LITERATURE REVIEW

Current trends in Restorative Dentistry: An overview

E.S. Akpata, BChD, MDSc, FDS

الاتجاهات الحديثة في مجال إصلاح الأسنان تأثرت بالتطورات الحاصلة في علم مواد طب الأسنان ، فهمنا الأكبر لتطور عملية نخر الأسنان ، والإقبال الكبير على الحشوات التجميلية والإنجازات في مجال زراعة الأسنان جعل الحشوات التجميلية المرممة للسن المحضر تحفظياً واسعة الانتشار في مجال إصلاح الأسنان المعاصر ، إضافة إلى ذلك فان عدداً أكبر من الأسنان المفقودة أصبحت تعوض عن طريق زراعة الأسنان بدلاً من استخدام التعويضات السنية الثابتة .

Current trends in restorative dentistry have been influenced by advances in dental materials science, better understanding of the caries process, increased demand for aesthetic restorations and developments in dental implantology. Thus, bonded tooth-coloured restorations in conservative preparations have become very popular in modern restorative dental practice. Furthermore, increasingly larger number of missing teeth are being replaced by implants rather than fixed partial prostheses.

Introduction

There is no universal definition of restorative dentistry. In many universities in the United Kingdom and Commonwealth countries, restorative dentistry comprises operative dentistry, endodontics as well as crown and bridge-work (or fixed prosthodontics). Because endodontics is a recognized specialty in the US and some other parts of the world, it is sometimes excluded from advanced training programmes and texts in restorative dentistry.[1] For the purpose of this paper, restorative dentistry will be defined to comprise operative dentistry and fixed prosthodontics.

Current trends in restorative dentistry have been greatly influenced by advances in dental materials science, better understanding of the caries process,[2] increased demand for aesthetic restorations and recent developments in dental implantology. In this paper, five main areas will be highlighted namely:

1. Restorative dental materials, especially dental amalgam and aesthetic restorative materials
2. Adhesive dentistry
3. Aesthetic dentistry
4. Cariology and its impact on restorative dental practice and
5. Dental implantology

Restorative Dental Materials

Future of dental amalgam

About 70% of all single tooth restorations are made of dental amalgam.[3] This restorative material consists of about 40% mercury by weight and has been in use in USA since 1832. One of the most topical issues in restorative dentistry today is the phasing out or curtailment of the use of amalgam as a restorative material and this has been supported by some legislative bodies in Japan and some European countries such as Germany, Sweden and Denmark.[4] This is because of the fears expressed in certain quarters that mercury toxicity arising from amalgam restorations will result in various forms of ill-health. These fears are not supported by scientific evidence.

Nevertheless, as mercury is known to be toxic, it is pertinent to ask whether the mercury in amalgam restorations constitutes a health hazard. To answer this question, it is important to highlight the various ways in which man is exposed to mercury. It is also necessary to discuss briefly the metabolism of this metal.[5]

Mercury is used in industry and in many other aspects of human endeavour. Its use in dentistry constitutes less than 3% of the total mercury used in industrialized countries. Mercury is constantly present in the biosphere and has great affinity for human tissues. In addition, the metal is present in high concentrations in fish as well as in depigmentation soaps and cosmetic preparations used by dark-skinned Africans.

For those persons not occupational^ exposed to mercury, the body retention of the metal is derived from the atmosphere, fish, non-fish dietary products and small amounts from drinking water. However, general dental practitioners who have been in practice for over 20 years have a higher level of mercury in their blood and urine. This is because they are exposed to the dental surgery atmosphere polluted with mercury that vaporizes when spilled, during mixing of amalgam

Received 30 Aug. 1999; Revised 22 Jan. 2000;
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Professor, Restorative Dental Sciences Department
College of Dentistry
King Saud University

Address reprint requests to:
Professor E.S. Akpata
Department of Restorative Dental Sciences
College of Dentistry, King Saud University
PO Box 60169, Riyadh 11545
Saudi Arabia

in an amalgamator or insertion of the restoration. The higher the room temperature, the more easily the mercury vaporizes. Even so, this level of exposure is below that which will precipitate symptoms of mercury toxicity.

More recently, it has been shown that mercury vaporizes in small amounts from amalgam fillings during mastication or when a dentist drycuts or grinds an amalgam restoration. Hence amalgam restorations constitute an additional source of mercury that maybe inhaled.

It needs to be emphasized that this source is approximately 1% of the dose obtained from the threshold limit value (TLV) of 50 (igm Hg/ m^3 of air set by the World Health Organization.[6] The TLV is set for industry and is the air-borne concentration of a substance to which all workers can be exposed 8 hours a day, 5 days a week for prolonged periods without suffering adverse health effects.

About 70-80% of the mercury vapour inhaled is rapidly absorbed across the pulmonary epithelium into the blood stream where it is partly oxidized into divalent ionic mercury. The unoxidized, blood-borne mercury and ingested methylmercury cross the blood-brain barrier into the brain where they are metabolized into divalent ionic compounds and stored cumulatively. Because the blood-borne mercury may cross the placental barrier, there is controversy whether fresh amalgam restorations should be placed in expectant mothers.[7]

The brain is the critical target organ for mercury vapour and methyl mercury while the kidney is the target organ for blood-borne ionic compounds of mercury. Thus, mercury toxicity disturbs the physiological functions of the central nervous system and kidney.

Apart from the very small number of individuals that show hypersensitivity reaction to mercury, dental amalgam has not been shown to be a health hazard to the vast majority of patients. Moreover, it is difficult to find any unequivocally convincing published data linking any specific human health problem with mercury vapour derived from amalgam restorations prepared and inserted according to the recommended procedures.[5]

In spite of this, some countries have legislated against amalgam restorations in certain patients, on account of its mercury content; and this is part of a broader policy to prevent environmental pollution.[8] However, environmental pollution with mercury has been found to be due mainly to other sources such as discarded household batteries, light bulbs, thermometers and pigments. In fact, discarded batteries accounted for 86% of discarded mercury in Sweden in 1989, while dental amalgam accounted for only 0.56%.[8] Whatever the case, amalgam restorations are already on their way out in some European countries and the amalgam age is most likely to come to an end in the new millennium.[9]

Attempts have been made to replace the mercury in dental amalgam with gallium, a metal which, like mercury, is liquid at room temperature. The resulting alloy is sticky and difficult to manipulate and there is, as yet, little information on the toxicity and environmental pollution problems associated with gallium for it to be recommended for clinical use.[10]

Tooth<oloured restorations

Because of the health concern articulated by sections of the mass mediaand the desire by many patients to have aesthetic restorations, attempts have been made to replace dental amalgam with tooth-coloured restorative materials.[9] Composite resins, glass-ionomer cements and compomers are the tooth-coloured materials currently used for direct tooth restorations. None of these materials is suitable for restoring areas of the tooth subjected to heavy masticatory loads.[10] Ceramics may be used for the restoration of stress bearing areas of the tooth, especially when fused to metal; but their use involves the indirect technique, with the attendant laboratory costs. Besides, the use of all-ceramic restorations requires considerable clinical expertise in adhesive dentistry.

Composite resins

Shades of composite resin can be chosen to perfectly match the natural tooth colour, such that the restoration is virtually undetectable. In addition, the material can be bonded to enamel and dentine, making macro-mechanical retentive features unnecessary during cavity preparation. Thus, cavities prepared for composite resin restorations are far more conservative of sound tooth tissues than those for amalgam restorations.

One of the disadvantages of composite resin restorations is that they wear faster than the tooth, especially in stress bearing occlusal areas and at approximal contacts. However, varieties of the resin with wear rate similar to that of enamel are now available and are in current use.[11]

Another disadvantage of composite resins is that they shrink on polymerization, resulting in micro-leakage. The micro-leakage may lead to

post-operative sensitivity, recurrent caries and pulp disease. There is ongoing research to produce shrink-free composite resins. In addition, ceramic inserts, which act as mega-fillers in composite resins, are currently in use. These ceramic inserts minimize polymerization shrinkage of the restorative material.[12]

Condensable composites are now available on the market, e.g. Solitaire (Hareus Kulzer, South Bend IN 46614) and Alert (Jeneric/ Pentron). Their properties will continue to improve so that composite resins can be condensed and carved like dental amalgam.[13] This will greatly reduce the technique sensitivity currently encountered in the placement of conventional composite resin restorations.

Glass-Ionomer restorative materials

Although aesthetic varieties of glass-ionomer restorative materials are now available, their translucence does not approximate to that of the tooth as accurately as that of composite resins. To further improve on aesthetics, resin modified glass-ionomer restorative materials are currently available in several shades.

Glass-ionomer restorative materials have two main advantages: they adhere chemically to enamel and dentine and also release fluoride, conferring on them anti-cariogenic property. Because their fluoride content is replaceable with that from oral fluids, they are able to release for prolonged periods fluorides for uptake by enamel and dentine.[14] The fluoride release is, however, independent of the amount required for re-mineralization of the tooth tissues. Actively smart aesthetic glass-ionomer restorative materials that will be rechargeable and release only the required amounts of fluoride may become available in the future.[4]

Compomers

In an attempt to improve the aesthetic qualities of glass-ionomer restorative materials, one-component resins containing alumino-silicate glass and phosphonate ester dentine-bonding agents have been developed and are referred to as compomers. On account of their high resin content their aesthetic qualities are excellent, but they do not behave like true glass-ionomer cements[15]. They do not release as much fluoride as glass-ionomer cements or bond mainly by ionic exchange to the tooth structure; rather, they depend more on the use of adhesive primers. They are, of course, not suitable for use in stress-bearing areas of the tooth.

Ceramic restorations

Ceramic restorations are biocompatible, can withstand masticatory stress and have excellent aesthetic qualities.[16] However, the restorations are fabricated by indirect technique, therefore incurring laboratory costs, although they can also be produced by computer-aided design and computer-aided manufacture (CAD/CAM). Furthermore, considerable clinical expertise is required for their resin bonding.

Ceramic inlays and onlays as well as all-ceramic crowns are becoming very popular and more of these restorations will continue to be used in restorative dental practice.

Adhesive Dentistry

Adhesion is playing an increasingly prominent role in restorative dental practice. For example, the retention of most tooth-coloured restorations depends on micro-mechanical and/ or chemical adhesion.

Enamel bonding

Buonocore, in 1955, was first to demonstrate the adhesion of acrylic resin to acid-etched enamel.[17] He used 85% phosphoric acid for etching, although 30-37% concentration of this acid is most often used for etching enamel today.

Etching of enamel produces a number of effects:[2]

1. It cleanses enamel of any deposits or acquired pellicle.
2. It increases the enamel surface area available for bonding.
3. It produces micro-pores into which there is mechanical interlocking of the resin.
4. It exposes more reactive surface layer, thus increasing its wettability.

The etched enamel surface contains indentations or micro-pores about 5-11 ^i deep. Restorative resin materials flow into these micro-pores as resin tags to aid retention of the restorative material.

Three enamel etching patterns have been described:[18]

Type 1-There is preferential demineralization of enamel prism core and the corresponding tags are cone-shaped.

Type 11 -There is preferential removal of inter-prismatic enamel and the corresponding enamel tags are cup-shaped.

Type 111-There is diffuse enamel surface roughening unrelated to the morphology of the enamel prisms. It gives rise to various shapes of resin tags that are poorly retentive. This type of etching pattern is usually seen on the buccal surfaces of deciduous teeth and cervical areas of permanent teeth, where the surface enamel is rather prism less.

Among the factors that affect solubility of enamel are its fluoride content[19] (as in dental fluorosis), enamel crystalinityaswell as impurities, e.g. presence of magnesium and carbonates in the hydroxyapatite crystals.

Dentine bonding

Among the factors that militate against dentine bonding is the presence of smear layer, i.e. little dentine particles adherent to cut dentine surface. There are currently a number of management options for this smear layer.[2]

Management of the smear layer

The smear layer is removed by etching with 37% phosphoric acid for 15 seconds. This does not only remove the smear layer, but also opens up the ends of the dentinal tubules. The etched inter-tubular and peritubular dentine allow penetration and bonding of resin, from dentine bonding agents, with the organic meshwork of the etched dentine surface to form the hybrid layer or inter-diffusion zone. This hybrid layer provides strong bond for the restorative resin. Furthermore, resin tags hybridized to the peritubular dentine seals the dentinal tubules, preventing ingress of microorganisms.

Alternatively, the smear layer may be retained, fixed or replaced. However, the bonding systems currently in use, i.e. the 4th and 5th generation bonding systems, depend on smear layer removal and hybridization. In the total etch technique, first advocated in the 1960s by Fusayama in Japan,[20] both enamel and dentine are etched and the bonding of the resin is mainly micro-mechanical to the micro-pores in the etched enamel and via the hybrid layer in dentine.[21]

Components of dentine bonding systems

Basically, dentine-bonding systems comprise three components: conditioner, primer and adhesive resin. However, two of the components maybe combined in one bottle.

Conditioners

The conditioners, usually acids or chelating agents, are used for etching enamel and dentine when following the total etch technique. Examples of conditioners are 30-37% phosphoric acid, 10% citric acid combined with 3% ferric chloride used with amalgambond as well as maleic acid which may be combined with HEMA and EDTA, once used with the GLUMA bonding system.

After etching enamel and dentine with the conditioner for 15-30 seconds, it is washed away with water and the etched surface air-dried. However, the dentine is left moist so as to prevent the collapse of the organic meshwork on the etched dentine surface.

Primers

These are applied to the etched dentine to promote wetting and adhesion to the dentine surface. Primers are not washed away and contain both hydrophilic and hydrophobic groups. The hydrophilic group bonds to wet dentine while the hydrophobic group is available for bonding to the adhesive resin.

Most primers are based in acetone or alcohol and a few, in water. Acetone has the advantage of being able to displace water from the organic meshwork of etched dentine surface, thereby facilitating penetration of the primer to bond with the dentine organic matrix and produce the hybrid layer. 21

Both the primer and conditioner may be combined in the same bottle to form the self etching primer.'

Adhesive resins

These are usually hydrophobic monomers such as bisphenol-A-glycidyl methacrylate (BISGMA) and triethylene glycol dimethacrylate (TEGDMA). They penetrate the etched dentine surface to copolymerize with the primer and intertwine with the organic matrix of the etched dentine to form the hybrid layer. The adhesive resin also bonds to

the matrix of the restorative resin to retain the restoration.

Both the adhesive resin and primer may be combined in one bottle, as in the 5th generation bonding systems.

Types of bonding systems

Bonding systems are most widely classified according to their evolution into 1st, 2nd, 3rd, 4th and 5th generations. However, only the 4th and 5th generations are in current use.

The 4th generation bonding systems have the following characteristics:

1. They consist of three components, viz. conditioner, primer and adhesive resin that are used sequentially.
2. They are used following the total etch technique.
3. They depend on hybridization on dentine surface and micropores in enamel to retain the restoration.

In the 5lh generation bonding systems, the primer and adhesive resin, or conditioner and primer are combined in one bottle. The aim is to simplify the use of the bonding system.

Clinical applications of bonding systems[2]

The following are some of the clinical applications of bonding systems:

1. Adhesion of composite resin restorations to enamel and dentine (total etch technique)
2. Bonding amalgam restorations to cavity walls
3. Repair of amalgam restorations
4. As a component of resin cements for bonding cast restorations, e.g. 4-methacryloxyethyl trimellitic anhydride (4-META) in some resin cements
5. Bonding of porcelain restorations, e.g. porcelain inlays, onlays and laminate veneers
6. Porcelain repair
7. Management of dentine hypersensitivity

Aesthetic Dentistry

The boost in aesthetic dentistry in recent times has been influenced by at least five factors:

1. The campaign by the mass media in Western countries against amalgam restorations, even though this has no scientific basis. This is compounded by the fact that some countries have legislated against or restricted the use of amalgam.
2. The development of tooth-coloured restorative materials with high aesthetic qualities.
3. The introduction of composite resins with high modulus of elasticity and wear resistance similar to that of enamel for use in posterior restorations.
4. Advances in the development of adhesive systems.
5. Increased demand by patients for tooth-coloured restorations.

Consequently, there has been a dramatic increase in the number of posterior composite resin restorations done in most countries. Furthermore, advances in adhesive dentistry has led to an increase in the prevalence of all-ceramic restorations such as porcelain inlays, onlays, laminate veneers and dentine-bonded ceramic crowns. Regrettably, composite resin is being increasingly used to restore very large approximal boxes and this sometimes leads to failure of the restorations.

The demand for the whitening of teeth has been heightened by the vigorous advertisement of home bleaching materials even on the INTERNET. In fact, most of these home-bleaching kits can be purchased across the counter.

Tooth-whitening procedures

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Vital bleaching with 35% hydrogen peroxide is becoming quite popular. Unlike in the past when the hydrogen peroxide was activated by heat, the bleaching agent is currently activated by the halogen curing light or argon laser.[22] An example of the commercial preparations for vital bleaching is HiLite (Shofu Dental Corporation, Menlo Park, Ca94025, USA)

Home-bleaching

In this tooth whitening technique, the patient dispenses carbamide peroxide (which releases 3% hydrogen peroxide) into a custom tray and wears the tray for 4-6 hours each night for 2-3 weeks until the desired colour is attained.[23] This technique is often accompanied by transient post-operative sensitivity. Opalescence (Ultradent Products Inc.) is a commercial example of a matrix home-bleaching kit.

Micro-abrasion

The whitening of teeth with deep-seated extrinsic stains or mild fluorosis is currently carried out effectively by micro-abrasion with hydrochloric acid/pumice mixture.[24] A slurry of 18% hydrochloric acid and pumice is used for abrading the tooth surface to remove not more than 100 microns of the surface enamel.[25] Commercial preparations of the hydrochloric acid/pumice mixture are currently available, e.g. Prema (Premier Dental Products).

Cosmetic operative procedures

Some of the cosmetic operative procedures have been discussed under tooth-coloured restorations. Among the conditions corrected by cosmetic operative procedures are:

1. Mal-aligned teeth
2. Mal-formed teeth e.g. peg-shaped lateral incisors
3. Discoloured teeth, e.g. due to dental fluorosis
4. Fractured incisors
5. Notched incisors

Composite resins are used for most of the cosmetic operative procedures and it is often wise to make use of diagnostic wax-up before the clinical procedure.

Laminate veneers

Laminate veneers have gained tremendous popularity within the past two decades. They are conservative of sound tooth tissue, as only about 0.5 mm of labial enamel is removed.[26] They may be made of composite resin or porcelain and are used for the management of most of the conditions described above.

Cariology

Our better understanding of the caries process has had a tremendous impact on the prevention of the disease. As a result, caries experience is on the decline in Western countries and the rate of progression of the lesion is slower, especially in the presence of topical fluoridation.[27,28] Furthermore, a number of carious lesions become arrested, especially when the patient's oral hygiene improves and dietary sugar is controlled. These facts have a bearing on the practice of restorative dentistry. For example, when an approximal radiolucent area is seen on a bite-wing radiograph, a decision has to be made whether to restore the tooth or to institute preventive measures so as to encourage remineralization. Similarly, a decision has to be made whether to pre-empt pit and fissure caries by fissure sealants, prevent further spread of the lesion by preventive resin restorations or to restore occlusal caries with composite resin or amalgam.[2]

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To appreciate the management of dental caries, it is necessary to discuss briefly its aetiology. According to the ecological plaque hypothesis, high sugar consumption results in high proportion of acid-producing and acid-tolerant plaque bacteria such as mutans streptococci and lactobacilli.[29] The bacteria produce more acids that cause the demineralization of the hard dental tissues, as demonstrated by Stephan's curve.[30] This is the caries process. Saliva, mainly on account of its bicarbonate content, acts as a buffer to raise plaque pH to its resting level, thus providing an environment for the remineralization of the hard dental tissues. Therefore, the caries process alternates between phases of demineralization and remineralization.

Carles risk assessment

Caries risk assessment has become an important part of restorative dental practice and this underscores the integration between operative and preventive management of dental caries.[31] The factors considered in caries risk assessment include the following: 1) past medical history, e.g. history of salivary gland hypofunction, as in Sjogren's syndrome, 2) past dental history, e.g. patient's DMFT, 3) systemic and topical fluoride exposure and 4) the population of cariogenic bacteria in saliva.

Salivary level of mutans streptococci on lactobacilli above 10^5 cfu/ml may indicate high risk for caries attack. The salivary levels of these bacteria can now be estimated at the chair-side, using the dip slide method developed by Larmas.[32]

Management of dental caries

The management options of a carious lesion depend on the extent of the lesion and may be categorized as follows:

Incipient caries

In an Incipient carious lesion, there is subsurface demineralization, but the enamel surface is clinically intact. There may be a white or brown spot lesion.

The lesion is managed by remineralization therapy i.e. improved oral hygiene, control of dietary sugar and topical fluoridation.

When an incipient carious lesion is in fissures, however, it may not be easily diagnosed and the affected area may not also be accessible for cleansing. Hence pit and fissure incipient caries is treated by preventive resin restoration.[33] There is indication that early carious lesions, sealed in by preventive resin/glass-ionomer restorations or fissure sealants, remain quiescent.[34]

Dentinal caries

Prior to cavitation, dentinal caries is managed by instituting preventive measures. Once there is clinical cavitation, however, the tooth is restored in addition to preventive measures. Just as it is difficult to diagnose early occlusal caries, it is also not easy to determine when an early approximal dentinal carious lesion iscavitated.

As early approximal carious lesions are often diagnosed by bite-wing radiographs, efforts have been made to correlate the extent of approximal radiolucency with the probability of clinical cavitation. A study carried out in Riyadh, Saudi Arabia showed that the probability of clinical cavitation was 0, 19.3, 79.1 or 100% when approximal radiolucency was confined to the outer half of enamel, inner half of enamel, outer half of dentine or inner half of dentine, respectively.[35] Apart from depth of radiolucency, it was observed that the probability of clinical cavitation on approximal surfaces of posterior teeth is affected by age and tooth type.[35]

Preservative Dentistry

It can be seen, therefore, that the practice of operative and preventive dentistry is closely related. Hence the current trend is to think in terms of preservative dentistry:

1. Preventive measures are instituted at all levels of caries progression.[36]
2. Sound tooth tissues are preserved wherever possible. To facilitate this, adhesive techniques are employed, often utilizing aesthetic restorative materials.
3. Minimal cavity preparation is the goal.

Replacement of missing teeth

As in the immediate past, the current trend is to replace missing teeth by fixed prostheses. Nevertheless, the outstanding work by Branemark and his colleagues in the 1950s and 1960s on osseointegration has been a turning point in fixed prosthodontics.[37] This gave birth to an area of dentistry known as dental implantology. Put very simply, a dental implant is made up of an artificial tooth or prosthetic component secured onto an artificial root or implant buried in bone. The surrounding bone grows intimately around, or rather, is integrated with the implant which is usually made of titanium.

Implant dentistry is currently practised not only by specialists in dental hospitals, but also, increasingly, by general practitioners in private dental offices.[38,39] The success rate of the various dental implant systems has been remarkably high both in single tooth replacements and the support of fixed partial prostheses.[40,41] In a 10-year prospective multicentre evaluation of 461 Branemark implants (Nobel Biocare, Goteborg, Sweden) in 127 partially edentulous patients in Sweden, the survival rate was over 90% and peri-implant marginal bone resorption was low (mean = 0.7 mm) while mucosal health was satisfactory.[42] Similarly, the success rates of implants in partially edentulous jaws observed over a 6-year period in Belgium and Australia were very high, being approximately 95%[43,44]

Osseointegration of dental implants in partially edentulous patients appears to be unaffected by age: in an evaluation of 45 implant supported prostheses over a period of 16 years, no statistically significant differences were observed in older (above 60 years of age) and closely matched younger (less than 50 years old) adults.[44,45] Nevertheless, it is influenced by bone quality, prognosis being better in the mandible than in the maxilla.[46,47]

Oral rehabilitation by means of dental implants is well accepted by patients. In a pre- and post-operative questionnaire evaluation of implant-restorative rehabilitation with Branemark implants, nearly all the patients reported comfort with eating, while aesthetics and phonetics improved significantly. The patients were generally satisfied; they experienced their implants as natural teeth

and indicted that they would recommend this form of dental treatment to others.[48]

Conclusions

1. Advances in dental materials science and our better understanding of dental caries have had a great impact on the current trends in the practice of restorative dentistry.

2. Recent developments in adhesive dentistry have resulted in more conservative approach to cavity preparation.

3. Tooth-coloured restorations have become the norm and most patients now demand these all over the world, especially in Western countries. Consequently, amalgam restorations are being phased out in some countries.

4. Dental implants are fast replacing bridges or fixed prostheses.

5. The current trend is towards preservative dentistry, rather than restorative dentistry.

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