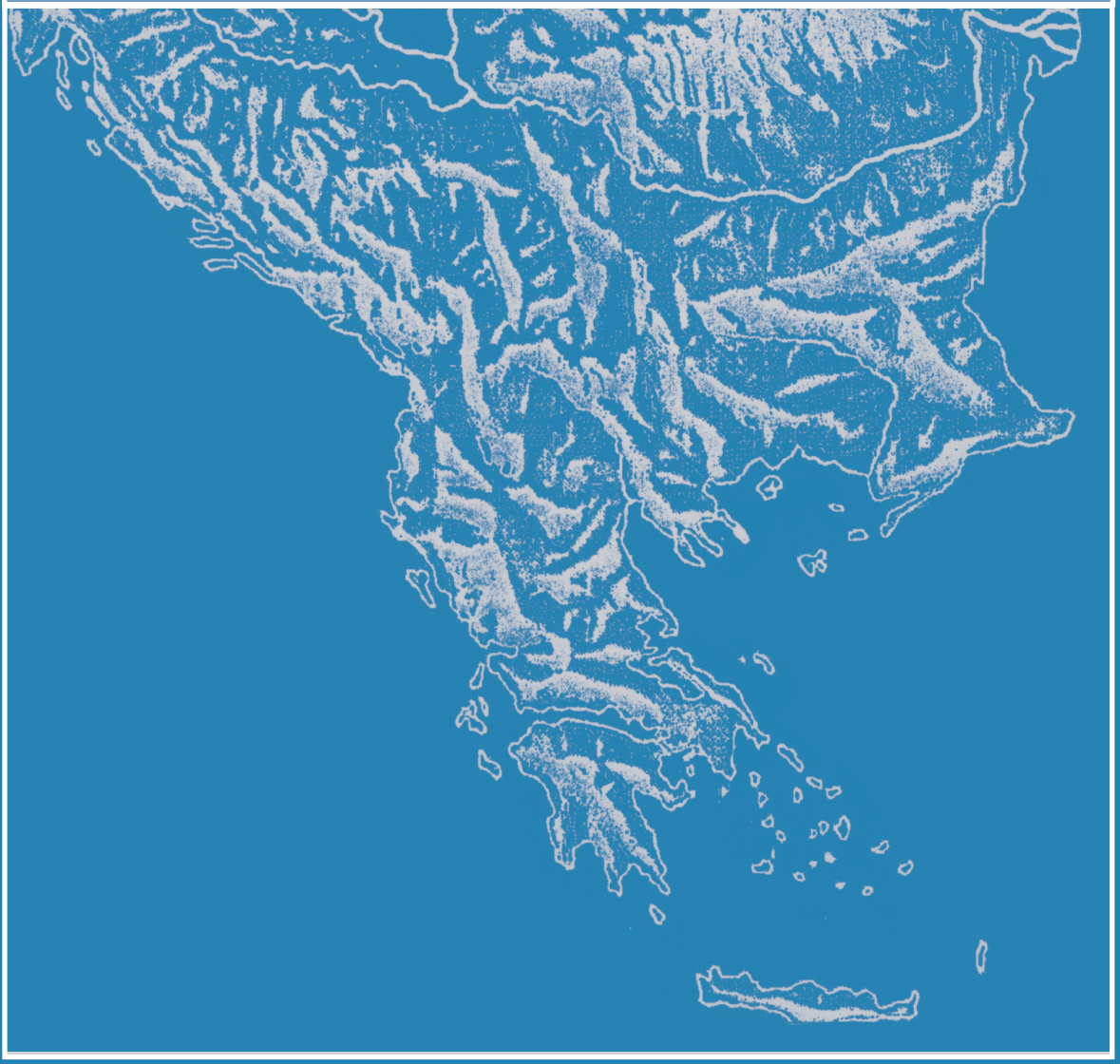

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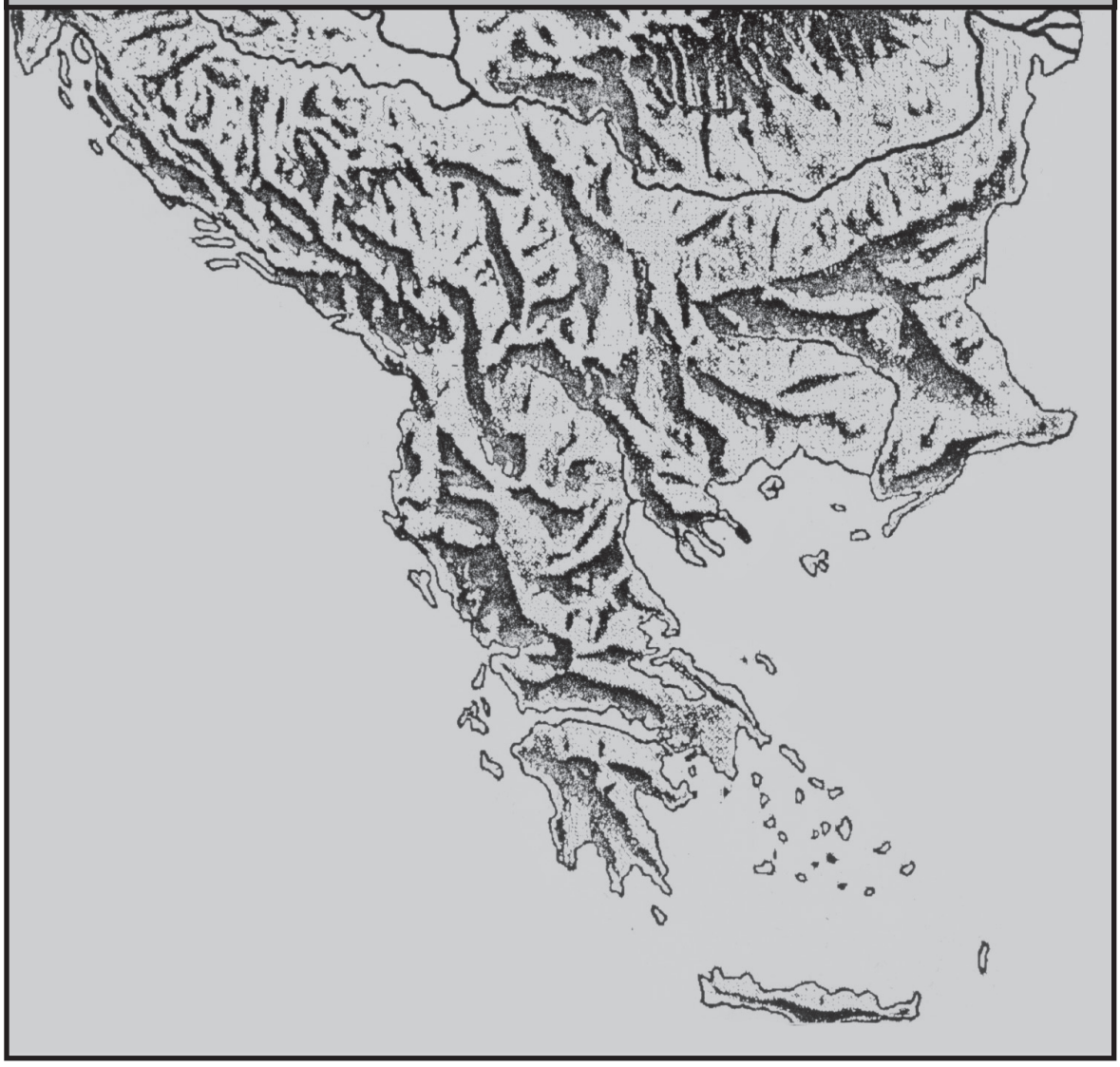

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Treatment of Deep Carious Lesions

SUMMARY

Treatment of deep carious lesions approaching the pulp, traditionally, mandates removing all the infected and affected dentin. Several studies call this approach into question. Electronic databases using selected key words to identify studies relating to partial versus complete removal of carious lesions yielded more than thousand reports but 23 authors judged to be relevant. The results of randomized controlled trials provide evidence of leaving behind the infected dentin, the removal of which would put the pulp at risk of exposure. Several studies have demonstrated that cariogenic bacteria, isolated from their source of nutrition by a restoration, either die or remain dormant and pose no risk to the health of the pulp.

Keywords: Deep Caries; Pulpal Exposure; Pulp Capping, direct

Rozarka Budina

University of Tirana, Medical Faculty
Department of Dentistry, Tirana, Albania

REVIEW PAPER (RP)
Balk J Stom, 2012; 16:4-9

Introduction

Traditional management of deep carious lesions dictates the removal of all infected dentin to prevent further cariogenic activity and provide the mineralized base dentin for restoration. Several studies call this approach into question, such as studies examining partial caries removal[4], randomized controlled trials[52]; studies examining the activity of pulp capping materials[6,12,53], and observational studies[6,54].

For the practitioners, the treatment of deep carious lesions presents some difficulties when the procedure carries risk of exposing the pulp, because the course becomes less predictable and may require such measures as indirect pulp capping, direct pulp capping, pulpotomy or pulpectomy[1,3-5,7,9,10]. Choosing among these options can be daunting for the dentist, as well as for the patient, who is advised of the risks and asked to share responsibility in the decision.

The major purpose of this paper was to evaluate the diagnosis, treatment options and prognosis of deep carious lesions when partial removal or complete excavation of the infected dentin was prepared. Several authors have investigated and proposed alternative approaches to preclude or at least minimize the possible complications of the complete excavation of carious dentin close to the pulp[12-14,26]. One method, a step-wise or 2-step excavation, involves the staged removal of carious tissue. At the initial visit the clinician, when established that the pulp still is vital, partially remove necrotic and infected dentin, which is often soft and can be removed easily with hand instruments[17,18,20-23]. Than the dentist seals the lesion up with a medicament, such as calcium hydroxide, and places a temporary restoration. At the second visit, a few months after the first visit, in some cases up to 2 years later, the clinician removes all or most of the remaining infected tissue. The rationale for this approach is that by this point any remaining bacteria will become dead, residual infected dentin, as well as a previously affected dentin will become re-mineralised, and reparative dentin will have been generated, making it easier for the dentist to remove any remaining carious tissue.

Conservative or ultraconservative removal of carious tissue, often referred to as “partial caries removal”, is more controversial approach. In this method the practitioner removes most but not all of the infected dentin, seals the cavity (with or without indirect pulp treatment) and proceeds with the restoration. The trade off for avoiding pulpal exposure, leaving behind a layer of infected dentin, is defended by citing the substantial evidence that cariogenic bacteria isolated from their source of nutrition by a restoration of sufficient integrity either die or remain quiescent and thus pulp may stay vital[11,16,25,27-30].

It is common to experience difficulties in distinguishing between dentine that should be removed,

and that which should be left[10,26,28]. During the course of excavating an extensively decayed tooth, the pulp might be exposed. In this case patient is informed of the possible problem and the treatment options, including a pulp capping, pulpotomy, pulpectomy and root canal therapy .The benefits, prognosis, future treatment needs, and fees are carefully explained. The worst possible scenario happens when the possibility of exposing the pulp during excavation has not been preliminary discussed with the patient. In that case, options, benefits and fees must be discussed with the patient being under stress, who is forced to make a decision. The alternative is for the dentist to make a treatment decision without the patient's approval and permission. Both alternatives are expensive and time-consuming.

Consideration and Treatment by Direct and Indirect pulp Capping

The literature regarding step-wise excavation has reported consistently that residual carious dentin recedes and hardens under temporary restorations in the interim between the initial excavation and re-entry[6,8,17]. Kidd stated "why re-enter"?[55] In other words, if the goal is to avoid pulpal exposure, and residual dentin poses no threat to the tooth, why should the patient be subjected to a second excavation?

Indirect Pulp Capping

Indirect pulp capping (IPC) is defined as those steps or procedures taken to protect or maintain the vitality of a carious tooth that, if being completely excavated, would result in pulpal exposure[1,5,8,15,25]. In these cases, the infected dentin, the more bacteria-ridden superficial layer, must be removed to eliminate most of the viable bacteria present in the tooth. Greater understanding of the caries process has led to the distinction between the infected and affected dentine. Stained dentine may be affected by caries (may be slightly demineralised or conversely may be sclerosed) but may not necessarily be infected and, thus, removal of such dentine would be over-preparation with unnecessary loss of tooth structure[1,7,25,29,32,34,39]. Thus, it could be argued that the first definition of an IPC (where stained, demineralised dentine is not removed and a calcium hydroxide lining placed) reflects nothing more than routine practice for pulp protection. The subjacent layer of the affected dentin, although demineralised, does not contain high counts of viable bacteria. It is this layer that is to be left behind after gross caries excavation.

This is a delicate procedure that involves careful judgment by the clinicians. The pulp no longer may respond favourably by re-mineralising the affected layer and producing secondary dentin[41,46,50]. Case selection is extremely important. Any tooth that is planned for treatment by basic restorative procedures (amalgams or composites) should be considered a good candidate for the IPC. If extensive tooth preparation is anticipated, it is unwise to utilize an IPC. Analyzing radiographs, the periapical region should have a healthy *lamina dura* and periodontal ligament space. Patients without spontaneous pain or with mild-moderate pain upon thermal stimulation or mastication may be considered as candidates for IPC. These symptoms usually represent degenerative changes in the pulp which will not respond favourably to IPC[15,19,30,39,46].

The procedure consists in achieving adequate anesthesia, isolation, obtaining a proper outline form, complete removal of carious tissue from cavity walls, but limited removal from the pulpal floor and axial wall. Caries should be removed to the level at which a change is noted in dentin consistency (infected to affected layer) or where suspected exposure is imminent. Cavity should be cleaned and dried with cotton pellets. A dressing with calcium hydroxide or zinc-oxide eugenol should be covered by a durable base material and finally permanent restoration.

Although several studies have been completed with regard to progression of caries and prognosis of teeth in which permanent restorations were placed over caries, there is at present insufficient evidence to support this approach. Prognosis of IPC depends on pulp vitality and age of the patient[20,26,27].

Direct Pulp Capping

Direct pulp capping (DPC) is defined as dressing of an exposed pulp with the objective of maintaining pulp vitality. Historically, the placement of a medicament or material against a direct pulpal exposure during caries excavation has been considered controversial, and instead, conventional endodontic therapy has been recommended[2,11,14,24,31,33,35]. DPC is a procedure in which a dressing/lining (or restorative material) is placed into direct contact with the exposed pulpal tissue. This is usually carried out following a carious or traumatic exposure. Calcium hydroxide is most commonly used; however some authors have directly bonded resin composite over exposures and mineral trioxide aggregate may be a promise as an alternative (although it is currently relatively expensive)[2,10,18,31,36,37].

Although both mechanical and a carious pulpal exposure result in pulp injury and inflammation, the prognosis for a successful DPC is greatly diminished with carious exposure. When the decay has progressed to such an extent that a pulp exposure results during preparation, it means that the pulp has already been chronically inflamed, either partially or totally. This is coupled with invasion of microorganisms associated with the carious exposure, and makes these teeth very poor candidates for direct pulp capping[33,35,37,38]. The traumatic or mechanically exposed pulp possesses a greater adaptive

ability for repair because it has not been previously compromised by inflammation from progressing caries or by the introduction of bacteria and infected dentin[37,38,40,43] (Figs. 1 and 2).

If a carious exposure is anticipated, the tooth should be isolated to prevent salivary contamination. Caries should be removed, first in the dentin-enamel junction, then in the lateral walls, and lastly at the deepest part of caries penetration. After pulpal exposure haemorrhage is controlled by pressure with a sterile cotton pellet. Strong or long burst of air should be avoided as this will cause pulpal damage. Calcium hydroxide is placed directly over the exposure site and finally a permanent restoration should be placed (Figs. 3-5).

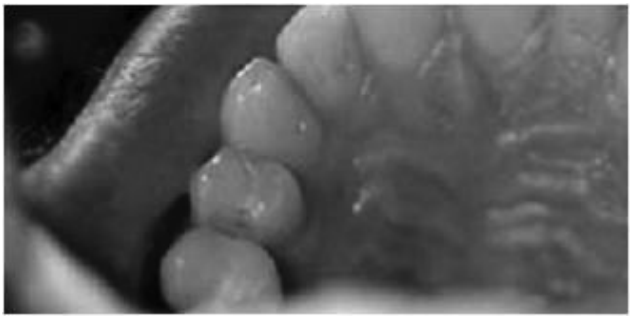

Figure 1. Exposure of 0.5 mm in the axial wall in a young patient

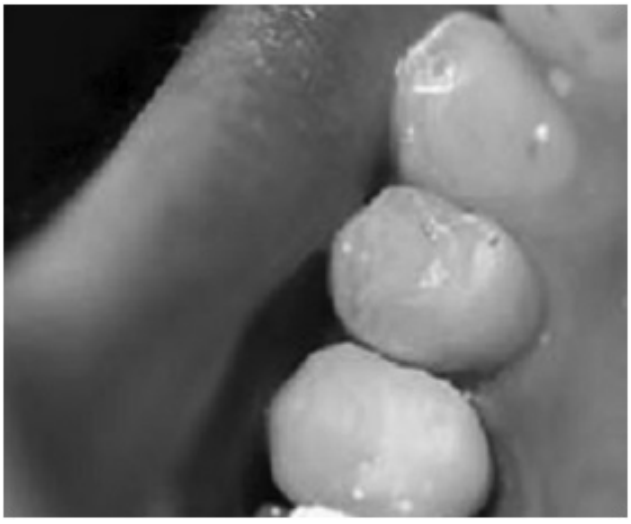

Figure 2. Patients shown at the figure 1: no symptoms after 2 months

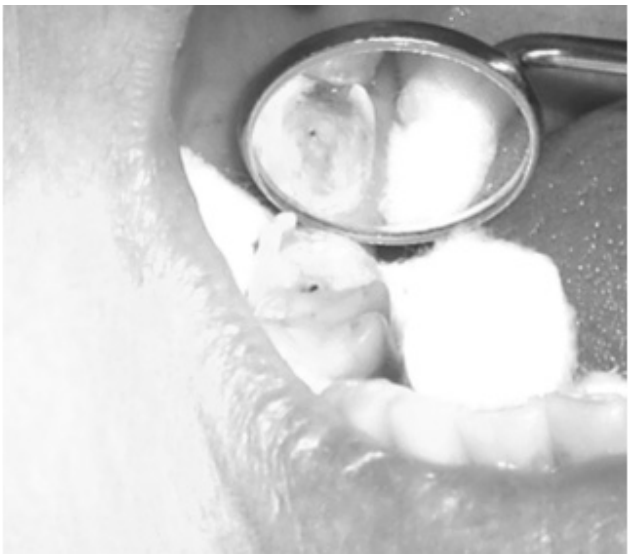

Figure 3. DPC-treatment sequence of a second mandibular molar that was symptomatic to cold testing in a 35-years-old female patient. Pre-treatment radiograph with no evidence of periradicular or furcation pathosis. Chief complaint sensibility to cold 6 months after placing amalgam restoration

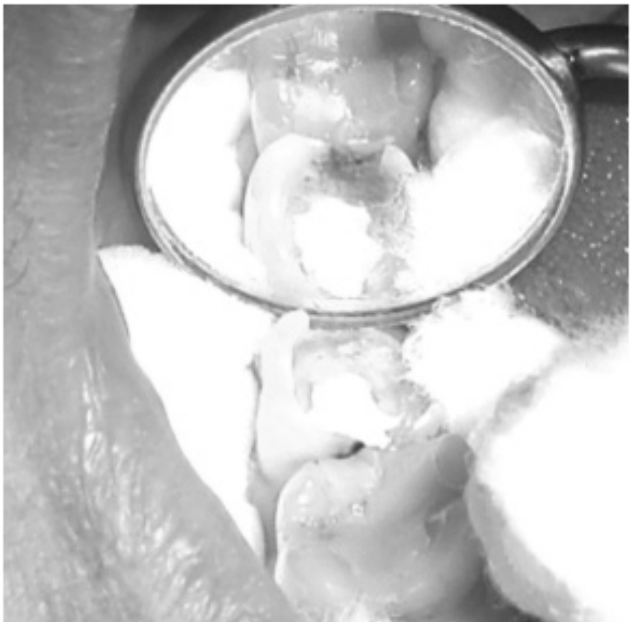

Figure 4. DPC-treatment of second maxillary premolar with deep mesial caries in a 20-year-old female patient exhibiting normal pulpal response to cold testing. 2 exposures 0.5 to 1.0 mm toward distal axial wall made after excavation. Haemostasis with 5.25% sodium hypochlorite, Dycal and temporary restoration (GIC). Recalls after 1, 2, and 3 months

Discussion

One of the most frequently discussed areas among dentists is the maintenance of pulp vitality in carious teeth, particularly by means of pulp capping procedures. It is a complex subject to be examined due to the wealth of contradictory and controversial information concerning pulp-capping[9,42,44,45]. The opinions of investigators examining the topic are often inconsistent, leaving the concerned clinicians more confused than satisfied.

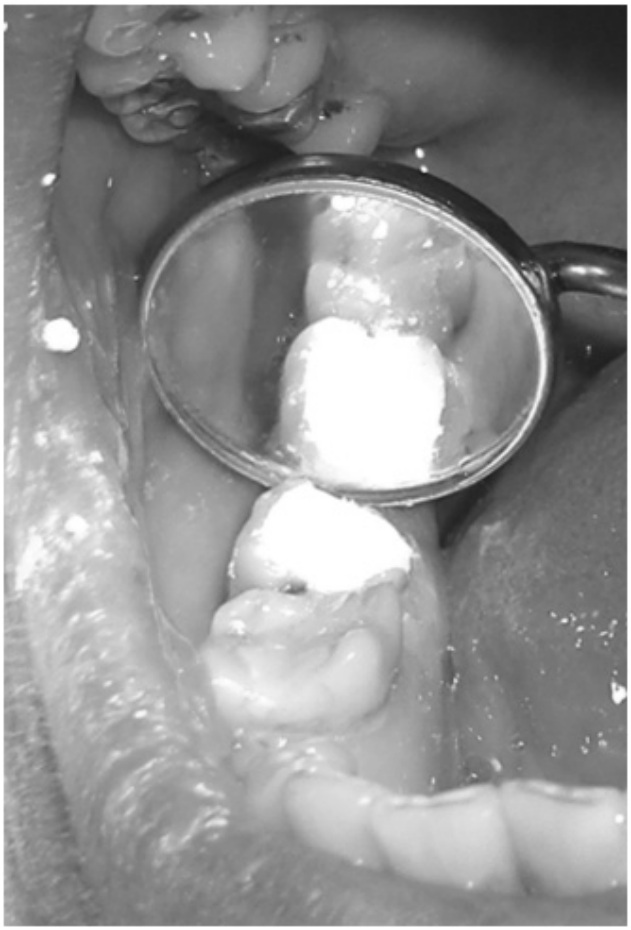

Figure 5. Patient shown at the figure 4 at the control examination after 4 months

Weather it is necessary to remove all carious tissue from lesions approaching the pulp? Many practitioners continue to follow the basic principle guiding any surgeon - that one must eradicate the affected tissue from the site of an infection[1,26-28,34,40,47-49], although there is substantial evidence to the contrary. The conventional treatment paradigm has a long history: GV Black in his classic 1908 text asserted that "it is better to expose the pulp of a tooth than to leave it covered only with softened dentine". The majority of survey on this subject indicated that all carious tissue should be removed even if the procedure would risk pulpal exposure.

Tooth Development

A younger patient's tooth with greater blood supply, better defences against insults, and if without previous restoration, it should be a better candidate for IPC than the multi-insulted tooth of the older patient[4,5,7,10,12]. In teeth with incompletely formed apices, pulp-capping is the recommended treatment procedure following vital pulp exposure[1,15,28,46,50,51]. In teeth with mature apices, there are conflicting opinions regarding whether the age is an unfavourable factor in direct pulp-capping[10,21,30,35,47,49]. Haskell et al[49] and Baume[47] have reported that age does not seem to be a factor. However, chances of successful pulp-capping are diminished with age because of decreased blood supply and increased fibrous and calcified deposits in the pulp[47,49].

Bacterial Contamination

The presence of bacteria is the most important consideration in predicting pulp-capping success. In the absence of bacteria, pulpal healing results regardless of the severity of the exposure. In contrast, pulp tissue contaminated by microorganisms does not heal[7,32,38-40,48].

Size of Exposure

Larger exposures result in more traumatized pulpal tissue, more lacerated blood vessels, greater haemorrhage, and greater pressures, resulting in severe inflammatory reaction[25,45,47,49].

Control of Haemorrhage

Any haemorrhage must be staunched with sterile cotton pellets because blood coagulum between the pulp and the capping material can reduce the rate of healing by about 50%[30,32,37,45].

The Condition of the Pulp

The condition of the pulp at the time of exposure is important for success. An inflammation-free pulp possesses a high regeneration potential; if the exposed pulp tissue is contaminated by bacteria before placement of the capping material, failure is the rule[9,13,14,16,18,39-41,45].

Selecting the Appropriate Pulp Capping Agent

A paste mixture of calcium hydroxide (CH) powder and sterile anaesthetic solution, Dycal or a paste mixture of MTA and sterile anaesthetic solution, or ProRoot MTA that prevent bacterial leakage should be selected[2,19,22,26,31-33,53]. When using calcium hydroxide for deeper cavities, where it is estimated that less than 2 mm of dentine remains, a preparation liner should be placed in the deepest parts of the preparation for direct pulp capping procedures (to encourage formation of tertiary dentine and minimise risk of future exposure, and to stimulate formation of repair)[49]; it should be also used for step-wise caries removal (to encourage formation of tertiary dentine, kill any remaining bacteria and reduce risk of exposure)[2,11,18,19,22,24,31,33,36,43,44].

Mechanisms of Activity of CH

Since its introduction, CH has been widely used in several clinical situation[22,30,33,34,36]. Various biological properties have been attributed to CH: antimicrobial activity; tissue dissolving ability; inhibition of tooth resorption; induction of repair and formation of hard tissue[14,19,20,25,31,33].

Temporary Coverage

Depending on the aesthetic and functioning needs of the tooth, the prepared cavity may be restored with a bonded composite resin, amalgam or temporary crown[30,34,35,49-51].

Success Rate

Clinical studies have reported extremely variable success rates after direct pulp capping, ranging from 97.8% after 1.5 years and dropping to 61.4% after 5 years, and only 13% after 10 years, while endodontically treated teeth revealed 93% success after 5 years and 81% after 10 years[2,7,29,31,40,47,49].

Summary

Depending on the clinical setting, vital pulp therapy can be managed with an indirect or direct pulp capping procedure. The determination of which kind therapy should be employed is a decision that must be made by the clinician at the time of treatment.

Conclusions

On the basis of the presented facts, there is substantial evidence that removal of all infected dentin in deep carious lesions is not required for successful caries treatment, provided that the restoration can seal the lesion from the oral environment effectively. Before this concept is fully accepted by dental professionals, additional clinical trials are needed.

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Correspondence and requests for offprints to:

Prof. Rozarka Budina
Klinika Stomatologjike Universitare
Q.S.U "Nene Tereza"
Tirana, Albania
E-mail: zarkabudina@yahoo.com

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Subcutaneous Emphysema after Root Canal Therapy

SUMMARY

The introduction of air into subcutaneous tissues during dental procedures can be harmful. However, subcutaneous emphysema after root canal therapy is a rare complication, which is usually restricted to only moderate local swelling on the face and sometimes the neck. This comprehensive review of the literature explains all the possible causative factors of emphysema, as well as symptoms and signs that can be noticed. Finally, it illustrates the preventive measures and the appropriate management of subcutaneous emphysema, which is usually benign and improves within 2 to 3 days.

Keywords: Subcutaneous Emphysema; Root Canal Therapy; Compressed Air; Facial Swelling

Sotiria Liatiri
Thessaloniki, Greece

LITERATURE REVIEW (LR)
Balk J Stom, 2012; 16:10-15

Introduction

Subcutaneous emphysema, sometimes abbreviated SCE or SE and also called tissue emphysema, occurs when gas or air is present in the subcutaneous layer of the skin. Subcutaneous refers to the tissue beneath the cutis of the skin, and emphysema refers to trapped air. Since the air generally comes from the chest cavity, subcutaneous emphysema usually occurs on the chest, neck and face, where it is able to travel from the chest cavity along the fascia[1]. Subcutaneous emphysema can result from puncture of parts of the respiratory or gastrointestinal systems. Particularly in the chest and neck, air may become trapped as a result of penetrating trauma (e.g., gunshot wounds or stab wounds) or blunt trauma. Infection (e.g., gas gangrene) can also cause gas to be trapped in the subcutaneous tissues. Subcutaneous emphysema can be caused by medical procedures and medical conditions that cause the pressure in the alveoli of the lung to be higher than that in the tissues outside of them[2]. It has been reported in the literature as a result of endodontic[3], periodontic[4], oral surgical[5] and operative procedures[6,7]. It is a possible complication of both nonsurgical and surgical endodontic treatment[8]. When the condition is caused by surgery it is called surgical emphysema[9]. Surgical emphysema may occur during root treatment and reports in the dental literature[3,15,25-27] indicate that the complication occurs most commonly as a result of over-zealous irrigation with hydrogen peroxide, or drying root canals with compressed air blasts[10]. Its progression and severity is limited by the fascial planes and by the amount of air that has been introduced[11]. Sometimes, spread of larger amounts of air into deeper spaces may cause more serious complications, including accumulation of air in the retropharyngeal space, pneumo-mediastinum, and pneumo-pericardium[12].

The purpose of this review is to describe all the possible aetiologies of subcutaneous emphysema and present all the clinical symptoms and their importance to diagnosis. It also aims to emphasize the clinical guidelines for prevention and management of subcutaneous emphysema during endodontic procedures.

Etiologic Factors

Physiologically, subcutaneous emphysema can occur as a complication of coughing, sneezing, nose-blowing and vomiting[13,14], or other patients' actions that raise intraoral pressure[15] following a dental extraction[13,14]. It can also be observed following facial injuries which involve nasal airways and paranasal sinuses[16-18]. It is believed that in these cases emphysema follows nose sneezing in an attempt to clear the nasal passages[16,19,20] or it may be due to oxygen administration with a

mask or anesthesia[16]. It is an infrequent occurrence following general anesthesia, but can occur due to hypopharyngeal[21], tracheal[22], or cervical esophageal[23,24] injury during the intubation procedure[11]. Subcutaneous emphysema occurring during dental procedures while using high-speed air or water drills has been documented mainly in the dental literature[25]. It can be caused by invasion of compressed air into soft tissues through the disrupted intraoral barrier (dento-alveolar membrane or root canal) during tooth extraction (particularly of the third mandibular molars)[26], restorative dentistry, dental implant surgery, and root canal or periodontal treatment[12]. The underlying mechanism in all these procedures is a disruption of the intraoral barrier, allowing air under pressure to tract subcutaneously[27]. A 1957 literature review by Shovelton[15] found 13 reports of air emphysema from endodontic treatment. One of these cited a clarinettist whose playing forced air through an open root canal into his neck[28].

While opening the access cavity for endodontic treatment, subcutaneous emphysema can be caused by the use of an air-driven high-speed handpiece and compressed air-syringe[29]. Especially the use of compressed air to dry a canal can be very risky for introducing air into tissues. Facial emphysema can also result from a series of technical errors[10], such as the enlargement of the perforation which increases the chances of injuring the periodontal tissues[10] and entering air into the tissue spaces. Many cases of air entering tissues are complicated by inflammation and infection, perhaps from canal debris and/or microorganisms or perhaps from opportunist microbes from other sources within the body that find the inflated space[28]. Further risk is found in the fact that typical dental air sources do not provide sterile air. Clinically, in the early phases of endodontic treatment, necrotic tissue and microorganisms are often present, so air pressure within even small diameters canals can plausibly force such irritants periapically to initiate or worsen an inflammatory reaction[28].

Hydrogen peroxide has been implicated, as well as compressed air, in aetiology of subcutaneous emphysema[10,15,30-32]. It has been used as a canal irrigant and disinfectant during routine root canal therapy[33]. When hydrogen peroxide comes into contact with blood or tissue proteins, it very rapidly undergoes effervescence and liberates oxygen[34]. This gaseous expansion may drive debris or simply gas through the apical foramen[34] or into the adjacent bone if an inadvertent perforation of the canal wall were present[8]. Kaufman et al[31] presented a case of delayed onset of emphysema subsequent to hydrogen peroxide irrigation[8]. Shovelton[15] also presented 4 cases where hydrogen peroxide in the root canal caused oxygen emphysema[28]. Most cases of pneumo-mediastinum and emphysema after endodontic treatment have been related to the root canal that was irrigated with hydrogen peroxide[35] or dried with compressed air[36].

Anatomic Pathways of Emphysema Diffusion

The prime area of air entry into anatomical spaces appears to be the root canal space[8]. But it can sometimes pass through the dento-alveolar membrane[36]. Following its introduction into the soft tissues, air remains in the subcutaneous connective tissue and does not spread to deep anatomic spaces in the majority of the cases[37]. However, emphysema can also involve deeper structures as the tissue planes commonly connect[38].

The potential avenues of travel for compressed air involve the superficial region, the parotid region, the submandibular and sublingual region, the tonsillar and masticator region and the parapharyngeal region[8] (Tab. 1). So, spread of larger amounts of air into these deeper spaces may sometimes cause serious complications. For example, the bases of the first, second and third molars directly communicate with the sublingual and submandibular spaces. These spaces, in turn, communicate with the parapharyngeal and retropharyngeal spaces, where accumulation of air may lead to airway compromise[39]. The retropharyngeal space ("danger space") is the main route of communication from the mouth to the mediastinum. Once air enters the mediastinum, it can also reach the pleural cavity, the pericardium, and even the retroperitoneum[26,40]. Consecutive cases of pneumothorax and pneumopericardium may cause cardiac and/or pulmonary failure[40,41]. Cases of fatal air embolism and optic nerve damage[42] (by access of air to the orbit) have also been described[12]. Generally, air which is introduced into or along fascial planes may present 3 potential sequelae. Initially, it can remain in the space until it is absorbed. This leads to the "ballooning" (emphysema) of tissue and the occurrence of crepitus along the overlying involved tissues, immediately after air entrapment[43]. Secondarily, it can escape along the path of introduction, such as a patent root canal, and be released into room air, causing no damage[15]. Finally, it can enter a blood vessel in a large enough volume to cause obstruction of coronary flow, resulting in cardiac air embolism, or to cause obstruction in cranial flow, resulting in cerebral ischemia (stroke)[44]; either of these 2 latter sequelae may result in death[8]. From Rickle's[45] post-mortem study, it is obvious that one definite risk of air emphysema during endodontic treatment is introduction of air into the cardiovascular system. In large volume, this can cause heart failure[28].

Respiratory and gastrointestinal tracts are closed systems surrounded by subcutaneous, prevertebral, visceral, and previsceral spaces. Air arising from a breach in mucosal integrity of the respiratory or gastrointestinal tract can enter visceral space and dissect along facial planes into the subcutaneous space, creating subcutaneous emphysema[46]. More distally, air can be introduced into

the subcutaneous space at the alveolar level in a non-traumatic fashion by alveolar disruption[46].

Table 1. Potential spread of compressed air

Region	Area of potential spread
Superficial	cheek, lower lip, intraorbital region
Parotid	along parotid duct, within parotid gland
Submandibular	superficial space, sublingual region, parotid gland, masseter region
Sublingual	submandibular, masseteric, parapharyngeal spaces and ultimately airway
Tonsillar	submucosa of soft palate, submandibular, sublingual region
Masticatory	parapharyngeal spaces, parotid, sublingual, submandibular regions, cavernous sinus via foramen ovale, orbit via infraorbital fissure
Parapharyngeal	carotid sheath and contents: difficulty speaking, swallowing, with eventual mediastinitis

(Adapted from Liebgott B. The anatomical basis of dentistry. Toronto: Decker, 1986; 457-463)[39]

These mechanisms involved in spontaneous mediastinal and subcutaneous emphysema are well described by Macklin and Macklin[47,48]. They suggested that over-distended alveoli rupture into the pulmonary vascular sheath, resulting in interstitial emphysema[49]. The basic requirement for rupture of the alveoli is the existence of persistent pressure gradient between the alveolus and the surrounding structures. The pressure within the contiguous alveoli is generally assumed to be equal, and therefore the inter-alveolar walls are expected to remain intact. However, in certain situations, (e.g. decrease in perivascular interstitial pressure or an increased intra-alveolar pressure, or both), a gradient is created[49]. As illustrated schematically, when a pressure gradient develops, alveoli may rupture at their bases, introducing air into the perivascular adventitia and resulting in interstitial emphysema[49]. Because mean pressure in the mediastinum is always somewhat lower than that in the peripheral lung parenchyma, air then dissects proximally along the broncho-vascular sheaths to the lung hilum and mediastinal soft tissue and then into the previously described fascial planes[50].

Symptoms and Diagnostic Signs

The most prominent clinical feature of the SCE is rapid swelling of the face and sometimes the neck[8]. However, it is usually restricted to discrete local swelling and tenderness[51]. The affected area becomes puffy and in almost every case crepitus may be elicited on palpation[15]. Oedema or lymphadenopathy[12] may also be observed. Pain is variable and is usually of short duration[8]. Some patients experience sharp pain as the swelling appears. Other patients complain of fullness due to the enlargement of the area. If the swelling involves the neck area, there is generally some discomfort or difficulty in swallowing, but this very rarely appears to be a respiratory embarrassment[37] (Tab. 2).

The initial change is soft tissue enlargement from the presence of air in deeper tissues[52]. Subsequently, the enlargement increases and spreads due to secondary inflammation and oedema. Facial erythema and mild fever may occur. Significant spread into the mediastinum can result in dysphonia, dysphagia or dyspnea[41] (Tab. 2). Stabbing precordial chest pain, the most common complaint of patients with pneumomediastinum (80-90%), is associated with stretching of interstitial soft tissues caused by dissection of air[53-55]. Other features suggestive of pneumomediastinum are dyspnea with a brassy voice, chest or back pain, and Hamman sign, which is a crunching and bubbling sound caused by movement or air accompanying cardiac pulsation[56]. The "mediastinal crunch" described by Hamman is reported in 50% to 80% of patients with pneumomediastinum[53,55]. The crunching or clicking sound is best heard over the retrosternal area and is occasionally audible without a stethoscope. While it varies with the respiratory cycle and patient position, the timing is synchronous with the heartbeat[57].

Table 2. Clinical symptoms and signs

immediate	subsequent
rapid swelling	facial erythema
crepitus	mild fever
pain (variable)	dyspnea
local discomfort	oedema
radiographic findings	difficulty in swallowing

While the SCE should be detectable by physical examination, an alert radiologist often makes the diagnosis[57]. Radiographic examination consists of a panoramic and an anterior-posterior radiograph[52]. The standard postero-anterior chest radiograph usually demonstrates a radiolucent line between the left heart border and the mediastinal pleura. Other findings include "highlighting" of the aortic knob and "the contiguous diaphragm" sign[35]. Postero-anterior chest radiographs can overlook 50% of cases of pneumomediastinum. Considering this fact, lateral chest radiographs, which increase sensitivity to almost 100%, should always be performed. These radiographs can also detect associated

pneumothoraces. Lateral decubitus radiographs can sometimes be useful for distinguishing a pneumothorax from a pneumomediastinum[25]. The SCE can also be seen in CT scans, with the air pockets appearing as dark areas. CT scanning is so sensitive that it commonly makes it possible to find the exact spot from which air is entering soft tissues[58].

Differential Diagnosis

Diagnosis of severe SCE can be misleading, when it occurs after a dental procedure[59]. Differential diagnosis of SCE should be made from an allergic reaction[8], gas gangrene[37], infection[28], hematoma, and angioneurotic oedema[8]. The allergic reaction is far more severe than SCE, with skin manifestations preceding serious cardio-respiratory manifestations[8]. Gas gangrene is also a far more severe condition than emphysema; severe systemic reactions, a very disagreeable odour and marked pain are often reported. It is always associated with deep wound[37].

Air emphysema during endodontic treatment may also be misdiagnosed as infection because of similar location and size of swelling. In fact, such accidents may develop into an infection from microbes forced into the spaces created by the air blast[28]. As far as hematoma regards, formation is rapid and often without initial discoloration. Although sponginess may be present, crepitus is absent in hematomas. In angioneurotic oedema, circumscribed areas of oedema, sometimes preceded by a burning sensation, may appear on the skin or mucous membrane[8]. The possibility of necrotizing fasciitis, in which bacterial gas production is possible, should also be considered[60].

Other differential diagnoses of acute swelling of the cervicofacial region include acute contact dermatitis and Melkersson-Rosenthal syndrome[12]. Finally, in those cases where general anesthesia was performed, subcutaneous emphysema might be misdiagnosed as a delayed hypersensitivity reaction to general anaesthetic[11].

Preventive Measures

During endodontic treatment, the SCE can be prevented by[29]:

- Using of a well-fitted rubber dam[37];
- Using remote exhaust handpieces[28,29] or electric motor-driven handpieces[29];
- Using high-speed aspiration or paper points to dry fluids from the root canal[8];
- Using loosely placed irrigation needles into the root canal[8], avoiding wedging the needle syringe or employing excessive pressure during intra-canal injection[61];
- Avoiding the use of compressed air once the root canal has been opened[8];
- Avoiding the use of hydrogen peroxide while irrigating canals[8].
- During surgical endodontic procedures, the SCE can also be prevented by[8]:
- Using specific surgical high-speed handpieces, which direct the high pressure exhaust away from the surgical site;
- Using a slow-speed, electrically-driven, or sealed-head air pressurized handpieces to remove bone, cementum and dentin when necessary;
- Using ultrasonic or sonic instruments for root-end cavity preparations.

Finally, early recognition may be of extreme importance to prevent possible secondary infections and cardiopulmonary complications[62].

Management of Subcutaneous Emphysema

Although the occurrence of the SCE is alarming, the condition is generally not dangerous[8]. There is no specific therapeutic protocol recommended for its treatment[37]. In mild to moderate cases, the treatment consists of observation and reassurance of the patient[63]. In the vast majority of cases, emphysema improves within 2 to 3 days, although residual swelling may be evident for up to 14 days[14]. Cold compresses should be used to minimize swelling and improve circulation to the affected area[61]. If solutions such as H_2O_2 or NaOCl are implicated, it is recommended to irrigate the area gently with water (distilled if available) through the portal of entry[8]. If patient complains for pain, local anaesthetics may be prescribed for discomfort in the appropriate area(s). Broad-spectrum antibiotic coverage is advised in all dental-related cases[48], since the introduction of air may include microorganisms[8]. If the amount of air is large, the emphysema can interfere with breathing and be uncomfortable[64]. If difficulty in breathing or swallowing occurs, and does not seem to be due to anxiety, prompt medical investigation should be considered[8].

In severe cases, immediate medical attention is mandatory[12]. Tracheostomy may become necessary in case of retropharyngeal-space emphysema with consecutive airway compromise[65]. It has also been reported that administration of 100% oxygen *via* a nonrebreather mask can hasten resolution of the emphysema, because oxygen, which replaces the air, is more readily absorbed[39,63].

Finally, in cases where the emphysema extends towards the neck or the mediastinum, hospitalization of the patient is necessary for a more complete control and continuous follow up[37].

Conclusion

Endodontic treatment is not frequently associated with the presence of the SCE. But it is very important to know how to recognize this situation when occurs, in order to treat the patient appropriately. The appropriate therapy is determined by its aetiology[11]. Thorough knowledge of the diagnostic clues is important for early recognition and initiation of treatment, which are essential to prevent possible complications[12].

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Correspondence and request for offprints to:

Sotiria Liatiri
Grabias 26
54645, Thessaloniki
Greece
E-mail: ria.dent@gmail.com

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When to Extract a Compromised Tooth

SUMMARY

There are often questions and doubts concerning the decision-making process in regard to the prognosis of an individual tooth. Unfortunately in dentistry, as in all biologic sciences, there are no straightforward answers to questions. Decisions concerning the survival of the tooth are often made by specialists without any uniform criteria, usually only on the base of their previous experience.

This article will look at the literature in this area to help the practitioner in the decision-making process what to do with the compromised tooth. In order to help clinicians to make better choice, factors and variables that can influence the final decision are discussed as factors influencing initial assessment, periodontal disease severity, furcation involvement, etiologic factors, restorative and other factors.

Although there are many literature data concerning this subject, no simplified and precise criteria are offered; so further work should be done in attempt to make some more uniform criteria concerning this subject.

Keywords: Tooth Extraction, criteria; Treatment Planning

Maja Pandilova[1], Silvana Georgieva[1], Mirjana Popovska[1], Lidija Kanurkova[1], Cena Dimovska[2], Katerina Smilevska

[1]University Dental Clinical Centre "St.Pantelejmon", Skopje, FYROM
[2]University "Goce Delcev", Faculty of Medical Science, General Stomatology, Stip, FYROM

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Introduction

Advanced technology of new materials, possibilities that prosthetic dentistry offers combined with implants, declines the decision whether to extract or maintain a tooth in favour of its extraction. But one should keep in mind that maintaining the natural dentition in adequate function and aesthetics is still the primary goal in dentistry. Prosthetics restorations can not be compared with the physical, biomechanical and sensitive receptions of the natural tooth. One of the main advantages of the natural teeth, compared to implant restoration, is the presence of bio-receptors and their possibility for adaptation under mechanical force provided from the periodontal ligament.

On the other hand, keeping teeth at any cost could represent a set of pathological conditions that cannot be predicted and can cause unwanted consequences, as lack of function or extension of the dental infection into the surrounding spaces.

Treating a compromised tooth, contrary to extraction, represents one of the most difficult decisions the practitioner has to make. He has to make this kind of decision based on certain criteria from the literature, but still personal experience is one of the most used, if not the only criteria, to do so.

In Moreira's[13] researches made in Brazil, 152 dentists with average of 15 years of experience, replied to the question how do they make the decision of extracting or maintaining a tooth. 55% of them answered that they refer their patients to a specialist. Although this kind of research is not conducted among our doctors, according to our experience, these kinds of decisions are usually made by specialist based on their own criteria and experience.

Unfortunately in dentistry, as in any other biological science, there is no concrete answer to problems of this kind - that's why this article will consult the literature, but also will sum the authors experience, all with one cause: to help the clinician in the decision making process concerning the compromised tooth.

Material and Methods

In order to meet the goal of the planned work, we looked into the available textbooks of Periodontology, Oral Surgery and Prosthetic Dentistry. Unfortunately,

we couldn't find precise answer to the question, or any criteria set for this matter. Certain data were mentioned in different chapters but with other purpose, and it was not possible to extract a worthy conclusion.

Afterwards, we searched all the available literature regarding this problem. The search was conducted by 3 key words: tooth extraction, therapy plan and criteria. After this was done, combined with authors' experience selection and systematization of the data was made.

Discussion

Most frequently mentioned factors that influence the decision making factor for prognosis or tooth extraction are: type of bone loss, pocket depth, attachment loss, furcation involvement, crown-root relation, mobility, root anatomy, occlusion and tooth replacement, condition of the pulp, type of rehabilitation that follows, strategic value of the tooth and personal factors, such as : patient's age, general health, oral hygiene, other risk factors and the possibility of their change, finances and parafunctional habits[8].

According to the clinicians, concerning of criteria they mostly use, they are ranged as follows: (1) mobility 41%; (2) bone loss 24.5%; (3) bone evaluation on the roentgenogram 22.1%; (4) prosthetic needs 19%; (5) furcation involvement 5%; (6) socio-economical possibilities 4.7%; (7) presence of extensive caries 2.3%; (8) systemic disease 2.1%; and (9) the existence of perio-endo lesions 1.8%[8]. Furthermore, Avila[3] separates the factors and variables in the decision, making 6 categories of the process, such as initial assessment, severity of the periodontal disease, furcation involvement, etiologic factors, restorative and other factors.

There are some factors that can't be measured objectively, but they are crucial in the decision making plan of the treatment and rarely considered by dentists such as: patient's desire to keep the tooth must be considered if there are minimal chances for fulfilling that wish; if not so, it is hopeless to expect from the patient to meet our treatments and recommendations.

Treatment expectations are an issue that should also be considered. Strategic value of some teeth is important segment in the decision making process of treatment. If we decide to keep a compromised tooth, we should have in mind that a long-term maintenance will be necessary under optimal conditions, which in certain cases is not realistic. Some authors suggest certain criteria to facilitate the decision in the maintaining certain teeth in the dental arch; Moreira[13] suggests criteria that separates teeth in 3 groups depending on their expected life time in the mouth.

Natural teeth get more than 10 years prognosis if the treatment has a complete success, and function and aesthetics are completely accomplished**.** These teeth can be considered even for a prosthetics restoration when the other abutment is an implant. When probing, if the pocket depth is bigger than 7-8 mm, with bleeding, those teeth have less than a 5-year prognosis. Maxillary molars with poor oral hygiene and second or third degree of furcation involvement have the biggest risk for complication, and their loss is supposed in less than 5 years. The situation is even more complicated when a tooth is in the same region or quadrant of bad prognosis. Recurrent periodontal abscess often results in fast attachment loss and active bone destruction. In those cases, prognosis of survival of the tooth is minimal.

When a tooth gets a survival prognosis less than 5 years, according to the suggested criteria, even when a proper periodontal treatment is applied, the clinician should not hesitate to extract the tooth and suggest an alternative treatment plan. Generally, when a tooth has a pocket depth on probing of 7-8 mm, in long-term studies, such teeth have a pore prognosis, and should be considered for 5-10 years survival. To this group belong molars with first degree of furcation involvement. When a tooth, regardless the treatment, has a 5-10 years prognosis for survival, the further outcome is uncertain.

In cases when the clinician has a doubt in which category a tooth should be placed (0-5, 5-10) then a category with weaker prognosis is suggested.

It is very difficult even for an experienced periodontologist to predict the progress of the disease, and even more difficult to maintain teeth between the limit checkups. According to Matthews[9], the percentage of lost teeth from periodontal reasons, after conducting the treatment, is 36.0% - 88.5%. In this study, component of the patient (age and smoking) and components of the tooth (type of tooth, location, position, initial prognoses of the tooth) were included. After analyzing these variables, it was concluded that age of the patient, smoking and initial prognosis should be the most frequent factors for tooth loss, even after appropriate periodontal treatment.

Aesthetics is also an important, if not the most important issue in today's dental practice. Patients ask for a treatment that besides a proper function, health and stability will provide aesthetics of high-quality. Appropriate gingival symmetry, papillary symmetry, appearance of the tooth and absence of a discoloration are the most important parameters for adequate esthetics[5]. Therefore, if aesthetic is not involved, the decision whether to extract or keep a tooth is less critical, but if the tooth does not fulfil aesthetic criteria, then there is a possibility to compromise the prosthetic restoration in the future, so we should consider whether to preserve it[7].

The financial status of the patient plays an important role in the decision making process for treatment. The traditional restoration procedures or implants are often more expensive than a conservative periodontal maintenance of the tooth.

Cooperation of the patient is also an important factor in the decision making process. Cooperative patients have a smaller degree of caries, progression of the periodontal disease and tooth loss compared to uncooperative patients. One should have in mind that patients with bad oral hygiene will have the same habit with their prosthetic appliances. This could be a problem especially if the prosthetic is combined with implants. With these kinds of patients no matter how the problem is solved, it would not be a long-term solution.

One of the crucial things in decision making for or against tooth extraction is periodontal pocket depth. Deep periodontal pockets and bleeding upon probing are indicators for presence of the disease and further attachment loss. Some criteria had been proposed according to the depth of periodontal pockets: if the depth is smaller than 5 mm, extraction is not recommended; if it is 5-7 mm, the tooth should be followed with precautions; if it is bigger than 7 mm, extraction is indicated[12].

In this context, the mobility of the tooth is the most used criteria for prognosis; yet, there is possibility this not to be a reliable factor. Mobility is divided in 3 classes: the first class refers to the physiological movement of the tooth; the second class refers to movement up to 1 mm in any direction (it is recommended for teeth of that class to be evaluated along with other factors, and then to decide the future treatment); the third class includes teeth with mobility grater than 1 mm in any direction, including vertical dimension too[1].

Bone loss can be seen on X-ray images, and mostly it has been used as a supplement factor, not as a main factor, in examining. Based on the amount of bone loss, 3 categories have been recommended: the first category refers to bone loss not grater than 30% (these teeth can be properly maintained and kept); the second category refers to the bone loss between 30%-65% (these teeth suffer a big attachment loss, but they can also be treated and maintained for a long period of time); the third category refers to bone loss greater then 65% and loss of the periodontal supportive tissue more then two-thirds (these teeth are difficult to be maintained)[4].

Recently, more studies of root relations have been made, especially analyzing the proximity in multiple rooted teeth. Heinz and Weider[6] analyzed 116 posterior, inter-proximal regions and they came to conclusions that if the inter-radicular proximity is smaller than 0.5 mm, then the spongious bone and *lamina dura* are histologically absent, while in the regions where the proximity is smaller then 0.3 mm, there is no bone support at all. Therefore, the smallest distance between the roots should be bigger than 0.8 mm, so we can have stability of the attachment loss, and bone resorption.

In assessment of furcation involvement, X-ray can be very useful. Furcation involvement can be divided in 3 classes: the first class refers to teeth which have less than 3 mm in horizontal penetration on probing. In these teeth the destruction is minimal and periodontal maintenance is easily accomplished. The second class refers to teeth which have horizontal penetration bigger than 3 mm on probing. Treatment of these teeth is less sure, yet personal experience stands in favour that a long-term maintenance can be accomplished with proper treatment. The third class refers to teeth with complete horizontal penetration, where extraction is advised. In furcation involvement assessment one should have in mind the inter-proximal length of bone at the furcation entrance. This part of bone has a crucial meaning in the treatment outcome, especially when teeth from the second and third classes are involved. When the roof of bone is above or at the same level with the furcation, the periodontal treatment is possible, but if it is below the furcation then the prognosis is not good. Beside the furcation involvement, for the outcome of the tooth, root anomalies are very important for plaque control in the same area. X-ray assessment provides significant data in that sense, such as crown-root relation. The ratio should be at least 1:1 in conditions of healthy periodontal ligament and controlled occlusion[2]. If the ratio is smaller than 1:1 the tooth should be kept and if it is bigger than it should be eremoved[10].

The teeth with root upgrade and prosthetic crown should be carefully followed.

Presence of risk factors for periodontal disease should also be seriously considered, although they are often underestimated or simply forgotten. McGuire and Nunn[11], working on this problem, came to the conclusion that the presence of IL-1 genotype and sever smoking play a big role in tooth loss. The presence of IL-1 increases the possibility of tooth loss up to 2.7 times, and smoking increases possibility of tooth loss up to 2.9 times. If both factors are present in same patient, then the possibility of tooth loss may increase up to 7.7 times. Patient with IL-1 genotype presence and bad habits, like smoking, have a bigger chance of losing their teeth, than a patients with IL-1 genotype presence who are not smokers.

Root canal therapy is also a factor that should be considered. In general, teeth which root canal therapy is performed only once have better prognoses than the teeth which treatment had been repeated[3]. Survival of the teeth with root canal treatment is bigger if the treatment is performed by a specialist (98.1%) compared to the treatment performed by general practice dentist (89.7%) in a 5-year period. The most important factor in this case is the data on the root canal treatment, presence of periapical changes, and the general health of the patient.

Systemic disorders, especially diabetes type 1 or 2, hypertension and osteoporosis, have an important role in the decision making process if the compromised tooth should be kept or removed. If the disease is not controlled, than favourable procedure is extraction, but if the disease is controlled, then the attempt to keep the tooth might be more successful. However, there are conditions where the extraction cannot be performed or even can worsen the

situation. In those cases we should make an effort to keep the tooth. The clinician experience is also an important factor in the treatment outcome.

Zitmann[14] summarizes all these factors and offers a pragmatic conclusion for this issue, of course, considering all the mentioned factors. Maintenance of the teeth, as he suggests, and acceptance of the risk factors, is suitable when: the tooth is not extensively affected and has a big strategic value, when we have contraindications for implants or the patient can't afford it, when the tooth is placed in a complete dental arch and the preservation of the gingival structures is very important. When complete restoration of the teeth is planed, especially if implants are included, then it is recommendable to minimize the risk of failure of the whole restoration.

Avila[3] offers a chart, labelling different factors with colours which seem rather complicated and, most of all, time consuming.

Conclusion

Although there are many literature data concerning this subject, no simplified and precise criteria are offered; so, further work should be done in attempt to make some charts or more uniform criteria.

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Correspondence and request for offprints to:

Pandilova Maja
University Dental Clinical Centre „St. Panteleimon"
Department of Oral Pathology and Periodontology
Skopje, FYR Macedonia
E-mail: mpandilova@yahoo.com

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Effect of Post Material and Amount of Coronal Destruction on Fracture Resistance and Failure Mode of Endodontically Treated Maxillary Central Incisors

SUMMARY

Introduction: *The purpose of this study was to evaluate the effect of post material and remaining dentin heights on the fracture resistance and failure mode of endodontically treated maxillary central incisors.*

Material and Method: *100 non-restored maxillary central incisors were divided into 2 groups with respect to the residual coronal dentin, as 0 or 2 mm from the cement-enamel junction. Each group was randomly subdivided into 5 subgroups: Fibre posts (F), Zirconium posts (Z), Gold plated posts (G), Titanium posts (T), and cemented with self-adhesive and dual-curing universal resin cement. In the control group no post was applied in the canal (A). All specimens were restored with composite core and all ceramic crown restorations. Static loading tests were performed on each specimen.*

Results and Conclusion: *The mean failure loads (N) were: 569.34 (F), 541.42 (Z), 599.28 (G), 594.82 (T), 507.53 (A). Highest fracture strength was obtained from the teeth with 2 mm coronal dentinal tissue, restored with fibre posts (642.68 N). The availability of 2.0 mm of coronal tooth structure has been shown to provide a ferrule effect, enhancing fracture resistance. Adhesive restorations without posts had similar fracture resistances and failure modes compared to those with various post systems.*

Keywords: Fibre Post; Fracture; Ferrule Effect

Burçin Vanlıoğlu, Buket Evren, Coşkun Yıldız, Yasemin Kulak Özkan

University of Marmara
Department of Prosthetic Dentistry
Istanbul, Turkey

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Introduction

Special care is indicated when selecting the most efficient way to restore endodontically treated teeth because they have a higher risk of biomechanical failure than vital teeth[1,2]. The fracture resistance of post-restored teeth has been the subject of numerous *in vitro* and *in vivo* studies[3-26]. The success achieved with aesthetic restorative techniques has resulted in increased patient demands, particularly for anterior teeth. Consequently, there has been a significant increase in the use of all-ceramic crowns, as well as endodontic post and core materials that do not affect the aesthetic results[10,11]. Many dentists prefer to use prefabricated post systems because they are more practical, less expensive and, in some situations, less invasive than customized post and core systems[15].

Restorative methods for pulpless teeth with post core systems have been widely investigated with the aim of achieving long-term promising prognoses. Despite the various attempts that have been made, vertical root fractures of pulpless teeth are still encountered in every day clinical practice. Although it is acknowledged that minimal tooth cutting in endodontic and restorative procedures is the most effective measure for preventing vertical root fractures in pulpless teeth[13], it is often necessary to restore teeth with extensive loss of structure, such as those without coronal portions. In such cases, the best restorative methods for effectively reinforcing pulpless teeth need to be identified.

Since endodontically treated teeth often suffer extensive defects, post placement is often clinically necessary to generate retention to core and restoration[17].

It was previously stated that further research is needed to elucidate whether a high or low elastic modulus of post and core materials helps to distribute occlusal forces to remaining dentin and improves the clinical outcome in the oral environment[23].

In recent years more emphasis has been placed on the "ferrule effect" in the restoration of endodontically treated teeth with posts and cores. It is a generally accepted restorative strategy to include a ferrule in the design of tooth preparation when restoring an endodontically treated tooth with a post and core and then restored with a crown. The availability of 2.0 mm of coronal tooth structure between the shoulder of the crown preparation and the tooth/core junction has been shown to provide a ferrule effect, enhancing fracture resistance and preventing fracture and dislodgement of the post[8,22].

Today, many adhesive systems which are not fully investigated regarding their ability for luting endodontic posts, are on the market. Furthermore, it is still not fully understood which mode of luting is most reliable to bond posts; however, conventional etch-and-rinse systems with dual-cured resin composites have been reported to be the gold standard for luting[27,28]. Simplified versions of these adhesives have made bonding simpler, faster, and more user-friendly[28].

Since it still remains unclear which endodontic post material is preferable, this study was carried out to investigate the impact of a rigid material in comparison to a more flexible post material. The influence of ferrule preparation and composite build-up alone was furthermore evaluated. The purpose of this *in vitro* study was to evaluate the effect of 5 different post materials, cemented with self-adhesive and dual-curing universal resin cement resin cement in 2 different amounts of remaining dentin heights, on the fracture resistance and failure mode of endodontically treated teeth. The null hypothesis tested was that the fracture resistance and failure pattern of endodontically treated teeth with 2 mm of coronal dentin will not be affected by the use of posts and, in teeth with no coronal dentin, the use of fibre posts will increase the fracture resistance.

Material and Methods

In this study 100 non-restored maxillary central incisors extracted for periodontal reasons were used. Immediately after extraction, the teeth were cleaned by scaling and stored in distilled water at room temperature. To ensure that the mean dimensions of the teeth were similar between the groups and subgroups, the root lengths measured from the root apex to the buccal midpoint of the cemento-enamel junction (CEJ), and the bucco-lingual and mesio-distal dimensions (at the level of the cervical margin), were measured using a calliper (Renfert 1119, Renfert GmbH, Hilzingen, Germany). Overall, the mean root length was 13.8 mm, while the mean bucco-lingual and mesio-distal dimensions were 6.7 mm and 6.1 mm, respectively. Analysis of variance (ANOVA) affirmed the absence of any significant differences in these variables between the groups and subgroups.

Then the teeth were mounted individually in acrylic resin (Meliodent Denture Material, Heraeus Kulzer, Berkshire, USA) with the long axis parallel to the centre of the ring with the guidance of a dental surveyor (Kavo EWL, Typ 990, Kavo Elektrotechnisches Werk GmbH, Leutkirch im Allgau, Germany). Each tooth was suspended in the middle of the ring by means of 0.8 mm orthodontic wire (Leowire round spring hard wire 0.8 mm, Leowire s.p.a. Firenze, Italy) that engaged the tooth at the CEJ and rested on the edges of the ring.

Endodontic treatment and preparation of coronal dental hard tissues: All teeth underwent root canal shaping and obturation. The canals were mechanically prepared using rotary endodontic instruments (Anthogyr, Sallanches, France). After the root canal preparation, the canals were obturated with gutta-percha (Dentsply DeTrey, Konstanz, Germany) and sealer (AH26; Dentsply DeTrey, Konstanz, Germany), using a lateral condensation technique. The anatomical crowns of the specimens were then sectioned to allow for uniform circumferential residual dentin heights of 0 and 2 mm (50 specimens for each residual dentin height) with a water-cooled diamond fissure bur making the coronal surface contours parallel to the CEJ profile. The same operator performed the root canal preparation and crown sectioning.

Within each residual dentin height, the specimens were divided into 5 subgroups: Fibre post (Postec, Vivadent, Schaan, Liechtenstein), Zirconium post (Cosmopost, Vivadent, Schaan, Liechtenstein), Gold plated posts (Gold plated posts, Svenska Dentorama AB, Solna, Sweden, Lot no: 07017/554), Titanium post (Euro. Post Titanium Screwpost, Anthogyr, Sallanches, France). They were cemented with self-adhesive and dual-curing universal resin cement (Multilink Automix, Vivadent, Schaan, Liechtenstein). In the control group no post was applied in the canal. In all groups, the cores were constructed with light cured composite (Multicore Flow, Vivadent, Schaan, Liechtenstein).

In the control group, excess gutta-percha was removed to a depth of 2 mm from the coronal surface of the preparation. In the test groups with no coronal dentin, post space was created by removing the gutta-percha within the root canals, to a depth of 8 mm from the coronal surface of the preparation. A stop was placed on the engine mounted drill at an 8 mm depth, and the twist drill was not forced, but used passively, following the course of the previously established canal. In other specimens with 2 mm of residual dentin height, the stop on the engine-mounted drill was placed at 10 mm to

maintain the post space length into the canal at a constant of 8 mm[20]. All the preparations of specimens were summarized in figure 1.

An additional silicone impression material (Virtual, Ivoclar Vivadent AG, Schann, Liechtenstein) was used for the impressions of prepared teeth. Custom acrylic trays were used, and each tray allowed an impression of 4 specimens. Impressions were cast in vacuum mixed die stone (GC Fujirock EP, GC Europe NV, Leuven, Belgium). Stone dies were recovered from impressions, and 2 coats of die spacer (Yeti Dental Clear Spacer, Yeti Dentalprodukte Gmbh, Engen, Germany) were painted 1 mm short of the finish lines of the preparations. Full ceramic crown restorations were made of a leucite-reinforced glass ceramic material, IPS Empress (IPS Empress Esthetic, Ivoclar Vivadent AG, Schann, Liechtenstein), using the staining technique, according to the manufacturer's recommendations.

The fracture loads were determined using a universal testing machine (Testometric Micro 500, Testometric Company Ltd., Lancashire, United Kingdom) at a crosshead speed of 0.5 mm/min. The load was applied at a 135° angle to the lingual surface of the test tooth. This orientation was standardized with a custom made mounting jig (Fig. 2). The load was consistently applied at 2.5 mm from the incisal edge with a customized plunger.

The mode of failure was recorded for each specimen and classified as either favourable (that would allow repair) or catastrophic (that would not allow repair)[19]. Fracture propagation was classified into 3 categories as follows: above CEJ (favourable), below CEJ extending to 1/3 depth longitudinally from cervical portion (favourable), fracture extending between 1/3 and 2/3 from cervical toward apical portion (catastrophic). The same operator recorded the mode of failure for all the specimens.

Statistical analyses were performed using Variance Analysis and the Tukey's Multiple Range Test.

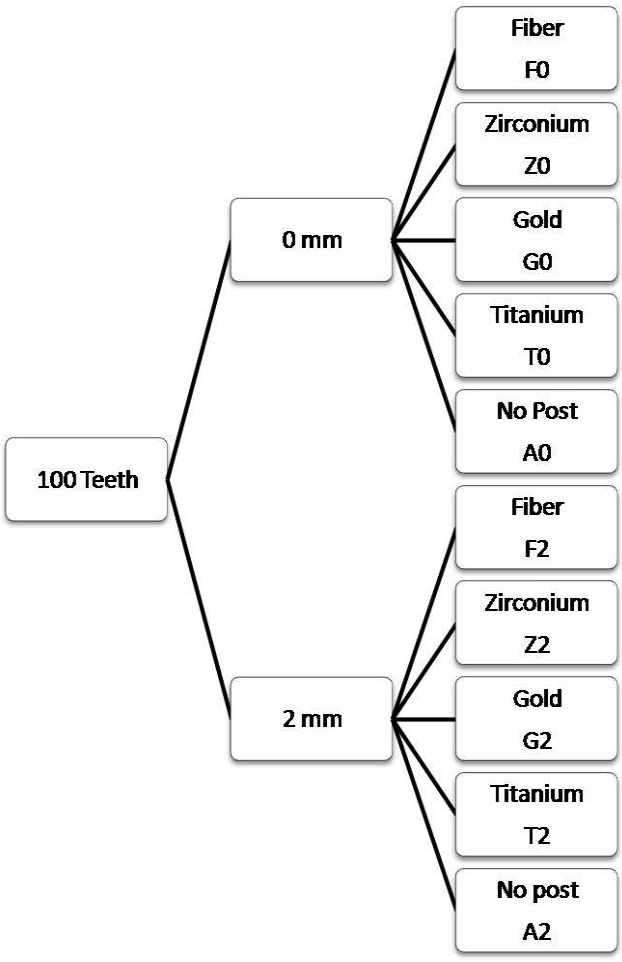

Figure 1. Schematic presentation of groups

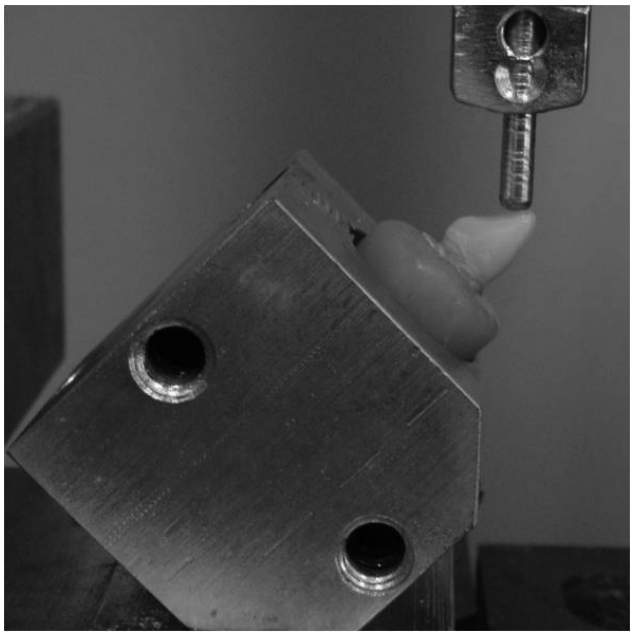

Figure 2. Determination of fracture resistance with a custom made mounting jig

Results

Means and standard deviations of failure loads of the fracture test are listed in table 1. ANOVA was performed to test the effect of post and amount of coronal dentinal tissue. The mean failure loads (N) were: 569.34 (F),

541.42 (Z), 599.28 (G), 594.82 (T), and 507.53 (A). Highest fracture strength was obtained from the teeth with 2 mm coronal dentinal tissue, restored with fibre posts (F2) (642.68 N).

Table 1. Means and Standard Deviations (SD) of the Fracture Loads (N)

Group	n	Mean	SD	Min	Max
F0	10	496	63.35	421.9	625.6
F2	10	642.68	38.99	605	729.9
Z0	10	517.6	59.58	414.7	596.6
Z2	10	565.23	23.72	530	596
G0	10	575.9	97.71	404	674.9
G2	10	622.66	117.38	416	761.5
T0	10	569.44	92.21	453	693.2
T2	10	620.2	108.48	413	694.7
A0	10	439.86	101.73	328	571.5
A2	10	575.2	20.94	542.5	598
Ferrule					
No coronal dentin	50	519.76	95.77	328.1	693.2
2 mm coronal dentin	50	605.19	77.84	413.5	761.5
Post					
Fibre	20	569.34	91.01	421.9	729.9
Zirconium	20	541.42	50.45	414.7	596.6
Gold	20	599.28	107.81	404.1	761.5
Titanium	20	594.82	101.4	413.5	694.7
No post	20	507.53	99.65	328.1	598
Total	100	562.48	96.86	328.1	761.5

There was statistically significant difference between groups (p=0.001). Results from the pairwise comparisons are shown in table 2. Lowest fracture strength was obtained from the teeth with no coronal dentinal tissue, restored without posts (A0) (439.86 N). The difference between A0 and F2, Z2, G0, T0, T2, A2 were statistically significant. The differences between the teeth without coronal dentinal tissue and restored with fibre posts (F0) exhibited lower fracture values than and F2, G2, T2 (p=0.001). In each group, the greater the height of the residual dentin, the greater the fracture resistance was. The teeth with no coronal dentinal tissue (693.2 N) showed lower strength values than teeth with 2 mm coronal dentin (761.5 N). The difference was statistically significant (Tab. 2).

Table 2. Results of statistical analysis

Groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	352526.388	9	39169.599	6.117	.001
Within Groups	576271.149	90	6403.013		
Total	928797.537	99			
Ferrule					
Between Groups	120527.009	1	120527.009	10.960	.001
Within Groups	1077747.728	98	10997.426		
Total	1198274.737	99			

Table 3. Frequencies of failure modes in the tested groups

Groups	Above bone level	Below bone level; upper one-third	Below bone level; middle one-third of root	Debonding of post
F0	10			
F2	10			
Z0	1	4	5	
Z2	7	3		
G0	2	2	4	2
G2	7	2	1	
T0	1	6	3	3
T2	6	1	3	1
A0	4	6		
A2	6	4		

The failure mode frequencies are shown in table 3. There were distinct differences in failure patterns between teeth restored with glass fibre posts and those restored with metal and zirconium posts. All of the teeth restored with fibre post fractured in a horizontal pattern through the facial side at the cervical part of the crown. All the teeth in the Z group fractured in a horizontal pattern through the facial side at the level of CEJ. In G and T groups most of the teeth experienced a horizontal fracture at the cervical and middle parts of the root and none of the metal posts fractured. Debonding of the post was seen in 2 samples in G0, 3 in T0, 1 in T2. In the groups with no post, all the restorations experienced a bond failure at the junction of the tooth and the composite core. The failure mode was catastrophic for none of A and F specimens.

Fractures that would allow repair of the tooth with 2 mm ferrule were observed in groups F, Z and A, whereas non-restorable, catastropic fractures were observed in groups G and T.

Discussion

Size deviations are inevitable when using natural teeth; therefore, in the present study, central incisors were allocated to experimental groups so that the mesio-distal and bucco-palatal dimensions were not significantly different among groups with different restorations.

The restoration of endodontically treated teeth frequently poses a challenge for the clinician. Apart from substantial tissue loss, which can be considered as one of the major obstacles, endodontically treated teeth are assumed to be more prone to fracture because of desiccation or premature loss of moisture supplied by a vital pulp.

Several studies have been performed to assess the mechanical resistance to fracture of post restored teeth[3-26]. Most studies have tried to identify the best technique and material to be used to increase the strength of the tooth restoration complex[14,15]. The use of static forces permits to simplify the study realization[17,19] and requires universal testing machines easier to use and less expensive than fatigue and thermo-mechanical cycling test workstations[14,16,19]. Different loading jigs were described in the literature in shape and material[14,19].

The loading was applied to the experimental teeth at an angle of 135° to the long axis to simulate Class I occlusion. This mode of loading was adopted from the method utilized by those authors who also evaluated the fracture resistances of maxillary incisor teeth[22,23]. In this study, rounded tip with a diameter of 5 mm have been chosen to homogeneously apply loads[14,17]. Due to the large number of secondary variables involved (i.e. tooth type and condition, restorative procedures and materials), it is hard to compare experimental data extrapolated by different *in vitro* studies[19], but the results obtained from this fracture test were comparable with some earlier reports[4,5].

There was significant difference in fracture resistance between the metallic post-cores and fibre post groups; the majority of fractures in the metallic post-core groups propagated over the middle portion of the roots, while those in the fibre post groups were limited to the cervical portion. This indicates that most of the fractured teeth restored with metallic post-cores were not reparable. In contrast, the majority of fractures in the fibre post group were limited to the cervical portion of the root including the core-dentin interface, since the stress was concentrated in the cervical area and the outer root surface. This type of fracture is most easy for repeated repair[9].

When a post-core with a high modulus of elasticity, such as a stainless steel post, is forced against radicular dentin with much lower modulus, the stress is transferred from the rigid post to the less rigid dentin. When a post with a similar modulus of elasticity to that of radicular dentin is used for restoration, such as a fibre post, less stress is transferred from the post to the dentin. Root fractures originate from regions with excessive stress concentration and propagate by exploring mechanically inferior areas in the restored teeth. All teeth restored with post-core systems fractured at the interface between the post-core and root dentin. These fractures could originate from the adhesive interface between the cores and root dentin, and propagate down, towards the post, by exploring an inferior adhesive area.

The choice of an appropriate post material is controversially discussed[25]: fibre posts have been recommended due to their dentin-like Young's modulus[7,23]. Fibre posts allow teeth to flex under applied loads, leading to an improved stress distribution between post and dentin[3,10,11]. The risk of root fracture should be reduced[3], but may concentrate stress between cement and endodontic post, resulting in loss of adhesion. Further, it is argued that a more rigid post would allow less invasive preparation with smaller post diameters[1,12] and avoid deformation of the entire post-core assembly. Root fractures have been attributed to extreme differences in rigidity of post and root dentin, with stress concentrations inside the root. Torbjorner et al[25] summarize that there is a choice between a low modulus post, possibly leading to reparable failures, or a high modulus post with probably later but more irreparable failures.

Meng et al[21] reported that the teeth restored with cast Ni-Cr dowel-cores and 2.0 mm ferrules demonstrated significantly lower fracture strengths. They found significant differences in the root fracture patterns between 2 dowel systems, with the carbon fibre-reinforced dowel-resin core system, being the less severe.

The fracture loads in all groups were found to be sufficiently greater than the ordinary chewing force, and even greater than the maximum bite force. There were significant differences between the specimens with 0 and 2 mm of remaining coronal dentinal tissue. The availability of 2.0 mm of coronal tooth structure provided a ferrule effect, enhancing fracture resistance. This result is in agreement with the findings of other studies[8,22]. It has been shown that the ferrule effect significantly reduces the incidence of fracture in non-vital teeth by reinforcing the tooth at its external surface and redistributing the applied forces. Within the limitations of this study and regarding the influence of the ferrule on fracture resistance, the null hypothesis was accepted.

Bonding to dentin may be achieved using etch-and-rinse (i.e. total-etch) and self-etch adhesives[27]. Simplified versions of these adhesives have made bonding simpler, faster, and more user-friendly[28]. Due to the alleged

technique-sensitivity of conventional adhesives, more and more all-in-one adhesives are at the market, promising easier handling combined with equally reliable results compared to etch-and-rinse adhesives. However, several studies clearly demonstrated that the simplification may ease handling for the general practitioner, but may not improve adhesive effectiveness. The choice of resin cements that rely on the use of etch-and-rinse adhesives has been shown to achieve higher interfacial strengths in post spaces when compared with those that utilize mild self-etching adhesives or self etching resin cement. For self-etching adhesives and the self-etching resin cements, the acidic monomers incorporated in these systems were not strong enough to etch through thick smear layers, to form hybrid layers along the walls of the post spaces. Dual-cured and self-cured adhesives and composites are generally favoured for post cementation[28]. In this study, self-adhesive and dual-curing universal resin cement with metal and zirconium primer was used.

Conclusions

Within the limits of this laboratory investigation, it is concluded that severely damaged and root filled maxillary central incisors, restored with direct resin composite restorations and full ceramic crowns without posts, have similar fracture resistances and failure modes compared to those with various posts, which suggest that posts are not necessarily required.

The load to failure of the gold plated and titanium posts were significantly stronger than fibre and zirconium posts. However, the mode of failure of the fibre posts is protective to the remaining tooth structure. The availability of 2.0 mm of coronal tooth structure has been shown to provide a ferrule effect, enhancing fracture resistance.

The results of this study suggest that the bond quality of new generation resin cements is adequate for cementation of different type of posts.

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Correspondence and request for offprints to:

Burçin Vanlıoğlu
Marmara University
Faculty of Dentistry, Department of Prosthodontics
Büyükçiftlik Sokak, No: 6
Güzelbahçe, 34365
Nişantaşı Istanbul, Turkey
E-mail: drburcinakoglu@hotmail.com

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Surface Finish Produced on 5 Aesthetic Restorative Materials by New Polishing Systems

SUMMARY

***Objective*:** *The purpose of this study was to investigate the surface finish of 5 different aesthetic restorative materials after polishing with 3 different polishing systems.*

***Materials and Method**: The materials included 2 nano-filled composites (Tetric Evo Ceram and Grandio), a compomer (Compoglass F), a resin-modified glass ionomer cement (Fuji II LC), and a highly viscous glass-ionomer cement (Fuji IX GP Fast). 32 specimens (6mm diameter x 3mm thickness) of each material were fabricated and divided into 4 groups. Specimens in the group 1 were left without finishing and polishing (matrix strip finish), while in the remaining groups specimens were finished with 30-fluted finishing tungsten carbide bur. The groups were then finished/polished with the following polishing systems: Group 2: Sof-Lex, Group 3: Optapol, Group 4: Diacomp. The surfaces were tested for surface roughness with a profilometer and examined with SEM. Data were subjected to ANOVA and Tukey's HSD test at significance level p<0.05.*

***Results*:** *The matrix strip group had the lowest Ra values and was significantly different from all of the finishing/polishing procedures. Tetric Evo Ceram, Grandio and Compoglass F had lower mean Ra values against matrix strip than Fuji II LC and Fuji IX GP Fast. For Fuji II LC and Fuji IX GP Fast there was no difference among the different polishing systems. For all materials a significantly smoother surface was obtained after polishing with Sof-Lex than with Optapol and Diacomp.*

***Conclusions:** There was a significant effect of the finishing methods and restorative materials on surface roughness (p<0.05).*

Keywords: Surface Finish; Surface Roughness; Polishing Systems; Restorative Materials

D. Dionysopoulos, E. Koliniotou-Koumpia, P. Dionysopoulos

Aristotle University of Thessaloniki, Dental School, Department of Operative Dentistry, Thessaloniki, Greece

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Introduction

The use of aesthetic restorations has increased substantially over the past few years due to the increased aesthetic demand by patients, improvement in formulation and simplification of bonding procedures. On the extreme ends of the continuum of direct aesthetic restorative materials are conventional glass-ionomer cements (GICs) and resin composites.

To combine the major advantages of GICs (fluoride release, chemical bonding to dental tissues and biocompatibility) with the easy handling and aesthetic properties of composites, various hybrid materials have been developed. These include resin-modified GICs and compomers (polyacid-modified resin composites). Resin-modified and highly viscous GICs were developed to overcome early moisture sensitivity and low mechanical properties associated with conventional GICs. Compomers are basically composites that contain essential components of glass- ionomer cements, but at a level insufficient to promote an acid-base reaction in the dark.

The advent of visible light-curing resins and the use of finer fillers permit tooth-coloured restoratives to be polished to a higher degree[1,2].

One of the most important advances in the last few years is application of nanotechnology to resin

composites. Nanotechnology is based on the production of functional materials and structures ranging from 1 to 100nm using various physical and chemical methods. One of these materials, Grandio, contains glass ceramic particles (1μm) and silica (SiO_2) particles (20-50nm)[3]. Another material, Tetric Evo Ceram, also comprises features of nanotechnology. It contains a small quantity of inorganic nano-particles, nano-additives, known as rheological modifiers that have been incorporated in a targeted fashion[4].

The longevity and aesthetic appearance of tooth-coloured dental restorative material greatly depend on the quality of finishing and polishing techniques employed[5-9]. Finishing and polishing in restorative dentistry refers to the steps of: (1) gross contouring of the restoration to obtain the desired anatomy; (2) the reduction and smoothing of the surface roughness and scratches created by finishing instruments in the process of gross reduction and initial polishing; and (3) the process of producing a highly smooth, light-reflective, enamel-like surface through final polishing[10].

A wide variety of finishing and polishing systems are available in the market to the clinician. For years, a set of highly flexible finishing and polishing discs coated with aluminium oxide (AlO) were widely used for polishing tooth-coloured restorations. More recently, silicone synthetic rubbers have been introduced for finishing and polishing aesthetic restorative materials to reduce the clinical time spent to finish the restoration. According to manufacturers, they can be used to complete finishing and polishing procedures using a single instrument (one step).

With the ultimate goal of achieving a smooth surface of composites, compomer, conventional and resin-modified GICs in fewer steps, it is common to see new polishing systems being introduced and therefore, updated evaluations are necessary. The **aim** of the current study was to examine the surface roughness of 2 nano-filled composites, a compomer, a resin-modified glass-ionomer cement, and a highly viscous glass-ionomer cement after polishing with 3 different polishing systems. The aim was also to evaluate the effectiveness of these polishing systems and its possible surface damage by scanning electron microscope (SEM) analysis.

Materials and Methods

2 novel resin composites containing nano-particles, a compomer, a resin modified and a highly viscous glass-ionomer cement were used in this study. The evaluated are presented in table 1. The polishing systems tested (Tab. 2) were Sof-Lex (3M ESPE), Optapol (Ivoclar Vivadent) and Diacomp (EVE).

Table 1. Characteristics of the restorative materials used in the study

Material	TYPE	Manufacturer	BATCH No	Shade
Tetric Evo Ceram	Composite resin (nanohybrid)	Ivoclar Vivadent Schaan, Liechtenstein	L01344	A3
Grandio	Composite resin (nanohybrid)	Voco, Cuxhaven Germany	492726	A3
Compoglass F	Compomer	Ivoclar Vivadent Schaan, Liechtenstein	K31913	A3
Fuji II LC	Resin-modified GIC	GC Corporation Tokyo, Japan	0106208	A3
Fuji IX GP Fast	Highly viscous GIC	GC Corporation Tokyo, Japan	0812031	A3

Table 2. Composition and manufacturers of the polishing systems used in this study

Polishing System	Composition	Manufacturer
Sof-Lex (multi-step)	Aluminium oxide-coated disk coarse (100μm), medium (40μm), fine (24μm), extra fine (8μm)	3M ESPE St Paul MN, USA
Optapol (one-step)	Caoutchouk, silicone carbide, aluminium oxide	Ivoclar Vivadent Schaan, Liechtenstein
Diacomp (two-step)	20μm aluminium oxide 7μm aluminium oxide	EVE, Ernst Vetter GmbH, Germany

Cylindrical moulds, measuring 6mm in diameter and 3mm in deep, were fabricated from Teflon. 32 specimens of each restorative material were made for this study. The moulds were slightly over-filled with material, covered on each side with matrix strips (Have-Neos Dental, Bioggio, Switzerland) and placed between 2 microscope glass slides (1mm thick); pressure applied to extrude the excess material. The samples were then light cured for 40 seconds (except Fuji II LC: 20 seconds) on both sides of the specimens with a light source (Elipar 2500, 3M ESPE, St Paul, MN, USA) through the matrix strip and glass slide, while the glass-ionomer cement Fuji IX GP Fast was allowed to set for 10 min. The intensity of light source was 810mW/cm^2 and was checked after every 5 samples using a photometric tester (Hilux, Curing Light Meter, Benlioglu Dental Inc. Turkey). Following light curing, the specimens were placed into 37ºC de-ionized water for 24h.

32 specimens of each material were made and divided into 4 groups of 8 specimens. Specimens in Group 1 (MS) were left without any finishing or polishing procedure (matrix strip finish), while the remaining groups, in an attempt to simulate the clinical conditions, were finished with 30-fluted finishing tungsten carbide bur (Diatech Dental AC, Switzerland). Specimens were then finished/polished with the following systems: Group 2 (SL): Sof-Lex, Group 3 (OP): Optapol and Group 4 (DC): Diacomp. Table 2 reflects the manufacturers and details of the finishing/polishing sequences that were based upon manufacturers' instructions.

Sof-Lex is a multi-step graded abrasive disk system, Optapol is a 1-step finishing/polishing system and Diacomp is a 2-step finishing/polishing system. The 1-step (OP) and 2-step (DC) polishing systems tested were manufactured in different shapes; however, disc shaped polishers were in this study used in order to obtain direct contact with the surfaces of the specimens. The Group 2 (SL) was polished with graded abrasive disks, applying feather light pressure on the discs with continuous water irrigation for 30 seconds. For Groups 3 and 4 (OP and DC), discs were used with moderate pressure in conjunction with copious water spray for 30 seconds.

To minimize the effect of operator variability, all finishing/polishing procedures were carried out by the same researcher. The polished specimens rinsed, cleansed in an ultrasonic cleaner for 3 min, allowed to dry and kept in 100% humidity for 24h, before measuring the surface roughness. The average surface roughness (Ra) of each specimen was measured using a surface profilometer (Mitutoyo SJ 201, Kanagawa, Japan). Readings were taken at the centre of each specimen and 5 sampling lengths of 0.8mm were used, giving a total evaluation length 4mm with a standard cut-off of 0.8mm, a transverse length of 0.8mm and a stylus speed of 0.25mm/sec. The Ra of a specimen was defined as the arithmetic average height of roughness component irregularities from the mean line measured within the sampling length. 5 profilometer tracings were made at the centre of each specimen and the numerical average was determined for each group.

2-way ANOVA ($p<0.05$) was used to determine significant interactions between materials and the finishing/polishing methods. 1-way ANOVA and Tukey's HSD test ($p<0.05$) were used to compare the mean surface roughness between materials for each treatment group.

One representative specimen of each group was prepared for the scanning electron microscope, SEM (JEOL, JSM-840, Tokyo, Japan). The specimens were sputter coated with carbon to a thickness of approximately 200Å in a vacuum evaporator. Photographs of the representative areas of the polished surfaces were taken at 500x magnification.

Results

The Ra values produced by the matrix strip, Sof-Lex, Optapol and Diacomp on the 5 restorative materials are presented in table 3. Results of statistical analysis are shown in tables 4 and 5. 2-way ANOVA revealed significant interaction among the materials and finishing/polishing techniques. The effect of finishing/polishing on surface finish was therefore material dependent.

Table 3. Average roughness values (Ra, μm) and standard deviations for 5 restorative materials and 3 polishing systems tested

Restorative material Polishing system	Tetric Evo Ceram (TEC)	Grandio (GR)	Compoglass F (CG)	Fuji II LC (FII)	Fuji IX GP Fast (FIX)
Matrix Strip (MS)	0.08 (0.02)	0.09 (0.01)	0.10 (0.01)	0.14 (0.02)	0.16 (0.02)
Sof-Lex (SL)	0.20 (0.04)	0.18 (0.03)	0.28 (0.04)	0.32 (0.03)	0.38 (0.06)
Optapol (OP)	0.31 (0.06)	0.30 (0.06)	0.46 (0.07)	0.66 (0.11)	0.71 (0.09)
Diacomp (DC)	0.30 (0.04)	0.31 (0.04)	0.42 (0.06)	0.70 (0.12)	0.74 (0.11)

Table 4. Comparison of mean surface roughness among restorative materials

Polishing Systems	Differences
Matrix Strip	TEC , GR , CG < FII , FIX
Sof-Lex	TEC , GR < CG, FII < FIX
Optapol	TEC , GR < CG < FII , FIX
Diacomp	TEC , GR < CG < FII , FIX

The symbol < denotes statistically significant difference

Table 5. Comparison of mean surface roughness among polishing systems

Restorative Materials	Differences
Tetric Evo Ceram	MS < SL < OP, DC
Grandio	MS < SL < OP, DC
Compoglass F	MS < SL < OP, DC
Fuji II LC	MS < SL < OP, DC
Fuji IX GP Fast	MS < SL < OP, DC

The symbol < denotes statistically significant difference.

The MS group had the lowest Ra value and was significantly different from all of the finishing/polishing procedures ($p<0.05$), when the 1-way ANOVA and Tukey's HSD tests were applied. Tetric Evo Ceram, Grandio and Compoglass F had lower mean Ra values against matrix strip than Fuji II LC and Fuji IX GP Fast ($p<0.05$).

For all the restorative materials, a significantly smoother surface was obtained from polishing with Sof-Lex, and a rougher surface resulted after polishing with Optapol and Diacomp. Qualitative assessment of the SEM photomicrographs accorded well with the quantitative results.

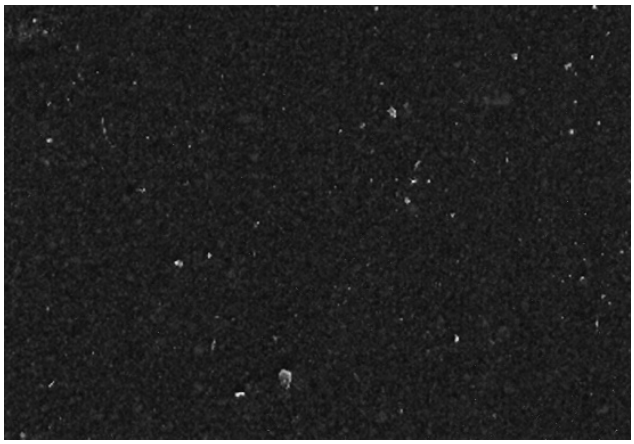

Figure 1. SEM photomicrograph of the Tetric Evo Ceram after removal of the matrix strip

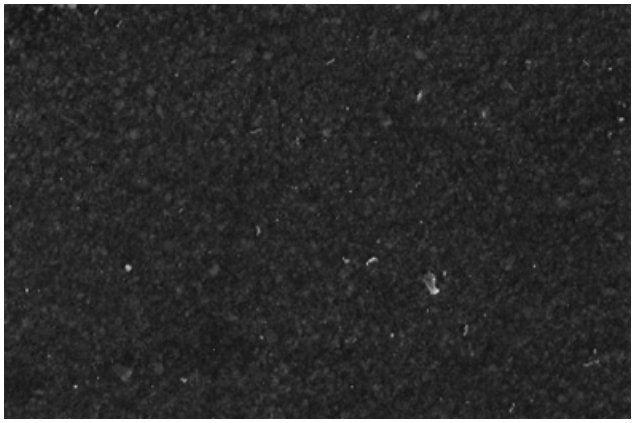

Figure 2. SEM photomicrograph of the Tetric Evo Ceram after polishing by Sof-Lex

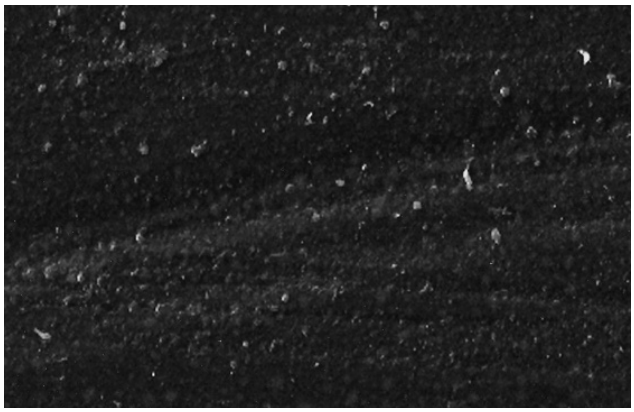

Figure 3. SEM photomicrograph of the Grandio after polishing by Optapol

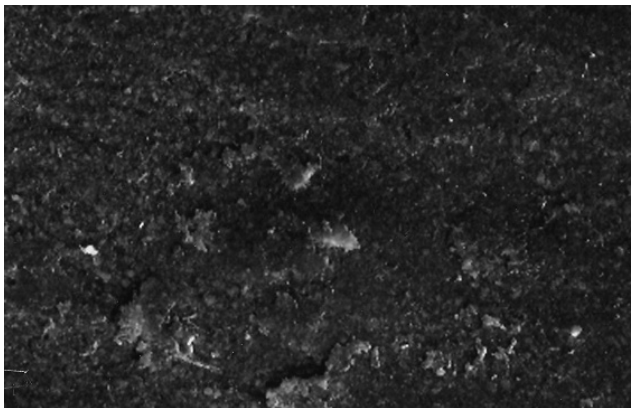

Figure 4. SEM photomicrograph of the Compoglass F after polishing by Diacomp

SEM analysis of the Tetric Evo Ceram and Grandio samples polished with Sof-Lex revealed the same surface appearance as the matrix strip, although the roughness values were not the same, while the surfaces polished with Optapol and Diacomp had some scratches (Figs. 1-3).

Specimen surfaces of Compoglass F, Fuji II LC and Fuji IX GP Fast after treatment with the 3 finishing/polishing systems were mainly characterized by the remaining minor grooves and surface irregularities (Figs. 4-6).

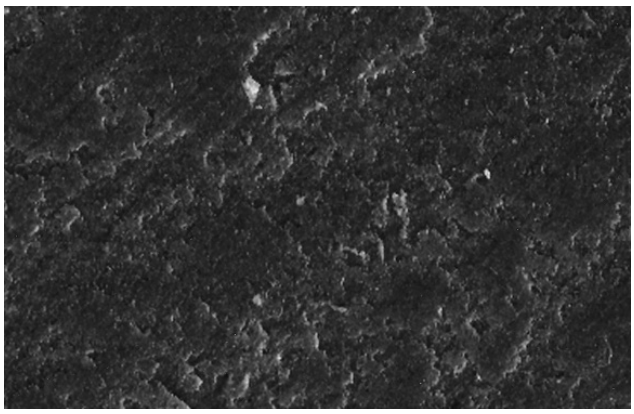

Figure 5. SEM photomicrograph of the Fuji II LC after polishing by Optapol

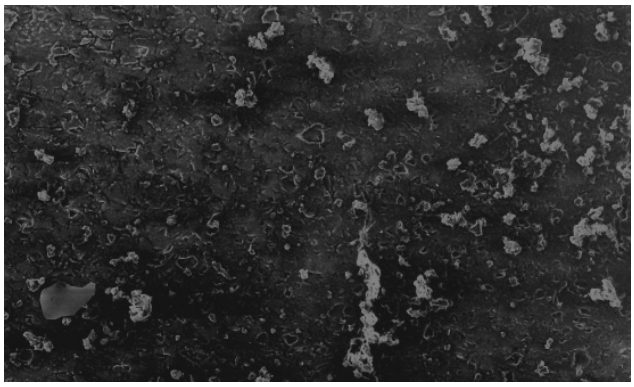

Figure 6. SEM photomicrograph of the Fuji IX GP Fast after polishing by Diacomp

Discussion

Effective finishing and polishing of dental restorations not only results in optimal aesthetics but also provide for acceptable health of soft tissues and marginal integrity of the restorative interface[7-9]. Some of the difficulties resulting from improperly finished and polished restorations are excessive plaque accumulation, gingival irritation, increased surface staining and poor or suboptimal aesthetics of the restored teeth[10,11]. In the polishing process, a series of abrasives of increasing fineness were used. To reduce cost and clinical time, multi-step (graded abrasive disks) systems were replaced with 2- and 1-step systems.

In this study, the smoothest surfaces were obtained from composite resins, compomer and glass-ionomer cements against a matrix strip. This finding agreed with previous studies on composite resins, compomers, conventional and resin modified glass-ionomer cements[12-17]. All finishing/polishing procedures decreased the smoothness obtained with matrix strips[18].

The surface finish of aesthetic restorative materials is dependent in part on their particle size range. The latter can be estimated by the mean particle size of the inorganic fillers of composite resins and the fluorosilicate glasses used in glass-ionomers and compomers. Glass-ionomers and compomers with larger particles are expected to be rougher than nanohybrid composite resins. Nanohybrid composite filling materials contain inorganic filler glass particles with size approximately 1μm and silica particles with size 5-60nm[3,4]. The mean particle size of Fuji II LC and Compoglass F is approximately 4.5μm, while that of Fuji IX GP Fast is approximately 7μm[10].

In view of the aforementioned, the significantly higher Ra values observed with Compoglass F, Fuji II LC and Fuji IX GP Fast after finishing/polishing is expected[19-23]. For all the materials a significantly smoother surface was obtained from polishing with Sof-Lex and a rougher surface resulted after polishing with Optapol and Diacomp[16,24].

Some authors have shown in their researches on packable, hybrid and micro-filled resin composites that Sof-Lex discs produced the best results in surface roughness[25-27]. With the exception of the composite resins when finished/polished with Sof-Lex, the finished/polished surfaces of all materials had Ra values greater than 0.2μm[28]. The differences in surface finish between materials were therefore clinically relevant.

When specimens were finished with matrix strips, Ra values between materials were significantly different. The differences may not be clinically relevant as values were all below the critical threshold value of 0.2μm[28]. The significant differences in Ra values may be attributed to inherent material properties, such as filler or glass particle sizes and their ability to form a polymer-rich layer when the material is cured.

Although the surface obtained by the use of the matrix strip is very smooth, it is rich in resin matrix; therefore, removal of the outermost resin by finishing/polishing procedures would tend to produce a harder, more wear resistant, and hence a more aesthetically stable surface[29]. Despite the careful placement of the matrices, removal of excess material or re-contouring of restorations by diamond and carbide burs is often clinically necessary. It was suggested that the determining step in finishing and polishing restorations might be the use of finishing carbide burs prior to using polishers[30,31].

Regardless of treatment groups, the surface finish of Tetric Evo Ceram and Grandio was significantly better than Compoglass F, Fuji II LC and Fuji IX GP Fast in this study. Harder filler particles were left protruding from the surface during finishing/polishing of composite resins, as

the softer resin matrix was preferentially removed. The set glass-ionomers are heterogeneous and biphasic in nature and consist of non-reacted glass particles embedded in a poly-salt resin matrix. During finishing and polishing, the softer matrix phases are preferentially removed, leaving the harder, non-reacted glass particles to protrude from the surface.

Profilometers used for *in vitro* investigations, provide limited 2-dimensional information, but an arithmetic average roughness can be calculated[32]. Therefore, the complex structure of a surface cannot be fully characterized by use of only surface roughness measurements. However, in combination with SEM analysis, more valid predictions of clinical performance can be made[32,33]. In this study, the texture of the surfaces was examined with SEM, additionally to the surface roughness measurements. The results of the profilometric measurements were largely confirmed by SEM analysis.

Conclusions

Under limitations of this *in vitro* study:

1. There was a significant effect of the finishing methods and restorative materials on surface roughness ($p<0.05$);
2. The use of matrix strip resulted in the best surface finish for nano-hybrid composite resins, compomer and resin-modified and highly viscous glass-ionomer cements;
3. All the used finishing/polishing systems decreased the smoothness obtained with matrix strip;
4. Among the aesthetic material evaluated, the surface finish of Compoglass F, Fuji II LC and Fuji IX GP Fast was significantly poorer than that of Tetric Evo Ceram and Grandio;
5. For all the materials, the smoothest surfaces were obtained with Sof-Lex discs.

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Correspondence and request for offprints to:

Dr. D. Dionysopoulos
Aristotle University of Thessaloniki
Dental School
Department of Operative Dentistry
Thessaloniki, Greece

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Interleukin-1 (IL1-α and IL1-β) in Gingival Fluid and Serum of Patients with Gingivitis and Periodontitis

SUMMARY

Objective. *The purpose of the present study was to evaluate the levels of interleukin-1 (IL1-α and IL1-β) in gingival crevicular fluid (GCF) and serum, the important cytokines for initiation and progression of periodontal disease in healthy patients and patients with gingivitis and periodontal disease.*

Material and Method. *90 individuals were subdivided into 3 groups of 30: control, gingivitis and periodontitis groups. GCF samples were obtained from 2 sites in each individual. Serum samples were also collected. Interleukin-1 (IL1-α, IL1-β) was evaluated using the commercial available ELISA technique.*

Results. *Mean gingival fluid levels of IL1-α and IL1-β in the 3 groups were, respectively: 19.39 pq/ml - 1.39 pq/ml in the control group; 28.27 pq/ml - 2.05 pq/ml in the gingivitis group; and 59.92 pq/ml - 5.25 pq/ml in the periodontitis group. Serum levels of IL1-α and IL1-β in the 3 groups were: 1.82 pq/ml - 0.09 pq/ml in the control group; 2.13 pq/ml - 0.35 pq/ml in the gingivitis group; and 2.46 pq/ml - 0.31 pq/ml in the periodontitis group. Levels of inflammatory cytokines in the gingivitis and periodontitis groups were significantly higher than in the control group ($p< 0.05$). In the serum, very low levels of cytokines were found. The level of serum IL1-α and IL1-β were, however, statistically significantly higher in the gingivitis and periodontitis groups ($p<0.05$).*

Conclusion. *Within the limits of this study, increased local production of immune inflammatory markers with increasing inflammation, and their monitoring in GCF, can help in the detection of the disease presence and/or its severity.*

Keywords: Cytokines; Gingival Crevicular Fluid; Serum; Gingivitis; Periodontitis

E. Stefanovska, M. Nakova, K. Ivanovski, M. Popovska

Faculty of Dentistry, Department of Oral Pathology and Periodontology, Skopje, FYROM

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Introduction

Cytokines have been defined as regulatory proteins produced by immune cells and other cells of the body. Their pleotropic action includes numerous effects on the cells of the immune system and modulation of inflammatory responses. The analysis of cytokine production levels has been also used as a tool for studying the local host response to a bacterial challenge.

Host response to periodontal pathogenic microorganism can be researched at many ways. Least invasive approach include analyzes of gingival crevicular fluid (GCF), inflammatory exudate which is released in the circumference of gingival sulcus. This exudate is a product of blood serum, and primary consists of inflammatory cells, much more noticeable polimorphonuclear leukocytes (PMN) and serums proteins[4].

Inflammatory cytokines are defined like cytokines (soluble proteins), which are induced as a result of inflammatory response and which are closely associated to the evolution and progression of the disease.

In particular, a large number of cytokines present in the GCF have been proposed as potentially useful diagnostic or prognostic markers of periodontal destruction[2,5]. Among these, interleukin IL1-α and

IL1-β have been shown to function in concert with other members of the cytokine network to regulate the cellular inflammatory response in the periodontium. This network comprises IL1-α, IL1-β, IL-6, IL-8, and TNF-α, which are generally classified as inflammatory cytokines and were observed to be of elevated levels in gingival fluid in patients with periodontal disease[7,9].

The **aim** of this study was to assess the relation between clinical parameters (such as dental plaque index and gingival inflammation index) and concentration of inflammatory cytokines (IL1-α, and IL1-β) within gingival crevicular fluid and serum samples with initiation and progression of periodontal disease in patients with gingivitis and periodontal disease.

Material and Method

At the Clinic of Oral Pathology and Periodontology, the University Dental Clinical Centre in Skopje, we examined 90 patients, divided in 3 groups. The first group, which represented the control group, consisted of 30 healthy patients without any sign of gingival or periodontal disease (verified clinically). Second group consisted of 30 patients with the diagnosed gingival disease, without signs of initial alveolar bone destruction (verified clinically and with radiogram). The third group consisted of 30 patients with the diagnosed initial periodontal disease (according to classification of AAP 1999, also verified clinically and with radiogram). The examined patients did not have any general disease and did not take antibiotic therapy in last 3 months.

All the examined patients undergone clinical and laboratories assays. Among clinical assays, we noted the dental plaque index (IDP - Silness-Loe) and gingival inflammation index (IGI - Loe-Silness). Laboratory assays for detection of gingival-fluid and serum levels of inflammatory cytokines (IL1-α and IL1-β) were realized at the Institute for Biology at the Faculty for Nature Sciences in Skopje. Gingival fluid was collected with filter perio-paper from mesiobucal surfaces of maxillary molars at the examined areas, with the action period of 30 seconds. Supragingival plaque was eliminated from teeth in the examined areas, and they were isolated to minimize possible salivary contamination. The gingival fluid was collected in micro-civettes with 0.5 ml phosphate buffered saline (pH=7.2) and then frozen on the -20ºC till the day of the analysis. Before the analysis, the samples were centrifuged and then analyzed for IL1-α and IL1-β with commercially available ELISA method. Serum samples were also analyzed with Elisa method for IL1-α and IL1-β. The data were statistically evaluated with standard statistics parameters (computer programme "statistics for Windows"- 7).

Results

Results of the study are presented in tables and figures (graphs). Table 1 shows the age distribution in the examined groups. As it can be seen, healthy patients were younger than patients with gingivitis, while patients with periodontal disease were the oldest.

Clinical parameters are presented in table 2 (the IDP) and table 3 (the IGI). As it can be seen, both indexes confirmed the statistically significant differences between the healthy patients and patients with gingivitis and periodontal disease.

Figures 1 and 2 show mean values of gingival fluid levels of IL1-α and IL1-β in the examined groups, respectively. Analysis of variance (ANOVA) showed statistically significant differences in gingival fluid levels of both, IL1-α (F=56.50; p=0.00000) and IL1-β (F=36.029; p=0.00000), in the examined patients.

Figures 3 and 4 show mean values of serum levels of IL1-α and IL1-β in the examined groups, respectively. Analysis of variance (ANOVA) showed statistically significant differences in serum levels of IL1-α (F=232.89; p=0.00000) and IL1-β (F=109.259; p=0.00000) in the examined patients.

Table 1. Age distribution of the examined groups (percentage values)

Age of the examined groups	16	17	18	19	20	21	22	32	34	35	36	total	%
Healthy	5	10	5	10	/	/	/	/	/	/	/	30	17.6
With gingivitis	/	/	3	7	5	10	5	/	/	/	/	30	23.9
With initial periodontal disease	/	/	/	/	/	/	/	4	7	9	10	30	34.6

Table 2. The IDP values of the examined groups

Examined groups	X	SD	df	t	p
Healthy	0.33	0.47	29	3.80	0.000672*
With gingivitis	1.30	0.534	29	13.30	0.00000*
With initial periodontal disease	1.73	0.44	29	21.10	0.00000*

Table 3. The IGI levels of the examined groups

Examined groups	X	SD	df	t	p
Healthy	0.00	/	29	/	/
With gingivitis	1.233	0.43	29	15.70	0.00000*
With initial periodontal disease	2.93	0.25	29	63.32	0.00000*

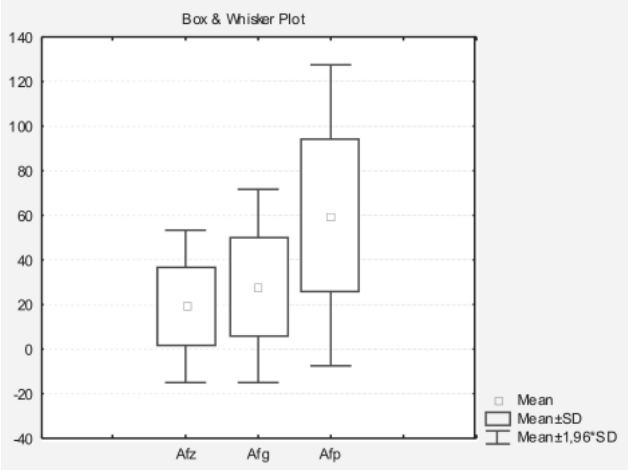

Figure 1. Mean values of gingival fluid levels of IL1-α in the examined groups. ANOVA confirmed the statistically significant differences (F=56.50; p=0.00000)

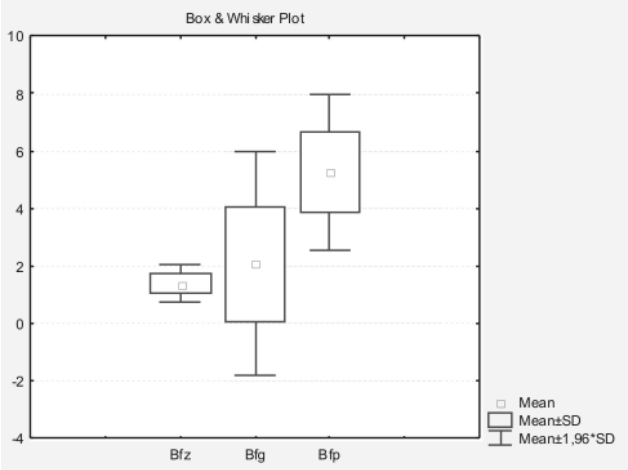

Figure 2. Mean values of gingival fluid levels of IL1-β in the examined groups. ANOVA confirmed the statistically significant differences (F=36.029; p=0.00000)

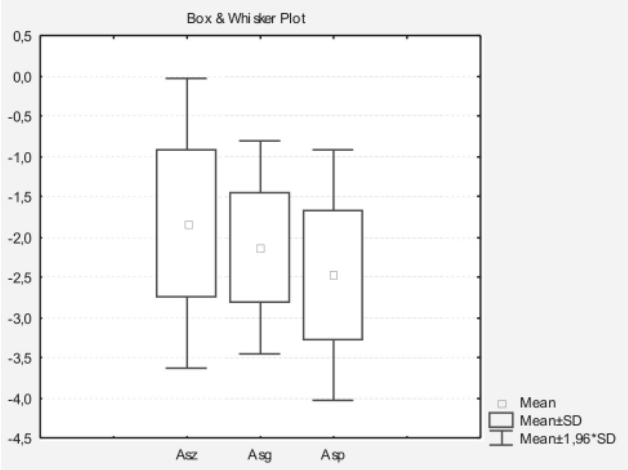

Figure 3. Mean values of serum levels of IL1-α in the examined groups. ANOVA confirmed the statistically significant differences (F=232.89; p=0.00000)

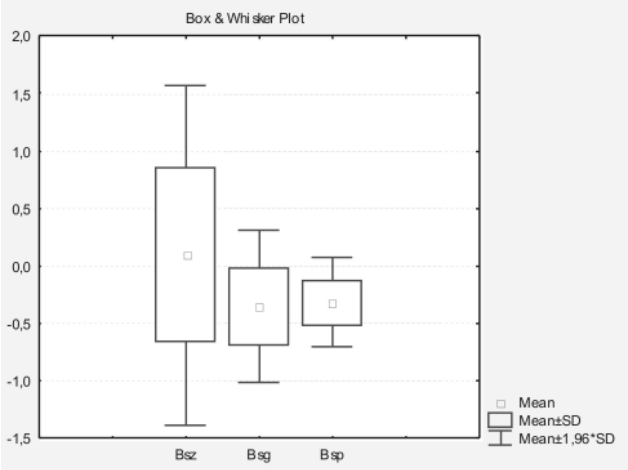

Figure 4. Mean values of serum levels of IL1-β in the examined groups. ANOVA confirmed the statistically significant differences (F=109.259; p=0.00000)

Discussion

Gingivitis and periodontitis are defined as multifactor pathogen entities, which are initiated and assisted by bacterial colonization, but significantly modified by immune host response to bacterial plaque[12].

When inflammatory response is generated in any tissue, the expression of different cytokines is usually increased, then starting deregulation of local immune response. Many research confirmed that non-restrictive production of cytokines leads to specific disease and eventual their progression. This also enhances the possibility of objective diagnosing the stage of inflammation through monitoring cytokine levels and their profile at the inflamed areas.

Gingivitis increases gradually in prevalence and severity from early childhood to the early teenage years, thereafter subsiding slightly and levelling off for the remainder of the second decade of life[1,6,15]. So far, only a few studies have considered age status as a modifying factor for variations in intracellular cytokine production that can be observed by comparing younger and aging adults, or children and adolescents[3,10]. Contradictory results have, however, been reported. Studies have shown both an increase and no change between different age groups examining alterations in proinflammatory systemic cytokine production. Healthy patients in our study had mean percentage age values of 17.6 years, patients with gingivitis 23.9 years, and patients with initial periodontal disease 34.6 years (Tab. 1).

The IDP of the examined groups showed statistically different levels in all the groups (Tab. 2). For the IGI (Tab. 3), we detected statistically significantly higher levels in the groups with gingivitis and initial periodontal disease ($p<0.05$) comparing to the healthy patients. Accordingly, differences in gingival fluid levels of IL1-α were statistically significant among all the examined groups (Fig. 1). These levels were 19.3 pq/ml in healthy examinees, 28.27 pq/ml in examinees with gingivitis, and in examinees with initial periodontal disease levels they rapidly increased to 59.92 pq/ml. Levels of IL1-β in gingival fluid of healthy examinees were 1.39 pq/ml, and they increased in examinees with gingivitis to 2.05 pq/ml and in examinees with initial periodontal disease to 5.25 pq/ml, which was statistically significantly different (Fig. 2).

Serum concentration for these inflammatory cytokines (IL1-α and IL1-β) were detected with very low levels. Our results are in accordance with Petrow at al[13], who also confirmed continuously increased levels of IL-1α, and their relation to the increased plaque inflammation, pointing out the relevant role of IL1-α and its presence in the gingival crevicular fluid as a sensitive marker for plaque induced gingival inflammation[13]. We also agree with findings of Orozco at al[11], who indicated the increased local production of IL1-β in gingival fluid with the increased gingival inflammation. Similar results are reported by Preiss at al[14] and Kinane at al[8], who detected the increased levels of IL1-α and IL1-β at the inflamed gingival tissue, and their extreme low concentrations in healthy individuals.

We suppose that this is the results of interaction between periodontal pathogenic microorganisms and the preserved host cells. This interaction activates the first step in the inflammatory response, cell activation in the connective tissue, and recruitment of neutrophyl granulocytes, a stage that presents the initiation of early lesion in clinically evident gingival inflammation. First cells that are changed in this interaction are epithelial cells. They are really first cells which sustain changes from bacteria in gingival sulcus or periodontal pocket.

Bacterial adhesion activates secretion of pro-inflammatory mediators (IL1-α, IL1-β, TNF-α) from epithelial cells. In the same time, virulent factors that diffuse into the connective tissue, as well as inflammatory mediators produced by epithelial cells, stimulate the host cells in that area - monocytes/macrophages, fibroblasts and mast cells, to produce and release pro-inflammatory cytokines (IL1-β, TNF-α, IL-6, IL-12), prostaglandin (PgE2), histamine and matrix-metalloproteinases (MMPs), which degrade the collagen from connective-tissue compartment. In the following clinical occurrence, the increased levels of IL1-α and IL1-β continue the chain reaction of releasing many other inflammatory mediators, which furthermore recruit the inflammatory process. Confirmation of these activities is presented by histological verification of progressive lesion, which points out periodontal destruction.

Low serum concentration of inflammatory mediators in our study can be considered as a result of the fact that patients that were included in the study were with good health condition, so that their systemic influence of inflammatory mediators should not be expected.

Conclusion

The local production of interleukin (IL1-α and IL1-β) in the gingival crevicular fluid increased with the increased gingival inflammation, which is the expression of the enhanced inflammatory response. This suggests that there is an association between the severity of plaque induced gingival inflammation and gingival fluid levels of these cytokines. So, we consider that they can be potent indicators of gingival and periodontal destruction.

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Correspondence and request for offprints to:

E. Stefanovska
Faculty of Dentistry
Department of Oral Pathology and Periodontology
Vidoe Smilevski Bato 16-2/ 34
1000 Skopje, FYR Macedonia
emistefanovska@yahoo.com

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Correlation between Oral Respiration and Dental Abnormalities

SUMMARY

Oral respiration is considered as an important etiological factor of anomalies in the orofacial region. Many studies have shown a correlation between the manner of respiration and antero-posterior relation of the jaws. Aim of this study was to find out the frequency of patients with oral respiration and to determine the reason for oral respiration, as well as to examine different anomalies caused by oral respiration and to determine the success of treatment of the dento-facial anomalies.

From 230 patients with different dental and skeletal anomalies, 16% had oral respiration. The patients were selected based on the kind of nasal pathologies (structural, mucosal and mixed), and the kind of malocclusion. Intra-oral radiological examinations were performed. Orthodontic treatment was planned regarding the kind of anomaly.

Authors concluded that the precise discovery of the reason of nasal obstruction prior to orthodontic treatment significantly contributes to the success of treatment.

Keywords: Oral Respiration; Anomalies; Treatment, orthodontic

Alketa Qafmolla, Edit Xhajanka, Fatmir Lelaj

Dental University Clinic, Tirana, Albania

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Introduction

Human organs and systems are subjected to many morphological changes during life, which are closely dependent with their function[1,3]. During childhood stage, the chewing system also shows correlation between form and function. Normally, the damage of this unity, due to different causes, creates pathological changes in this apparatus. Such changes can create different abnormalities of teeth and jaws. For this reason the study of the consequences of abnormalities is very important, as their recognition will help in planning prevention measures more exactly the.

Orofacial abnormalities are caused by different factors[11]. In accordance with contemporary concepts, oral respiration is considered as an important factor in etiology of different anomalies. Many authors consider the existence of correlation between abnormalities of jaws and teeth and the way of respiration[2,5,7,8,10]. Oral respiration is very important for the occurrence of different anomalies[1,5], especially for anterior-posterior relations of the jaws. It was also shown that correlation between the manner of respiration and the development of face in vertical plane[3,5,8].

The enlargement of palatine tonsils in the nasal-pharyngeal system create sensibility of neighbouring structures, changing of conversation and, also, anatomic changes of the teeth and jaws[1,4,6,9,11]. The difficulty in physiological way of respiration causes oral respiration. The child sleeps with open mouth; as a consequence, the faces and neck musculature change, which send up at the change of the upper teeth size. In this case, the lower jaw and tongue are together in the lower position, and as a result of continuing changes, the tonic equilibrium of the interior-anterior muscles of the mouth creates morphological changes of tooth positions and skeletal morphology of the jaws, with typical pattern[2-4].

In order to arrive to successful results of the orthodontic treatment of different anomalies, determination of the cause of the existing anomaly is needed[11]. As pathology in oral respiration is widely accompanied with different dental-facial anomalies, the aims of this study were: (1) to establish correlation between pathological manner of oral respiration and the present the dental anomalies in investigated patients; (2)

to determine reasons that had created the pathological way of respiration; (3) to apply the combined methods ENT-orthodontic treatment in order to achieve successful treatment.

Material and Methods

Continually for 2 years, among patients presented at the stomatological division of the Faculty of Medicine, as well as at the private clinic, we selected 230 patients with dental and skeletal anomalies, 6-20 years old. We determined that oral respiration was the reason of these anomalies. Out of these 230 patients that were examined, 37 patients (16.08%) had different barriers during respiration, and were referred for a specialized observation to the ENT department, in order to treat the cause of oral respiration. The nasal barriers for these patients were characterized as: (a) structural barrier; (b) mucosal barrier; and (c) mixed barrier. Patients were selected in accordance with nasal pathology and anomaly item.

All patients were examined and respective ENT treatment, as well as orthodontic treatment, was performed.

Results

Due to ENT examination, reasons for oral respiration in 37 patients were adenoids, deviations of nasal septum, allergic chronic rhinitis, etc (Fig. 1).

Orthodontic examination revealed that 13 patients (35%) had long face and labial incompetence, and 17 patients (45.9%) had open bite (Fig. 2). 7 patients (18.9%) shown very deep palate, with protruding upper teeth (Fig. 3).

We establish absolute correlation (100%) between adenoid vegetation and other nasal-oral pathologies with anomalies of the jaws-teeth system in accordance with below formula: nasal-oral pathology ® oral respiration ® dental-maxillary anomaly.

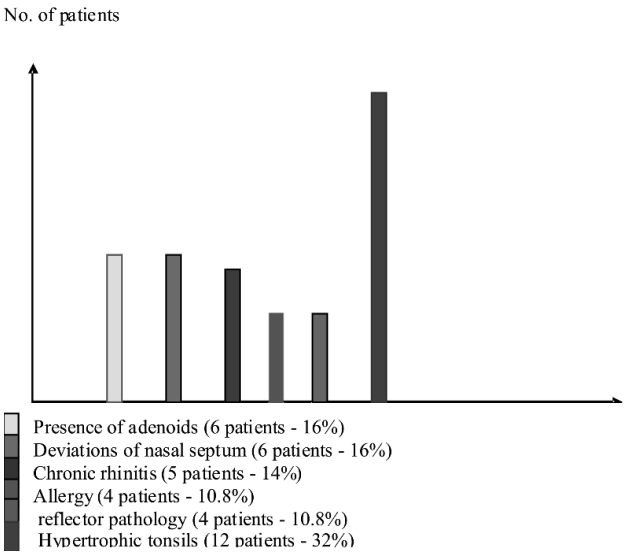

Figure 1. Nasal Pathologies

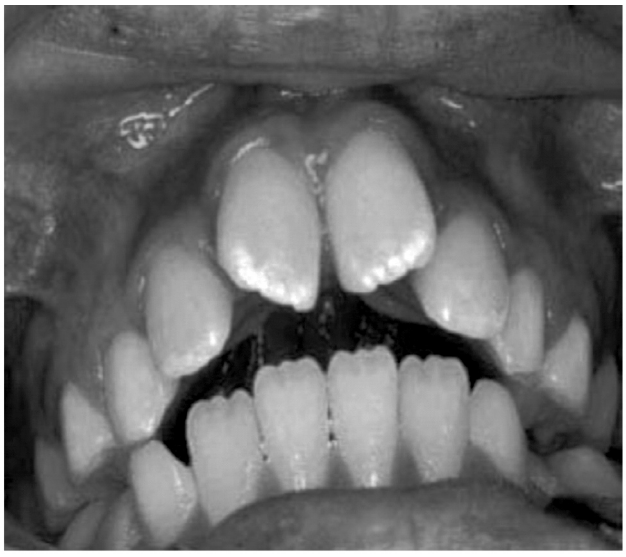

Figure 2. Patient with open bite

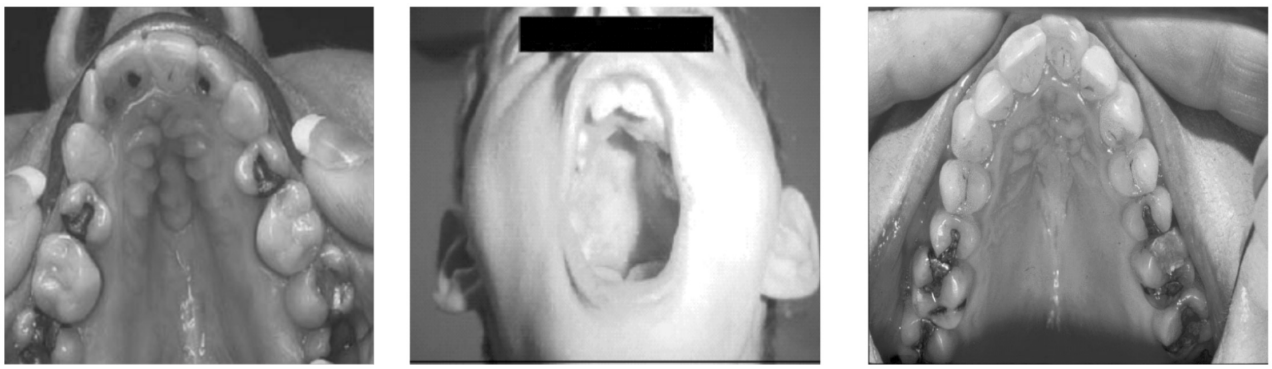

Figure 3. Patient with deep palate and protruding maxillary frontal teeth

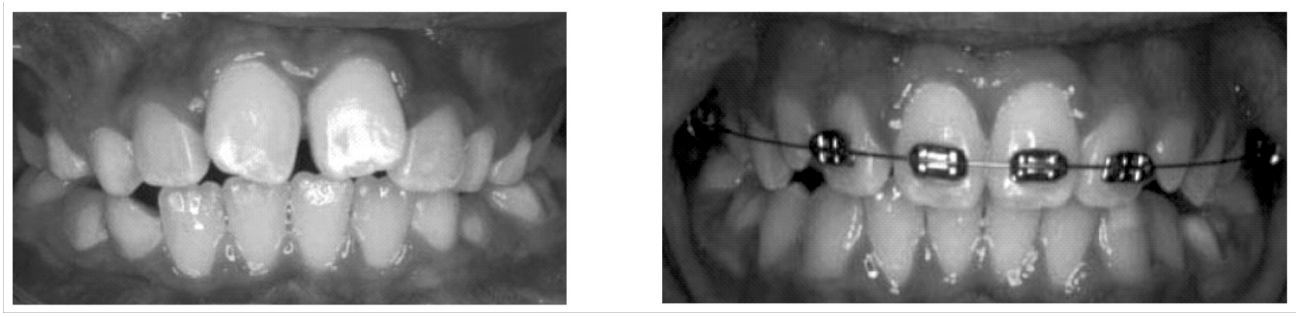

Figure 4. The result of orthodontic treatment of 1 patient

The positive results of the orthodontic treatment based at the fixed and removable appliances (Fig. 4) were noticed in 24 patients (64.8%) with adenoid vegetations (Fig. 5), nasal septum deviations and hypertrophy of tonsils. In patients with chronic rhinitis and allergy, the orthodontic treatment was performed only after ENT treatment and the positive results were received in 24.32% of all cases after 3 years. For 10.81% of all cases positive results were not received by general specialists.

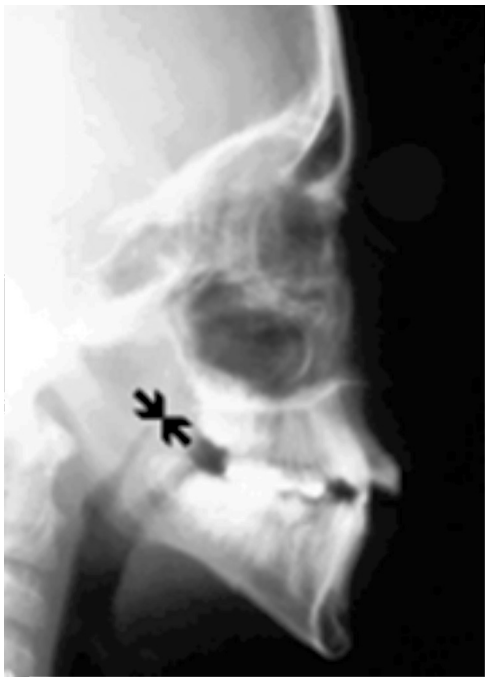

Figure 5. Cephalometric image of a patient with the presence of obstacle in breathing

Discussion

Correlation between oral respiration and anomalies of dento-maxillary segment is frequently discussed in orthodontic literature. An absolute correlation has been observed between adenoid vegetations, the breathing items and jaw-tooth anomalies, which is in accordance with our results and results other authors[2,11]. It has been noticed that hypertrophic tonsils at 2-year-old children grow very quickly, being larger in 55% of the cases at 6-year-olds and in 71% of the cases in 13-year-olds[11].

Dental specialists may observe different oral-facial symptoms that are caused by changes in the respiration pattern, such as wide face with deformation of the superior arcades, posterior rotation of the lower jaw, hypertonic or hypotonic upper lip, as well as the open bite. Intraorally, contracted of teeth arcs, narrow and deep palate, as well as a view like “astonished” face may be noticed. After determining diagnoses like these, dentist should refer children to ENT specialists.

In cases with typical wide face with deformation of superior arcade and posterior rotation of the lower jaw, transversal extension of the palate movable appliance with posterior surface should be applied at the beginning. To achieve favourable alignment of frontal teeth, we used the fixed appliance (Fig. 4). Patients with deep palate were treated depending on the phase of tooth eruption - treatment was postponed till tooth eruption and than so-called REM appliance was fixed. After adjusting the occlusion the fixed appliance was used at the final phase.

Conclusions

Based on the results of our study, a full correlation between oral respiration and dento-maxillary anomalies exists, and is more frequently the cause of different anomalies. Before the beginning of orthodontic treatment, a precise manner of nasal respiration barrier should be discovered, and a close relationship with ENT specialists should be established. By interceptive countermeasures, we could possibly interrupt the aggravation of the facial-oral problems.

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Correspondence and request for offprints to:

Dr. Alketa Qafmolla
Dental University Clinic
Tirana
Albania

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Application of Gengigel in the Treatment of Gingival Inflammation

SUMMARY

Introduction. *Dental plaque is a major cause of gingival inflammation, which is, if not treated, transformed to periodontal disease. So, prevention and medication of gingival inflammation is focused on dental plaque control. Therefore, many professional pastes, gels or solutions are available at the market. We aimed to investigate the effectiveness of Gengigel® gel (Ricerfarma, Milano) in the treatment of gingival inflammation.*

Material and Methods. *The study encompassed 40 patients, divided in 2 groups: 20 of them maintained regular oral hygiene and applied Gengigel through gum massage twice a day after brushing their teeth, and 20 patients, who also maintained regular oral hygiene, did not apply the gel. Both groups were tested at the beginning of the study and after a month.*

Results*: Index values of dental plaque and gingival inflammation after the treatment were evidently reduced in both groups. Particularly good results were noted in the group of patients who practiced gum massage with Gengigel.*

Conclusion*: The comparative analysis of the index values pointed out statistically significant improvement in patients who used Gengigel - the reduced gingival inflammation, which is directly connected to the minimized plaque accumulation.*

Keywords: Oral Hygiene; Gingival Inflammation; Gengigel Gel; Hyaluronic Acid

M. Popovska[1], R. Kievski[1], B. Angelovski[1], Z. Belazelkoska[1], E. Stefanovska[1], L. Kanurkova[2]

Faculty of Dentistry, Skopje, FYROM
[1]Department of Oral Pathology and Periodontology
[2]Department of Orthodontics

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Introduction

Gingival inflammation is a result of the presence of local irritations and microbes and their products from dental plaque. Direct association among colonized microbes in dental plaque and inflammatory disorders of gingival tissue is an introduction in periodontal destruction, which results in loss of teeth at the end[4].

The evidence that dental plaque is the major responsible factor for initiation of gingival inflammation is shown in study of Loe, where experimental gingivitis is initiated at clinic health gingival tissue[8]. The disease can affect different age groups: children, adolescents and adults. Previous experiences proved that 90% of the adults faced problems with gingivitis in some period of live. If it is not treated on time and effectively, it can progress, and intake the other structures of the periodontal complex. In severe conditions, in cases of continuous bad oral hygiene, total destruction of the bone-connective complex may occur, which definitely leads to tooth lost.

The last epidemiological analysis showed that 90% of European population aged between 35 and 54 has some form of periodontal disease. After reaching 40 years of age, more teeth are lost as a result of periodontal disease then as a consequence of caries. In this sense, the fact that 6% of all children from 8 to 9 years of age have inflamed gums should be a concern of every dentist[5,9].

Having this in mind, the necessity of direct control of dental plaque intrudes. Therefore, there are many anti-plaque preparations at the dental market, which can be used with preventive and curative aims. Prevention and treatment of gingival and periodontal disorders, based on better cooperation with patients, becomes more and more important each day. Prevention of plaque control, and its timely elimination, may be carried out by use of

various products placed at the pharmaceutical market[3,6]. The aim of this research was to confirm the effectiveness of Gengigel® gel (Ricerfarma, Milano, Italy) in reducing gingival inflammation in patients with gingivitis.

Material and Methods

At the Clinic of Oral Pathology and Periodontology, Faculty of Dentistry in Skopje, FYROM, 40 patients with clinically diagnosed gingival inflammation were followed-up. The patients were at age from 12-19 years. Diagnose was based on medical history and clinical examination. At clinical examination, the presence or absence of gingival inflammation and plaque dental accumulation were noted. Every patient was treated by conservative measures (elimination of dental calculus and soft dental deposits), and they were divided into 2 groups:

- the first group encompassed 20 patients, who applied Gengigel® gel (Ricerfarma Milano, Italy) through gums massage after brushing their teeth, twice a day;
- the second group of 20 patients held only basic oral hygiene without applying the gel.

All the examinees were motivated for regular maintain of oral hygiene during the study (2 times a day). The index of dental plaque (Sillness-Loe) of patients in both groups was determined, as well as the index of gingival inflammation (Loe-Sillness). Index values were determined in 2 occasions - at the beginning of the treatment and 1 month after the treatment. The results were processed statistically according to Student t-test and presented graphically.

Results

Index values of dental plaque and gingival inflammation in patients who did not used Gengigel gel in their first visit and after 1 month of the treatment are presented in figure 1. It is evident that at the first visit the index of dental plaque was 1.90 and the index of gingival inflammation 1.85. After a month, both indices were reduced, which was statistically highly significant.

Index values of dental plaque and gingival inflammation in patients who used Gengigel gel at their first visit and 1 month later are presented in figure 2. Index of dental plaque at the beginning was also 1.90 and the index of gingival inflammation is 1.85. After 1 month of using Gengigel gel, the index values of dental plaque was only 0.50 and the index of gingival inflammation is 0.45, which was statistically highly significant ($p<0.001$).

Index values of dental plaque and gingival inflammation after the conducted treatment in both groups, i.e. in those who conducted gum massage with Gengigel and those who did not use it, at their first visit and 1 month after the treatment, are presented in figure 3. Patients who conducted gum massage with Gengigel beside the usual conservative treatment shown evidently better results compared with those who did not use gum massage ($p<0.001$).

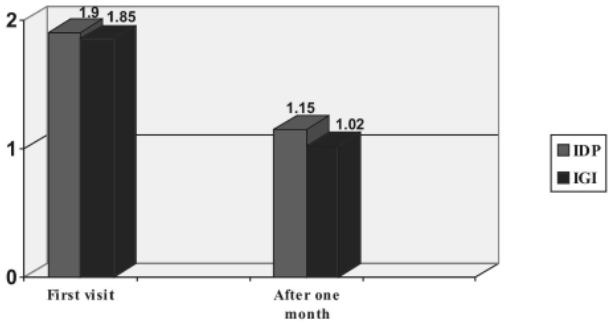

Figure 1. Representation of indices of dental plaque and gingival inflammation in patients who did not use Gengigel gel at their first visit and 1 month after the treatment

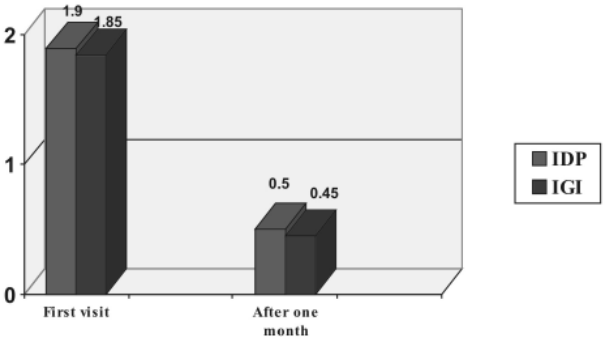

Figure 2. Representation of indices of dental plaque and gingival inflammation in patients who used Gengigel gel at their first visit and 1 month after the treatment

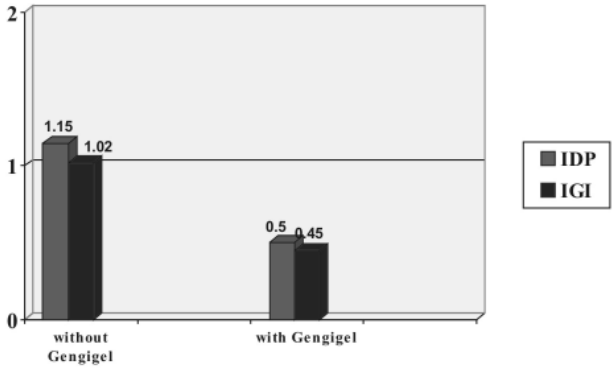

Figure 3. Summary preview of indices of dental plaque and gingival inflammation after 1 month in both the examined groups

Discussion

The fact that untreated or badly treated gingival inflammation results in periodontal disease is indisputable. The incidence of this disease is continuously increasing. The main etiological factor responsible for the occurrence of gingival inflammation is dental plaque. Therefore, prevention of plaque accumulation and treatment procedures actually include its daily and continuous control. Today, the primate belongs to preparations that contain hyaluronic acid. Its role is actually in prevention and treatment of gingivitis and periodontal disease, as well as different injures and inflammatory processes in oral cavity[13,16]. Therapeutic efficiency and compatibility of this medicament are confirmed in many countries in Europe and wider through controlled use on hundred thousand of patients, showing positive results concerning the occurrence of dental plaque and gingival inflammation[6,7,9].

From the obtained results of the present study, it is evident that all patients at their first visit had symptoms of gingival inflammation provoked by the existing dental plaque (the index of dental plaque was 1.90 and the index of gingival inflammation 1.85). After 1 month duration of treatment, the indices values in patients who did not use Gengigel were significantly reduced (IDP=1.15; IGI=1.02). This was the result of patients' motivation for maintenance of oral hygiene.

However, in patients who used Gengigel, we noted statistically significant reduction of the values of both indices, which was even greater than in the previous group. Namely, in patients who used Gengigel the index of dental plaque was reduced to 0.50 and the index of gingival inflammation to 0.45 after 1 month of the treatment. Compared with the values at the first visit, it was highly statistically significant ($p<0.001$). We consider that this finding was not just the consequence of good oral hygiene and motivation of the patient for proper implementation of the same, but also of the use of Gengigel gel and its therapeutic effect during gum massage treatment, as hyaluronic acid has anti-inflammatory, anti-swelling and reparatory effect. In fact, hyaluronic acid is essential component of the periodontal connective tissue, and acts as barrier for plaque bacteria.

The comparative analysis of the index values between the examined groups indicated the statistically significant differences; patients who where treated with Gengigel showed better therapeutic result, which is directly connected to the minimized plaque accumulation due to the use of Gengigel.

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Correspondence and request for offprints to:

Dr. M. Popovska
Department of Oral Pathology and Periodontology
Faculty of Dentistry
Vodnjanska 17
Skopje, FYR Macedonia
popovskam2002@yahoo.com

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Sizes of Pulp Chambers of Molars with Severe Root Curvatures: *In Vitro* Comparative Study

SUMMARY

The macro-morphology of pulp chambers has been studied in the last few decades, but there is still a lack of knowledge on sizes of molar pulp chambers. The aim of the present study was to measure the size of the pulp chambers of upper and lower molars with different root curvatures and to compare them with same dimensions in molars without root curvatures.

77 upper and lower molars, matured, fully mineralized and sound were selected in the following groups: 2 groups - upper and lower teeth, and 3 sub-groups, with straight roots up to 25-30º, severe curvatures up to 45º and with abnormalities 45º- 90º from the axial axis. 3 dimensions of the crowns were measured for each tooth in mm: mesio-distal, bucco-lingual, from the top of buccal cusp to the top of the mesio-lingual (palatal) cusp. All teeth were submitted to x-rays and photographed after opening the pulp chambers with horizontal cuts, 1 mm apically from the equator with diamond blend. Both bucco-lingual dimensions were measured as L1 and L2 (the mean as L), and the mesio-distal as MD; sizes were measured in mm with endodontic file and endoblock in the widest part of the pulp chamber.

These findings are important for prevention of crown and root fractures, tooth loss, and the use of crowns and bridges in young age groups.

Key words: Endodontics; Pulp anatomy; Root canals, curved.

Ekaterina Boteva[1], Dimitar Iovchev[2]

Faculty of Dental Medicine, Sofia, Bulgaria
[1]Department of Conservative Dentistry
[2]Department of Oral Roentgenology and Oral Diagnostics

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Introduction

Macro-morphology of pulp chambers has been widely studied[1]. However, there is a serious lack of knowledge on the sizes in different dimensions of the molar pulp chambers and information on the sizes of pulp chambers of teeth with roots with severe curvatures and root abnormalities also do not exist[2,3,9,13,15]. This is an important matter for forming the proper sizes of endodontic cavities and preventing iatrogenic errors[4,11,12].

All sizes of endodontic cavities are usually defined as distance between cusps from buccal and lingual walls, or from respective walls in relation of the tooth type and sex/age of the patient, not in any relation of the size and anatomy of the particular tooth roots. Very little information can be found concerning sizes of the crowns and roots of molars, but completely out of date, in a book of Wetzel from 1947[15].

Relation between size and shape of the crown and size and shape of the pulp chamber in youth age, and age changes related to reduction of the pulp chamber parameters, have been established in the dental literature[1]. Unfortunately this fact is not always considered during endodontic cavity preparation, leading sometimes to iatrogenic errors[5,6]. A practical review on sizes of clinical crowns in the last 40 years indicates a significant reduction of the mesio-distal and bucco-lingual dimension of the molars. An important matter is the preparation of the pulp chamber on teeth with massive enamel and dentine loss.

From the literature review of the last 20 years, only 8 articles can be related to the macro-morphology of the molars. 5 of these studies are *in vitro* studies with large variation in the number of cases from 5 up to 700 root canals. Only in 2 of them sizes of the pulp chambers are measured. Only in 1 study differences are observed between "young" and "old" teeth[1]. The **aim** of the present study was to measure the range and mean dimensions of the pulp chambers of upper and lower molars with

different root curvatures, and to compare them with same dimensions in molars without root curvatures.

Material and Methods

Teeth: 77 upper and lower molars from both sides. All teeth were matured, fully mineralized and sound.

Groups: 2 groups (upper and lower teeth), and 3 sub-groups (with straight roots up to 25-30º, severe curvatures up to 45º, and abnormalities 45º-90º from the axial axis).

Measurements of the clinical crown: 3 dimensions (in mm) were measured for each tooth: mesio-distal (distance from the approximal marginal ridge), bucco-lingual - from the top of buccal cusp to the top of the mesio-lingual (palatal) cusp, and the height of the crown at the buccal side (h) from the enamel border to the middle part of the line between the cusps.

X-Ray: all teeth were submitted to x-rays and photographed after opening the pulp chamber (Fig. 1).

Figure 1. Pulp chambers of lower and upper molars, measured in the study

Measurements of the pulp chambers: following method was used:

1. The pulp chambers were opened with horizontal cuts with diamond blend, 1 mm apically from the equator.
2. After polishing the ridges, the final size of the chamber was 2 mm bellow the equator.
3. Both bucco-lingual dimensions were measured as L1 and L2, and the mean as L, and the mesio-distal sizes (MD) were measured in the widest part of the pulp chamber.
4. Measurements were performed with endodontic file and endoblock in mm.

Exclusion criteria: non vital teeth, massive tooth losses, teeth with root caries, incisors and premolars, teeth with hypoplasia and non-caries enamel defects and non-matured teeth.

Results

Sizes of the clinical crowns of upper and lower molars, as well as sizes of their pulp cambers, are presented in tables 1 and 2. As it can be seen, all dimensions of pulp chambers in upper molars and most in lower molars of the teeth with root canal curvatures were smaller than the sizes of the pulp chambers of teeth with straight roots.

Table 1. Sizes of pulp chambers of the molars

Size	Up to 25-30º n=20		30-45º n=20		45-90º n=37	
Teeth	Upper	Lower	Upper	Lower	Upper	Lower
L1	5.58	4.37	5.01	4.80	5.14	4.15
L2	4.91	3.62	4.14	4.15	4.05	3.55
MD	3.16	3.50	2.57	3.30	3.05	3.25

Table 2. Sizes of clinical crowns of the molars

Type of tooth	Dimension	Mean	Range mm
Upper Teeth n=161	BL	6.5	5.8 – 7.8
	MD	8.1	7.9 – 9.4
	H	4.5	4.0 – 6.2
Lower teeth n=125	BL	5.3	4.0 – 8.0
	MD	9.9	8.0 – 13.0
	H	5.2	3.5 – 7.0

Discussion

The importance of these findings is related to the fact that the bucco-lingual size of the crowns and the pulp chambers are very similar. On the other hand, reducing preparation of hard dental tissues in this area is very important and directly related to the lower amount of active axial root surface bellow this area in teeth with severe root canal curvatures.

The non existing data on the size of the pulp chambers of molars in the literature is a fact. This is an

explanation why, after endodontic treatment, the most common mistakes are: Remaining pulp tissue in retentive lodges in the pulp chamber – sources of infection and periapical lesions, which are 19.8% of all endodontic re-treatments in the Faculty of Dental Medicine in Sofia, shown in our previous study. Non-accurate exposure of pulp chamber is the reason of failures in working length estimation and poor preparation of root canals[14,16]. Over-preparation of cavity walls and crown fracture, mostly due to over-preparation of medial and distal walls, followed by use of posts and pins, meets in 18.2% of all endodontic treatments.

It is proved in many literature sources that nearly in 50% of all endodontic treatments there are failures especially when it is considered that with age all pulp chambers lower their sizes and orifices migrate up on cavity walls[6,12].

Conclusions

1. There is a need of up to date knowledge not only on the pulp anatomy but on pulp chamber sizes and crown sizes of molars with curved roots.
2. A careful approach to these sizes can lead to safe hard dental tissues treatment during endocavity and pulp chamber preparation.
3. Smaller pulp chambers in molars with curvatures can be important knowledge for prevention of crown and root fractures, and teeth losses, as well as to lower need for tooth extractions, use of posts and pins and the use of crowns and bridges in young patients.

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Correspondence and request for offprints to:

Dr. Ekaterina Boteva
Dept. of Conservative Dentistry
Faculty of Dental Medicine
1 Georgy Sofiisky str, Sofia, Bulgaria
E-mail: e_boteva@ abv.bg

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Effect of Staining Solutions on the Colour Stability and Surface Properties of Denture Base Material

SUMMARY

Objectives: *The aim of the study was to examine the effects of staining solutions on the colour stability of heat-cured denture base acrylic resins and cold-curing hard denture liner after 1 month of immersion.*

Methods: *Meliodent, SR Ivocap, Lucitone 199 and Ufi Gel Hard, as well as coffee, tea, orange juice and red wine, were used. 40 disc-shaped specimens from each material were prepared, divided into 4 groups and immersed in solutions everyday. Surface roughness and colour measurements were made before and after immersion. Colour values of the specimens were measured with colorimeter. Surface roughness measurements were made by using profilometer. Statistical analysis was performed with 1 way ANOVA and the Tukey multiple comparison test ($\alpha = .05$).*

Results: *Ufi Gel Hard showed clinically unacceptable ΔE values in all the solutions except coffee. In coffee, no significant difference was determined between the Δ values of the materials. In tea and red wine the greatest mean colour change was determined in Ufi Gel Hard. In orange juice, SR Ivocap and Ufi Gel Hard showed significantly higher ΔE values than Meliodent and Lucitone 199 ($p < .01$, $p < .05$). The initial and last surface roughness values of Ufi Gel Hard and Ivocap 199 were highest and lowest respectively ($p < .05$).*

Conclusions: *Δ of all 3 heat-cured denture base acrylic resins and cold-curing hard denture liner was changed after the immersion in all of the staining solutions during the experimental process. The combination of acrylic resins, staining solutions and surface properties are significant factors affecting the colour stability.*

Keywords: Colour Stability; Surface; Staining Solutions; Denture Base Materials

Sebnem Begum Turker, Isıl Damla Sener, Emek Akkus, Burcu Bugurman

Marmara University, Faculty of Dentistry, Department of Prosthodontics, Istanbul, Turkey

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Introduction

It is often difficult to restore a satisfactory smile to patients with removable dentures. Acrylic resin, a denture base material, that is used commonly in dental practice, has disadvantages of being hard, easy to fracture and staining[1,2]. The most popular denture base material for more than 50 years has been heat-cured poly (methyl-methacrylate) (PMMA); however, impact resistant resins have been developed[3,4]. One of the properties of acrylates is water sorption and release[4]. Water absorbed into the acrylic resin acts as a plasticizer and decreases the mechanical properties, such as hardness, transverse strength and fatigue limit[5]. Water sorption can also influence dimensional stability that may result in crack formation and fracture of the denture[4,6,7].

Most resin based materials used for prosthetic treatment are prone to absorption and adsorption of liquids[6,8,9]; thus staining may produce colour changes during service in the oral environment.[1] Scotti et al[2] and Um and Ruyter[5] determined that discoloration of denture base resin is related not only to the chemical-physical properties of the resin, but also to patients' dietary habit. The staining of resin based materials by coloured solutions, such as coffee, tea and other beverages, and colour stability after aging in different solutions, have been reported[10]. There is evidence that beverages, such as tea, coffee and wine, significantly increase the development of stain on acrylic resin. Researchers have studied the effect of denture cleaners, fluids and foods. They have been reported that the staining and physical properties of denture base polymers, both hard

acrylics and soft lining materials, have had effect[11]. Discoloration of the denture base polymers may be caused by oxidation of the amine accelerator or by penetration of coloured solutions[12]. Purnaveja et al[13] showed that cold-cured resins have colour stability inferior to that of heat-cured materials. Autopolymerizing denture base resin materials have been found to be less stable than conventional acrylic resins. The colour stability of autopolymerizing denture base acrylic resin varied with chemical composition of the monomer. The quantitative evaluation of colour difference (ΔE) with a colorimeter confers advantages, such as repeatability, sensitivity and objectivity. In general, if a material is completely colour stable, no colour difference will be detected after its exposure to the testing environment (ΔE=0)[14,15].

Bacterial adhesion on hard dental surfaces is followed by accumulation of dental plaque. Surface roughness and the surface free energy play a key role during this process[16]. Several studies have demonstrated that rough acrylic resin surfaces are significantly more prone to bacterial accumulation and plaque formation than smooth surfaces[16-19]. Radford et al[20] maintained that acrylic resin has been less frequently investigated for its surface roughness, effects of polishing, bacterial adhesion, and plaque formation than other dental materials.

The purpose of this *in vitro* study was to investigate the effect of staining solutions on the colour stability and surface properties of 3 different denture base materials and hard relining material. The null hypothesis for this study was that the different denture base and hard relining materials have different colour stability and surface properties after exposure to coffee, tea, orange juice and red wine.

Materials and Methods

The 3 base poly (methyl-methacrylate) heat-cured denture base acrylic resins (Meliodent, SR Ivocap, Lucitone 199) and a PMA-based, cold-curing, permanently hard denture liner material (Ufi Gel Hard) and 4 staining solutions (coffee, tea, orange juice and red wine) and as a control group distilled water, were used in this study (Tab. 1). 40 disc-shaped specimens from each material (160 specimens in total), 12 mm in diameter and 3 mm in depth, were prepared in customized stainless steel moulds. Acrylic resins and hard denture liner were mixed and manipulated according to the manufacturers' instructions.

Table 1. The tested materials

Material	Product name	Manufacturer
Heat-cured denture base acrylic resin	Meliodent	Bayer Dental, Newburg, Germany
Heat-cured denture base acrylic resin	SR Ivocap	Ivoclar AG, Schaan, Liechtenstein
Heat-cured denture base acrylic resin	Lucitone 199	Dentsply Trubyte, York, Pa
PMA-based, cold-curing permanently hard denture liner	Ufi Gel Hard	VOCO GmbH, Cuxhaven, Germany
Tea	Lipton	Gayrettepe, Istanbul, Turkey
Coffee	Nescafe-Classic	Karacabey, Bursa, Turkey
Orange juice	Cappy	Yenibosna, Istanbul, Turkey
Red wine	Yakut red wine	Kavaklıdere,Ankara, Turkey

For the heat-cured denture base acrylic resin specimens - Meliodent (Bayer Dental, Newburg, Germany), SR Ivocap (Ivoclar AG, Schaan, Liechtenstein) and Lucitone 199 (Dentsply Trubyte, York, Pa) - the waxes (Cavex set up modelling wax, Haarlem, Holland) were prepared in 12 x 3 mm (in diameter and depth) dimensions. They were then moulded. The flask was used with dental stone to permit processing of multiple samples[11].

For the compression-moulded method, Meliodent and Lucitone 199 (Dentsply Trubyte, York, Pa) specimens were mixed in a mixing cup for 40s with a glass spatula to a homogenous mix according to the manufacturer's directions - liquid:powder ratio (3:1)[21], and while the resin was in dough stage, it was packed into the stainless steel mould. The halves of the flask were pressed together in a pneumatic press (Kavo EWL, Germany). The pressure was increased up to 40.000 N in several steps in order to remove excess resin[3]. They were prepared in conventional metal denture flasks and polymerized in a water bath for 9 hours at 74°C[21,22]. For the injection-moulded method, SR-Ivocap (Ivoclar AG, Schaan, Liechtenstein) specimens were prepared in special flasks with the injection unit (Dentsply/De Trey). Injection of encapsulated heat-polymerizing resin was done under a pressure of 6 x 10^5 N/m^2. The pressure was maintained during a 45-minute polymerization in hot water (100°C) and 20-minute cooling off period in cold water[16].

For Ufi Gel hard, PMA-based, cold-curing permanently hard denture liner material, specimens were mixed in a mixing cup for 40s with a glass spatula to a homogenous mix according to the manufacturer's

directions, and while the resin was in dough stage, it was packed into the stainless steel mould. The specimens were removed from the mould after they completely polymerized. After the preparation of the specimens, all the specimens were polished on both sides with 300, 400 and 600 grit silicone carbide paper (Fuji Star water paper 933.1200; Chiao-Cen Trading Co, Taiwan), respectively, under water flow, and placed into desiccator (Normax, Fabrica de Vidros Cientificos, Portugal) containing silica gel at 37°C ± 1°C until a constant weight was attained. Specimens were then stored in distilled water at 37°C ±1°C for 24h.

To prepare a standard solution of coffee, 15g of coffee (Nescafe Classic; Karacabey, Turkey) was poured into 500ml of boiling distilled water. After 10 minutes of stirring, the solution was passed through filter paper. The tea solution was prepared by immersing 5 tea bags (Lipton, Gayrettepe, Turkey), into 500ml of boiling distilled water and used after 10 minutes of waiting period. 40 specimens of each material were divided into 4 groups for each test solution and 2 of all 10 specimens stored in distilled water as control groups. Base-line surface roughness and colour measurements were made before immersion in 4 different staining solutions (coffee, tea, orange juice and red wine), and as a control in distilled water, and repeated at the end of the first month. 8 specimens from each material were immersed in each of the 5 solutions for an average of 8 hours per day. Fresh solutions were made each day[11]. The control specimens were kept in distilled water that was changed daily. At the end of the staining procedures, all of the specimens were rinsed with water and kept in fresh distilled water until the next daily application.

To evaluate colour differences, the CIELAB calorimetric system was used. Before colorimetric measurement, the colorimeter was calibrated according to the manufacturer's recommendation by using the supplied white calibration standard[14]. Colour values (L*, a*, b*) of the specimens were measured with a colorimeter (CR-508; Minolta Co., Tokyo, Japan). The CIELAB system is an approximately uniform colour space that coordinates for lightness, namely white-black (L*), redness-greenness (a*) and yellowness-blueness (b*)[14]. Colour difference (ΔE) was calculated from the mean ΔL*, Δa* and Δb* values for each specimen with the formula[14,23]:

$$\Delta E = [(L_1-L_0)^2 + (a_1-a_0)^2 + (b_1-b_0)^2]^{1/2}$$

where (L_1-L_0), (a_1-a_0) and (b_1-b_0) are the differences in L*, a* and b* values of a specimen immediately following fabrication and after immersion in beverages and distilled water. Each specimen was measured 3 times by placing each specimen on the measuring head and covering with the black cover. The mean ΔE value of 3 measurements was automatically calculated by the colorimeter and recorded[24].

Surface roughness measurements were made by using profilometer (Miyutoyo Surfest SV-400). The profilometer was calibrated at the beginning of each measuring session. The specimens were rotated through the profilometer clockwise at random angles. 12 transverses of the stylus were made across the diameter for each specimen so that the entire surface of each specimen was evaluated. The mean roughness parameter (Ra in micrometers) for each specimen was recorded as the average of 12 readings. All readings were performed by the same researcher[25]. All the data were calculated with computer software (Excel 7.0; Microsoft) and statistical analysis was performed within each variable with 1 way ANOVA and the Tukey multiple comparison test (α = .05).

Results

In the CIELAB colour system, ΔE value signifies the combination of differences in the 3 dimensions of the colour space. In Meliodent and Lucitone 199 acrylic resin materials, no significant difference was determined between the ΔE values of tea, coffee, orange juice and red wine (Tabs. 2 and 3). SR Ivocap acrylic resin material showed significantly higher E values in tea and orange juice, 1.95±0.22 and 4.74±3.25, respectively (Tab. 4). Ufi Gel Hard material showed clinically unacceptable ΔE values (ΔE > 3.7) in all the solutions except coffee (Tab. 5).

Table 2. The mean values and standard deviations (SD) of the colour changes of Meliodent

Meliodent	ΔE		+p
	Mean ± SD	Median	
Tea	1.42 ± 1.13	1.32	
Coffee	3.25 ± 4.81	1.55	
Orange juice	2.08 ± 1.46	1.58	0.162
Red wine	1.62 ± 2.16	0.84	
Distilled water	0.99 ± 0.59	0.87	

+ Kruskal Wallis Test ++ Mann Whitney U Test

Table 3. The mean values and standard deviations (SD) of the colour changes of Lucitone 199

Lucitone 199	ΔE		+p
	Mean ± SD	Median	
Tea	2.25 ± 2.36	1.18	
Coffee	4.09 ± 5.28	1.73	
Orange juice	1.76 ± 1.97	1.15	0.250
Red wine	1.38 ± 0.45	1.33	
Distilled water	2.02 ± 0.85	1.85	

+ Kruskal Wallis Test ++ Mann Whitney U Test

Table 4. The mean values and standard deviations (SD) of the colour changes of SR Ivocap

SR Ivocap	ΔE		+p
	Mean ± SD	Median	
Tea	1.95 ± 0.22	1.86	
Coffee	3.32 ± 3.02	3.57	
Orange juice	4.74 ± 3.25	4.25	0.034*
Red wine	1.76 ± 0.57	1.70	
Distilled water	1.42 ± 0.87	1.22	
Tea-Coffee ++*p*	0.093		
Tea-Orange juice ++*p*	0.093		
Tea-Red wine ++*p*	0.248		
Tea-D.water ++*p*	**0.021***		
Coffee-Orange juice ++*p*	0.401		
Coffee-Red wine ++*p*	0.753		
Coffee- D.water ++*p*	0.103		
Orange juice-R. wine ++*p*	0.060		
Orange juice-D.water ++*p*	**0.016***		
Red wine-D.water ++*p*	0.093		

+ Kruskal Wallis Test ++ Mann Whitney U Test

Table 5. The mean values and standard deviations (SD) of the colour changes of UfiGel Hard

Ufigel Hard	ΔE		+p
	Mean ± SD	Median	
Tea	4.06 ± 1.30	3.85	
Coffee	3.02 ± 1.87	2.72	
Orange juice	4.58 ± 1.42	4.23	0.003**
Red wine	5.73 ± 1.30	5.88	
Distilled water	2.60 ± 1.45	2.35	
Tea-Coffee ++*p*	0.103		
Tea-Orange juice ++*p*	0.462		
Tea-Red wine ++*p*	**0.027***		
Tea-D.water ++*p*	0.093		
Coffee-Orange juice ++*p*	**0.036***		
Coffee-Red wine ++*p*	**0.009****		
Coffee- D.water ++*p*	0.529		
Orange juice-R. wine ++*p*	0.127		
Orange juice-D.water ++*p*	**0.027***		
Red wine-D.water ++*p*	**0.002****		

+Kruskal Wallis Test ++ Mann Whitney U Test
* $p<0.05$ ** $p<0.01$

When ΔE was examined in coffee, no significant difference was determined between the Δ values of the materials (Tab. 6). In tea, the greatest mean colour change was determined in Ufi Gel Hard, which had significantly higher E values than all other materials (Tab. 7). In orange juice, SR Ivocap and Ufi Gel Hard showed significantly higher ΔE values than Meliodent and Lucitone 199 (Tab. 8). In red wine, again Ufi Gel Hard showed the highest Δ value than the others (Tab. 9).

Values of mean surface roughness and standard deviations for each material group are given in table 10. The initial and 3rd week surface roughness value of Ufi Gel Hard was higher than all the other materials; initial and 3rd week surface roughness value of Ivocap 199 was lower than all the other materials. No statistically significant difference was determined between the initial and 3rd week surface roughness values of Ufi Gel Hard and Lucitone 199. However, Meliodent and Ivocap 199 3rd week surface roughness values were statistically higher than the initial values (Tab. 10).

Table 6. The mean values and standard deviations (SD) of the colour changes of Meliodent, SR Ivocap, Lucitone 199, and Ufi Gel Hard in coffee

Coffee	ΔE		+p
	Mean ± SD	Median	
Meliodent	3.25 ± 4.81	1.55	0.677
SR Ivocap	3.32 ± 3.92	1.57	
Lucitone 199	4.09 ± 5.28	1.73	
Ufigel Hard	3.02 ± 1.87	2.72	

+ Kruskal Wallis Test ++ Mann Whitney U Test
* $p<0.05$ ** $p<0.01$

Table 7. The mean values and standard deviations (SD) of the colour changes of Meliodent, SR Ivocap, Lucitone 199 and Ufi Gel Hard in tea

Tea	ΔE		+p
	Mean ± SD	Median	
Meliodent	1.42 ± 1.13	1.32	0.005**
SR Ivocap	1.95 ± 0.22	1.86	
Lucitone 199	2.25 ± 2.36	1.18	
Ufigel Hard	4.06 ± 1.30	3.85	
Meliodent-Ivocap ++*p*	0.093		
Meliodent-Lucitone ++*p*	0.600		
Meliodent-Ufigel Hard ++*p*	**0.003****		
Ivocap-Lucitone ++*p*	0.248		
Ivocap-Ufigel Hard ++*p*	**0.002****		
Lucitone-Ufigel Hard ++*p*	**0.036***		

+ Kruskal Wallis Test ++ Mann Whitney U Test
* $p<0.05$ ** $p<0.01$

Table 8. The mean values and standard deviations (SD) of the colour changes of Meliodent, SR Ivocap, Lucitone 199 and Ufi Gel Hard in orange juice

Orange Juice	ΔE		+*p*
	Mean ± SD	Median	
Meliodent	2.08 ± 1.46	1.58	0.007**
SR Ivocap	4.74 ± 3.25	4.25	
Lucitone 199	1.76 ± 1.97	1.15	
Ufigel Hard	4.58 ± 1.42	4.23	
Meliodent-Ivocap ++*p*	**0.036***		
Meliodent-Lucitone ++*p*	0.462		
Meliodent-Ufigel Hard ++*p*	**0.009****		
Ivocap-Lucitone ++*p*	**0.027***		
Ivocap-Ufigel Hard ++*p*	0.753		
Lucitone-Ufigel Hard ++*p*	**0.009****		

+ Kruskal Wallis Test ++ Mann Whitney U Test
* $p<0.05$ ** $p<0.01$

Table 9. The mean values and standard deviations (SD) of the colour changes of Meliodent, SR Ivocap, Lucitone 199 and Ufi Gel Hard in red wine

Red Wine	ΔE		+*p*
	Mean ± SD	Median	
Meliodent	1.62 ± 2.16	0.84	0.001**
SR Ivocap	1.76 ± 0.57	1.70	
Lucitone 199	1.38 ± 0.45	1.33	
Ufigel Hard	5.73 ± 1.30	5.88	
Meliodent-Ivocap ++*p*	0.093		
Meliodent-Lucitone ++*p*	0.248		
Meliodent-Ufigel Hard ++*p*	**0.006****		
Ivocap-Lucitone ++*p*	0.208		
Ivocap-Ufigel Hard ++*p*	**0.001****		
Lucitone-Ufigel Hard ++*p*	**0.001****		

+ Kruskal Wallis Test ++ Mann Whitney U Test
* $p<0.05$ ** $p<0.01$

Table 10. The surface roughness values and standard deviations (SD) of the colour changes of Meliodent, SR Ivocap, Lucitone 199 and Ufi Gel Hard

	Surface Rougness		
	Initial	3. Weeks	+++*p*
	Mean ± SD	Ort ± SD	
Meliodent	0.26 ± 0.11	0.29 ± 0.10	0.015*
SR Ivocap	0.15 ± 0.04	0.19 ± 0.05	0.001**
Lucitone 199	0.28 ± 0.11	0.31 ± 0.14	0.221
Ufigel Hard	0.78 ± 0.23	0.82 ± 0.16	0.106
+*p*	**0.001****	**0.001****	
Meliodent-Ivocap ++*p*	**0.005****	**0.004****	
Meliodent-Lucitone ++*p*	0.908	0.855	
Meliodent-Ufigel Hard ++*p*	**0.001****	**0.001****	
Ivocap-Lucitone ++*p*	**0.001****	**0.001****	
Ivocap-Ufigel Hard ++*p*	**0.001****	**0.001****	
Lucitone-Ufigel Hard ++*p*	**0.001****	**0.001****	

+ Oneway ANOVA test ++ Tukey Test +++ Paired Sample t test
* $p<0.05$ ** $p<0.01$

Discussion

Discoloration can be evaluated with various instruments. Since instrument measurements eliminate the subjective interpretation of visual colour comparison, spectrophotometers and colorimeters have been used to measure colour change in dental materials[9,15,26]. Various studies have reported different thresholds of colour difference values above the colour change perceptible by human eye. The values ranges from Δ equal to 1, between 2 and 3, greater than or equal to 3.3 and greater than or equal to 3.7[14]. The value of ΔE represents relative colour changes that an observer might report for the materials after treatment or between the time periods. Thus ΔE is more meaningful than the individual L*, a* and b* values[24,27].

Seghi et al[28] and Um and Ruyter[5] reported that Δ value equal to L* is considered visually detectable 50% of the time, whereas a ΔE value greater than 2 is detectable 100% of the time. A perceptible discoloration that is $\Delta E_{ab^*} > 1.0$ will be referred to as acceptable up to value $\Delta E_{ab^*} = 3.3$ in subjective visual evaluations made *in vitro* under optimal lighting conditions[29]. Johnston and Kao[30] reported that if ΔE is less than 1, this chromatic value deemed to be slight and the average colour difference between compared teeth rated as "match" in the oral environment was 3.7 (ΔE). Goldstein and Schmitt[31] reported that when ΔE is more than 3.7, it is no longer within the limits of clinical acceptability and it assumes the quality of visual detectability. Yannikakis et al[27] referred discoloration below or above the value ΔE 3.7 as "acceptable" or "unacceptable", respectively. In the present study, as in Yannikakis et al[27], the Δ 3.7 was accepted as clinically acceptable and above this value was considered as clinically unacceptable.

Many resins, including conventional denture base acrylic resins (heat-cured resins), denture base repair acrylic resins and hard denture liners (cold-cured resins), were activated by visible light and microwave, and they were for prosthetic applications[11]. All these materials are known to be affected by food, drink and tobacco[11,13,32]. 4 common used beverages (tea, coffee, orange juice and

red wine) were used to measure the colour stability of denture resin materials. They were chosen as the test agents because they have been shown to have greater staining ability on anterior composite resins and natural tooth structure[11,33].

Causative factors that may contribute to the change in colour of aesthetic restorative materials include stain accumulation, dehydration, water sorption, leakage, poor bonding and surface roughness, wear or chemical degradation, oxidation of the reacted carbon-carbon double bonds that produces coloured peroxide compounds, and continuing formation of the coloured degradation products[34,35]. The degree of colour change can be affected by a number of factors, including incomplete polymerization, water sorption, chemical reactivity, diet[2], oral hygiene and surface smoothness of the restoration[15]. According to May et al[32], colour change may be associated with porosity caused by overheating or insufficient pressure during polymerization.

In this study, Meliodent specimens exhibited ΔE values at clinically acceptable levels in all solutions; Lucitone 199 and SR Ivocap also exhibited ΔE values at clinically acceptable levels in 3 of 4 solutions, except in coffee (ΔE=4.09) and orange juice (ΔE=4.74). Ufi Gel Hard exhibited the greatest staining in red wine (ΔE= 5.73). Colour changes exhibited by all specimens after immersion in test solutions were at clinically unacceptable levels, except coffee (ΔE=3.02).

Yannikakis et al[36] and Güler et al[15] used coffee and tea as staining agents and found that coffee stained provisional resin restorative materials more than tea. On the other hand, it is known that tannic acid, which is present in tea and coffee, caused the staining[12]. The study of Crispin and Caputo[37] determined that quality and concentration of tea and coffee products can affect the degree of colour changes. Also the excessive staining in coffee observed with Lucitone may be related to the rubber phase in its structure[38]. There are no studies in the literature which used red wine and orange juice as a staining solution for acrylic resins. Red wine ΔE values were within the limitations of the clinically acceptable levels except for Ufi Gel Hard. Ufi Gel hard is a PMA-based, cold-curing, permanently hard denture liner. Being a hard material, similar to denture acrylic, it can be trimmed and polished in the same way as denture acrylic. Orange juice ΔE values were also within the limitations of the clinically acceptable levels except for Ufi Gel Hard and SR Ivocap. When long term lining is required, the drinking habits of the patients must be considered while choosing the type of lining material.

According to *in vivo* studies by Bollen et al[39] and Quirynen et al[40], clinically acceptable roughness (Ra) of hard surfaces in the oral environment after polishing should not exceed 0.2 μm. In the presented study, SR Ivocap initial and last values were within this limits; Meliodent and Lucitone 199, initial and last values were slightly higher than 0.2 μm; Ufi Gel Hard values were higher than 0.2 μm (0.78±0,23, 0,82±0,16). However, the surface roughness values determined in this study were lower than in Zissis et al[41] study. Zissis et al[41] reported roughness values of 3.2 μm for auto-polymerized resilient liners and values ranging from 3.5 to 4.0 μm for heat-polymerized resilient liners. When evaluating surface properties of denture base materials, a higher variability of Ra values of polished acrylic resin should be expected in clinical practice than in the presented study. Because of polishing of dentures is never performed on completely flat surfaces and the recommended speed and maximum allowable pressure of a rotating polisher are not easy to control, especially at chairside[42].

This *in vitro* study provides information about different types of acrylic resins with respect to colour and surface changes by various solutions. The results may be useful to clinicians when selecting the material to be used for acrylic dentures.

Conclusions

Within limitations of this *in vitro* study, the following conclusions may be drawn: tea, coffee, orange juice and red wine did not cause significant changes in the surface roughness of Ufi Gel Hard liner and Lucitone acrylic resin, but did cause significant changes in the surface roughness of Meliodent and SR Ivocap acrylic resins for the time period tested. ΔE of all 3 heat-cured denture base acrylic resins and cold-curing hard denture liner changed after immersion in all of the staining solutions during the experimental process. Combination of acrylic resins, staining solutions and surface properties are significant factors affecting the colour stability. When choosing the type of lining material and acrylic resin, the drinking habits of the patients should be considered.

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Correspondence and request for offprints to:

Dr. Sebnem Begum Turker
Marmara University
Faculty of Dentistry
34365 Nisantası
Istanbul, Turkey
E-mail: begumturker@hotmail.com

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Rehabilitation of Anterior Maxillary Teeth after Trauma: A Clinical Report

SUMMARY

This clinical report describes the treatment of a 56-year-old female who had mobile maxillary anterior teeth due to trauma. The purpose of this article is to evaluate clinical success for splinting anterior mobile teeth with osseointegrated implants that were injured by trauma. The patient was treated with 5 implants (ITI, Straumann, Waldenburg, Switzerland) in the maxillary posterior region. After 3 years, the patient was referred with a trauma by fall. The anterior teeth were mobile but there was no damage in the posterior region and the implants. It was decided to splint the mobile teeth with osseointegrated implants. New metal ceramic restorations were fabricated connecting implants with mobile natural teeth. The patient was recalled at 1, 2, and 3 years. The patient was satisfied with the new prosthesis. The treatment outcome was satisfactory and successful, there was no bone loss around the implants, there was no bleeding on probing at abutment connection and at the 3 year recall, peri-implant tissues were healthy.

Keywords: Implant; Trauma; Implant-tooth supported

Yaşar Özkan[1], BurçinVanlıoğlu[2], Mert Uçankale[2], Yasemin Kulak Özkan[2]

University of Marmara, Faculty of Dentistry
Istanbul, Turkey
[1]Department of Oral Surgery,
[2]Department of Prosthodontics

CASE REPORT (CR)
Balk J Stom, 2012; 16:57-59

Introduction

Initially, oral implants were used in the completely edentulous situation[1,2]. Success of implants became approved, so the use of implants expanded to include anterior and posterior regions. However, there is a controversy regarding whether implants should be connected to natural teeth[3,4].

Dental and facial trauma can occur in old people, frequently due to hypertension and vertigo. There are few studies in the literature about dental trauma and the treatment of the teeth which have been affected[5-8]. Dental implants have been used for replacing the teeth that have been extracted or removed. It is believed that teeth do not stabilize implants, but fully integrated implants can stabilize periodontally compromised teeth. The problem with a combination of implant-tooth supported prosthesis originated from knowledge that the tooth and the osseointegrated implant have dissimilar mobility patterns[9-11].

The purpose of this article was to evaluate clinical success of splinting anterior mobile teeth that were injured by trauma with already osseointegrated implants.

Case Report

A 56-years-old female patient was referred to Marmara University Faculty of Dentistry with complaints about the maxillary and mandibular removable prosthesis. The remaining dentition included 4 maxillary teeth (right first central incisor, left central and lateral incisors and left canine) and 3 mandibular teeth (right canine, left lateral incisor and canine).The patient was treated by 7 implants (ITI, Straumann, Waldenburg, Switzerland) to reconstruct the posterior edentulous maxillary and mandibular jaws. 3 implants were inserted in the right and 2 implants in left posterior maxilla (Fig. 1). 2 implants were inserted in the mandibular arch in the place of first premolars. 1 week after the right mandibular implant insertion, the implant was lost due to infection of the root canal treated canine. 3 months after the extraction of the canine, 2 implants were inserted in that area.

The anterior teeth were treated with metal-ceramic crowns and the posterior implants treated with implant supported fixed prostheses in the maxillary arch. The mandibular anterior region was treated with implant-teeth supported prosthesis. The posterior region was treated

with precision attachment prosthesis. The patient was comfortable and, at annually recalls, the implants were in function and clinically stable when tested individually; there was no pain from the implants, and the peri-implant soft tissues were clinically healthy.

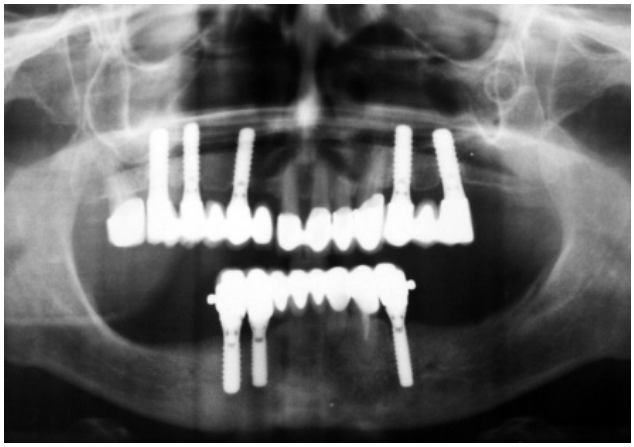

Figure 1. Radiographic view before trauma

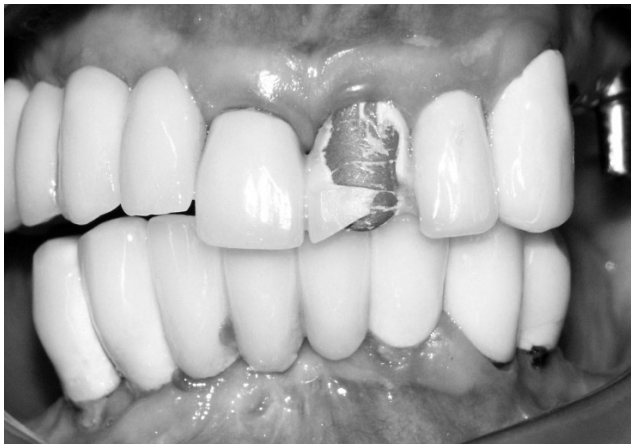

Figure 2. Intraoral view after trauma

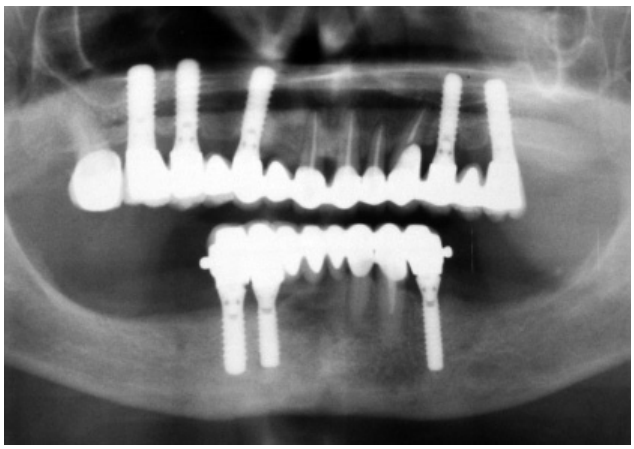

Figure 3. Radiographic view after treatment

3 years after the treatment the patient came with an anterior teeth trauma by a fall. The intraoral and radiographic examinations were done and it was seen that the anterior teeth were mobile but there was no damage in the posterior region and the implants were clinically and radiographically healthy (Figs. 2 and 3). There was a segmental movement in the anterior region.

The anterior teeth were treated by root canal treatment. After the root canal treatment it was decided to splint the anterior teeth with implants. The implants were thought to be used for treatment of missing teeth and they would also be used to fix the anterior mobile teeth. Maxillary full arch bridges were fabricated for the anterior teeth and posterior implants to splint the anterior mobile teeth (Fig. 4). After the insertion of the bridge, the implants were evaluated by clinical and radiographic parameters at 1, 2 and 3 years. The status of the peri-implant tissues and of the periodontal tissues of adjacent teeth was assessed according to plaque index, bleeding upon probing, probing depth, mobility index, suppuration upon palpation.

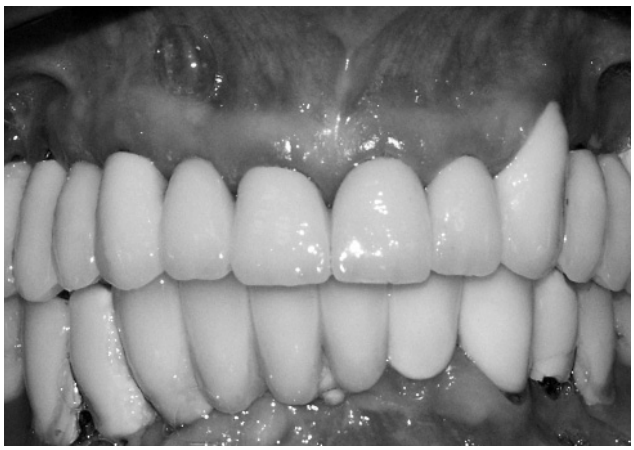

Figure 4. Intraoral view after treatment

The patient was satisfied with the new prosthesis, there was no mobility, no pain, no bone loss around the implants, no bleeding on probing at abutment connection and at the last recall, peri-implant tissues were healthy. The teeth were asymptomatic and there was no pain on percussion. In the radiographic examination there were no lesions around the teeth and the implants.

Discussion

Treatment of an injury in the anterior maxillary area is usually challenging and difficult. Unfortunately, trauma to this region is very common[5-9]. There are various post-

traumatic bone or tooth conditions that demand different treatment strategies. Patients often present loss of tooth and surrounding bone, a tooth remnant with or without inflammatory lesion, an ankylosed tooth. An appropriate treatment plan can usually improve the success and results of these injuries.

Teeth and implants have different mobility patterns. Thus, it has been believed that implant-supported restorations should not be connected to natural teeth. However, this is not always the case[10]. Palmer et al[11] demonstrated fully functional successful restorations with no evidence of tooth intrusion and with stable bone levels at both teeth and implants in 3 years. It is believed that teeth do not stabilize implants but fully integrated implants can stabilize periodontally compromised teeth. In this case report, it was decided to fix the mobile teeth with the already osseointegrated implants instead of extraction, and the patient was fallowed for 3 years. The treatment outcome was satisfactory and successful, but long-term clinical evaluation is needed for advising to splint the traumatized teeth to osseointegreated implants.

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Correspondence and requests for offprints to:

Burcin Vanlıoğlu
Güzelbahçe, Büyükçiftlik Sokak, No: 6
Marmara University
34365, Nişantaşı, Istanbul
Turkey
E-mail: drburcinakoglu@hotmail.com

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Fabrication of a Custom Protective Guard for an ERA Maxillary Overdenture: A Case Report

SUMMARY

Management of complete edentulous patients suffering neuromuscular disorders or having parafunctional habits, such as bruxism, is a challenging task. It requires modification of traditional techniques for complete denture construction even in overdenture cases. Additional appliances, such as a protective guard, may also be necessary.

This clinical report addressed the difficulties encountered and the prosthodontic management of a 64-year-old medically compromised patient. A maxillary overdenture was constructed, as well as a protective night guard for the overdenture abutments, to avoid wear due to the patient's parafunctional habits.

Keywords: Overdenture; ERA Attachments; Protective Acrylic Guard; Prosthodontics

Harry P. Papanagiotou[1], Meropi N. Armaou[1], Phophi Kamposiora[1], George A. Papavasiliou[1], Alexandra Sklavounou[2]

University of Athens, Dental School
Athens, Greece
[1]Department of Prosthodontics
[2]Department of Oral Pathology

CASE REPORT (CR)
Balk J Stom, 2012; 16:60-64

Introduction

Placing an overdenture on natural teeth or dental implants is an alternative solution for many patients who have restrictions or difficulties in the use of conventional complete *dentures*[1]. Some of these restrictions include absorbed alveolar crests, poor neuromuscular adaptation *and maxillofacial deficiencies after surgery*[2-4]*. The use of attachments on natural teeth or implant abutment*s increases retention and stability, minimizing possible complications that can be caused from a removable prosthesis' use. The patients with this kind of prosthetic intervention adjust themselves faster to the new conditions[5,6].

As with conventional complete dentures, daily removal of overdentures is recommended in order to allow supporting tissues to relax and rebound[7,8]. Removal of the prosthesis is recommended to be done overnight as at that time the aesthetic and functional needs are not of a particular concern. The prosthesis' removal, may allow for undesirable contacts between the abutments and the artificial or natural opposing dentition, or even with the soft tissues. These contacts, especially in cases of parafunctional habits, such as bruxism, may cause discomfort to the patient and lead to wear or fracture of teeth or attachments[9]. To avoid such consequences, the use of protective elastic cups is suggested over metallic overdenture attachments, such as the ERA. However, there are restrictions with their use, since time and skills by the patient is required for the implementation of the individual elastic cup on each abutment. This is a particularly difficult process for elderly patients with physical disabilities. Furthermore, the soft material's wear is not eliminated and there is risk of detachment and swallowing or aspiration of the elastic parts during sleep. For these reasons the construction of protective guards, which are supported by the overdenture's abutments is a more indicative solution.

The present paper describes fabrication of a protective overdenture night-guard with the process of hot cured acrylic resin over teeth, reconstructed with ERAs on cast posts[10,11].

Clinical Review

A 64-year-old male patient presented in the Graduate Prosthodontics Clinic of the University of Athens, wearing a maxillary overdenture, retained by cast ERA attachments over metallic cups using teeth #11, 14 and 15 as abutments. Prosthetic rehabilitation of the mandible consisted of a metal-ceramic fixed partial denture (FPD) with teeth #43, 33, 35 as abutments, and a removable partial denture (RPD) for the posterior area.

In the patient's medical history a *bone marrow transplantation 9 years ago* was reported *due to myelodysplastic syndrome. Removal* of a vocal cord polypoid was done 4 years ago. The patient received cortisone (Dexamethasone tab.), systematically, and was under medical treatment for high blood pressure and hypercholesterolemia.

In his dental history presence *of* angular cheilitis (Fig. 1) of pharmaceutical aetiology was reported, showing exacerbations and remissions. Extended areas of atrophic mucosa, combined with non-peeled white lesions were observed on the left buccal area and the left side of the palate. The mucosa was non-elastic and fragile, particularly on the left side of the mouth, which bled easily. Furthermore, upon removal of the overdenture, wear of the metallic ERA on tooth #11 was observed (Fig. 2) due to the contact with the opposing metal-ceramic FPD. The other 2 attachments, placed on teeth #14 and 15, were not showing wear since they did not have antagonists as the lower PRD, which was being removed from the mouth at night as well (Fig. 3). The abraded surface of the attachment combined with the extensive wear of the existing overdenture lead to the conclusion of parafunction.

The patient desired to replace the overdenture due to the extended wear of the acrylic teeth (Fig. 4), as well as loss of retention (Fig. 5). The treatment plan also included construction of a protective acrylic night-guard over the ERAs.

To compensate for the wear of the acrylic teeth and reduce the symptoms of angular cheilitis, the new overdenture *was* decided to be fabricated in a slightly increased vertical dimension of occlusion (VDO). The absence of stomatitis during clinical appointments allowed selective pressure to be applied in order to achieve border moulding and a successful final impression. The attachments were activated intra-orally while, due to lack of space, metallic housings were not use for the retentive ERA elements.

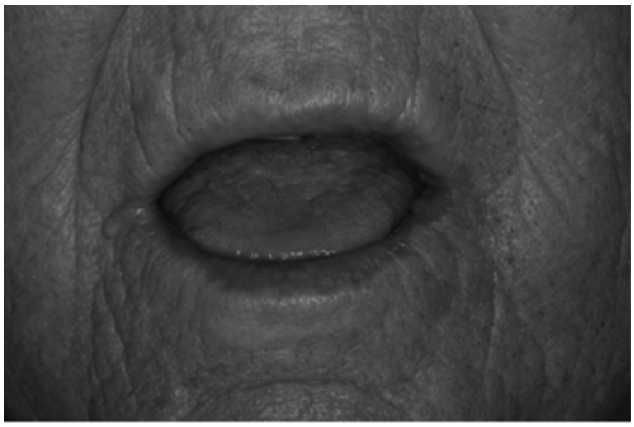

Figure 1. Presence of angular cheilitis

Figure 2. Wear of the ERA attachment on the tooth #11

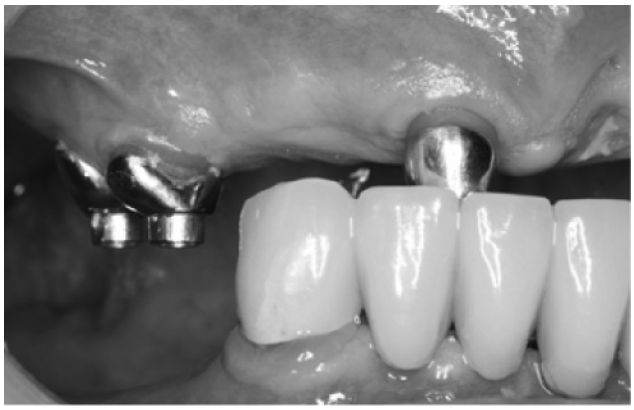

Figure 3. Contact of the ERA metallic attachment with the opposing FPD; when the maxillary overdenture is removed from the mouth, the other 2 ERA attachments have no opposing dentition

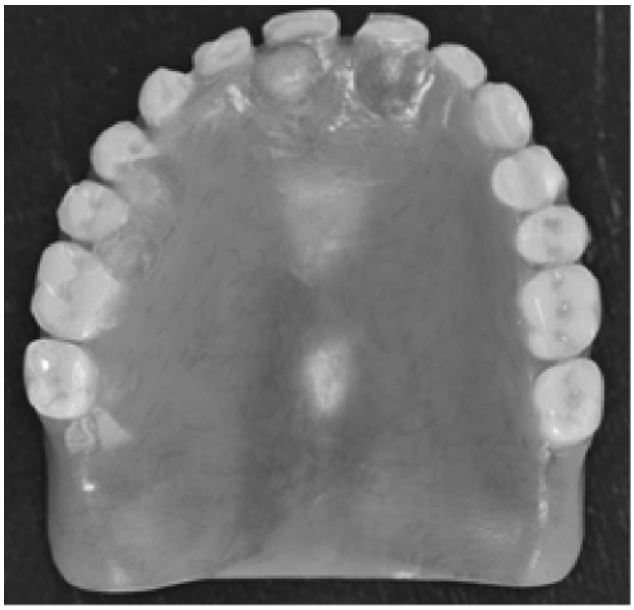

Figure 4. Old overdenture - wear of the acrylic teeth

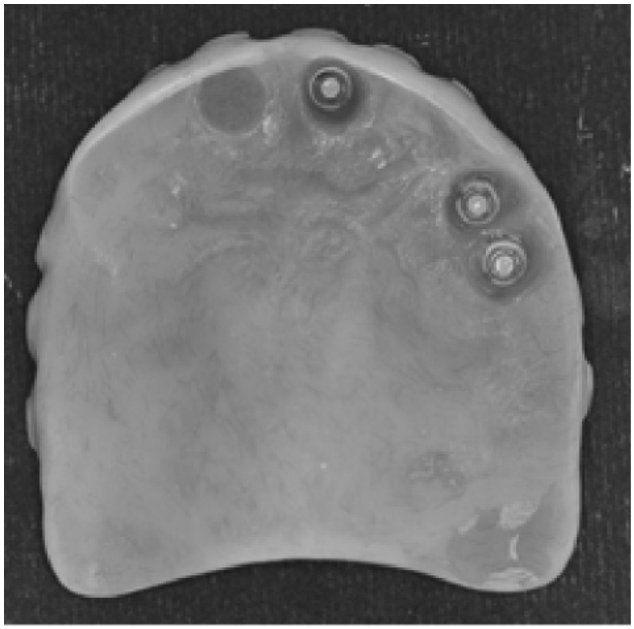

Figure 5. Old overdenture - the retentive elastic elements have lost their yielding ability

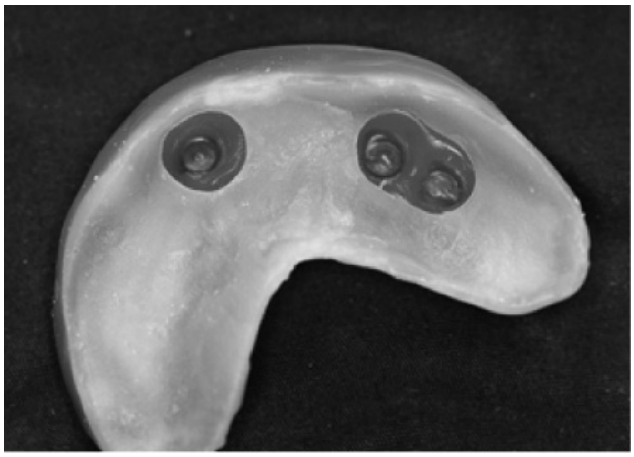

Figure 6. A record base plate with wax rim is fabricated on the duplicated cast

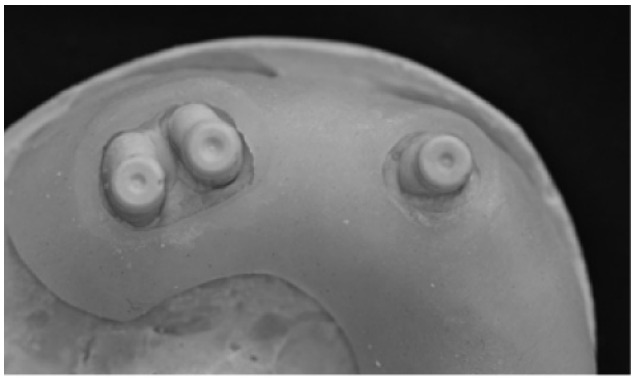

Figure 7. A record base plate is fabricated on the duplicated cast. The laboratory retentive analogues are duplicated too

Fabrication Technique for the Protective Night Guard

Following delivery of the overdenture, the protective night-guard was fabricated as follows:

Laboratory ERA retentive elastic elements (black colour) were placed on the laboratory analogues of the working cast which had been duplicated. The protective night-guard had to be teeth supported in order to achieve tissue relaxation. Therefore, the dimensions of the night-guard had to be limited*;*

A record base with wax rims was fabricated on the duplicated cast (Figs. 6 and 7);

The record base was placed into the mouth and VDO was adjusted. The desired VDO was the same as that of the new overdenture;

The night-guard' wax-pattern was removed from the working cast and, using a sharp instrument, a small amount of wax was removed from the reception area of the retentive ERA elements;

The night-guard was fabricated with heat cured methyl-methacrylate resin;

The guard was activated intra-orally (Figs. 8A and 8B) using the laboratory (black coloured) retentive elements and cold cured acrylic resin. The occlusion on the guard was adjusted in order to achieve equally distributed occlusal contacts.

Delivery of the Night Guard - Maintenance

At a delivery appointment, occlusal contacts, retention and stability of the guard (Figs. 9A and 9B) were adjusted. Emphasis was given to the ease of use of the device, as well as avoidance of potential discomfort and trauma. The patient was instructed to use the protective guard each time the overdenture (Fig. 10) was being removed from the mouth in order to protect the metallic attachments from further wear. A recall schedule was set for the patient, once a week for the first month, once a month for the next 3 months and then every 6 months. During the first recall examination, the size of the night-guard on the left side was reduced as the mucosa, being non-elastic and fragile, was traumatized causing bleeding.

The laboratory retentive elements which were decided to be activated for the intraoral implementation of the device provided comfort ease of use and sufficient level of retention. In case additional retention was needed, these elements could be replaced with more retentive ones, available for ERA's

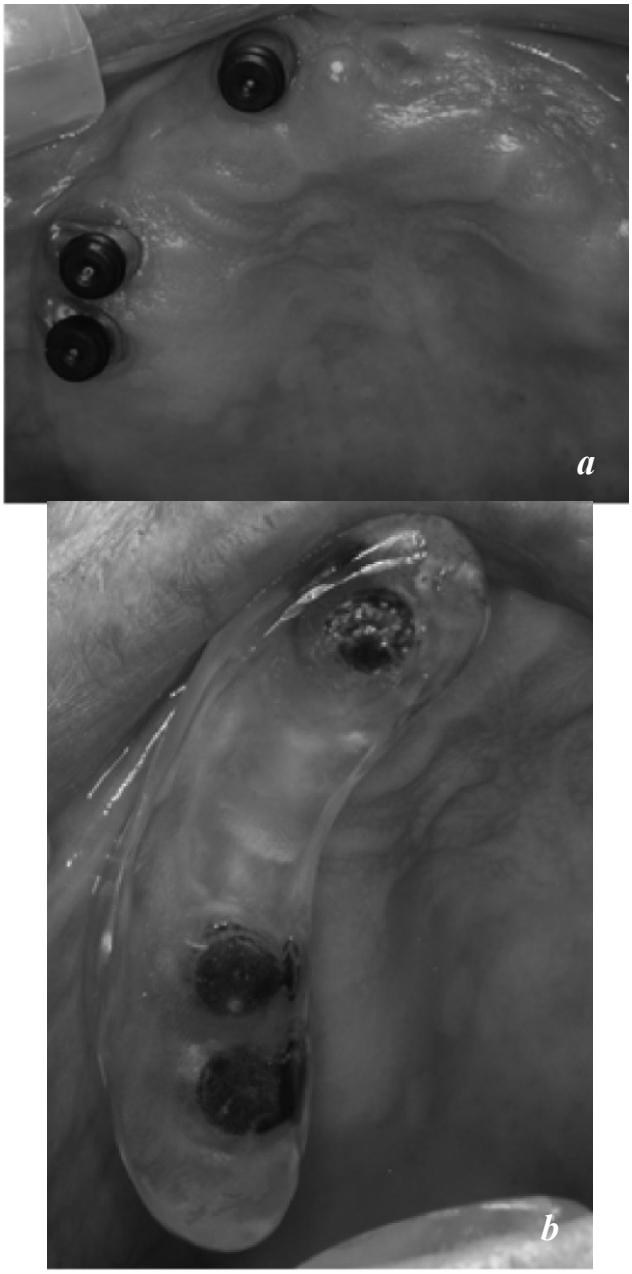

Figure 8, A and B. The laboratory retentive analogues are positioned on the ERA attachments. The new protective guard. The laboratory retentive analogues are activated intra-orally

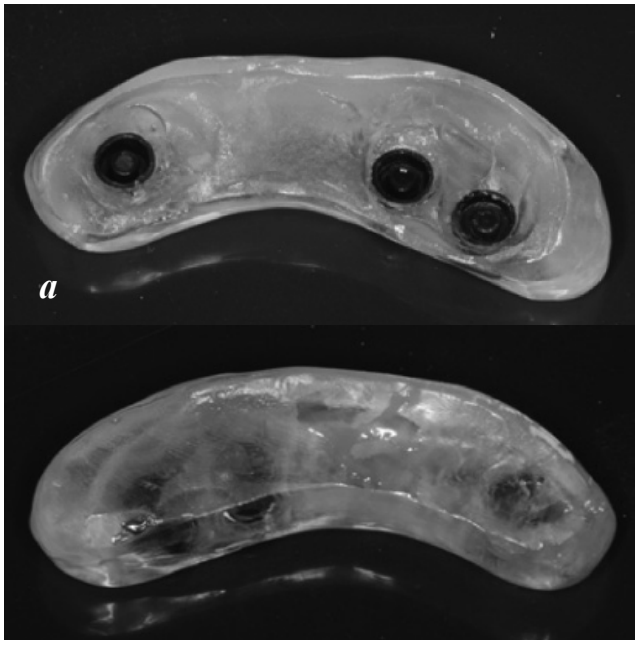

Figure 9, A and B. Views of the new custom made protective guard

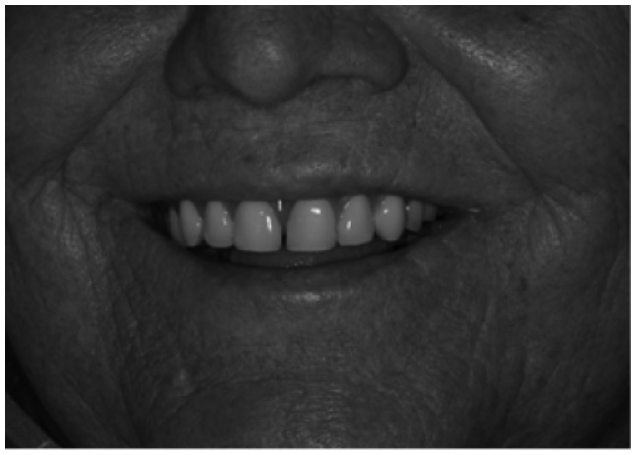

Figure 10. Buccal view of the new overdenture

Conclusions

Parafunctional habits, such as bruxism, are not only observed in patients with natural dentition or fixed prostheses. They also appear in patients with extensive edentulous areas using removable prosthetic appliances. Therefore, it is essential to ensure protection of the dental or mechanical overdenture abutments with the fabrication of protective guards, which can be easily adjusted and individualized depending on the patient needs.

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Correspondence and request for offprints to:

Harry P. Papanagiotou
124B Vas. Sofias Av
11526 Athens
Greece
Email: hpapanag@hotmail.com

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Text. The complete title should preceed 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:

1. Brown JS, Browne RM. Factors influencing the patterns of invasion of the mandible by squamous cell carcinoma. Int J Oral Maxillofac Surg, 1995; 24:417-426.
2. Sternbach RA. Pain patients - traits and treatment. New York, London, Toronto, Sydney, San Francisko: Academic Press, 1974; pp 20-30.
3. Koulourides T, Feagin F, Pigman W. Experimental changes in enamel mineral density. In: Harris RS (ed). Art and Science of Dental Caries Research. New York: Academic Press, 1968, pp 355-378.