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A simplified aesthetic concept: part one

Douglas Terry1 and Karl Leinfelder2

A good leader voraciously studies history in an attempt to learn from the past. To fully understand the historical progression of a nation, a people, an industry or a concept, one must look at all of the layers of history. Like a good leader, a good scientist, clinician and manufacturer must also review concepts of the past.

The history of dentistry teaches that each new discovery concerning material science helps the clinician learn from the past scientific and clinical efforts and move forward to the development of future techniques.

Traditionally, the hybrid composite resin was used for its strength and fracture resistance, whereas the microfill was necessary to attain not only an improved polishability, but to maintain the durability of the polish.

However, it was soon discovered that this process of stratification – which used the attributes of both the hybrid and the microfill to create an optimal restoration with enhanced mechanical properties – provided another advantage, a variation in the shades and opacities of colour that created the illusion of three-dimensionality – the polychromatic effect (Kovarik, Ergle, 1993; Rinn, 1990).

By using an anatomic stratification with successive layers of dentine and enamel, a more realistic depth of colour could be achieved (Larson, 1986), as well as surface and optical characteristics that mimic nature (Dietschi, 1995; Donly, Browning, 1992). Therefore, past clinical and scientific efforts and requirements to create a more ideal restorative material for function and anatomical form resulted in the development of colour within a tooth.

Furthermore, advancements in restorative materials continue to enhance the practice of dentistry. Newer formulations of composite resin systems have improved physical, mechanical and optical characteristics, which are directly related to the filler particle size, distribution, orientation and the quantity incorporated.

Prior to the introduction of this small-particle composite resin, it was often necessary to combine hybrid and microfilled composites to achieve proper aesthetics (ie, lustre, colour) and mechanical stability (ie, strength, wear resistance, fracture resistance) in adhesive restorations. Since the development of the small-particle composite resin, it appears that these properties have been incorporated into a single restorative material.

Although polychromatic stratification techniques are still necessary with this revised composite resin formulation, they are used only to attain natural aesthetics and colour rather than physical requisites.

This article describes a simplified concept of utilizing a stratification technique of the past with a new biomaterial designed from this concept.

Natural tooth aesthetics

The successful determination and transfer of colour to an aesthetic reproduction of the natural dentition requires an understanding of the interrelationship of optical properties to the anatomical morphology of the tooth.

As light passes through the natural tooth, it is reflected, refracted, absorbed, or transmitted by a multi-layered complex tooth structure that varies according to the optical densities of its hydroxyapatite crystals, enamel rods, and dentinal tubules (Winter, 1993). In natural teeth, differing colours are distributed, and various optical characteristics are observed through the enamel and dentine (Rinn, 1990). This
better explained in terms of tooth anatomy. The degree of translucency or opacity is determined by the structure and the thickness of enamel and dentine as well as the amount of light that penetrates the tooth or restoration. Although both dentine and enamel are translucent in natural dentition, the enamel layer is virtually transparent and colourless. Opalescence is primarily observed in enamel, and in teeth it appears as a light-scattering effect that is associated with the diameter of enamel rods.

Iridescence produces a rainbow effect within the object being viewed. While colours change based upon alterations to viewing direction, location and illumination of an object, the manner in which these parameters change is dependent upon the wavelengths of dispersion, interference, and diffraction of light.

Surface gloss affects the appearance and vitality of teeth and aesthetic dental materials. The surface morphology of natural teeth influences the surface gloss. While macro- or micro-morphologically roughened or coarse surfaces allow diffuse reflection, flat or smooth surfaces allow specular reflection. This optical scattering of light has an effect on the colour perception and translucency of the tooth.

Fluorescence occurs when ultraviolet (UV) light rays are absorbed and blue or white visible light is emitted. Due to
way light is reflected, refracted, transmitted, and absorbed by these dentine and enamel microstructures when restoring the anatomical surface (Winter, 1993). Recreating a natural anatomical surface requires a similar orientation of enamel and dentine. Newer formulations of composite resins possess most of the optical properties that render the tooth polychromatic (Figure 1).

Dentine shades are available in a variety of shades and translucencies, and enamel shades that are highly translucent, fluorescent, and opalescent have been developed. Utilising these composites, it is now possible for the clinician to fabricate a durable, long lasting restoration that is aesthetically indistinguishable from natural tooth structure.

Exacting shade matching and localised characterisation is entirely possible. However, with some composite systems, the attainment of ultimate aesthetics can take a considerable amount of time and experience.

Most composite systems have standard composite resin shade guides that are manufactured from unfilled methacrylates, and do not accurately represent the true shade, translucency or opacity of the final polymerised restorative material (Baratieri, 1998). Furthermore, the range of shades in these standard shade guides is not consistent with natural tooth colour. In addition, many of the composite resins are synchronised to the Vita Lumin shade guide, which was designed for porcelain systems and not composite resin systems. Unfortunately, many of these composite resin systems do not correspond to the true Vita shades.

These discrepancies are the reason for inconsistent colour matching.
matching, which requires a trial and error method through the fabrication of multiple custom shade tabs from the actual restorative material. Also, the use of colour modifiers and opaquin resins can be required to modify and adjust composite colour to attain all the possible natural tooth colours.

A recently developed composite resin system (Amaris, Voco) may provide solutions to these inequities, by offering more accurate shade development. This system was designed from the stratification concepts of the past and a biomaterial fabricated from those concepts. It provides a simplified method of combining dentine colour and enamel value in relationship to the natural tissue anatomy to more evenly distribute and attain natural tooth colour.

This colour management concept was designed with the consideration of varying combinations of enamel and dentine shaded composite instead of using a single monochromatic composite resin colour. The concept that most of the colour (ie, yellow, orange and red) originates from the dentine provided the insight of grouping Vita shades of similar hue and chroma to realistically replicate the optical properties of the natural tooth.

The composite system has six base opaque dentine shades arranged respectively, according to increasing chroma (ie, 01-05 or 0 Bleach-05). There are three enamel translucent shades that provide value (ie, brightness to the restoration) and the aforementioned secondary optical properties (ie, translucency, fluorescence, iridescence and opalescence) (Figure 2). In addition, it provides two additional special shades – a high translucent and opaque shaded flowable composite.

The high translucent shaded composite can be used for incisal edges, enamel or incisal defects and to achieve a high gloss surface reflectivity. The opaque shaded composite can be used for masking discolourations (ie, amalgam staining, improved colour transition for endodontic access openings in ceramic restorations).

This duo shade concept, utilised with these designed shades, allows for an improved and even distribution of the entire tooth colour space.

It provides 18 possible tooth colour combinations while synchronising to the Vita shade guide. Furthermore, this system’s shade guides are manufactured from the composite resin material and so they accurately represent the true shade, translucency or opacity of the final polymerised restorative material.

Therefore, the shade matching system provides the best replication of dental composite colour since it is synchronised with the same polymerised restorative material as the composite system that is being matched. This synchronisation process allows the clinician to compare the actual polymerised restorative material of the composite system to the natural tooth colour for a more accurate ‘aesthetic colour matching’.

This concept utilised with the Amaris composite resin system not only simplifies the replication of the optical properties of the natural tooth but also provides consistent and predictable results.

Part 2 of this article will describe the process by which anterior and posterior composite resin restorations can be developed in a more efficient period of time using sound scientific principles to achieve ultimate aesthetics using this concept.

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A simplified aesthetic concept: part two

Douglas Terry¹ and Karl Leinfelder²

Using a simplified placement technique

The method of restoring the prepared tooth has been the subject of considerable discussion. A myriad of restorative techniques have been developed to avoid the limitation of depth of cure, to reduce the effects of polymerisation shrinkage, improve marginal adaptation and seal (Dietschi et al, 1995; Lutz, Kull, 1980; Eick, Welch, 1986; Koenigsberg, Fuks, Grajower, 1989; Tjan, Berg, Lidner, 1992) to enhance aesthetic results (Tjan, Glancy, 1988; Kovarik, Ergle, 1993) and provide the clinician with maximum benefit for their application (Davidson, Feilzer, 1997).

Several of the incremental stratification techniques include horizontal, vertical oblique, centripetal, three-sited light-cure, and centripetal build-up. These various methods are recommended according to the type and dimension of the cavity preparation (Terry, 2004).

While it is commonly believed that segmentally filling the preparation generates the least pull on the buccal and lingual cusps, not all literature agrees. In a study conducted at the University of Minnesota, Versluis et al (1996) demonstrated that bulk fill produced the least strain on the opposing cusps.

Although these stratification techniques allow the clinician to provide beautiful results, the use of intricate multi-layering with numerous shades of composite may not be efficient, realistic, or practical for the modern dental practice.

In an effort to simplify, improve efficiency and provide optimal aesthetics, a new nano-composite formulation was designed and integrated to the following duo-shade modified placement technique for posterior and anterior composite restorations.

Posterior restorations

For posterior restorations (Figures 1-6) this technique uses one continuous increment (ie, tubular shaped) that is placed and adapted in an oblique layer against the cavity wall with a round tipped composite instrument (PKT-3A, Brasseler, USA). The increment is cured through the cusp and the original cavity floor becomes part of the cavity walls. This process reduces the ratio of cavity volume to an area of the cavity walls, which results in a substantial reduction in the

Figure 1: Preoperative occlusal view of defective amalgam restorations with recurrent decay on maxillary first and second premolars.
eliminates all residual composite extended beyond the preparation but it also fills in any region that may have been somewhat underfilled. Upon completion, the same burnishing instrument can be used to develop the central fissure, buccal and lingual developmental grooves and the incline planes. After light curing, the rubber dam is removed and an articulating paper is employed for the purpose of determining the existence of prematurities.

Anterior restorations

This same duo-shade placement technique can also be utilised in direct anterior composite restorations (Figures 7-
The magnitude of the shrinkage stresses, however, generated from polymerisation shrinkage is less for most anterior composite restorations, since the ratio of bonded to unbonded surfaces is generally less for these restorations. Therefore, considerations for utilising stratification techniques to minimise the effects of shrinkage stress are minor.

We prefer to use a long bladed interproximal carver for placement and adaptation and a sable brush to smooth the surface. A curved instrument (TINL-R, Brasseler, USA) can be
Terry / Leinfelder

dentine cause considerable light scattering, which produces internal diffusion of incident light and allows the composite restoration to blend with the tooth appearance. This ‘blending effect’ or ‘chameleon effect’ occurs as diffused light enters from the surrounding tooth and, when emitted from the restoration, alters its colour by absorbing colour from the tooth. This colour alteration depends on the scattering and absorption coefficients, which can produce an undetectable colour match by blending with tooth colour (Hall, Kafaslias, 1991).

Conclusion
As we compare the old and the new in history, only time can provide the answers of knowledge, wisdom and truth. Knowledge of a concept of the past and a desire to create are limited by the materials clinicians have available to them for restorative procedures. Advancements in composite resin technology continue to improve the practice of dentistry. Continuing technological breakthroughs allow the clinician to not only comprehend the ‘building blocks’ of the ideal composite restoration, but also to implement and maximise the potential of new materials to attain more predictable and aesthetic results.

Since only the passage of time can provide the answer to the success of a material, future clinical trials will be required.
to determine the long-term benefits of Voco’s resin formulation.

The clinical examples provided in this article demonstrate the ability of this nanoparticle hybrid formulation to simulate the optical properties of the natural tooth.

References


Figure 12: The postoperative result achieved with this simplified two-layer nano-composite system reveals the natural integration of composite resin with tooth structure.


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Making sense of mouth ulceration: part two

Crispian Scully

Blood and blood vessel disorders
The clinical appearance of an oral ulcer on its own is rarely diagnostic. In the light of multiple causes, some systematic way of dealing with ulceration is needed, such as my system of splitting the causes into:
• Systemic
• Malignancy
• Local
• Aphthae
• Drugs.
This article discusses the first of the systemic causes – blood or blood vessel disorders.
The main disorders of blood or blood vessels that may present with mouth ulceration include:
• Anaemias
• Leukaemias and myelodysplastic syndromes
• Lymphomas
• Neutropenias
• Vasculitides.

Anaemia
Anaemia underlies a small minority of people who suffer recurrent ulceration; usually these are due to a haematinic deficiency of iron, folate or vitamin B12.
Diagnosis is usually from a blood test; treatment is attention to the underlying cause and replacement of the missing factor. In some, the ulcers may abate.

Leukaemia
Leukaemia is a malignant proliferation of leucocytes, which presents with:
• Lymphadenopathy (and enlarged liver/spleen)
• Effects from bone marrow malignant proliferation of leucocytes:
  – Anaemia
  – Thrombocytopenia
  – Infections.
Common oral manifestations may include:
• Lymphadenopathy
• Bleeding and petechiae
• Gingival swelling (Figure 1)
• Ulceration (Figure 2)
• Others:
  – Sensory changes (particularly of lower lip)
  – Extrusion of teeth
  – Painful swellings over mandible
  – Parotid swelling (Mikulicz syndrome)
  – Infections: fungal and herpes virus lesions.
Diagnosis is from:
• Blood film
• White cell count (raised)
• Differential count (shows blasts)
• Platelet count (reduced)
• Bone marrow biopsy.
Treatment is mainly by chemotherapy. Mouth care is important:
• Oral hygiene should be maintained (using chlorhexidine mouth rinses and a soft toothbrush)
• Prophylactic antifungal and antiviral therapy
• Use oral cooling to reduce ulceration caused by chemotherapeutic agents. Methotrexate ulceration may be prevented or ameliorated by intravenous folinic acid (‘leucovorin rescue’) or topical folinic acid.

Lymphomas
Lymphomas are malignant tumours that originate in lymph...
Vasculitis associated with the anti-neutrophil cytoplasmic antibody (ANCA) affects small- to medium-sized blood vessels, causing chronic inflammatory diseases with widespread manifestations. The most common is granulomatosis with polyangiitis (formerly known as Wegener’s granulomatosis). Features affect ear, nose, throat, lungs and kidneys, while oral features may include gingival swelling (strawberry gingivitis), mouth ulcers as well as underlying bone destruction.

Diagnosis includes positive ANCA test, confirmed by

nodes and lymphoid tissue. They are classified as Hodgkin’s disease, non-Hodgkin’s lymphoma (NHL) or Burkitt’s lymphoma (seen mainly in Africa) (see Table one).

Lymphomas are:
- Diagnosed by a full blood picture and bone marrow biopsy
- Treated mainly by chemotherapy
- Managed by improving oral hygiene, therefore mouth care is important. Use antimicrobials as necessary.

Neutropenia
Neutropenia is where there is deficient polymorphonuclear neutrophilic leucocytes – the main protection against bacteria. Patients with defective neutrophils suffer much the same problems as those with immune defects – susceptibility to respiratory and mucocutaneous infections. Neutropenia may result from viral infections (especially HIV), drugs, irradiation, or can be idiopathic.

Neutropenia can cause:
- Persistent ulcers lacking an inflammatory halo (Figure 3)
- Bleeding tendency
- Lymphadenopathy
- Infections.

Diagnosis is by a full blood picture and bone marrow biopsy. Oral management is by improving oral hygiene, and by using antimicrobials as necessary.

Table 1: Lymphomas key facts

<table>
<thead>
<tr>
<th>Hodgkin’s disease:</th>
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<tbody>
<tr>
<td>• Particularly affects middle-aged males, with progressive lymphoid tissue involvement</td>
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<td>• Often begins with enlarged, discrete and rubbery neck lymph nodes</td>
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<tr>
<td>• Drinking alcohol may cause pain in lymph nodes</td>
</tr>
<tr>
<td>• Symptoms include pain, fever, night sweats, weight loss, malaise, bone pain and pruritus</td>
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<tr>
<td>• Treatment by chemotherapy and radiotherapy is remarkably successful.</td>
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<table>
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<tr>
<th>Non-Hodgkin’s lymphoma:</th>
</tr>
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<tbody>
<tr>
<td>• Is more common than Hodgkin’s disease</td>
</tr>
<tr>
<td>• Has poorer prognosis</td>
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<tr>
<td>• Affects the gastrointestinal tract and central nervous system</td>
</tr>
<tr>
<td>• Enlargement of cervical lymph nodes is often a symptom</td>
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<tr>
<td>• Often affects the gingivae or faucial region</td>
</tr>
<tr>
<td>• Is a recognised complication of HIV/AIDS</td>
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<tr>
<td>• May be Epstein-Barr virus (EBV) related.</td>
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Vasculitides
Vasculitides are conditions where there is blood vessel inflammation (vasculitis). They include giant cell arteritis, anti-neutrophil cytoplasmic antibody-associated vasculitides, and lupus erythematosus (LE).

Giant cell arteritis typically causes pain in the temple, tongue or masticatory muscles – rarely necrosis and ulceration of lip or tongue. As the retina may also be damaged, systemic steroids are indicated as an emergency.
biopsies from sites of active disease. Therapy for a localised disease is co-trimoxazole, while for organ-threatening disease is prednisolone plus cyclophosphamide or rituximab.

There are two types of lupus erythematosus:
- Chronic discoid lupus erythematosus (DLE)
- Systemic lupus erythematosus (SLE).

DLE has:
- No involvement of internal organs
- Erythematous rashes
- Mucocutaneous white/red patches with ulcers
- White patches with central ulceration.

SLE is a systemic vasculitis that is more widespread than DLE. Lesions may be:
- Gastrointestinal
- Haematological
- Mucocutaneous
- Musculoskeletal
- Neuropsychiatric
- Ocular
- Pulmonary
- Renal.

Mouth ulcers are similar to lichen planus but can be unilateral. Diagnosis is confirmed by auto-antibodies to DNA (anti-DNA) and extractable nuclear antigens (nuclear ribonucleoprotein [RNP], Sm, Ro, and La).

Treatment is with non-steroidal anti-inflammatory drugs, antimalarials, corticosteroids, and other immuno-suppressants or biologic agents.

References


Disclosure

This series offers a brief synopsis of the diagnosis and management of mouth ulceration – a complex topic that includes common disorders, and less common but life-threatening conditions. It does not purport to be comprehensive, and the series may include some illustrations from books written or co-authored by the author and colleagues from UK and overseas, published by Elsevier-Churchill Livingstone, Wiley-Blackwell, or Informa/Taylor & Francis – all of whose cooperation is acknowledged and appreciated.

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Making sense of mouth ulceration: part three

Crispian Scully

Viral infections

The clinical appearance of an oral ulcer on its own is rarely diagnostic. Any ulceration with fever or with other orofacial or extraoral lesions may be suspect. In the light of multiple causes, some systematic way of dealing with ulceration is needed, such as my system of splitting causes into:

- Systemic
- Malignancy
- Local
- Aphthae
- Drugs.

This article discusses the second of the systemic causes — infections, which include those mentioned in Table 1.

The main infective viral disorders that may present with mouth ulceration include: herpes simplex stomatitis; varicella zoster virus (VZV) infections; Epstein-Barr virus (EBV) infections; cytomegalovirus; Coxsackie and ECHO viruses; chikungunya fever; and HIV/AIDS.

Herpes simplex stomatitis

The primary infection with herpes simplex virus (HSV) may present, usually in a child or teenager, with a stomatitis manifesting with:

- A sore mouth, with gingival swelling plus scattered vesicles leading to multiple ulcers affecting any area of the mouth (Figure 1)
- Fever
- Cervical lymphadenopathy
- Malaise.

The diagnosis is clinical, though rising antibody titre is confirmatory. The differential diagnosis is from other mouth ulcers especially other viral infections, and viral DNA studies can help.

Management is mostly symptomatic — controlling pain and fever with paracetamol, and there is typically spontaneous remission within seven to 10 days. If the patient is symptomatic, or immunocompromised, systemic aciclovir may be indicated.

Herpes labialis is a recurrence that affects the lips with prodromal paraesthesia, erythema and vesicles. It heals in seven to 14 days.

Penciclovir 1% or aciclovir 5% cream applied in prodrome may help and, in immunocompromised people, systemic aciclovir, valaciclovir or famciclovir are indicated.

Table 1: Infections

<table>
<thead>
<tr>
<th>Viral:</th>
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<tbody>
<tr>
<td>• Herpes simplex virus (HSV)</td>
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<tr>
<td>• Varicella zoster virus (VZV)</td>
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<tr>
<td>• Epstein–Barr virus (EBV)</td>
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<tr>
<td>• Cytomegalovirus (CMV)</td>
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<tr>
<td>• Human immunodeficiency virus (HIV)</td>
</tr>
<tr>
<td>• Coxsackie viruses</td>
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<tr>
<td>• ECHO viruses</td>
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<tr>
<td>• Chikungunya fever</td>
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<thead>
<tr>
<th>Bacterial:</th>
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<tbody>
<tr>
<td>• Mycobacteria</td>
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<tr>
<td>• Treponema pallidum</td>
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<tr>
<th>Mycotic:</th>
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<tbody>
<tr>
<td>• Candidiasis</td>
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<tr>
<td>• Histoplasmosis</td>
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<tr>
<td>• Paracoccidiiodomycosis</td>
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<tr>
<th>Parasitic:</th>
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<tbody>
<tr>
<td>• Leishmania</td>
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<td>• Others</td>
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infectious mononucleosis, and also in lymphomas and HIV/AIDS.

The Paul-Bunell test and antibody studies can be diagnostically helpful. There are no cures or drug treatments; symptomatic treatment usually suffices.

Cytomegalovirus
Cytomegalovirus can cause ulcers, especially in immunocompromised people. There are no cures or drug treatments though ganciclovir may help; symptomatic treatment usually suffices.

Human herpesvirus-8 (HHV-8) or Kaposi’s sarcoma-associated herpesvirus (KSHV)
KSHV can cause Kaposi’s sarcoma, especially in immunocompromised people. There are no cures or drug treatments; symptomatic treatment usually suffices.

Coxsackie and ECHO viruses
These enteroviruses can cause ulcers, especially in epidemics in children. Occasionally there can be cardiac, neurological or other sequelae. There are no cures or drug treatments; symptomatic treatment usually suffices.

Chikungunya fever
This is an RNA virus infection transmitted from a mosquito bite, mainly contracted from areas around the Indian ocean, with an incubation period of usually two to four days and symptoms such as:

- Oral ulceration
- Rash
- Headache, malaise
- Arthralgia
- Fever to 39 degrees.

There are no cures or drug treatments; symptomatic treatment usually suffices.
Worldwide, the RNA human immunodeficiency virus (HIV), which progresses over months or years to the acquired immune deficiency syndrome (AIDS), is mainly heterosexually transmitted. Nevertheless, in general, infection is more common in:

- Young persons
- Travellers
- Men who have sex with men
- Urban areas
- Africa and people of heritage
- Asia
- The Americas
- Eastern Europe.

The UK has one of highest rates of new HIV diagnoses in Europe, outstripped only by Portugal, Ukraine, Estonia and Russia. Most HIV infections are in heterosexuals, contracted on vacation. Many men who have sex with men have HIV. Transnational gay men sexual networks exist, as shown by syphilis and lymphogranuloma venereum (LGV) outbreaks among HIV-positive men, and high rates of migration and travel between Amsterdam, Barcelona, Berlin, London and Paris.

HIV can cause infections and tumours in most tissues and, in the mouth, presents with (Table 2):

- Aphthous-like ulcers
- Candidiasis (Figure 2)
- Hairy leukoplakia
- HIV-related gingival and periodontal disease
- HIV salivary gland disease
- Kaposi’s sarcoma
- Lymphomas (Figure 3)
- Viral infections
- Warts.

Fungal infections

Fungal (mycotic) infections are mainly seen in immunodeficient people, in whom disseminated disease is
common. Seriously ill patients (especially those who have immune defects) may be infected with other fungi, such as candida, mucor and aspergillus.

Increasing population mobility means a wide range of fungal infections (deep mycoses), formerly seen mainly in the tropics, may now also be seen globally. Healthy individuals in endemic areas (often in the developing world) are often infected with these fungi, typically involving the lungs, but often asymptomatic.

Even acute pulmonary and primary mucocutaneous symptomatic mycotic lesions, in otherwise healthy persons, may resolve spontaneously. Chronic pulmonary infections tend to progress and disseminated infections can be fatal.

Orofacial lesions caused by these mycoses are typically associated with lesions elsewhere, often in the respiratory tract. The diagnosis may be suggested by a tumour-like nodule or mass, chronic ulceration, chronic sinus infection, or bizarre mouth lesions, especially in immunocompromised patients, those who have been in endemic areas, or where there is granuloma formation found on biopsy.

Investigations include smear, biopsy, culture, sometimes serology, physical examination and chest radiography. Tissue forms of the fungus may be visible but special stains are often required.

Patients should be managed by a specialist, usually with systemic anti-mycotic drugs.

References


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Diagnosis 2013: the things you need to know for successful endodontic treatment

Thomas Jovicich

The goal of endodontic treatment is for the clinician to achieve an effective cleaning and debridement of the root canal system, including the smear layer and all of its mechanical and bacterial byproducts. Traditionally this is accomplished via mechanical instrumentation in conjunction with chemical irrigants together and actively engaged to completely debride and sterilize the root canal system.

The root canal system is a vast and complex threedimensional structure comprising deltas and lateral canals, along with multiple branches off of the main root canal system (Figs. 1, 2, 9).

Before the clinician can begin to treat a patient in need of endodontic treatment, he or she first must come up with the proper diagnosis. Once the diagnosis has been made, it then must be integrated with the treatment plan. Taking that treatment plan and presenting it to the patient creates the next challenge: creating value for the patient. One of my most difficult challenges as a working endodontist is creating value for the patient in my chair who has no pain and is here because his or her dentist “saw something” on the radiograph. Pain is the greatest patient motivator we have in dentistry today.

The focus of this article is on diagnosis, and it is my goal to provide the reader with a good grasp of diagnosis as it relates to endodontic treatment.

Endodontics is all about vision. You have it. I have it. The dentist down the street has it. Doing root canals today is all about having the confidence to make the proper diagnosis. This is achieved through repetition. The more you do it, the easier it becomes. In addition, you need consistency that is achieved through positive reinforcement. Once you believe you can do it and the results support that, you then develop competence. This allows you to retain the skills you have worked hard to hone. The most important trait to utilize in clinical practice today is common sense. This is what separates the true artisans from tooth mechanics.

The key component to endodontic treatment is diagnosis. It is based upon using a multifocal approach that involves:
- patient report,
- medical and dental history,
- clinical signs and symptoms,
- diagnostic testing,
- radiographic findings,
- restorability.

Taking and collating all of this information will allow the clinician to arrive at a proper and thorough diagnosis. Let’s break these down and delve into what needs to be done.

**Patient report**

This is the first opportunity to create a road map to a diagnosis. The goal is to ascertain the nature of the problem. Step one: Ask the patient the where the pain is located.

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Once you’ve localized the area, it’s imperative to ask a few more questions. The next question should involve determining pulpal vitality through the use of an ice pencil.

Other times the patient will volunteer this information with a statement like: “The minute I put anything cold on this tooth, the pain is present and quite intense.” This information suggests that the pain may be pulpal in origin. Because the trigeminal nerve is involved in endodontics, it is important to determine any type of radiating pain. It is not uncommon for maxillary root to radiate from the mandibular area and vice versa. A final area of feedback I want from patients relates to biting and chewing.

The patient’s report is the foundation upon which we begin the diagnostic procedure. Asking probing and leading questions in “plain English” will allow the patient to give you critical diagnostic information.

Medical and dental history
Once you have the patient’s report, probing his or her medical and dental history gives clarity to the background. What are the patient’s medical allergies? What recent dental treatment has the patient had? Was there any mention of restorations placed that were near or at the pulp?

Many times a patient will mention having heard the dentist tell his assistant that they were close to the pulp during the excavation of decay. Asking detailed questions enables you to enrich the diagnostic canvas as to why the patient is sitting in your chair.

Clinical signs and symptoms
By this point, you have listened to the patient’s chief complaint and you have taken radiographs or digital images. It’s time to “test” the patient. The “bite test” involves having the patient attempt to reproduce the pain through biting on an orangewood stick or a cotton swab or a wet cotton roll. If there is pain to bite, you are dealing with some degree of pulpal inflammation with secondary involvement of the periodontal ligament. Once you have this information, the next step is to look at your digital imaging and analyze the relationship of the periodontal ligament (pdl) to the root. Is there a thickening? Is there a widening?

If the patient reports pain to bite upon release, this infers that there may be some structural root damage (Figs. 5a & b). At that point is it essential to look at the occlusal surface of the tooth, account for the type and age of any restoration and inquire if any recent dentistry has been done. In addition, it is imperative to probe the suspected tooth.

Probing from buccal to lingual with at least four measurements per side is the best barometer to assess periodontal health. If you find an isolated defect in any single probing, you are most likely dealing with a fracture of the root. Endodontic treatment to confirm or rule out a fracture is indicated in these clinical situations.

Diagnostic testing
The percussion test involves using the blunt end of a mouth mirror or periodontal probe to assess for periodontal inflammation. It is imperative that the clinician gets a frame of reference. This is accomplished by testing the same tooth on the opposite side of the arch. In addition, it is prudent to test the suspected tooth as well as the teeth on either side. Testing should involve both the occlusal and facial surfaces.

Thermal tests utilizing hot or cold are the definitive modality to assess pulpal vitality. There are a myriad of ways to test with cold, including CO2 systems, refrigerant sprays and ice cubes (pellets). I believe ice pellets are the best way to evaluate pulpal vitality.
Jovicich

the maxilla, referred pain can be related to sinus issues, such as sinusitis, allergic rhinitis and rhinovirus.

If the patient does not respond to any thermal tests, both hot and cold, it is a sign that the pulp is necrotic, dying or infected. In this instance, studying the digital imaging may aid the diagnosis. One caveat: It is possible to have a necrotic pulp without being able to quantify it via digital images. In many incipient pathology issues, it takes approximately 90 to 120 days for breakdown to manifest itself on imaging. Today’s cone-beam imaging technology can shorten that process to 30 days. It is not uncommon to have a patient in the chair with symptoms that you cannot quantify radiographically.

Radiographic findings

Radiographic findings (Figs. 8a & b) are the road map for endodontics. Thorough study and evaluation of imaging allows the clinician to determine a multitude of facts about the tooth in question. What does the image reveal? Can you see if there is a widening of the pdl? If there is a widening of the pdl, it is essential to have the patient bite down on a bite stick. Once he or she does that, you must ask if the pain, if present, is worse upon bite or upon release of bite. The latter is highly correlated with root fracture. Once that is confirmed, the next step is to prepare the patient for a root canal.

The dentist must convincingly explain the procedure’s value as well as caution the patient about the possibility of losing the tooth due to the fracture extending apical from

to test for cold symptoms. In our practice, we use anesthetic carpules that are filled up with water and frozen.

This method is cheap, efficient and plentiful. The goal is to reproduce the patient’s symptoms. Many patients who report pulpal hyperemia have managed this symptom by utilizing the opposite side of their mouth. Temperature symptoms are a major motivator for patients to seek dental care.

Testing with ice involves establishing a baseline to cold. Typically, I chose to test the same tooth on the opposite side or the maxillary central incisor. I ask patients to tell me when they feel an “electrical shock or jolt” to the tooth. As soon as they do that, I remove the ice from the tooth. This is easily accomplished on the buccal surface of the tooth at the margin of the gingiva. When porcelain restorations are present, I strive to put the ice right at the margin on or above any metal margins.

Sometimes it is necessary to apply the ice on the lingual aspect of the tooth. As unresponsive as porcelain restorations can be, the clinician needs to be aware that pulp testing gold restorations can have the opposite effect. This is because of the metallurgical properties of gold. It is an amazing conductor of temperature. Always forewarn the patient when testing gold-restored teeth.

Ask the patient if the cold on the tooth reproduced his or her pain. Also, ask if the pain lingered after you removed the ice from the test site. If the pain it is lingering, it is a sign of irreversible pulpitis.

In some cases the pain can and does radiate along the pathway of the trigeminal nerve. Sometimes, especially in

Figure 4a: The presence of caries under the margin of a restoration. The caries extend to the pulp and will need endodontic treatment.

Figure 4b: The endodontic treatment is completed. In this case, the patient was lost to the practice for three years and came back when his face was swollen because of incomplete treatment.
Save the tooth. Decisions involving the long-term prognosis of the tooth were relevant. Decisions about the type of restoration were discussed. Decisions about the osseous health of the roots and surrounding bone structures were relevant.

The goal of every specialist is to be an extension of the general dentist’s practice. To that end, deciding whether a tooth was restorable or not was, at a minimum, a conversation to be had between the specialist and the general dentist.

Leap forward to the new millennium, and dentists no longer fight to save teeth. Dentists realize the financial windfall that implants offer their practices. Dentists can attend a myriad of continuing education courses over a weekend and on Monday become nascent implantologists. This fact makes diagnosis and saving a tooth the most important facet of restorative dentistry moving forward.

Treatment planning and restorability are integral to success both for the patient and the dentist. A patient in pain presents a unique opportunity for the dentist. Many questions need to be asked and answered. Among them: What can the dentist do to manage the pain? What is the cause of the pain? How long has the patient been in pain? Once the initial triage phase is complete, other factors must be addressed. These include: Is the tooth restorable? If endodontic treatment is indicated, what further treatment will be needed? Is there a need for periodontal intervention? If so, what type of treatment is it? Osseous surgery? Does the tooth need crownlengthening surgery? How will these procedures affect the adjacent teeth?

The above paragraph speaks volumes as to the complexities of treatment planning in dentistry today. Every day in offices around the world, a patient visits his or her dentist in pain. How the dentist responds to this will go a

Figure 5a: Cracked tooth syndrome. Pre-treatment radiograph.

Figure 5b: What can happen in a cracked tooth when you obturate with warm, vertical condensation of gutta-percha.

the cementoenamel junction (CEJ). Is there a lesion (Figs. 3a & b) present? This information allows me to frame my diagnostic questions to the patient. These include: Is the tooth sensitive to cold? I know from the lesion that the answer to that should be no. If, however, the answer is yes, it automatically triggers my mind to look for another tooth.

Generally, speaking teeth with lesions of endodontic origin (LEOs) test non-vital to thermal or electric pulp testing. In sequencing, I first ask for the patient’s report, followed by radiographic findings, which I then augment with clinical testing to tie it all together and arrive at a diagnosis. Lastly, are caries present? The location of caries is a determining factor as to whether a root canal is needed (Figs. 4a & b).

**Restorability**

Restorability is an issue that has been a hot topic in dentistry for years. Its meaning has evolved as technology has become the backbone of modern dentistry. Prior to the incorporation of implant dentistry, restorability had a very different meaning. Dentists were much more motivated to save teeth. Options and creativity were necessary for clinical success, both in endodontics as well as in restorative dentistry.

Technology has taken away one form of resourcefulness and replaced it with the promise of a panacea. It has become far too easy for general dentists to recommend removal of a tooth to a patient with the promise that an implant will save the day.

Historically speaking, the diagnosis of a tooth being non-restorable came after a myriad of attempts to save the tooth. Every aspect of dentistry came into play. Periodontists did osseous surgery and root amputations. Endodontists performed conventional endodontics and, if necessary, surgical intervention to do everything possible to save the tooth. Decisions involving the long-term prognosis of the tooth were relevant. Decisions about the type of restoration were discussed. Decisions about the osseous health of the roots and surrounding bone structures were relevant.

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The above paragraph speaks volumes as to the complexities of treatment planning in dentistry today. Every day in offices around the world, a patient visits his or her dentist in pain. How the dentist responds to this will go a
endodontic treatment, or extract the tooth and place an implant. Too soon today, dentists will opt to extract a tooth that has a questionable prognosis in favour of placing an implant. It is my opinion that dentists should exhaust all possible options before opting to place an implant. Recently, I treated two of my colleagues with cracked teeth who wanted to exhaust every option (both were treated surgically). Ironically, they are two dentists who are heavy into implant dentistry. There has never been a better time to employ the “Golden Rule” for treatment planning.

What are the factors involved in the decision? Is there enough bone to support an implant? Will you have to augment or condition the site? If you elect to do endodontic treatment and it fails, are you willing to surgically try to save the tooth? If so, and it still fails because of a fracture, by doing surgery have you destroyed the bone? Can the patient afford to place an implant? And are they prepared for the amount of time they may be edentulous in that spot? All of these situations merit a thorough and honest discussion with the patient. In addition, the dentist needs to take into consideration the patient’s motivation to go through these procedures. Many times I speak to patients about implants, and they are surprised by the cost and shocked by the time it will take before they have an implant crown functioning in their mouths.

In modern endodontics, as technology advances and we bring on file systems that shape more efficiently and safely—and we develop a greater understanding of the role of irrigation in endodontics — we can offer higher success rates than at any time in history. This paradigm starts with long way in determining the patient’s dental well-being. A well rounded practice with high moral fiber will enable the dentist and patient to work synergistically to develop a realistic treatment plan.

The last essential ingredient to success is that the dentist knows “when to say when” (Fig. 7). As a specialist and lecturer, I believe that if a general dentist does roughly 80 per cent of the endodontic cases that walk in the door of his practice and refers out the remaining 20 per cent, he or she will have a very busy endodontic practice. In the past five years, especially since the decline in the economy and busyness of practices, more than 50 per cent of my practice consists of retreatment. The general dentist should have never attempted more than half of those cases. I can only speculate how much more there would be if dentists didn’t have implants to fall back upon.

Implants vs. endodontic treatment

The next aspect of the diagnostic conundrum is the increasing role implants play in treatment planning. When I first began practicing endodontics in 1988, implants were in their nascent stages. If a patient had a root canal and continued to experience pain or discomfort, both the dentist and the endodontist had a myriad of choices, from retreatment to surgical correction. In 2013, the knee-jerk reaction to placing implants has never been greater. More and more general dentists go to weekend “seminars/courses,” and on Monday morning they are placing implants. Much of this is based on the financially lucrative aspect of implant dentistry.

This has created polarizing arguments: save the tooth via endodontic treatment, or extract the tooth and place an implant. Too soon today, dentists will opt to extract a tooth that has a questionable prognosis in favour of placing an implant. It is my opinion that dentists should exhaust all possible options before opting to place an implant. Recently, I treated two of my colleagues with cracked teeth who wanted to exhaust every option (both were treated surgically). Ironically, they are two dentists who are heavy into implant dentistry. There has never been a better time to employ the “Golden Rule” for treatment planning.

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Understanding the patient’s symptoms and medical contraindications, correlating them with the proper diagnosis and then having the ability to honestly look in the mirror and decide that you can perform this treatment successfully.

These are the core decisions that need to occur on every level of dentistry. Successful implementation of these values and diagnostic procedures will lead to a profitable and stress-free practice.

Summary

Does the dentist have all of the salient dental facts? By asking for the patient’s symptoms, you begin the diagnostic process. From there the journey begins. Next, does the dentist understand the patient’s chief complaint and symptoms? Once I understand what the patient is in my chair for, I calculate a path that will get me the most diagnostic information. I will need to use imaging, thermal sensitivity tests and bite tests. Imaging gives me the direction. Once I determine the vitality and take the periodontal health into consideration, it’s time to discuss the diagnosis and treatment options with the patient.

I always present treatment in sequences. The first option for the patient would be to take my findings “under advisement.” Those are patients who typically do not present with pain and at that moment in time do not appreciate the need for a root canal. I never worry about those people, because nine times out of 10 they will be back in my chair sooner rather than later. The second choice revolves around the need for endodontic treatment.

With this option, I create value for the need for treatment. Couple that with the patient being in pain and wanting relief, and the decision and diagnosis is easy for this patient type. The third option I give each and every patient involves letting him or her know that extraction is a viable option for his or her tooth. With that, I explain if the site is a good candidate to receive an implant and give him or her information on the time, cost and procedure involved in placing an implant. It is legally very important that your consultation and diagnosis involve every possible option.

In sum, the goal of diagnosis is to be able to collate the patient’s chief complaint with his or her clinical symptoms. Once that is done, the dentist moves through a logical progression of treatment options, with the goal of providing excellence (Fig. 6). In this paradigm, both the patient and the dentist benefit from superior service and treatment.

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Figure 8a: Initial digital image with a patient whose chief complaint was mild pain to bite and chew.

Figure 8b: Digital photo of the tooth after I extracted it, showing a gross negligence. The tooth was perforated through the furcation, and gutta-percha was placed in what the dentist thought was the root canal system.

Figure 9: The complexities of maxillary molar endodontics and multiple portals of exit. Of note, I was never able to shape the MB2 canal.

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BIO-ESTHETICS: giving a new face to smile enhancements

Bio esthetics is the quintessence of biology, biomechanics and esthetics and aims to more conservative, ethical solutions to a myriad of esthetic deficiencies.

Introduction
A more attractive smile, improved dental esthetics and durable results have been for long intimately linked to ceramic restorations such as veneers and crowns and remain strongly anchored in patients and dental professional minds. Modern composite resin technology has however challenged this assumption because they offer excellent aesthetic potential and acceptable longevity, with a much lower cost than equivalent ceramic restorations for the treatment of both anterior and posterior teeth. Moreover, composite restorations allow for minimally invasive preparations or no preparation at all when modifying existing tooth anatomy or assuming the replacement of decayed tissues; this constitutes an unparalleled advantage of “free-hand bonding” also due to its relative simplicity. This rationale has been the foundation of a new concept named „bio-aesthetics”, giving priority to additive, minimally or microinvasive procedures to preserve tooth biology and biomechanics.

While resin composites are universally considered the “standard of care” material for the filling of small to medium class III, IV and V cavities, they can be used today in many more indications such as the correction of small to moderate aesthetic and functional deficiencies. Recent developments in composite optical properties and physical properties have also significantly contributed to simplifying their application and improving treatment outcome and
This rationale has been the foundation of a new concept named ‘bio-aesthetics’, giving priority to additive, minimally or microinvasive procedures to preserve tooth biology and biomechanics.

The aim of this short article is then to demonstrate the potential and multiple applications of composite as a modern aesthetic restorative material in the context of bio-esthetic treatment approach. Predictability.4-6

Figure 1a and 1b: Preoperative views of a young patient presenting relatively large diastemas distally to lateral incisors. The case is complicated by improper occlusal relationship with lower canines which reduce the space available for restorations.

Figure 1c, 1d and 1e: Post-operative views showing an improved smile configuration using «no-prep» direct composite restoration (inspiro, EdelweissDR). This treatment illustrates the «bioesthetic» philosophy which truly represents a breakthrough in modern restorative dentistry.
Dietschi

Table 1: Treatment decision process

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Direct option veneer ..to.. crown</th>
<th>Indirect option</th>
</tr>
</thead>
<tbody>
<tr>
<td>age of the patient</td>
<td>younger</td>
<td>older</td>
</tr>
<tr>
<td>size of the decay</td>
<td>smaller</td>
<td>larger</td>
</tr>
<tr>
<td>tooth vitality</td>
<td>vital</td>
<td>non-vital</td>
</tr>
<tr>
<td>tooth colour</td>
<td>normal</td>
<td>non-treatable discolouration*</td>
</tr>
<tr>
<td>facial anatomy</td>
<td>normal</td>
<td>altered</td>
</tr>
<tr>
<td>number of restoration</td>
<td>unrelated</td>
<td>unrelated</td>
</tr>
</tbody>
</table>

*using chemical treatments (vital & non-vital bleaching or microabrasion)

Table 2: Modern progressive treatment concept and various types of procedures

<table>
<thead>
<tr>
<th>Types of procedures</th>
<th>Typical procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non restorative</td>
<td>Esthetic chemical treatments (bleachings, micro-abrasion)</td>
</tr>
<tr>
<td></td>
<td>Direct bonding</td>
</tr>
<tr>
<td>Minimally invasive</td>
<td>Direct bonding</td>
</tr>
<tr>
<td></td>
<td>Ultra-thin Veneers</td>
</tr>
<tr>
<td></td>
<td>Modern inlays and onlay techniques</td>
</tr>
<tr>
<td>Micro-invasive</td>
<td>Classical veneers, inlay and onlays</td>
</tr>
<tr>
<td>Macro-invasive</td>
<td>Crowns and bridges</td>
</tr>
</tbody>
</table>

Revisiting smile rehabilitation concepts: Bio-esthetics

Choosing the right restorative approach (direct or indirect, composite or ceramics) has been debated over decades and finally, the decision largely depends on the practitioner’s own education background and experience with each of the aforementioned options. Only “extreme” conditions such as minor aesthetic form and color corrections or extensive decays in non-vital teeth, lead to evident solutions (direct and respectively indirect restorations), while the majority of other cases lie in a “gray zone” which actually makes a pertinent choice more intricate. A simple yet effective approach to this dilemma relies on a sound bio-mechanical analysis of the teeth potentially involved in the treatment status, combined to the usual functional and aesthetic analysis. Then, having as a prime objective the respect of tooth biology and conservation guides clinician to a logical decisional tree, such as presented in table 1.

The “Bio-esthetic” philosophy actually give priority to chemical color improvements (vital bleaching, non-vital bleaching, micro-abrasion), associated to direct composite restorations and bonded ceramic restorations for more extensive decays, limiting the use of traditional full crowns to existing restoration replacement and a few conditions of extreme tooth fragilization. The progressive treatment concept presented in table 2 then summarizes the modern vision of esthetic restorative dentistry.
New shading approach: the natural layering concept
To achieve perfect direct restorations has been for long and hypothetical aim due to the imperfect optical properties of many composite resins systems. So far, the oversimplification (mono-incremental) as well as over-complexity...
Figure 3a: Preoperative views of a young patient showing enamel hypocalcifications and asymmetrical tooth forms.

Figure 3b and 3c: Shade selection is performed using a special dual-laminate shade guide which grants color predictability (inspiro).

Figure 3d and 3e: A partial mockup (teeth #11 & #12) is made to assess the impact of planned restorations on the smile configuration.
(multi-incremental) of shading systems has tremendously limited the benefit of direct composite restorations. Even today, the complexity of some systems is often associated to shading concepts mimicking ceramic systems (which are applied in totally different layer thicknesses) or the influence of over-meticulous clinicians who compensated deficient composite optical properties with intricate layering concepts. The use of the natural tooth as a model and the identification of respective dentine and enamel optical characteristics (tristimulus L*a*b* colour measurements and contrast ratio) has then been a landmark in developing better direct tooth coloured
So far, the over-simplification (mono-incremental) as well as over-complexity (multi-incremental) of shading systems has tremendously limited the benefit of direct composite restorations. The ‘natural layering concept’ is then a simple and effective approach to creating highly aesthetic direct restorations which has become a reference in the field of composite restorations.

Dietschi
References

Laser versus conventional therapies

Cristiane Meira Assunção,1 Joanna Tatith Pereira,1 Renata Schlesner Oliveira1 and Jonas de Almeida Rodrigues2

Introduction
In recent years, several studies have been conducted on the clinical applications of laser in dentistry. At the same time, there has been a marked emergence of organisations in support of the use of laser in dentistry. In the last decades, laser therapy has been used in dentistry as an adjunct or alternative to conventional approaches. In this paper, the following topics will be reviewed: the application of laser in caries prevention and diagnosis, hard- and soft-tissue treatments, and periodontal and endodontic procedures. There is a large research effort into new indications for laser in dentistry. It is expected that laser will become an essential component of the dentist's armamentarium.

While the technology was regarded as complex and of limited use in clinical dentistry in the past, a growing awareness of the usefulness of laser in the modern dental practice has been observed. Laser can be used as an adjunct or alternative to conventional approaches.1 When comparing the use of laser with conventional therapies, three important areas must be considered: safety, efficacy and effectiveness. From an ethical standpoint, it is important to use the best available evidence when making clinical decisions.2

Diagnostic laser applications
The most common methods for caries detection are visual and radiographic examination.3 However, visual examination is a subjective method that depends on the knowledge and clinical experience of the examiner.3-6 Several studies have demonstrated that radiographic examination demonstrates poor sensitivity to non-cavitated lesions.3, 7-9

For this reason, fluorescence-based methods have been developed, aiming at the detection of occlusal and approximal carious lesions, for example DIAGNOdent 2095 (KaVo; LF; Figs. 1a-c) and DIAGNOdent 2190 (LF pen; Figs. 2a & b). They rely on the same principle: a laser diode emits red light at 655nm and a photodetector quantifies the reflected fluorescence from bacterial metabolites (fluorophores) in carious lesions, showing values ranging from 0 to 99.3,9

A study that assessed the performance of a visual method, radiographic examination and fluorescence-based methods in detecting occlusal caries in primary teeth found that the visual method and VistaProof fluorescence camera (Dürr Dental; FC) exhibited better accuracy in detecting enamel and dentine carious lesions, whereas the visual method combined with LF, LF pen and FC better detected dentine lesions on occlusal surfaces in primary teeth, with no statistically significant difference among them.3

Another study compared the performance of fluorescence-based methods (FC, LF and LF pen), radiographic examination, and another visual method called the International Caries Detection and Assessment System (ICDAS) II on occlusal surfaces. This study demonstrated that the combination of ICDAS and bite-wing radiographs yielded the best performance for detecting caries on occlusal surfaces.9

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Caries prevention: Enhancing enamel resistance
In the past, several in vitro studies have shown that enhancing enamel demineralisation resistance can be achieved by irradiation with lasers. In a blind in vitro study, Ana et al. 2012\(^1\) compared the effect of professional fluoride application with that of laser irradiation with regard to the demineralisation of enamel and fluoride formation and retention. The study found that both methods enhanced enamel resistance, and no side-effects were found. A greater concentration of retained calcium fluoride-like material was found in the laser group. Formation and retention of calcium fluoride were also improved with laser irradiation.

The wavelengths absorbed most strongly by dental enamel are the 9.3 and 9.6 µm carbon dioxide laser wavelengths. The reduction in acid dissolution of enamel is said to be caused by a loss of the carbonate phase of enamel crystals due to the heat of irradiation. Rechmann et al. 2011\(^2\) demonstrated that short-pulsed 9.6 µm carbon dioxide laser irradiation successfully inhibited enamel caries without any harm to the pulp tissue of the teeth irradiated. The efficacy of carbon CO\(_2\) laser irradiation regarding its long-term effect on caries resistances can be verified by further studies.

Hard-tissue applications: Caries removal
There is limited evidence to support the effectiveness of dental lasers in the removal of caries compared with rotary burs. In order to evaluate this, a systematic review of seven studies with adequate methodologies was performed.\(^8\) Two of the studies found that there was no difference with regard to time taken for caries removal and cavity preparation. Four of the studies found that the laser took up to three times longer to perform these procedures. Four of the studies found that there were no differences between lasers and rotary burs with regard to pulpal effects. One of the studies found that dentists preferred the bur to the laser, and all the studies found that patients favoured the laser with respect to comfort. The studies found that adult patients prefer the laser, although the response from children was inconclusive. The results are not surprising, considering that local anaesthesia is often not needed when using a laser, making the overall dental experience more pleasant for the patient.\(^10\)

Endodontic laser procedures (disinfection)
The main causes of endodontic treatment failure are the presence of persistent micro-organisms and recontamination of the root canal owing to inadequate sealing.\(^11\) The long-term success rate of conventional endodontic treatment depends on several factors, such as the diverse and complex anatomy of the root-canal system that consists of small canals diverging from the main canal. This complex system does not allow direct access during biomechanical preparation because of the canals’ positioning and diameter.\(^6\) New antimicrobial approaches to disinfecting root canals have been proposed; these include the use of high-power lasers and photodynamic therapy, which works by dose-dependent heat generation. However, in addition to killing bacteria, they have the potential to cause collateral damage such as charred dentine, ankylosed roots, melted cementum, root resorption and periradicular necrosis.\(^2\)

In order to compare the effectiveness of antimicrobial photodynamic therapy with standard endodontic treatment and combined treatment to eliminate bacterial biofilms
wavelength of between 655 and 980nm, can accelerate wound healing through the facilitation of collagen synthesis, promotion of angiogenesis, and augmentation of growth factor release. Furthermore, the diode laser has in vitro bactericidal and detoxification effects and can prevent ablation of the root surface, which theoretically reduces the risk of removal of normal root tissue.13

Sgolastra et al. 201214 did not observe significant differences for any investigated outcome (clinical attachment level, probing depth, and changes in the plaque and gingival indices) in their systematic review. These findings suggest that the use of the diode laser as an adjunctive therapy to conventional non-surgical periodontal therapy did not provide additional clinical benefit. However, given that few studies were included in the analysis, the results should be interpreted with caution. Important issues that remain to be clarified include the influence of smoking on clinical outcomes, the effectiveness of the adjunctive use of the diode laser on microbiological outcomes, and the effect of adverse events. Future studies are required to assess the effectiveness of the adjunctive use of the diode laser, as well as the appropriate dosimetry and laser settings.

Soft-tissue applications

There are numerous soft-tissue procedures that can be performed with laser. Two key advantages of this are reduced intra-operative bleeding and less post-operative pain compared with conventional techniques, such as electrosurgery. Certain procedures in patients with bleeding disorders are better suited to lasers with greater haemostatic capabilities.5

Periodontal laser procedures (disinfection)

Conventional periodontal therapy procedures include mechanical scaling and root planing, which has some limitations, especially in reducing bacteria inside deep pockets. In order to overcome the limitations of conventional mechanical therapy, several adjunctive protocols have been developed. Among these, laser has been proposed for its bactericidal and detoxification effects and for its ability to reach sites that conventional mechanical instrumentation cannot.14

Different lasers could be used in periodontal therapy for calculus removal, periodontal pocket disinfection, photoactivated dye disinfection of pockets and de-epithelialisation to assist regeneration.15

Several studies have indicated that the diode laser, with a wavelength of between 655 and 980nm, can accelerate wound healing through the facilitation of collagen synthesis, promotion of angiogenesis, and augmentation of growth factor release. Furthermore, the diode laser has in vitro bactericidal and detoxification effects and can prevent ablation of the root surface, which theoretically reduces the risk of removal of normal root tissue.13

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There are numerous soft-tissue procedures that can be performed with laser. Two key advantages of this are reduced intra-operative bleeding and less post-operative pain compared with conventional techniques, such as electrosurgery. Certain procedures in patients with bleeding disorders are better suited to lasers with greater haemostatic capabilities.5

Conclusion

Although the results of laser therapy are similar (in safety, efficacy and effectiveness) to those obtained with conventional methods, new techniques and devices have been developed. Laser could thus be an evidence-based and well-supported technique for a variety of dental procedures.
Rodrigues

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Figure 2a: Cylindrical tip for occlusal surfaces.

Figure 2b: Wedge-shaped tip for proximal surfaces.

Figure 3: Infra-red laser therapy for treatment of a primary herpetic infection in an adolescent patient undergoing chemotherapy (Therapy XT, DMC).

The use of Registrado X-tra in the fabrication of a multi-unit all-ceramic restoration

Jean Lecerf and Yvan Bedouin

Registrado X-tra is an addition-curing silicone with the following special properties:
- High Shore D hardness (about 51)
- Working time of 30 seconds
- Intraoral retention time of 40 seconds
- Linear shrinkage less than 0.1% after 24 hours.

This makes it a particularly suitable material for registering interocclusal distances and enables it to be used as an alternative to materials such as acrylic resins which are tried and tested, yet less ergonomic to use.

The following report demonstrates one clinical application of this type of material, using a prosthetic restoration in the posterior region of the lower jaw as an example.

Figure 1: Initial clinical situation: the patient is wearing very old collar crowns which are inadequate in the cervical region. These crowns are replaced as part of a comprehensive prosthetic restoration.

Figure 2: Clinical situation after removal of the crowns: the preparations are reworked, bonded or cast crown-root build-ups are fabricated and inserted.

Figure 3: Temporary crowns supplied by the dental laboratory are used in the course of the overall treatment. The original clinical situation is resumed for the temporary restoration.

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Figure 4a and 4b: Impressions are taken of the preparations using the double-mix technique which enables a very accurate registration of the cervical preparation margins.

Figure 5a, 5b, 5c: The impressions are used by the dental laboratory to fabricate individual models. However, the models cannot be positioned exactly in the articulator as there is no longer any occlusion in the posterior region. The use of an occlusal registration material (Registrado X-tra) in the clinical situation enables the models to be stabilised at a later stage. In this case, where the models are positioned in the maximum intercuspation position, the registration material must only be placed within the regions where there is no occlusion (this region is shown in the example by the prepared teeth).

Figure 6a, 6b, 6c: The register produced in this way is first prepared for its positioning on the working model. By trimming the occlusal register, it is possible to ensure it fits optimally on the working models. The process of positioning in the articulator is now complete.
Figure 7a and 7b: The very stable zirconia frameworks can now be fabricated thanks to the working models arranged in the articulator.

Figure 8a, 8b, 8c, 8d, 8e: Zirconia frameworks have been in successful clinical use for many years. At this stage of the prosthetic reconstruction the positioning in the articulator can be checked before the application of the veneer ceramic by checking the interocclusal distances using the occlusal register (Registrado X-tra). The process of trimming the registration material is indispensable here as well. It is only by trimming the occlusal register that it can be correctly re-positioned on the zirconia frameworks and on the occlusal surfaces of the opposing teeth.
Figure 9a and 9b: Provided these checks have been correctly carried out, the veneer ceramic can be applied to the frameworks.

Figure 10a, 10b, 10c: After being returned from the laboratory, the crowns are first checked and then permanently cemented.

Clinical implementation
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