Review of dental repair concepts and methods

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Abstract
This review covers the main aspects of dental care in terms of repairing teeth and how this has evolved from an era of ‘cut and fill’, usually with dental amalgam. Current concepts include treating decay in the tooth rather than removing all of it and restoring teeth with adhesive materials to avoid the need to cut undercuts which weaken teeth. Teeth can now be repaired more conservatively than previously using the systems outlined in this review. New concepts such as the use of inserts and CAD/CAM are included, both seen as ideal methods of repairing teeth with enamel-like substitute materials in a single dental appointment. The development of dental drills, still the best means of reshaping teeth, has lead to highly-engineered devices although having efficient means to cut teeth has encouraged destructive treatment modalities to develop. There is an increase in the application of lasers and abrasive cutting technologies. The need to repair teeth following tooth decay is still present, and there are also increasingly demanding problems such as tooth wear, particularly erosion. The increasing demand from patients for cosmetic improvements is discussed. Future concepts should aim at replacing what is missing with aesthetic adhesive materials with minimal adverse impact on the surrounding tissues and the patient.

1 Introduction
Dentistry has traditionally dealt with the diagnosis and treatment of a wide range of oral diseases with much necessary emphasis on caries (tooth decay) and gum disease. Despite tooth decay being well-understood and preventable, it still remains a worldwide disease. More recently tooth wear has been identified as another major dental problem due to an increased intake of acidic drinks which can accelerate normal ‘physiological’ rates of tooth wear to a pathological level. Teeth become sensitive and may fracture leading to poor aesthetics and ultimately tooth loss. As more people are retaining more teeth to an older age and also as people live longer the damaging effects of tooth wear will impact on more people. This may be made worst as older people are now expecting more youthful-looking dentitions. Particularly in affluent countries, there is a shift from disease-oriented health care to an increase in fashion and lifestyle-driven cosmetic treatments ranging from orthodontics to tooth whitening and procedures such as veneering teeth aimed solely at changing the appearance of teeth and the smile.

This chapter looks at current trends in restorative dentistry and the use of emerging technologies in relation to the repairing of teeth following damage caused by caries or tooth wear.
2 Dealing with tooth decay

2.1 Traditional removal and refilling

The treatment of tooth decay has until recently been limited to the surgical removal of the diseased tissue. This can be achieved by cutting away the decayed tooth tissue, usually with a sharp steel hand instrument or a drill, or by removing the entire tooth and the disease along with it.

Cutting through the hard outer enamel layer of the tooth, the hardest tissue in the human body, requires high-speed drills with diamond or tungsten carbide burs. Dentine can be cut at lower speeds, and decayed dentine can be cut with steel burs. Drills have advanced from the slow peddle-driven devices into the currently available water-cooled handpieces with burs rotating at over 200,000 rpm powered by compressed air passing around a finely-balanced turbine (Figure 1). Although such drills can reach a high speed, they have low torque and generate a characteristic and unwelcome noise. They also generate vibration and can cause subsurface cracking within the tooth [1]. Alternative handpieces use an electric motor running at 4,000 rpm with a small gearbox providing a 1:5 ratio and a drill speed of 200,000 rpm with high speed and high torque characteristics (Figure 2).

Dental handpieces, while generally disliked by patients, have enabled more sophisticated dentistry to be carried out to the benefit of patients, although there is an increasing awareness of the damage generated by overcutting a precious resource such as tooth enamel. Once gone, it is gone forever and more powerful handpieces might make this all the more likely.

Handpieces display advanced engineering to satisfy the requirements of high-speed precision cutting, usually in a confined space and sometimes at an awkward angle within the patient’s mouth while being able to survive cross-infection measures and the need for sterilisation at 134 °C. The majority of dentists use rotary drills but there are also drills with oscillating tips (Figure 3) as well as sonically and ultrasonically vibrating cutting instruments.

![Figure 1: An air-turbine handpiece with cut-away area to show the turbine.](image)
High-power drills are essential when cutting through failed restorations, as these materials can be harder than the enamel. This is becoming a more common situation as dentistry moves away from metal-based reparative materials due to concerns over aesthetics, toxicity and allergies. Some of the newer metal-free restorative materials are based on zirconium dioxide, satisfying the demands for good aesthetics and strength in function, but becoming a problem when they need to be removed years later when the restoration fails. The concept of salvage is still new in dentistry but will become more relevant during treatment planning when the outcome of treatment and the potential for retreatment and repair is taken into account.

Besides their use in the repairing of dental disease drills are also required to reshape teeth during some cosmetic procedures. The front of a tooth may be reduced in order for it to be covered with a veneering material to change its colour and shape, discussed in a later section.

The most familiar and feared feature of the dental drill is the noise they make, which is upsetting for patients but also can lead to partial deafness in members of the dental team. Research is underway on noise reduction mechanisms including active and passive filtering as well as antinoise.
Lasers can also be used to cut dental enamel although their high cost and limitations restrict their widespread use. Some dental procedures cannot be achieved by laser alone, so drills are still required. Other tooth cutting systems include air and fluid abrasion utilizing aluminium oxide particles [2]. Cutting of the soft tissues within the oral cavity can be achieved by diode and CO₂ lasers, the former becoming more popular with dentists. A lower cost alternative option is electrosurgery where the radiowaves at the tip of the tungsten cutting probe vapourise the surrounding tissue, enabling precision reshaping of the gingival tissues.

The approach to caries treatment, ideally alongside a prevention programme, is the gaining of access to the diseased inner dentine layer by cutting through the outer enamel shell. Once the enamel has been cut away, the softer decayed dentine inside the tooth can be removed by hand instruments or slower speed drills. These drills usually have steel cutting bits although plastic drills, designed to cut the softened diseased dentine, but not the hard healthy dentine, have become available (SmartPrep™).

More recent developments in techniques designed for removing carious dentine include the use of an enzyme cocktail to further soften the decay, thereby enabling its easier removal with blunt hand tools (Cariousolv™). Lasers, air and fluid abrasion are also new developments in the field of cutting dentine [3].

The removal of the entire tooth is now a less common form of treatment for tooth decay in advanced countries [4] but even this has developed with the increased use of tools to make extraction less brutal. Dentists do not actually ‘pull’ out teeth but instead insert the tip of the forceps or thin steel luxators between the tooth and the bony socket to expand the bone and create a wedge effect to ‘push-out’ the tooth. Having removed the tooth, a replacement may be provided by attaching a false tooth to the adjacent teeth using an adhesive bridge or onto an implant embedded into the underlying bone. A few dentists place a bone substitute material directly into the tooth socket after extraction to reduce the resorption than normally occurs.

2.2 Alternatives to the removal of tooth decay

One of the problems in removing the disease is that much tooth tissue is removed with it. Removal of dentine, even if infected, limits the natural defence mechanism of the body, making exposure of the pulp more likely. Recent research has suggested alternative approaches to managing caries [5] to avoid its complete removal, which can leave teeth permanently compromised [6, 7]. One such concept is to treat the caries in situ and render it inactive. Long-term results from carefully controlled studies where caries is not removed but sealed in have been encouraging and challenge the current thinking [8]. A combination approach is now used by some clinicians, where the caries may be partly removed and then the remainder is covered with a fluoride-releasing material, which also creates a seal to prevent further nutrients from the mouth reaching the bacteria in the carious dentine. The soft decay hardens as the tooth pulp lays down further mineral and protects the underlying pulp.

Others have gone further and attempt to add caries sterilisation procedures to the above proven regimes where the remaining caries is not only left but is rendered inactive before sealing. Such novel treatments often lack evidence from rigorous independent research studies. Two controversial treatments in the repair of dentine are the use of ozone and lasers.

Ozone has been recognised as a powerful sterilising agent that can destroy bacteria and viruses. The application of ozone has been advocated for use in dentistry for the sterilising of cavities, root canals, periodontal pockets and herpetic lesions [9]. Much of the published work to date has been in relation to caries although many consider that there is a lack of evidence supporting the application of ozone gas to the surface of decayed teeth stopping or reversing the decay process [10].
use of ozone is also advocated [11] when used as a denture cleaner to eliminate methicillin-resistant Staphylococcus aureus (MRSA) as well as viruses. However, the use of ozone is controversial [12] with independent reports questioning its therapeutic effect and recent Department of Health advice suggesting that ozone is of ‘no benefit and do not use’ [13]. Current National Institute of Clinical Excellence (NICE) guidelines [14] advise against the use of ozone in general dental practice.

Photo-activated disinfection (PAD) is another recent idea where a photosensitive agent is applied to the carious dentine in the form of a dye. These photosensitive molecules attach to the cell membrane of the bacteria. This is followed by irradiation with red light from a diode laser, the wavelength of which is matched to the peak absorption of the photosensitiser, which then ruptures the cell wall and kills the bacteria [15]. Likewise, it lacks independent research data to support its use at present.

3 Restoration of teeth

Following the removal of tooth decay the resulting hole would usually be filled with a restorative material. For many years this material has been amalgam, an alloy of silver and tin with mercury. Dental amalgam was a key material throughout the last century due to its low cost, ease of use and longevity in the harsh oral environment. Almost 50% of the restoration is mercury, which is now known to slowly leach out in small amounts, particularly while chewing. There is public concern about the potential health effects of exposure to mercury vapour released from dental amalgam.

Most concern focuses on possible damage to nerve tissue. However, there is no convincing evidence pointing to any adverse health effects that are attributable to dental amalgam restorations besides hypersensitivity in some individuals, despite many extensive investigations [16]. However, there are studies showing a lack of general systemic pathology associated with amalgam.

A recent large, randomized clinical trial concluded that there is no adverse neurobehavioural effects of dental amalgam in children, and that amalgam should remain a viable dental restorative option for children [17]. Another large, randomized clinical trial concluded that there were no adverse neuropsychological or renal effects from dental amalgam [18].

In some countries the use of amalgam is driven by state regulations which favour low-cost, long-lasting therapies and may not permit the alternative, and more expensive, materials to be used. Many countries are regulating and restricting the use of amalgam while a few now ban its use. In the Western world it seems that the use of amalgam will be limited more by stricter environmental regulations governing its disposal, rather than dental concerns. Environmental pollution is a concern because dental amalgam releases mercury into waste and drainage systems and even the vapour from crematoria is a cause for concern. It seems that the least regulated place to put dental amalgam is actually a patient’s tooth!

A typical concern expressed by patients is the colour of amalgam, and alternative tooth coloured materials are much more popular (Figure 4). The alternatives to amalgam depend on the different clinical applications and include polymerisable resins (‘Composite’), ceramic materials, glass ionomer cements, glass fibre-reinforced composites and mineral trioxide aggregate, interestingly, a refined version of Portland cement.

A significant development has been the mechanism by which these materials are retained within the cavity in the tooth. Dental filling materials used up until the 1970s required mechanical retention with undercuts being cut into healthy tooth tissue for retention of the material. However, this often weakened the remaining part of the tooth. Nowadays, adhesive materials can be utilised to encourage a more conservative approach to be used. These materials also have the advantage in being tooth coloured.
These adhesive systems have enabled dentistry to move away from an era of ‘cut and fill’ to a philosophy which emphasises tooth preservation and replacing what is missing rather than cutting away more tooth tissue (Figure 5). Traditionally when a restoration fails it is often removed, making an even bigger hole in the tooth which is then restored. These bigger restorations fail soon, again to be removed and replaced. How long restorations last is a complex interaction of variables including the dentist, the material and the patient [19].

The cycle of restorations failing and being replaced with larger ones is recognised as the restorative spiral which eventually leads on to tooth loss. This destructive cycle can be broken by dentists avoiding cutting teeth in the first place by utilising improved diagnostic procedures, applying preventative regimes, avoiding cutting unless absolutely necessary, by adopting a ‘repair not replace’ philosophy and using treatments with a good salvage potential. The state also has a role to play as it may require changing payment schemes away from paying dentists only when they cut teeth to one that rewards prevention, instituting preventative measures such as water fluoridation and supporting campaigns for a reduction in sugar intake through banning tuck-shops as an example.

Another technique aimed at slowing the restorative spiral is to avoid removing failed restorations by employing repair techniques. Removing an amalgam filling, which can be easily seen and is not bonded to the tooth, results in the cavity becoming 10% larger [20], so it is not surprising that the removal of an adhesively retained tooth-coloured material results or can result
in cavities becoming even larger [21]. Repairs can be achieved by dentists using new adhesive systems to bond new materials to existing restorations. Such work is clinically demanding and often requires working under magnification and protecting teeth with a barrier system such as rubber dam (Figure 6).

Adhesive materials have been advancing since the 1970s and the latest materials polymerise following activation of the initiator with blue light at about 470 nm wavelength. The technology was first developed by ICI to create blue-light curing paint for the car industry to reduce the costs associated with solvent-based and heat-cured paints. Blue light, which replaced the earlier self-curing or UV-cured products, soon became popular and is still in use. ICI developed the first commercially available light-activated, tooth-coloured composites, which are still providing clinical success today (Figure 7). Today’s wide range of materials provide adhesive tooth-coloured restorations which can bond to both the highly inorganic enamel as well as the organic phase of the dentine. Unfortunately, these materials shrink by about 2% on polymerisation and are moisture sensitive until polymerised, making their use in the oral environment difficult and longevity problematic.

Composite bonding to enamel requires etching with 30–40% phosphoric acid for 20–30 s to create an opaque rough surface, as can be seen in Figure 6. The different levels of enamel solubility between enamel prism centres and periphery provide a rough surface into which the
Figure 6: A latex barrier (rubber dam) protects the patient while the dental repair work is carried out. The opaque margin around the cavity has been etched with phosphoric acid and is ready for the application of an adhesive material.

Figure 7: An example of a 20-year-old composite restoration performing well.

resin penetrates. Removal of surface enamel initially (0.1 mm) greatly improves bond strengths as the tooth surface is heavily contaminated with food debris; fluoride and the enamel prism ends are damaged through wear. Bevelling of the cavity edges will increase the bonding area and expose the enamel prism ends to improve the etching and bonding procedure.

Bonding the restoration to the dentine is essential to provide a seal in the bulk of the cavity, to eliminate gaps where bacteria may survive, and resist polymerisation contraction of the restorative material. Early dentine adhesives etched dentine and enamel using phosphoric acid, followed by a primer, to link the hydrophilic dentine to the hydrophobic resin and then to the polymerisable resin itself. More recent developments have seen the introduction of self-etching adhesives with single compounds designed to etch, prime and bond to tooth tissue.

Shrinkage remains a problem with all polymerisable materials. Direct placement composite resin is often used clinically but is associated with polymerisation shrinkage, which can result in marginal failure with gap formation and microleakage leading to post-operative sensitivity [22] and physical distortion of the tooth due to cusp flex [23]. These problems may not be overcome by incremental placement but can be reduced by increasing the filler content of materials. However,
too high a filler loading results in poor handling properties although this can be partly overcome by elevating the temperature of the restorative material during use. Another technique is to place a filler particle, called an insert, into the unset material before polymerisation. The use of these inserts [24] has been shown to reduce polymerisation shrinkage [25], which has resulted in reduced marginal gaps [26] resulting in improved margins and less microleakage [27]. The insert is fabricated to be more wear resistant than composite resin with improved occlusal wear rates reported in some studies [28], and inserts have been considered useful as a means of maintaining contacts between adjacent teeth. In general, the beneficial effects of the insert are largely due to the increase in the filler:resin ratio, which reduces the shrinkage.

The most popular insert system that provides easy-to-place yet hard wearing restorations with the aesthetic qualities of ceramic is Cerana (Nordiska Dental, Sweden). This single-visit system has undergone longitudinal clinical evaluation [29, 30]. These inserts are formed from pressed leucite and are surface-treated ready for bonding into the tooth with an adhesive cement. Leucite (K$_2$O Al$_2$O$_3$ 4SiO$_2$) is used as it has physical properties more comparable to enamel than most materials. Furthermore, it can be etched with hydrofluoric acid and silanised with methacryloxypropyl-trimethoxy-silane before it is sealed into a sterile blister pack. Figure 8 shows an example of a Cerana insert.

![Figure 8: A cavity (above) is prepared and then a leucite insert is removed from its sterile packet (see inset) and placed into the adhesive resin material, producing an aesthetic, long-lasting inert restoration (below).](image_url)
An emerging technology in dentistry has been the application of computer-aided design (CAD) and computer-aided manufacturing (CAM) of indirect restorations, particularly using the Cerec system, (Figure 9) [31]. The application of CAD/CAM has been developing in dentistry over the past 20 years and enables tooth-coloured restorations to be made in a short time in a dentist’s surgery at the chairside. The technique involves data acquisition using a dedicated digital camera to record the tooth and cavity outlines in 3D. This is followed by the design of the restoration on a computer by the clinician. The information is then sent to the milling device which will accurately cut the restoration from a solid block of restorative material, usually a ceramic. The restoration can then be adhesively bonded into the tooth at the same appointment. The technique offers well-fitting ceramic restorations which may reduce the number of patient visits, albeit at a higher cost.

The problem of shrinkage of the composite resin materials on polymerisation, around 2%, has led to alternative techniques being used. The use of inserts to increase the non-shrinking component of the repair material has been discussed. Another option is to make the restoration indirectly, outside the mouth such as on a model replica of the tooth. Here, it can be more completely polymerised and more aggressively polished before being cemented in place with an adhesive cement. Advantages in curing the material outside the mouth is that higher temperatures can be used, in conjunction with blue light, to achieve higher levels of polymerisation as well as being able to use alternative materials (Figure 10).

Figure 9: An example of a CAD/CAM unit for use in dentistry.
Figure 10: The use of an indirect, laboratory-made ceramic restoration (see inset) to restore the fractured tooth (a) with an adhesive and aesthetic outcome (b) without any further tooth tissue reduction.

4 Others forms of loss of tooth substance

Tooth surface loss (TSL, tooth wear) is an increasing problem requiring a different approach with different repair strategies. TSL needs to be identified early by dentists to enable a diagnosis to be made and preventative measures to be put in place [32]. TSL includes all forms of loss of tooth material not due to disease of bacterial origin (i.e. caries) and is usually considered to be one or more of:

Erosion – acidic attack from acids of dietary or gastric origin
Attrition – tooth-to-tooth contact, typically grinding of teeth while asleep (bruxism)
Abrasion – where a material is wearing the teeth, often due to inappropriate toothbrushing
Abfraction – occlusal forces causing tooth flexion and chipping away at the neck of the tooth due to mechanical failure;
Fractures – loss of fragments of tooth, often due to habits such as clamping objects between the teeth or attempting to crack nuts.

While it can be argued that caries is the result of a poor-quality diet (high on refined carbohydrates) tooth surface loss can be related to a healthy diet. Sports drinks are seen as part of a healthy lifestyle with regular exercise, yet many have a pH between 3.16–3.70 and can erode enamel at a rate of up to 5 µm/h [33]. Enamel will dissolve at pH 5. Fruit juice is similarly erosive. However, it seems to be the carbonated drinks, especially in children and young adults, and the high-energy drinks, which appear to have the greatest damaging potential of all. The content of the drinks has been modified by some manufacturers, but still some drinks are being promoted under the banner of lifestyle and general health while containing chemicals injurious to teeth [34]. Gastric acid is another cause of dental erosion, although with a different pattern of damage, and can cause severe enamel loss in a short period of time.

Early monitoring and intervention is important to prevent an unrepairable tooth wear condition from developing. Monitoring includes examination, photography and the recording of models which can be laser scanned to determine changes over time. Damage can be severe even in young patients (Figure 11), and it becomes clear that the teeth will not sustain a lifetime at current rates of wear.

Preventative measures are important in tooth wear, as in the other oral diseases, and are applied ideally as measures taken to prevent the occurrence of the disease (primary prevention). An example in dentistry is the use of water fluoridation to reduce the incidence of caries in a
population. Educating young people about carbonated drinks is another. Early detection of a disease followed by intervention to prevent its progress is secondary prevention. An example would be the halting of the progression of tooth erosion through dietary change.

Tertiary prevention is the limiting of the effects of the disease on function and activity and prevention of recurrence, usually through careful intervention to avoid initiating a restorative spiral effect. In the case of tooth wear the repair of damaged tooth surfaces should avoid the removal of further tooth tissue and utilise adhesives and tooth-coloured resin materials to replace the missing tissue. These resins can withstand acidic attack better than the teeth and so have a dual function of repair as well as preventing further damage. Figure 11 shows an example of this repair concept in action where the amount of tooth tissue lost through wear has been replaced by a synthetic replacement material, bonded to the remaining tooth without any reduction of the tooth itself. Unfortunately, many clinicians would still opt for the more destructive, and higher cost, crown technique where the teeth need to be reduced further, using drills, in order to create more space to cover them to ‘restore’ them with a 1.5 mm thick crown.

5 Tooth replacement

There is evidence that a full dentition of teeth is not required for oral and general health and the concept of 20 upper and lower teeth making functional contact during chewing has been described as a satisfactory unit, the ‘shortened dental arch’ [35]. However, many patients will
seek options for the replacement of missing teeth, even posterior teeth. The provision of a fixed replacement tooth, rather than a removal denture, can be destructive as teeth adjacent to the space are cut down to receive a crown. This traditional form of bridgework, which has poor salvage potential when it does fail, has been gradually replaced with the lower-cost minimally invasive adhesive bridges and the higher-cost implant retained restorations. Adhesive bridges are retained by bonding the thin rigid, metal frame (often a nickel chromium alloy) to adjacent teeth and this supports the replacement tooth. Replacement crowns can be attached to a titanium implant, which is inserted into the jaw where bone osseointegrates with the implant surface to form a solid bond [36], as described in the chapter by Baldini et al.

6 Cosmetic dentistry

Increasing numbers of people are seeking an attractive smile, including good oral aesthetics, as part of creating a positive self-esteem and general feeling of well-being, as well as recognising its possible advantage towards business and social success [37]. The attractive smile is believed to result in greater success for its owner! The mouth and eyes play a major role in facial appearance. Because of this some patients will approach the dentist because of dissatisfaction with the appearance of their teeth. Aesthetics is more important than health and function for a great majority of individuals [38].

What patients are seeking, in simple terms, is to have straight, ‘white’ perfect teeth, which makes them look younger and more perfect in appearance. Some requests for help will be realistic but others will not with, at the more severe end of the spectrum, patients with dysmorphophobia having an urgent desire for treatment due to an altered self-image [39]. Aesthetic harmony can, in some situations, also lead to a functional improvement of the dentition but few patients will seek treatment for this alone. An unhealthy but attractive dentition is seen as more desirable than a healthy unattractive one.

A popular technique to improve the appearance of teeth is to face them with a new material (Figure 12). This veneer can be composite resin or ceramic and can be long-lasting, conservative of tooth tissue, and offer excellent salvage opportunities should it fail [40]. The emerging opinion is that crowning teeth should be a treatment of the past. Where the aesthetic problem is only due to tooth colour then the ultra-conservative technique of tooth whitening with peroxide gels can be used. If it is only tooth alignment that is of concern then orthodontics is the favoured option. Often a combination of therapies is best to treat the variety of conditions encountered. Figure 13 illustrates the repairing of a white flecks on the front teeth using tooth whitening to brighten the surrounding tooth to make the white fleck less obvious, the space between the teeth being closed with a two-layered adhesive restoration without any need for tooth cutting.

Figure 12: The use of 0.5 mm thick ceramic veneers to improve the shape and size of the teeth without any tooth cutting, a highly conservative technique when used in this way.
The process of redesigning anterior teeth requires the dentist to understand the patient’s perceptions and desires and this can be assisted through the use of models showing different possible outcomes. Computer programmes can be used to adjust photographs of the patient as a starting point. Mock-ups, which can be tried on top of the existing teeth to evaluate the effect, have become available to help predict the outcome of treatment and assess the different possible treatment options. When designing a new smile dentists can take into account general aesthetic principles such as the ‘golden proportion’ (Figure 14), which has a long history of application in mathematics, Greek and art going back as far as 3200 BC as well as in dentistry [41] (Figure 15).

The golden proportion is usually referred to as \( \phi \) which has the mathematical derivation:

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\phi = \frac{1}{2} (1 + \sqrt{5}) \approx 1.618033989
\]

7 Repair concepts and philosophy

The earliest concept in dentistry was probably tooth extraction as the cure for all problems. This advanced from the eighteenth century onwards to a philosophy embracing the removal of the infected material (decay) and replacing it with a substitute material locked into undercuts. The intention was to remove as much decay as possible, and while remarkable work was carried out...
with crude equipment this was still destructive dentistry, although less immediately destructive than the extraction-only formula. During the twentieth century dental equipment improved greatly, enabling more efficient tooth cutting and a standardised approach to cavity design evolved. More efficient cutting equipment meant that teeth could be trimmed down in realistic times and then covered with crowns, usually gold, to protect them against further damage.

The most significant event in recent years, which is bringing about changes in repair concepts today, has been the rapid development of adhesives to bond restorative materials to teeth. The emerging philosophy is now one of ‘preservative dentistry’. Decay can be treated in situ and possibly disinfected rather than completely cut away. A popular approach nowadays is to remove the bulk of the decay but not the deeper layer where tooth damage can occur. New restorative materials are adhesively bonded to avoid the need for creating the highly destructive undercuts. These materials restore the tooth while allowing the tooth to repair itself underneath.

Complete coverage of a tooth with a crown is still used to protect teeth which have been weakened by decay and the subsequent effects of restorations and the restorative spiral. Today it is possible to adhesively bond a restoration in place (Figure 10) and avoid the further destruction necessary prior to covering the tooth with a crown. Where protection from chewing forces is required, then the use of an adhesive partial coverage gold veneer is less destructive (Figure 5b). Another indication for crowning teeth was to improve their appearance but today’s repair concepts would urge dentists to be more tooth-friendly and cut less away. Such techniques again include the use of adhesive partial coverage restorations, in this case tooth-coloured veneers (Figure 12).

Patients and dentists should also move away from the focus being on how long will the restoration last, a frequently asked question, to the more important how long will the tooth last. Far better to have a tooth, or restorative material, repaired as required as part of a maintenance programme than have a more invasive treatment carried out which technically lasts longer but where repair is not possible and failure, when it happens, will be catastrophic, perhaps resulting in tooth loss.

Likely, outcomes and the concept of salvage when repair is required should become part of treatment planning. The replacement of missing teeth is a good example of this. Missing teeth can be replaced with implants rather than cutting down healthy adjacent teeth, and crowning them, to support a bridge. Less cutting means less fear of drills, and less need for anaesthesia which can overcome another fear in dentistry, the needle.
Clearly, if a dentist embraces current evidence-based practice they would be encouraged to step beyond a form of dentistry based on cutting to one of minimal intervention and the use of adhesive materials to replace what is missing. Learning these new repair philosophies and techniques is a challenge to dentistry, particularly as it requires the updating or re-educating of dentists worldwide. Dentists need to be educated in current evidence-based concepts otherwise they tend to practice the same techniques as they were taught when in dental school, or follow therapies which lack an evidence base.

Continuing professional education is now compulsory in most developed countries. The rapid increase in knowledge raises the need for all clinicians to keep themselves updated all the time. For the continuous development of dentists the internet seems well suited [42]. Advanced dental skills are now being taught using multimedia ranging from short courses of 6-hr duration to complete masters degree programmes. An international virtual medical (IVIMED) school exists and a dental equivalent is now being developed (IVIDENT).

Future repair concepts may see dentistry become even less mechanical and more biological with the replacement of missing tooth tissue with laboratory-grown enamel and dentine. The implantation of bovine enamel into teeth faces public opposition. Those at the forefront of research in this field have demonstrated the potential for the use of laboratory-grown dental tissues, which could in theory be shaped and implanted into damaged teeth, and work is underway into the growing of new teeth [43, 44].

Fortunately dentistry is advancing and repair concepts are evolving, embracing new materials and technologies, often from other disciplines. It is an exciting time to be a dentist and a much less unpleasant time to be a patient!

References


