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Microinvasive treatment modalities in operative Dentistry

The College of Dentistry, University of Baghdad, Department of Conservative in Partial Fulfillment for the Bachelor degree of Dental Surgery

By:
Maha Maroof Majeed

Supervised by:
Assistant professor Dr. Lamis A.Al-Taee
BDS, MSc, PhD. United Kingdom

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Certification of the Supervisor

I certify that this project entitled “**Microinvasive treatment modalities in operative Dentistry**” was prepared by **Maha Maroof Majeed** under my Supervision at the College of Dentistry/University of Baghdad in partial fulfilment of the graduation requirements for the Bachelor Degree in Dentistry.

Supervisor’s name: Assistant professor Dr. Lamis A. Al-Taee

Date: 4/2023

Dedication

To my father for his support,

To my kind mother for her patience,

To my brothers and sisters and for their encouragement.

Acknowledgment

First and foremost, praises and thanks to **Allah** Almighty for helping me to fulfill my dream, for his blessings throughout my work to complete it successfully.

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I would like to show my deep and sincere gratitude to my research supervisor, **Assistant professor Dr. Lamis A. Al-Taee** for her advice, encouragement, and guidance in planning and conducting this project.

List of contents

List of Figures

List of Abbreviations

KHN	Knoop hardness number
Er:YAG	Erbium-doped yttrium-aluminum-garnet
CO2	carbon dioxide
WSL	white spot lesion

Introduction

The traditional restorative techniques in caries management involve the removal of large amounts of tooth structure to eliminate the cariogenic bacteria and demineralized tooth tissues and prepare the tooth to receive restorations that can preserve function and aesthetics **(Banerjee et al., 2017)**. However, the advent of adhesive and bioactive materials that can bond chemically, made the extensive removal of tooth structure for the retention of restorations is unnecessary. These materials also provide an excellent peripheral seal and isolate the carious lesion from the oral environment, to arrest caries without the need for complete decay excavation **(Paddick et al., 2005)**. Recent studies suggest that demineralized but structurally intact dentine can be remineralized **(Ngo et al., 2006)**. To preserve the affected dentine that can be remineralized, attempts are made to selectively remove infected dentine from deep carious lesions during cavity preparation. Clinical studies have shown that this approach reduces the risk of pulp exposure and increases the probability of treatment success in comparison to the conventional excavation **(Ali et al., 2018)**. Thus, a better understanding of the caries pathology combined with newer dental materials and evidence gathered from clinical studies have paved the way for the minimally invasive treatment approaches, which emphasize the maximum conservation of healthy tooth structure and avert the need for conventional restorations that often plunge the tooth into a treatment-retreatment cycle, often referred to as the “death spiral of restoration” **(Qvist, 2021)**.

The non-invasive treatments include the use of prevention measures such as dental floss and fluoride application that focus on the reduction of the biofilm cariogenicity via plaque control and rely largely on patient compliance **(Pitts, 2004)**, whereas minimally invasive treatments (e.g., resin infiltration and sealants) involve the formation of a mechanical barrier to protect the tooth against the biofilm and are less dependent on patient compliance **(Splieth et al.,**

2020). Specific indications for each of these techniques vary and their efficacy is governed by factors such as individual caries risk, lifestyle, and extent of decay, tooth surface involved, number of surfaces involved and type of dentition. When used appropriately, these treatments yield results comparable to traditional treatment in terms of clinical outcomes and restoration longevity and have been found to be less time-consuming **(Elamin et al., 2019)**, associated with less dental anxiety and discomfort and more cost-effective in the long term. Therefore, it is imperative to use these techniques as the first line of treatment whenever possible, resorting to invasive restorative approaches only when these strategies are deemed to be insufficient for caries management. Lastly, the overall success of these techniques in preventing and arresting carious lesions provides impetus for the continued development of these approaches **(Jorge et al., 2019)**.

The approach of minimally invasive operative dentistry should be **(Banerjee and Watson, 2015)**:

1. The excavation of the unrepairable, diseased enamel and dentinee only, keeping cavities as small as possible and preserving sound and repairable tissue where possible
2. Physically and chemically modifying/optimizing the remaining cavity walls in order to
3. Restore cavities with suitable adhesive materials which will:
   - Support and strengthen the remaining tooth structure
   - Promote remineralization and potentially have antibacterial activity
   - Seal off any remaining bacteria from their nutrient supply, thereby arresting the caries process in the residual caries retained within the cavity depths.

Aims of the study

To review the available literature regarding different microinvasive treatment modalities in operative dentistry and their clinical applications

Chapter one: Review of literature

Microbiological aspects of caries treatment

Microbe invisibility makes it easy to deny their presence. The microbes in dental caries have generally been disregarded clinically. The emphasis clinically has been on removal of damaged tooth structure and insertion of various materials to restore the tooth's form and function. Little attention has been given to the possibility that the microbes that caused the original lesion might remain present, viable, and able to reinitiate destruction of the tooth after placement of the restorative material. More recently clinical emphasis has moved toward slowing lesion progress and cutting minimally, or not at all. However, attention to the lesion microbes has remained secondary to saving time, cost, and trauma during treatment **(Jorge et al., 2019)**.

Current thought defines dental caries as "a biofilm disease" caused by microbe shifts due to changes in the oral environment from inappropriate diet, poor oral hygiene, and/ or medications that alter saliva flow and composition. Authorities say these factors causing microbe shifts can be managed behaviorally, thus preventing development of dental caries. However, experienced clinicians say patient behavior changes occur sporadically, or not at all, and dental caries seem to be inevitable over a human's lifetime **(Banerjee and Watson, 2015)**.

Although there are studies showing an association between dental caries and S. mutuns, lactobacilli and Actinomyces, most of samples were collected from caries sites wherein these groups of bacteria cannot be isolated. This could suggest that other microorganisms can contribute to the dental caries process. Therefore, it is the change in dental plaque ecology that leads to caries lesion development. Whenever there are non-shedding surfaces, bacterial cells will attach to saliva film called the pellicle; the bacterial cells start to multiply to form a microcolony. If left undisturbed the growth continues, resulting in a mature type of biofilm within a week. Different types of acids are created as a result of biofilm metabolism, which causes a shift in oral pH under the critical level. This reduction in the pH level will influence the chemical composition of the tooth surface. The cumulative result of many pH fluctuations over a long period of time is the loss of calcium and phosphate, which makes the enamel surface seem porous (which can be detected clinically as a white spot lesion). Thus, the caries lesion is a result of an imbalance in the equilibrium between tooth mineral loss and biofilm fluid **(Al-Shahrani, 2019)**.

Minimally Invasive materials and Techniques

1- Air abrasion

Air abrasion may be broadly defined as a method of delivering an abrasive material under varying pressures for removing deposits and stains from teeth, modifying the surface of dental materials, or cutting tooth structure. Air abrasion may also be called air abrasive, micro air abrasion, kinetic cavity preparation, or accelerated particle ablation. It can utilized as a prophylactic and polishing applications (lower pressure), the removal of enamel and dentine (higher pressure) or modifying surfaces to enhance bonding **(White and Eakel, 2000)**.

Types of particles

Most devices utilized for air abrasion cavity preparation have used aluminum oxide as the abrasive agent. It contains no silica, and is classified by the U.S. government as a "nuisance dust." If inhaled, particle sizes larger than 10 microns cannot enter the alveoli and therefore this powder has low potential for causing respiratory problems. Proper use of evacuation and rubber dam that extends over the nostrils minimizes inhalation of particles by the patient."

More recently, a bioactive glass powder (calcium sodium phosphosilicate) is also being used as an oral cavity abrasive polishing agent for the removal of weakened or decayed small enamel lesions and for the cleaning of enamel surfaces. It is contraindicated for patients with allergy to silica. This biologically compatible powder is significantly softer [420 Knoop hardness number (KHN)] than aluminum oxide (2100 KHN), **(Banerjee et al., 2011)**.

An additional application is the ability of bioactive glass to close the exposed dentine tubules. A clinical study (**Banerjee et al., 2010)** reported used double-blind, split mouth investigation involving 25 patients assessed the effectiveness of prophylaxis treatment using bioactive glass in an air polishing device in reducing dentinal sensitivity to cold air and cold contact (ethyl chloride). They found that the treatment was clinically effective in reducing sensitivity for the duration of the 10-day study period, and indicated physical occlusion of dentinal tubules.

The use of bioactive glass for remineralization have been studied. An in vitro investigation **(Parker, 2007)** showed that it can increase the mineral content of artificial white spot lesions in human enamel samples following a 10-second air-abrasion exposure to bioactive glass at relatively low air pressure of 20 psi. This was followed by application of bioactive glass slurry twice daily, 5 minutes per application, for 21 days.

Clinical applications

Clinical applications of air-abrasive cavity preparation devices **(Graeber, 2021)**:

- Penetrating and excavating enamel and dentine
- Preparing small class I, class II, class III, class IV, class V, and class VI cavity preparations for composite restorations
- Excavating preexisting composites, glass ionomers, porcelain inlays and onlays, fractured facings, and residual amalgam stains (amalgam restorations require removal via rotary instrumentation)

- Repairing failed composites and glass ionomers, fractured porcelain and facings, and margins of porcelain-laminated veneers
- Preparing the surface of abfractions and abrasions
- Cleaning and removing cements and adhesives from castings, bridges, and crowns extraorally, prior to re-cementation
- Achieving greater retention by roughening inner surfaces of crowns and during application of pit and fissure sealants
- Diagnosing and treating decay difficult to detect by other means, as a conservative method for early interception of decay
- Opening the porcelain surface of a porcelain- fused-to-metal restoration when endodontic access is desired (rotary instruments are used to remove the metal and remaining dentine)
- Opening acrylic or porcelain jackets (rotary instruments are used to remove the tissue beneath the jacket)
- Preparing adhesive surfaces of orthodontic bands and brackets to increase retention

2- Dental Lasers

Many dental lasers have been used effectively for the minimally invasive treatment and selective tooth tissue removal. Moreover, they provide un painful treatment reducing the need for anesthesia, since the pulse time is much shorter than the nerve impulse time, so the patient rarely senses pain and thus indicated for patients who exhibit fear from conventional drilling **(Parker, 2007)**. However, their use are limited when in large cavities or the caries near old fillings, and in some cases, the conventional drilling is still required for bite adjustment, and shaping and polishing the fillings. Moreover, it is considered as costly method of treatment with the need of special equipment for safety issues.

A- Erbium: YAG laser

The Erbium laser can be used for cavity preparation and caries management. It can selectively ablate the infected tissues only since they have high water content, while the healthy tissue with less water content cannot be easily removed using the same parameters. Furthermore, this laser don’t create a smear layer that affects the bonding to enamel or dentine **(Júnior et al., 2009)**. The use of laser is beneficial for bacterial decontamination of the irradiated area, due to the ability to eliminate the bacteria that extend nearly 1 mm inside the dentinal tubules **(Konopka and Goslinski, 2007)**. Moreover, this laser don’t create friction, therefore, there is no possibility of micro-cracks in the remaining structure. However, to reduce the harmful effect of heat on dental pulp, the handpiece tip must not touch the tooth structure during laser emission. It is indicated in pit, fissures, and smooth surface caries removal (class I, II, III, IV, and V) and fissure sealant. Also used for conditioning the superficial enamel 'laser etching'. However, it is regarded as slower operation compared to high-speed hand piece.

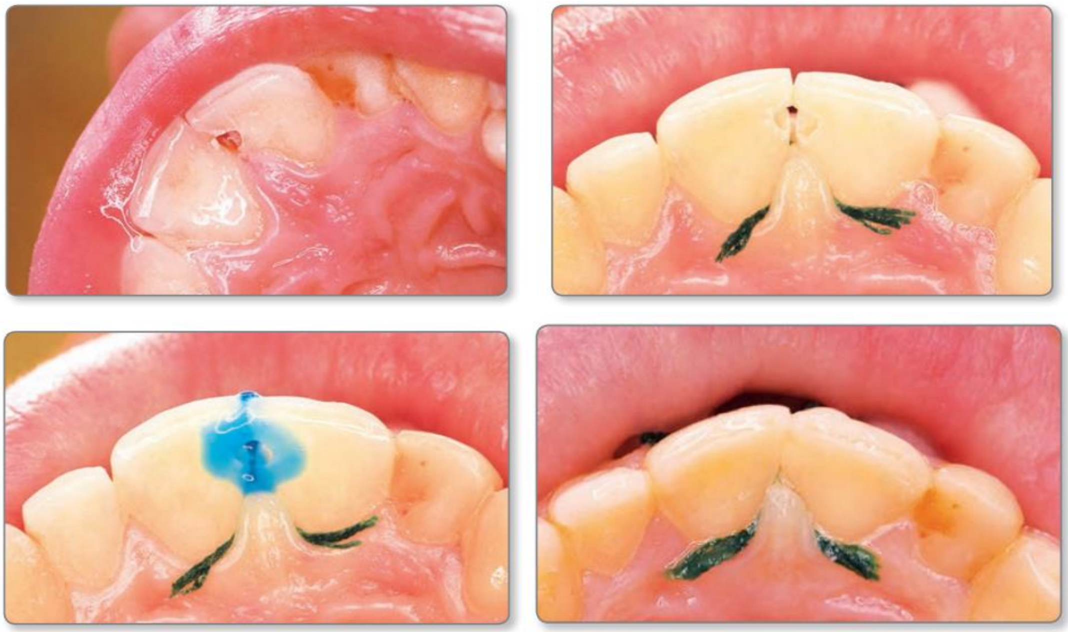

Figure 1: Class III caries removal using Erbium laser

As carious dentine and enamel possess a much higher amount of water than sound dental tissues, the intrinsic tissue properties allow for a selective ablation. In this case, the delivered laser energy has to be lower than the ablation threshold for sound enamel and dentine ablation, but high enough to cut the diseased tissues. The combination of laser fluorescence by means of a diode laser in Er:YAG laser equipment has shown to provide secure information and to be able to guide selective ablation **(Hibst, 2002)**. Furthermore, acoustic feedback mechanisms have also been developed to guide selective ablation. A comparative study **(Arslan et al., 2012)** was done comparing the removal of root caries by bur versus Er,Cr:YSGG laser (20 Hz, 140 µs pulse duration, noncontact mode using a 600-µm tip with power outputs up to 4 W). It showed that caries removal by laser was associated with excessive loss of marginal seal in composite resin restorations, with the presence of residual caries as compared to the conventional method. In contrast, **Strakas and Gutknecht, (2018)** showed a minimum amount of microleakage of conventional glass ionomer restorations for root caries when the Er,Cr:YSGG laser was used at 2.5 W and energy density of 44.64 J/cm^2, in comparison to hand excavation and rotary carbide burs.

Figure 2: Er,Cr:YSGG no. 36–37 caries removal with a MZ6 tip

B- Carbon Dioxide lasers CO_2

In December of 2013, Convergent Dental introduced a completely new laser, the carbon dioxide (CO2) laser operating at a new wavelength of 9300 nm (Solea) (Figure 3) **(Fantarella and Kotlow, 2014)**. This isotopic C12018 laser was developed with the promise of making the restoration of decayed teeth almost completely anesthetic free and allow for minimally invasive conservative restorative dentistry techniques with minimal peripheral thermal or mechanical damage to the surrounding tissues or dental pulp. This is very useful for children and adults, reducing the stresses and anxiety of dental treatment **(Nguyen et al., 2011)**.

Figure 3: Solea 9300nm laser

The role of CO_2 lasers in caries prevention has been explored since the 1960s. For caries prevention purposes, it is likely that the most effective wavelengths are those are most strongly absorbed by the mineral of dental hard tissues. The CO_2 laser wavelengths of 9300 nm, 9600 nm, 10,300 nm, and 10,600 nm showed a strong absorption of phosphate bands in tooth mineral. To prevent dental caries, the laser light must alter the composition and solubility of the dental substrate and the energy must be strongly absorbed and efficiently converted to heat without damage to underlying or surrounding tissues. Studies on the effects of CO_2 lasers focused on increasing the resistance to caries by reducing the rate of subsurface enamel and dentine demineralization. A greater depth of carbonate loss in enamel was gained by using 10,600 nm CO_2 laser compared to 9600 nm. Featherstone et al. (2007) reported that the use of pulsed CO_2 laser at 9600 nm produced 84% inhibition of demineralization in a clinical study. Furthermore, some studies have combined the effects of lasers with fluoride **(Chang et al., 2017)**. In an in vivo study, **Rechmann et al. (2013)** showed that occlusal fissures irradiated by a 9600 nm CO_2 laser followed by fluoride varnish application twice a year are more resistant to caries than fissures without irradiation. Another study using a 9300 nm CO_2 laser showed that mineral loss was reduced by 55% compared to fluoride application. However, it was reported that there was no increase in acid resistance in dentine when 9300 nm CO_2 lasers was used **(Luk et al., 2019)**.

3- Dentine regeneration

In dentine, the carious tissue is categorized into two main layers; the superficial caries-infected dentine that shows destructed dentinal tubules and collagen fibres beyond repair with prominent bacterial invasion. Whilst, the deeper caries-affected layer characterised by demineralization of intertubular dentine, deposition of crystals in tubules, less destruction of collagen matrix without bacterial penetration. This structurally intact dentine can be remineralised and thereby must be preserved **(Ngo et al. 2006)**, however, the discrimination between these layers is difficult clinically. The complete removal of carious dentine in deep lesions is considered overtreatment and no longer advocated **(Schwendicke et al., 2016)**. In contrast, the selective removal of infected tissues and maintaining a layer of the affected dentine will preserve the structural integrity of remaining dentine and avoid pulp exposure **(Guedes et al., 2021; Chow et al., 2007; Williams et al., 2004)**.

Interestingly, the incomplete removal of the caries-affected dentine combined with the use of specific therapeutic materials that contain calcium and phosphate ions will provoke a pulp response and modulate the reparative dentinogenesis process which involve the formation of new odontoblast-like cells from stem/progenitor of the pulp that deposit reparative dentine to protect the pulp structure and increase the longevity of pulp-dentine complexes **(Guisti et al., 2008)**. Studies found that the selective removal of the heavily infected dentin biomass while leaving affected dentin near the pulp has favorable results **(Banerjee et al., 2010)**. This is preserved in order to avoid pulp exposure & is covered with a suitable material. A clinical study **(Gruythuysen et al., 2010)** has shown that this technique results in a high 3-year survival rate in primary & permanent teeth when examined clinically & radio-graphically. The survival rate was 96% for 86 primary molars and 93% for 34 permanent teeth.

Another study **(Falster et al., 2002)** demonstrated a high clinical & radio-graphic success rate after 2-year follow up when indirect pulp capping treatment of 48 primary molars was accomplished using an adhesive resin system vs. calcium hydroxide. Indirect pulp protection in another study **(Mukhopadhyay et al., 2004)** had a 94% success rate compared to a 70% success rate of pulpotomy therapy in primary molars.

4- Resin infiltration Technique

This technique relies on the penetration of a low-viscosity resin into porous demineralized enamel for initial caries management. Under isolation, an acid is applied to the affected enamel to provide access into the porous subsurface (lesion body). Then, after rinsing and drying, a low-viscosity resin (with a high penetration coefficient) is infiltrated by capillary action into the lesion, where the resin is polymerized. The resin infiltration recovers part of the structural integrity of the lesion body and occludes the porosities with an acid-resistant material, blocking the diffusion pathways of the biofilm-derived acids and halting the lesion progression. Additionally, it has an aesthetic benefit especially in the buccal surfaces derived from the refractive index of the infiltrant, which is close to the enamel’s refractive index. Consequently, when water and air are replaced by resin in the lesion body, the appearance of the infiltrated lesion becomes similar to sound enamel **(Phark et al, 2009)**.

The prevalence of approximal carious lesions is high, particularly in deciduous molars and permanent posterior teeth. When these lesions are diagnosed earlier, they can be treated non-invasively to enhance the remineralisation and arrest the progression of the lesion. These approaches include; oral hygiene instructions, dietetic counselling and an individualized fluoride regime. Unfortunately, the approximal carious lesions may progress faster than occlusal caries and being more advanced in patients who didn't follow the behavioral recommendations for the non-invasive therapy **(Paris et al., 2010)**. When the caries progress and cavitation is observed, an operative intervention is required. Cavity preparation and restorative procedures in approximal surfaces are laborious procedures and, in some cases, difficulties in accessing the lesions lead to invasive preparations that sacrifice sound dental structure. When a primary carious lesion is treated by means of a restoration (particularly in young patients), it may begin a cycle of successive restorative procedures known as 'tooth death spiral'. This suggests the use of alternatives to arrest caries progression effectively rather than using only traditional secondary prevention measures that could prevent the need for restoration, filling the gap following the philosophy of minimally intervention dentistry **(Hilgert et al., 2016)**. the resin infiltration technique can be performed in just one session, since previous tooth separation is rarely required. A plastic wedge is used to create a minimal interproximal space where a special applicator tip is inserted. The applicator tip allows the operator to control which of the approximal surfaces should receive the product. The first step of the resin infiltration protocol involves etching the lesion surface with a hydrochloric acid to erode the lesion surface layer (approximately 30–40 μm) and to promote access to the porous lesion body. After rinsing and drying with alcohol and air, a very low-viscosity resin is applied. The resin then infiltrates the porous enamel by capillarity, after which the material is light cured **(Meyer et al.., 2007)**.

Treatment of white spot enamel lesions (WSL)

Enamel decalcification occurs when bacterial flora remains on enamel surface for a long time. Organic acids produced by bacteria enter interprismatic spaces in tooth enamel, resulting in white lesions due to dissolution of apatite crystals, calcium and phosphate ions, and demineralization **(Summitt et al., 2006)**. It is commonly seen on the buccal surfaces of anterior teeth when the aesthetic issue is essential. These whitish lesions are caused by many reasons, however, more frequently associated with the fixed orthodontic appliances. Several treatment options have been used for WSLs such as; inducing the remineralization potential of enamel by enhancing the oral hygiene combined with fluoride application associated with changes in dietary habits, microabrasion, restorations and resin infiltration **(Heymann and Grauer, 2017)**. The non-invasive remineralisation measures are mostly indicated for arresting the carious process and inactivating the lesion. In the buccal surfaces, the removal of orthodontic brackets is usually enough to allow better hygiene standards and to arrest the lesion progression. In the case of shallow white spot lesions, the visual aspect of sound enamel might be obtained by a combination of remineralization and microabrasion, owing to access saliva with the effect of tooth brushing with fluoride toothpaste. However, in deeper white-spot lesions, the remineralisation/abrasion process usually does not involve the entire carious lesion. As a consequence, the subsurface lesion body remains porous and filled with water or air that has a lower refractive index than sound enamel. In these cases, the carious lesion is clinically judged as inactive, since the enamel is now shiny and smooth, but the white spot is still visible and may remain visible for many years. Moreover, during the remineralization process, pigments may be incorporated into the enamel and result in brownish-stained areas **(Mattousch**

et al., 2007). In both situations, it is accepted that the carious lesion is controlled, while the aesthetic appearance of the enamel may not be satisfactory. If so, different approaches might be proposed according to the severity of the lesion to the patient, as follows **(Hilgert et al., 2016)**:

• Resin infiltration: The principle is based on filling the subsurface porous enamel of the lesion body with a resin infiltrant that has a refractive index at 1.52 which is closer to that of sound enamel (1.62) than are the indices of water (1.33) and air (1.00). In this way, the color difference between infiltrated white-spot lesions and sound enamel is reduced, and, in most cases, it becomes imperceptible or, at least, more aesthetically acceptable. It is considered a microinvasive procedure since it requires the erosion of enamel surface layer (approximately 30-40 µm) to create access to the lesion body.

• Microabrasion: In this technique, an association of an acid with abrasive agents produces a chemical-mechanical wear of the enamel surface, removing the superficial (affected) enamel. The depth of enamel wear depends on the micro abrasion product, pressure of application and number of applications, but it is estimated to be on average around 200 µm. Microabrasion is an effective treatment for lesions that are not much deeper than the depth of worn enamel **(Murphy et al., 2007)**.

• Cavity preparation: This can be achieved by the removal of the affected enamel using rotary instruments and restoring WSLs with composite resins. This method is called 'macroabrasion', it is indicated for those lesions that are not treated by the non-invasive procedures, or there is poor esthetics.

The ability of resin infiltration to mask carious white-spot lesions has been evaluated in vitro, and the results suggest that it is an effective treatment **(Torres et al., 2011)**. A clinical study **(Kim et al., 2011)** tested the efficacy of resin infiltration in masking post-orthodontic carious white-spot lesions and whitish lesions caused by developmental defects (fluorosis and hypomineralization). In teeth with developmental defects, a complete masking occurred in 25 % of the cases; partial masking was achieved in 35 %, and 40 % showed no relevant aesthetic improvement. In infiltrated post orthodontic carious white-spot lesions, a complete masking was observed in 61 % of the cases, a partial masking in 33 % and in only 6 % was no showed any improvement.

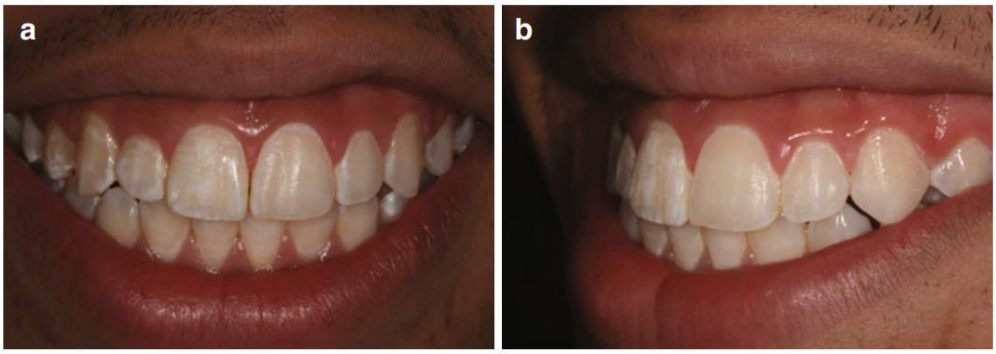

Figure 4: The immediate result after resin infiltration of teeth that allow visual comparison with the non-treated homologous teeth. (a) Frontal view, (b) Left-side view

5- Ozone Therapy in Dentistry

Ozone has been successfully used in medicine for many years, due to its bactericidal properties against oral bacteria such as: Streptococcus mutant, Lactobacillus acidofilus, Enterococcus faecalis, Porphyromonas gingivalis, Tannerella forsythia, Parvimonas micra, Fusobacterium nucleatum, Candida albicans, Candida glabrata and Herpes viruses **(Song et al., 2019)**. It has also used in dentistry in various applications. Ozone is used not only in dental treatment and aesthetic procedures such as teeth whitening, but also for disinfecting the waterline of the dental unit and the dental office itself **(Seydanur et al., 2019)**. Ozone therapy modalities include; ozone gas, ozonated water, and ozonated olive oil. Water and olive oil have the capacity to capture and then release ozone, providing greater control over the procedure than when using ozone in gaseous form. The aforementioned modalities are used alone or in combination depending on the clinical application and the expected results of treatment of the teeth and periodontal tissues **(Smith et al., 2017)**. The use of ozone in the above-mentioned modalities is not limited to conservative dentistry, but has found applications in many treatments representing various fields, including endodontics, periodontics, surgery, and even head and neck oncology **(Isler et al., 2018)**.

Ozone therapy in conservative dentistry

Dental caries is a chronic multifactorial disease caused by bacteria that can damage teeth in both children and adults. Caries is widespread in all cultural groups and is one of the most common health conditions affecting the world population (WHO 1990). Treating and preventing dental caries is the remit of restorative dentistry, and in this field, ozone has also been considered as a treatment and prevention modality **(Barczyk et al., 2023)**.

Ozone has been shown to have a toxic effect against some groups of bacteria, and this has given rise to the hope that ozone delivered into a carious lesion can be used to reduce bacterial counts. Control of the bacterial biofilm is one of the pillars of conservative dentistry. The study conducted by M. Nagayoshi demonstrated the effect of ozone on bacterial plaque. After exposing the sample to ozonized water, there was a significant decrease in the number of bacteria including S. mutans, the major pathogen of dental caries. During the experiment, a decrease in the viability of bacteria S. mutans was noted at 58% after exposure to 0.5 mg/L of ozonated water for 10 s, while using concentrations of 2 mg/L and 4 mg/L, the reduction in bacteria was 100%. Survival of other microorganisms important in the cariogenic process, such as S. sobrinus, S. sanguis, and S. salivarius, was recorded at a similar level to S. mutans. The results suggest that ozonated water may be useful in controlling oral infectious microorganisms present in dental plaque **(Rumbaugh and Sauer 2020)**.

In modern dentistry, the use of ozone has been tested as a treatment for cavities of carious origin. One such attempt was undertaken by Aylin Baysan and Edward Lynch. Ozone was applied to root carious lesions. The study showed a statistically significant reduction in the bacterial count in the carious lesion, leading to a change in the disease process to a stage making it possible to conclude that further progression had stopped. Overall, however, research findings are inconclusive. Experiments by other researchers found no effect of ozone therapy on halting or delaying disease progression **(Rickard et al., 2004)**.

Ozone therapy in teeth whitening

The oxidizing properties of ozone have inspired researchers to use it as an alternative bleaching substance for stained teeth. Tessier et al., showed that the yellowing of tetracycline-stained rat incisors was diminished after applying ozone for a minimum of 3-4 min. However, more recent reports point out that the above study should not be regarded as sufficient evidence for the efficacy of ozone in removing these stains, due to the differences in size and chemical composition of rat and human teeth, their pigmentation and the application technique **(Naik et al., 2016)**.

In a comparison with hydrogen peroxide, ozone was not shown to be a more effective bleaching agent, which may be due to the pH-reducing hydroxyl radicals produced by hydrogen peroxide. A higher pH has been associated with more effective tooth bleaching **(Zanjani et al., 2015)**.

However, the synergistic effect of ozone on bleaching with simultaneous use of hydrogen peroxide remains debatable. In the study by Naik et al., this effect was not demonstrated, while another study showed that the use of 38% hydrogen peroxide together with ozone provided an improved bleaching effect **(Al-Omiri et al., 2018)**.

Chapter two: Discussion

Minimal Intervention Dentistry (MID) is the modern medical approach to the management of caries, utilizing caries risk assessment, and focusing on the early prevention and interception of disease. Moving the focus away from the restoration of teeth allows the dentist to achieve maximum intervention, with minimal invasive treatments. The four core principles of MID can be considered to be: (1). Recognition: Early identification and assessment of potential caries risk factors through lifestyle analysis, saliva testing and using plaque diagnostic tests. (2). Reduction: To eliminate or minimize caries risk factors by altering diet and lifestyle habits and increasing the pH of the oral environment. (3). Regeneration: To arrest and reverse incipient lesions, using appropriate topical agents (4). Repair: When cavitation is present and surgical intervention is required, conservative caries removal is carried out to maximize the repair potential of the tooth and retain tooth structure. Bioactive materials are used to restore the tooth and promote internal healing of the dentine. Effective implementation of MID involves integrating each of these four elements into patient assessment and treatment planning **(Walsh and Brostek, 2013)**.

As the dental technology continues to evolve, new methods of performing certain dental procedures will continue to replace those which were once thought to be the pinnacle. These new technologies include air abrasion, dental lasers, dentin regeneration, resin infiltration and ozone therapy **(Graeber, 2021).**

Chapter three: Conclusion

1. Air abrasion dentistry has evolved over a period of time from a new concept of an alternative means of cavity preparation to an essential means of providing a truly conservative preparation for preservation of a maximal sound tooth structure.
2. Erbium family lasers have shown their great benefits in different fields of operative dentistry, including painless cavity preparation and caries removal, enamel and dentine modification for bonding and smear layer elimination with respect to pulp tissue.
3. The 10,600-nm CO_2 laser is widely accepted for soft tissue surgery applications. Although CO_2 lasers have been studied extensively in caries prevention, they have not been applied in clinical practice. The optical properties of 9,300-nm and 9,600-nm CO_2 wavelengths are suitable for dental hard tissue treatment.
4. Resin infiltration technique is indicated for treating non- cavitated proximal lesions in both primary and permanent teeth. Also, resin infiltration may be used aesthetically to improve the appearance of white-spot lesions and other hypomineralised lesions in anterior teeth, since successfully infiltrated lesions clinically look similar to sound enamel.
5. Ozone therapy is used mainly as an adjunct to the primary clinical or pharmacological treatment. In some cases of oral mucosal disease, it has proven effective as a primary therapy.

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