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Titanium implants may carry risk of corrosion, study finds

“...wearing of the titanium in the tissue results from micro-motion and localised corrosion in surface crevices.”

Globally, more than 1,000 tonnes of titanium are implanted into patients in the form of biomedical devices every year. Metallic prostheses, fixation and anchoring devices are used extensively for dental, orthopaedic, and craniofacial rehabilitation and their effects on the body are widely perceived to be predictable following initial implantation.

The development of peri-implant inflammation may result in the premature loss of the implanted device or the requirement for revision/rescue surgery, which are scenarios that can “impact on patients’ well-being and economically on the health service provider,” the authors concluded in the study. “Our results emphasise the need to understand further both the physical and chemical mechanisms leading to the dispersal of titanium species in tissue around implants and their potential to exacerbate inflammation.”

Addison commented that while the findings pose no alarm to those with BAHA implants or similar devices, they demonstrate that improvements in materials like titanium can be sought. Research is currently being conducted to look at the biological consequences and to understand the mechanisms by which the debris is produced.

Study links bisphosphonates to osteonecrosis of the jaw

Cumulative incidence of ONJ significantly higher among patients who had received BP

KYOTO, Japan: A new study has shown that bisphosphonates (BP), a class of drugs commonly used to treat bone diseases such as osteoporosis, is associated with an increased risk of developing severe bone disease of the maxilla and the mandible. The researchers found that especially elderly patients who had received intravenous BP had an increased risk of osteonecrosis of the jaw (ONJ).

The study was conducted among 3,216 male and female patients aged 20 or older mostly diagnosed with osteoporosis and various types of cancer. They had undergone tooth extraction at the Kyoto University Hospital’s Department of Oral and Maxillofacial Surgery between April 2006 and June 2009. About 4 per cent (126) had received either oral BP (99) or intravenous BP (27), while 96 per cent (3,090) had not received such treatment.

Researchers from the institute found that at 42 months following tooth extraction the cumulative incidence of ONJ was significantly higher among patients who had received BP. According to the study, five patients to whom BP had been administered developed ONJ, compared with only one patient in the control group.

They observed a significant difference with regard to age and prevalence of cancer or osteoporosis between the two groups. The risk ratio for ONJ was particularly elevated in patients aged over 65 who had received intravenous BP, according to the researchers.

In addition, they found that alveolar bone loss could be a risk factor for BP-induced ONJ after tooth extraction. Thus, they suggested that inflammation of the periodontal tissue might predispose people to the condition, and preventive treatment of oral bacteria might be essential for a favourable outcome of tooth extraction.

BP is usually administered to prevent further bone loss, reduce pain and increase bone mineral density in patients with bone disorders. A study published in the September 2003 issue of the International Journal of Oral and Maxillofacial Surgery was the first to suggest osteonecrosis as a side effect of bisphosphonate treatment. In the current literature, the estimated incidence of BP-induced ONJ ranges from 8.3 per cent to 40 per cent.
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Endodontic retreatment

Achieving success the second time around

The success rate of retreatment has been shown to be in the range of 80% healing. Phases III and IV of the Toronto Study showed such a healing rate four to six years after non-surgical retreatment.

When considering treatment for a tooth that has not healed successfully without-canal therapy, there are significant challenges to address before attempting to attain complete healing of the diseased tooth. The armamentarium and techniques available today allow us the ability to disinfect the root-canal system properly after initial treatment has led to post-treatment disease.

The presentation of apical periodontitis is one factor that has been shown to decrease the success rate. Without apical periodontitis, a ten-year success rate of 92% to 98% has been shown for both initial and retreatment root-canal therapy. With the preventative presence of apical periodontitis, there is a decrease in the success rate from 74% to 86% over the ten years. From this, it is evident that endodontic healing is attainable through retreatment procedures, allowing us to maintain our patients’ natural teeth (Figs 1a–c). Although the alternative clinical treatment option of implant placement can provide an effective method for replacing a missing tooth, healthy maintenance of the natural tooth should remain the overall goal.

Post-treatment disease is, inevitably, a result of the bacterium and the host response to the bacteria. These microorganisms are the most critical aetiology of post-treatment disease, as they are present within the root-canal system of a previously endodontically treated tooth owing to a combination of substandard endodontic techniques, iatrogenic treatment issues and restorative failure.

Intra-radicular bacteria are the primary aetiology of post-treatment disease and eradication of these bacteria is the primary goal of retreatment procedures. The intra-radicular bacteria present in the previously treated tooth are persistent and resist management. Bacteria are able to hide and survive in canal ramifications, deltas, irregularities (fins) and dentinal tubules.

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Figure 2 shows the complex root-canal anatomy preoperatively (green areas) and the minimal amount of canal-wall cleansing that was accomplished during canal instrumentation (red areas). The remaining green areas illustrate the space that might be left untreated, thereby providing a source of bacteria and supporting substructure for intra-canal infection. The potential substrates that are found inside the canal and help the bacteria survive can include untreated pulpal tissue, the presence of a biofilm and tissue fluid. This may be present in the canal owing to a poor coronal or radicular seal and microbial proliferation. The presence of a poor seal, bacteria and substrate for their growth results in ideal conditions for persistent inflammation and disease.

The bacteria present in the initial infection of a root canal differ markedly from the bacteria infecting a previously treated tooth. Pulpal treatment flora is polymicrobial with equal numbers of Gram-negative and -positive bacteria. Post-treatment bacteria are predominantly Gram-positive and they have been shown to be able to survive in harsh environments and to be resistant to many treatment methods.

There are high numbers of Enterococcus species. Enterococcus faecalis, for example, has been shown to be a common isolate in 27 to 77% of teeth with post-treatment disease. A contaminated canal space may result from incomplete cleansing initially or subsequent leakage into root-canal spaces following root-canal treatment. Once present inside the canals, E. faecalis has a variety of characteristics that allow it to evade our best efforts to eradicate it from the root-canal system, including the ability to invade dentinal tubules and adhere to collagen. It is also resistant to calcium hydroxide application inside the canal system, which is an inter-appointment treatment technique used to help remove microorganisms and their by-products, such as lipopolysaccharides, from the canal space. E. faecalis’s resistance of calcium hydroxide action arises from its ability to pump hydrogen ions from a proton pump. The hydrogen combines with the hydroxyl ions of calcium hydroxide and neutralises the high pH value.

E. faecalis is also able to resist calcium hydroxide by being part of a biofilm. The protection of bacteria within a biofilm matrix prevents the contact of the bacteria with irrigants and medicaments, and allows communication between bacteria to aid in survival capabilities. The presence of E. faecalis is well documented, however, its role in post-treatment disease has yet to be proven definitively. In survival mechanisms, however, shine a light on the persistent capabilities of these bacteria, and our clinical techniques must be focused on the challenge of eliminating them.

Iatrogenic issues encountered during the initial root-canal treatment may be the cause of intra-canal bacterial infection. These issues may include a lack of root-canal cleansing and shaping, inadequate canal enlargement, missed canals, ledging, canal transportation, overinstrumentation, and the deposition of the canal by debris or separation of instruments. Failure to use or use too small a volume of an appropriate irrigant solution, such as sodium hypochlorite, is an iatrogenic error.

Full-strength 6% sodium hypochlorite has been shown to be highly antimicrobial and able to dissolve tissue and disrupt bacterial biofilms. These qualities in an irrigant are ideal for the debulking of residual bacterial tissue and debris. Use of the rubber dam to isolate the treatment field is the standard of care for endodontic treatment. Failure to use a rubber dam to isolate the treatment field is a common error in clinical practice.
may be a fundamental contributor to post-treatment disease. The following case illustrates the ability to overcome prior incomplete treatment to achieve successful healing (Figs 3a–c).

**Clinical example**

Restorative failure is a common cause of post-treatment disease. Failure to place an effective permanent access restoration in a timely manner can allow for bacterial entry into the root-canal system by coronal leakage. Submarginal leakage on a crowned tooth can also allow bacterial entry to occur.

Decay in a previously treated tooth is another source of bacterial contamination. Structural damage to a tooth by trauma, cracking or fracture can provide an entry point for bacterial contamination of the canals. Our patients are responsible for their own oral health and must commit to effective oral hygiene techniques. Failure of the patient to perform effective oral hygiene can result in the failure of even the most well-executed root-canal and restorative treatments.

With the bacterial challenges clinicians have to face, retreatment techniques must be capable of effective elimination of bacteria and their substrates. The use of a dental operating microscope and ultrasonic instruments allows clinicians to recover all existing canal anatomy properly to ensure that they are able to cleanse the root-canal system completely. The following clinical case (Figs 4a & b) illustrates the extent of the canal space left untreated in the initial root-canal therapy by not opening the mesiobuccal canal adequately and not locating and cleansing the hidden second mesiobuccal canal.

Endodontic ultrasonic tips are highly efficient at removing core build-up material, paste fills, posts and silver-point fillings, as demonstrated in Figure 5. These instruments allow clinicians to conserve root dentine by highly flexible and resistant to separation. Current NiTi rotary files can remove root fillings and rotary instrumentation without altering the working length of canals as compared with needle irrigation alone. It has been demonstrated that passive ultrasonic irrigation can remove dentine debris in a canal up to 3 mm in front of where the tip extends apicocoronal to straight or curved canals. This evidence shows that an effective flow of irrigation can assist in the cleansing of teeth in which canal alteration occurred during the initial root-canal treatment.

The following silver-point case (Figs 8a–c), with a large distal post and apical transportation in the mesial root, demonstrates the successful healing of post-treatment disease when proper disinfection has been accomplished. This case illustrates the reason that retreatment is the primary treatment option for post-treatment disease.

Once debridement and disinfection have been completed, appropriate obturation methods are used to seal the canal spaces. The warm vertical technique using gutta-percha or resin with an appropriate sealing agent provides a thorough seal of the well-cleaned and shaped canal spaces. The final restoration must provide a proper seal of the pulp chamber to prevent coronal micro-leakage.

Current evidence has demonstrated that we can retreat previously endodontically treated teeth properly and successfully. The literature has also shown that specific bacteria, such as *E. faecalis*, are able to survive inside a previously filled canal. The use of a dental operating microscope, ultrasonic instruments, irrigants, rotary NiTi files and appropriate obturation materials increases our ability to attain healing after retreatment. As we continue to strive to maintain healthy teeth for our patients, endodontic retreatment should be the primary option for patients with post-treatment disease.

A complete list of references is available from the publisher.

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Silane coupling agents and surface conditioning in dentistry

Dr Christie Ying Kei Lung, Jukka Pekka Matinlinna

In dental restorations, it is desirable to have durable and strong bonding between resin composite and dental restorative materials. Weak bonding at the interface can be dramatically enhanced with a coupling agent.

Silane coupling agents, which are synthetic hybrid inorganic-organic compounds, are used to promote adhesion between dissimilar materials. They are good at promoting adhesion in silica-based materials such as porcelain. However, adhesion in non-silica-based restorative materials such as zirconia, metals and metal alloys is not satisfactory.

A solution to this problem may be surface-conditioning of the restorative materials. Currently, a widely used surface-conditioning method in dentistry is tribochemical silica coating. After this treatment, a silica layer is formed on the surface so that the silane coupling agent can react chemically to form a durable bond with non-silica-based materials. Moreover, this treatment increases surface roughness, which will enhance micromechanical interlocking for bonding.

This review will discuss surface-conditioning methods and some new surface-conditioning techniques, silane chemistry, silane application in dentistry, and the limitations of silanes in adhesion promotion.

The silane monomer most commonly used in clinical commercial products is 3-methacryloxypropyltrimethoxysilane. This is pre-hydrolysed in a solvent mixture usually consisting of ethanol and water that is acidified with acetic acid.

The shelf life for a single-bottle silane solution is relatively short. The solution will turn cloudy over time and cannot be used for adhesion. Two-bottle silane systems have been developed to offer a more stable system. One bottle contains an unhydrolysed silane in ethanol and another one contains an aqueous acetic acid solution. The two solutions are mixed for silane hydrolysis before use.

Surface-conditioning methods

The surface conditioning of restorative materials is an important preliminary step in clinical practice to modify surface properties for durable and hydrophilically stable adhesion. The surface pretreatment methods widely used in dental technology are grit blasting, tribochemical silica coating and hydrofluoric acid etching, which will be discussed briefly in the following section.

Grit blasting

The surface of materials such as metals, alloys and some ceramics is sand-blasted with alumina particles of 110 μm in size at a perpendicular distance of 10 mm under an air pressure of 380 kPa for ten to 15 seconds. This process is intended to increase the surface roughness of the materials. It also enhances micromechanical retention for bonding.

Pyrochemical silica coating

Over the years, several silica-coating systems have been used in dental laboratories. Briefly, they are Silicocenter Classical, Silicocenter MD and Silic (All Heraeus Kulzer) and PyroSilPin (SURA Instruments). In these systems, a tetraethoxysilane solution is injected into a flame and burned with butane in oxygen. The silane decomposes and forms reactive Si-O-Si fragments, which are deposited on the substrate surface. A glasslike silica layer is thereby formed on the surface. The use of this surface treatment is not popular in clinical practice.

Tribochemical silica coating

The tribochemical Rocatec system (3M ESPE) that uses silica-coated alumina particles was introduced in 1989. It is indicated for silica coating of ceramic and metal surfaces. It enhances the adhesion of a silane coupling agent to a silica-coated material by forming a durable siloxane Si-O-Si bond. This surface treatment also increases the surface roughness that provides micromechanical retention for resin bonding, that is, for the resin to penetrate pores on the surface.

Hydrofluoric acid etching

Hydrofluoric acid is normally used to etch porcelain veneers and for intra-oral repair of fractured porcelain restorations before cementation. Low concentrations of 4 to 10 % hydrofluoric acid are used in clinical practice. When a porcelain surface is etched with hydrofluoric acid etching gel, the acid dissolves the glassy matrix of the porcelain. A microscopically porous and micro-retenive surface is thus produced and micromechanical interlocking for resin bonding is enhanced.

New surface-conditioning methods

The quest for enhanced and durable bonding continues. Several new surface-conditioning methods are currently under investigation globally. These include laser surface treatment, selective infiltration etching, nanostructured alumina coating, laser irradiation of a ceramic surface and plasma fluorination.

Laser surface treatment

Laser stands for light amplification by stimulated emission of radiation and the technology was introduced in the 1950s. Er:YAG, Ne:YAG, and CO2 lasers are used in dentistry for soft-tissue surgery and hard-tissue treatment and surface treatment.

Internal porosization with porcelain

The zirconia surface is sand-blasted with alumina particles of 70 μm in size. Then, the surface is coated with high-fusing porcelain which is prepared by stirring the porcelain powder into an excess amount of distilled water. The porcelain is fired at a high temperature. After the firing process, the surface is sand blasted again. A silica-containing layer forms on the zirconia surface. This enhances adhesion with a silane coupling agent, that is, siloxane linkage formation.

Chemical vapour deposition

In a chemical vapour deposition system, the zirconia surface is exposed to a vapour mixture of tetra-chlorosilane and water. The silane hydrolysates and a Si02 seed layer is deposited as a coating on the surface. The thickness of the seed layer is controlled by deposition time. This silica seed layer provides the reactive sites for the silane coupling agent.

Plasma fluorination

In a plasma reactor, the zirconia surface is exposed to sulphur hexa-fluoride plasma. An oxygen fluoride layer is formed on the surface. This layer may increase the reactivity of zirconia towards a silane coupling agent. However, the exact mechanism of the bonding formation between the zirconia oxygen fluoride layer with silane is still unclear.

Silane chemistry

Functional and non-functional silanes

Functional silanes contain two different functional groups that can react with inorganic matrices, for example ceramics, and organic materials, for example resins. Therefore, they can be used as coupling agents to connect dissimilar materials.

There is also a group of silanes called the non-functional silanes. They contain one reactive functional group that can react with inorganic materials. They are widely used for some specific surface modification of materials. In addition, there are bis-functional/cross-linking/dipodal silanes that possess two silicon atoms with three hydroxyalkyl groups. Cross-linking silanes are used in the steel and tyre industries. Such silane is also incorporated with functional silane to increase the bonding and hydrophilicity of resin composite to titanium.

Silane activation mechanism

Silanes can create a bond between inorganic and organic materials. A silane coupling agent decomposes, releasing a functional silane coupling agent Z(CH3)2Si(OH)2. The second oxygen in the molecule is extracted by a functional organo-silane group which reacts with organic resin, linking the inorganic and organic components.
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tilustrated using a ball-and-stick model (Fig. 2).

As shown in Figure 2, the steric re-

Application of silanes in dentistry

Ceramic restorations and repairs Silane coupling agents are used in dental restoration, such as ceramic repairs of onlays, inlays, crowns and bridges. For most patients, repair is more economical and time-saving than the fabrication of new restora-

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Extending the boundaries of feasibility in direct restorative procedures

A clinical case combining a high-performance material and clearly defined protocol

Dr Gauthier Weisrock
France

Modern high-performance composite materials and standardised treatment protocols have led to more direct composite restorations being fabricated in the anterior region than ever. Even extremely challenging cases may now be treated chairside with predictable results and minimal loss of tooth structure.

A 24-year-old female patient presented at our practice with a request regarding aesthetics. She disliked the severe discolouration after endodontic treatment. A clinical examination revealed that the root had been extirpated after an accident and that a fractured piece had been reattached with a composite material (Figs 1 & 2). Upon radiological examination, it was found that the root-canal treatment had not been performed correctly. However, a true diagnostic situation would depend.

First, internal bleaching was performed on the tooth, on which the access to the endodontic chamber was created through the old restoration. The gutta-percha increment was removed up to 3 mm below the cemento-dentinal junction. At the bottom of the cavity, a plug with a thickness of 2 mm made of glass ionomer cement was inserted to prevent the bleaching agent from accessing the sensitive areas. We used a mixture of sodium perborate and distilled water for the bleaching procedure. The access to the cavity was then sealed with a temporary material.

Since the desired tooth shade was not achieved upon initial bleaching, the entire procedure had to be repeated after one week. After another week, the result was finally optimal (Fig. 3). In order to neutralise the bleaching agent, calcium hydroxide was placed into the cavity and left in place for at least one week. (An adhesive cementation, it was necessary to protect the operatory field from saliva or blood in the oral cavity. Therefore, we isolated the anterior teeth, including the canines, with a rubber dam. The expanded treatment area allowed us to assess the incisal line, and the size and shape of the adjacent teeth.

Preparation and application of the adhesive

The expanded treatment area allowed us to assess the incisal line, and the size and shape of the adjacent teeth.

Aesthetic diagnosis and shade determination

After tooth-shape analysis, we concluded that the proportions were harmonious compared with tooth #21. In order to avoid a misinterpretation of the shade owing to dry adjacent teeth, the tooth shade was determined prior to any intervention and in daylight. The IPS Empress Direct shade guide was used for the determination of the enamel and dentine materials. We determined the dentine shade based on the cervical third and the enamel material based on the incisal third of the adjacent tooth. Particular attention was paid to the anatomical structure of the adjacent tooth and the various opalescent reflections visible on the incisal surface, since it was our aim to imitate these features. A layering diagram detailing all the materials that we planned to use was prepared. In this case, only four shades were used: A3/A2 Dentin, A2 Enamel and Trans Opal.

Subsequently, we created a palatal silicone key on tooth #11 with the appropriate shape and occlusion. Once in place intra-orally, this key helped to create the palatal wall of the restoration in one step. The key included the teeth adjacent to the tooth that needed to be restored and covered the incisal area.

Fig. 1: Severely discoloured tooth #11.—Fig. 2: The shape of tooth #11 appeared to be harmonious with tooth #21. The substance loss amounted to somewhat less than half of the tooth.—Fig. 3: After the bleaching procedure, the shade of tooth #11 was optimal.—Fig. 4: Prepared tooth #11 with vestibular chamfer and straight, right-angle palatal margin.

Before proceeding with the adhesive cementation, it was necessary to protect the operatory field from saliva or blood in the oral cavity. Therefore, we isolated the anterior teeth, including the canines, with a rubber dam. The expanded treatment area allowed us to assess the incisal line, and the size and shape of the adjacent teeth.

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Subsequently, the adhesive was applied, while the adjacent teeth were protected with a metal matrix. We used the ExciTE F total-etch adhesive (Ivoclar Vivadent) for this step. Owing to the non-retentive preparation design and the fact that most of the restoration would be created on enamel, this type of adhesive proved superior to self-etching products. In order to facilitate penetration into the dentine tubules, the adhesive was gently massaged into the cavity walls. (After the adhesive has dried, the cavity must exhibit a glossy appearance. If this is not the case, the procedure needs to be repeated.) The adhesive was then light-cured for 10 seconds with a bluephase curing light (Ivoclar Vivadent).

Building up the palatal and proximal walls
As a first step, the palatal enamel was built up. A thin layer of enamel material (shade A2) of less than 0.5 mm was applied to the palatal key and smoothed out with a brush. Then the key loaded with composite material was placed in the mouth and the fit was checked again. If necessary, the material may be modified before it is polymerised for 10 seconds.

The palatal wall created in the process showed the exact desired shade and did not touch the adjacent teeth (Fig. 5).

Applying a thin layer of enamel material (A2) to the proximal walls changed the complex cavity into a simple one. In order to create the thin layer, we fixed a transparent matrix in place with a wooden wedge, which allowed us to create the transition lines of the convex area that separates the proximal from the vestibular area. The restorative outcome is influenced by the successful design of these transitional areas because it is not possible to design them with rotary instruments. We then applied composite material from the distal side of the tooth #11, while tightening the matrix from the opposite side and polymerising the material in this position (Fig. 6). Thus, sufficient composite material could be added until the desired transitional area was achieved. The mesial side was built up in the same manner (Fig. 7).

Building up the dentine core
Using dentine materials, a restoration is created that shows decreasing saturation from the cervical to the incisal and from the palatal to the vestibular area. In order to achieve this, a 3D layering technique is applied, using materials with different levels of saturation. In our case, a material with a saturation one degree higher than the desired final tooth shade was applied. Therefore, material in shade A3 was used in the area of the cervical margin.

The layer was applied to the palatal wall using a flat spatula suitable for composite resins (Fig. 8). Subsequently, a layer consisting of dentine material with a lower saturation was applied (shade A2). A pointed silicate instrument was used to design a slightly wary margin covering half of the chamfer up to 1 mm below the incisal edge (Fig. 9). If this technique is applied, the translucency of the enamel material becomes visible in the area of the incisal edge and the transition from tooth structure to composite material is masked.

Each layer was polymerised with the bluephase curing light for ten seconds.

Designing the enamel portion
The opalescence effect was enhanced by applying a thin layer of Trans Opal material in the area of the incisal edge. Since the visible effect of this material is very intense, only a small amount could be used. An enamel layer (shade A2) was applied in several steps to the vestibular area, then contoured with brushes and caressed for ten seconds. This enamel material covered the entire restoration (Fig. 10).

Finishing and polishing
The patient’s teeth exhibited a very pronounced macro- and microtexture (vertical pits and horizontal streaks, respectively). Imitating these features to achieve a lifelike reflection on the restorative surfaces was a challenging task.

This step was similarly important to determining the appropriate shade. We imitated the surface texture with fine-grain diamond-coated burs, using flame- and lens-shaped instruments (first with the red and then with the yellow colour codes). The burs were used in the red handpiece without water irrigation.

Another important step was the finishing of the transition lines and the interproximal areas. It is advisable to use abrasive strips for this purpose because rotary instruments may produce flat areas that cause inappropriate reflections. OptraPol Next Generation polishing (Ivoclar Vivadent) with water irrigation were used for the polishing process.

Europe closer to amalgam ban
A new study, conducted on behalf of the European Commission, has recommended phasing out dental amalgam use over the next few years owing to mercury’s negative impact on the environment. The decision to effect a ban would probably be made in 2013, and become applicable five years later, the authors suggested.