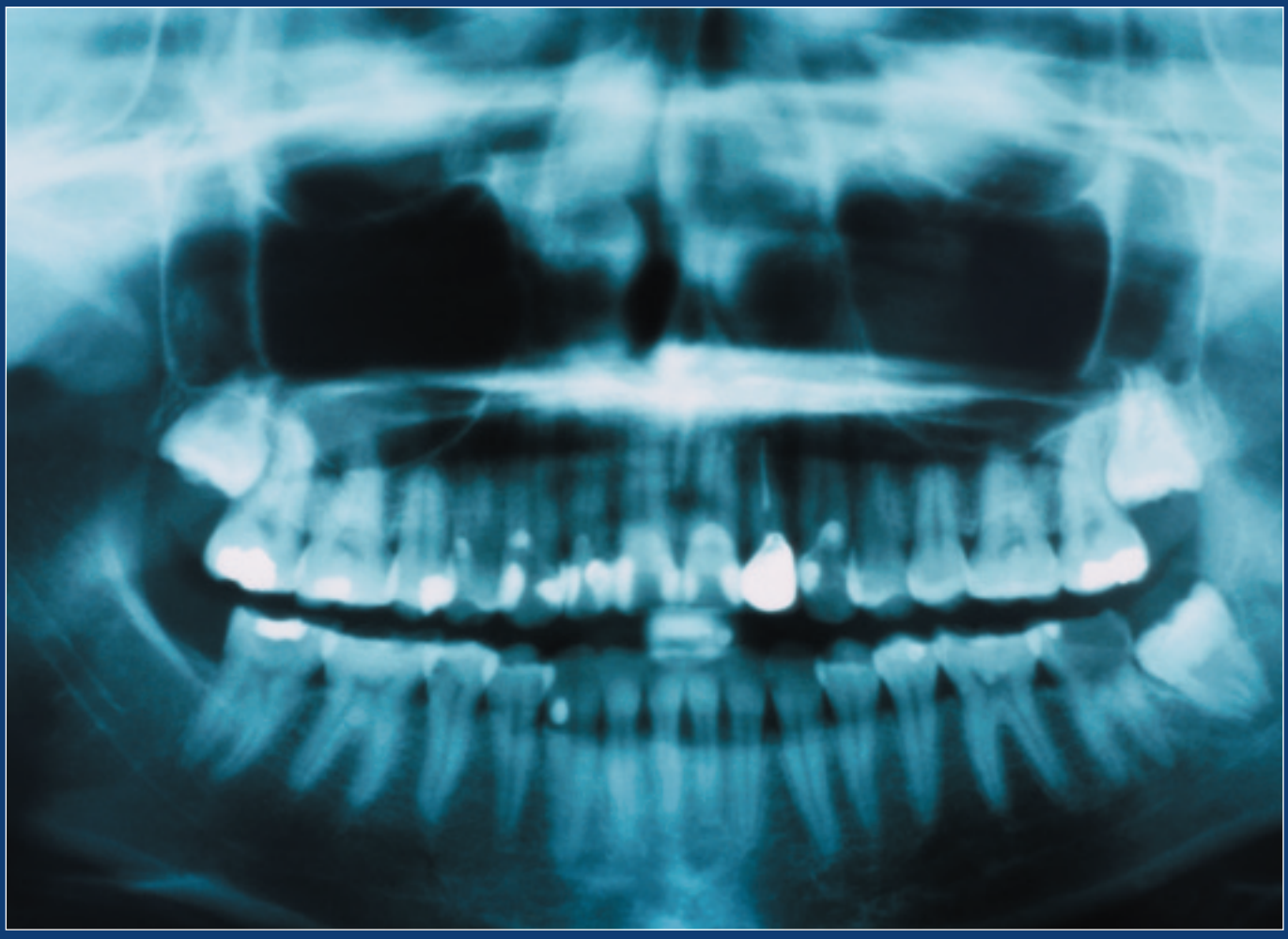

"TODAY'S RESTORATIVES ARE ABLE TO SUSTAIN WEAR THAT IS AS LOW AS THREE MICROMETERS PER YEAR, WHICH RIVALS ACTUAL ENAMEL"

Located in Branford, Connecticut USA, DRM Research Laboratories, Inc. has been in existence for 10 years, although its expertise in dental material science dates back 25 years, to 1978. The company is a research development and manufacturing institute of dental restorative materials including a spectrum of filling, crown and bridge, cements, adhesives, bone repair-graft-augmentation and implant materials.

Dr Samuel Waknine is the President of DRM Research Labs. His role, which mostly involves research and development, takes him all over the world lecturing and providing instruction, be it operative or technological, to clinicians and technologists either at the academic level or the private sector. Dr Waknine talks to *Enlargement EU* about the importance and advantages of using the optimum materials in modern restorative dentistry.

EEU. Could you tell us a little about the history of dental restoration and the advances that have been made in recent years?

SW. Traditionally, metallurgical materials were used for restorations. This was a very well established practice for the best part of 150 years. In the case of fillings, silver amalgams were used to a large extent worldwide. These amalgams are 50 percent powder – composed of silver, tin, copper and a trace amount of zinc – and 50 percent liquid – which is pure mercury – amalgamated to form a paste, which is placed into the cavity. The silver amalgamates by reacting with the free mercury, while the copper interacts with the tin to create a cupric-tin complex strengthening/hardening interphase and the zinc acts as a scavenger to rid any unreacted metallic oxide residue. This material is not very technique sensitive, with near zero handling/manipulation error characteristics, so it is

advantageous to the clinician due to the fact that it can be placed in a slightly moist environment, forgiving to isolation technique acuity, in lieu of deleterious effects to its tooth-margin interfacial integrity.

However, there are serious disadvantages to this type of silver amalgam material in comparison to the modern poly-ceram composite fillings.

The silver amalgam is not tooth coloured and is rather obvious when placed in the anterior sector of the oral environment. However, the modern poly-ceram composite can attain a near perfect tooth colour match.

Further, in the event the silver amalgam is applied beyond one-third of the cuspal incline, it tends to undermine the surrounding thin-walled remaining enamel leading to cuspal fracture and/or radial cracks compromising the retentive surrounding tooth aspects, or the restoration itself. The poly-ceram is capable of achieving a chemical bond-linkage to the underlying organic dentin and a micro-mechanical bond to the surrounding enamel honeycomb prismatic structure with the aid of modern seventh generation adhesive technology. This allows for a more conservative approach to tooth preparation guidelines criteria, with a greater emphasis on conservation of sound non-carious tooth structure. Conversely, such advances in adhesion technology have allowed for more substantial, larger restorations, in lieu of hampering the strength of the remaining tooth structure, especially with the advent of extra-oral processed inlay-onlay (three-quarter)-crown luted cemented restorations.

The metallurgical silver-amalgam product is electrically conductive, so it is not the most pleasant material to have in your mouth. By contrast, the poly-ceram composite filling is electrically non-conductive.

The silver amalgam also undergoes an abrasion phenomenon leading to degradation, allowing the leaching of certain mercuric contents from the filling, which have been known to affect certain kidney and liver enzymes and even permeate the blood brain barrier. Although, the mercuric salt differs from the free mercury in its unamalgamated form, this remains a controversial issue. Whereas the poly-ceram composites of the 1960s ensued upward of 150 micron wear per year, today's (circa 1993-2003) modern poly-ceram composites are able to sustain a clinical wear rate of 3-35 microns per year, a pivotal improvement.

The corrosion by-product of the dental silver amalgam serendipitously seals the tooth restoration margin, in lieu of chemical adhesion, otherwise known as the Gamma-II Phase. In order to passivate this corrosion phenomena, both marginal breakdown, surface pit-corrosion patterns and tarnish, high-copper amalgams were innovated, however, a clear disadvantage of the accentuation of the Gamma-I Phase is that it leads to more prevalent bulk fracture and facilitated mercuric-salt by-product release.

The G.V. Black rules of cavity preparation protocol innovated in 1898, and still practised today, state the necessity of 'extension for prevention', in other words extending the cavity preparation/excavation beyond the carious limit zone in order to prevent recurring caries, thereby, consuming more tooth structure. In addition, due to the fact that silver amalgams do not chemically adhere to tooth structure, creating diatoric forms, undercuts, channelling and macro-mechanical retentive sites during the cavity preparation is both necessary to retent the amalgam as well as deleterious in sacrificing more sound tooth structure. On such occasion that the tooth preparation has been compromised to a great extent, the tendency is to use gold retentive pins in order to anchor and sustain the silver-mercury admix, a further unnecessary invasive step.

Previous research has shown that a silver amalgam 'MOD' 3-surface, slot-like cavity preparation, restored class II molar tooth, sustains only 50 percent of a sound unrestored molar intercuspal flexural strength. Further, a modern poly-ceram composite restoration strengthens the tooth to 2xfold its potential intercuspal transverse strength.

Silver amalgams used in large class II molar restorations, invariably cause a tattoo phenomenon of permanent tooth discolouration to a violet-grey/green tinge and even brown/black tint, this is quite evident when a clinician attempts the removal, replacement or repair of a failing old silver-amalgam restoration. This is not the case with modern poly-ceram composite filling materials.

As a consequence, such restorations have, over the past 20-25 years, become less and less popular and alternatives, otherwise known as bonding or white fillings (or more prevalently known as composites) are now available.

EEU. Could you tell us about your particular area of specialty?
SW. At DRM Research Labs our area of specialty lies with these alternative restorations, which are composed of polymeric materials and glass ceramic fillers for reinforcement. Such restorations are used for a plethora of intraoral care including liners, cement, sealants, class V cervical erosion sites, and direct fillings, class I, II, III and IV in anterior and posterior tooth restoration. They were originally available in autocure format (2-part systems) throughout the 1950-60s, then in photocure UV-light initiated (200-400 nanometers). In the early 1970s and in the late 1970s the entire industry merged to photocure blue or halogen light cure materials, which are initiated by a blue light ranging from 400 to 700 nanometers wavelength irradiated for 10-40 seconds. The light triggers a free-radical addition reaction in the material that converts it from a monomer (liquid state) to a polymer (solid form), hardened material.

Such materials have experienced a lot of problems, most of which have been resolved over the years as the technology has become more refined. Our area of concentration and original innovation is the semi-crystalline poly-ceram nanoreinforced technology, and the particular line adjunct and borne of this pivotal innovation is the Diamond product line. There is an entire series affiliated with this ranging from the advanced adhesive, DiamondBond, the liner/cement/sealant, DiamondLink, the filling material, DiamondLite to the prosthodontic, crown and bridge system, DiamondCrown. It is the crystalline morphology and special oligomer-ceram interfacial characteristics that affords these materials certain physical, mechanical, optical and wear resistance properties that rival the standard amorphous polymer composites. This special technology has afforded improved colour stability,

better tooth colour matching ability, significantly higher fracture-strength resistance, near-zero leaching/solubility, tremendous wear resistance, negligible polymerisation-contraction forces, shrinkage, substantially improved tooth-adhesive marginal integrity due to advanced bonding mechanisms, biocompatible formulation and remarkable toughness, shock absorbing character, carrying this technology above the norm of the restorative niche into the realm of reconstructive materials, including prosthetics and implantology.

Of special interest is field prosthodontics and implantology due to the fact that the traditional superstructure encapsulating or crowning the underlying metallic alloy substructure is usually dental porcelain characterised as a very hard and brittle surface that is relatively unforgiving and complex in its laboratory application methodology.

The PFM (porcelain fused to metal) restoration, although very popular, is infused with a spectrum of relative disadvantages:

i. The mechanical properties of dental porcelain exhibit an unusually hard material, four times that of natural tooth structure, which is rather non-forgiving, wears opposing dentition, weak in tension and flexure mode (low strength), and most importantly attains very low toughness, hence, unable to dissipate cyclic masticatory energy. Therefore, it is prone to fracture, delamination from the underlying retentive metal framework, eventually necessitating complex intra/extra-oral repair.

ii. This is further complicated by the use of popular dental alloys as the copings or frameworks for these dental porcelains such as nickel-chrome and silver-palladium, which have been documented to ensue cytotoxic reactivity with the intraoral epithelial mucous membrane soft tissue contact zones, leading to cervical erosion, pocket formation, degradation of the interdentinal papillae and loss of periodontal ligature attachment, accelerating mobility and jeopardising the overall stability of tooth structural-architectural ergonomics.

iii. The underlying metallic substructure's lack of aesthetic quality or tooth colour matching ability necessitates greater tooth structure compromise in order to plunge the metallic collar of the crown restoration, yielding a cervical margin below the gingival gum-tissue line, subgingival. This leads to further bio-interaction at the sulcus with perio-ligature deterioration and poor hygienic maintenance due to inaccessibility to tooth brushing and dentifrice activity.

iv. These factors collectively are of great ramification when such materials, dental porcelain, are used in implant prosthodontics. Especially in single implants and the more popular immediate loading techniques, where the shock absorbing, high toughness, form and functional maintenance coupled with superb aesthetics of the semi-crystalline poly-ceram nanoreinforced DiamondCrown technology rivals any dental porcelain titanium implant superstructure. This is of great importance in particularly frail osseo integration transitional implant-prosthesis (crown) loading periods that will dictate the eventual success rate of the implant prosthesis integration and maintenance thereof. Further, in complicated cases where temporomadibular joint disorder is prevalent and eventual characteristic tooth bruxism and jaw clenching phenomena is evident, the semi-crystalline DiamondCrown technology, serves its purpose par excellence as the restorative of choice for occlusal rehabilitation. Whereby the shock-absorbing, cyclic masticatory energy dissipating special micromorphology of the crystalline lamellae leads to a microelastic behaviour, the reinforcing poly-ceram interdendritic structure allows for macrorigidity and architectural stability in spite of the tormented occlusal disappropriation. Further, enhanced by the ability to repair and maintain intra-orally opposed to the standard of the industry, dental gold.

EEU. Do you think the Central and Eastern European market is ready for your products with their high aesthetic quality and state-of-the-art materials?
SW. I think so. I have had a vast amount of experience lecturing worldwide and interacting both in the industrial sector as well as in the clinical and academic sector with many technologists, professors and clinicians whether it is in Lithuania, the Czech Republic, Poland or Russia. Indeed such materials are becoming more and more popular in those venues due to the fact that firstly, they are easier to use, secondly, they require less machinery and equipment in the laboratory and thirdly, chair-side time is significantly reduced.

The main disadvantages to this more sophisticated material is that it requires a dry field of operation during the momentary placement procedure, however, I think the advantages outweigh the disadvantages due to the fact that one has a material that is functional, aesthetic, matches tooth colour, that is serviceable and is biocompatible, healthier overall compared to the traditional silver amalgam fillings and the standard crown and bridge alloys; nickel-chrome, chrome-cobalt and silver-palladium products.

With traditional materials it takes two to three days and an innumerable amount of equipment, instruments and adjunct materials before a crown or a bridge is fabricated, whereas with our materials one is able to fabricate a rather vast or large restoration in less than one hour. So from a time, effort and equipment perspective, this is the preferred methodology for the laboratory.

EEU. So would you say that while these materials might perhaps be slightly more expensive, in the long run they save so much time that they work out to be more economical?
SW. Well, cost is certainly one element, but in today's society people are more health conscious and aesthetically aware, which are also factors that need to be considered. I think that a silver restoration for a posterior molar tooth is 50/50. No-one looks back there so it may not be too important. However, for an anterior restoration there is really no choice in the matter, the thought of seeing gold or silver as you smile is rather awkward, therefore, more aesthetically pleasing materials become a matter of necessity. So for the anterior sector of the intra-oral environment it is a necessity. Furthermore, as far as the laboratory technician is concerned, modern materials are quicker and easier to use so there is really no reason why they should not be chosen.

EEU. And what about the issue of durability?
SW. That is a very good point. There is a propensity to judge today's restoratives of the poly-ceram category by 'bunching them' with those of 40 years ago, particularly among dentists who were accustomed to those products then. However, composites or bonding materials from 40 years ago are a far cry from what is available today. Since then, we have gone through about seven generations of products and probably tens of thousands of research projects documented in the form of manuscripts and patents, so there has been a good deal of innovative progression in this field of technology.

Consequently, today there are several products that are very reliable. From the perspective of wear resistance, today's restoratives are able to sustain wear that is as low as three micrometers per year – which rivals actual enamel. This compares with 40 years ago when it was 150 micrometers per year.

According to statistics from pooled clinical data, today's restoratives have an average half-life of 17-22 years, which is very close to a silver amalgam restoration and or a porcelain fused to metal crown. From a colour stability perspective these products no longer have residual oxide by-products, they tend to be very stable and tend to maintain their anatomical form, contour and texture and overall physico-mechanical functional state. So yes, there are still some materials today that are not very reliable, and then, there are a few materials that are extremely advanced and are capable of rivalling any metallurgical or ceramic adjunct material.

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EEU. Are there any other advantages of modern restorative materials?
SW. If we look at dental restoration in a chronological manner from infancy to adulthood, from paediatric dentistry to geriatric dentistry, we start out with a little tiny one-surface cavity, that escalates to a two-surface filling, then possibly leaks and has to be repaired and becomes a pin-retented three- or four-surface silver amalgam filling undermining the surrounding enamel, and then onward to a crown (usually poorly adapted or sealed), followed by endodontic treatment and a post/core build-up encapsulated by a crown prosthesis and possibly an extraction, even a bridge, usually non-precious alloy (porcelain fused to metal), subsequent alveolar bone resorption and then possibly a removable prosthesis; partial or denture followed by ridge augmentation and possibly an implant. The approach with the new modern poly-ceram restorative materials is that if one can achieve a very good seal at a tooth-restorative interface, which is really the hub or area of concentration of the technology, then one can reduce the possibility of having to remake the restoration and ensue this very tedious and complicated voyage.

Because silver amalgams are very limited they usually have to be repaired somewhere down the line. By the time they have to be repaired, the carious lesion site usually has progressed so vastly that it invariably turns into a three-quarter crown or a full crown. On occasions, one even has to resort to crown and bridgework. This is not the case with the advanced restorative materials. If there is a failure it tends to be rather minor and require very quick patch-up and repair at the adhesive interface and so the incidences of secondary caries, remakes or repairs is significantly lower in potential expenditure and tooth loss. Which is a massive advantage whether you are in Prague, London or New York City.

EEU. Would it be advisable to undertake specific training before using the new restorative materials?
SW. Yes, training and education is a key factor in disseminating the proper methodology and operative techniques affiliated with this new generation of materials. The learning curve associated with the older generation metallurgical materials, from an intra-oral placement care point of view, is not very steep, so in order to become more adept at this type of restorative dentistry, it is very important to hold clinics, workshops and get-togethers or even chair-side practical workshops to bring about greater awareness as to what is the proper either surgical, operative or technical protocols that bring about a higher chair-side success rate, their corresponding clinical indications and material ramifications.

EEU. Who would conduct these workshops?
SW. We actually conduct these workshops with an entire team of technologists, clinicians and scientists. We go from country to country and attempt to help generate a greater awareness of the proper clinical methodologies associated with advanced biomaterials chemical engineering. That's what brings about the real success in this restorative science – the education. ■