# Restorative Dentistry

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## Chapter 1

# Dental Restoration

A **dental restoration** or **dental filling** is a dental restorative material used to restore the function, integrity and morphology of missing tooth structure. The structural loss typically results from caries or external trauma. It is also lost intentionally during tooth preparation to improve the aesthetics or the physical integrity of the intended restorative material. Dental restoration also refers to the replacement of missing tooth structure that is supported by dental implants.

Dental restorations can be divided into two broad types: *direct restorations* and *indirect restorations*. All dental restorations can be further classified by their location and size. A root canal filling is a restorative technique used to fill the space where the dental pulp normally resides.

### *Tooth preparation*

Tooth #3, the upper right first molar, with the beginning of an MO preparation. Looking into the preparation, the white, outer enamel appears intact, while the yellow, underlying dentin appears recessed. This is because the dentin was decayed and was thus removed. This portion of the enamel is now unsupported, and should be removed to prevent future fracture.

Restoring a tooth to good form and function requires two steps, (1) preparing the tooth for placement of restorative material or materials, and (2) placement of restorative material or materials.

The process of preparation usually involves cutting the tooth with special dental burrs, to make space for the planned restorative materials, and to remove any dental decay or portions of the tooth that are structurally unsound. If permanent restoration can not be carried out immediately after tooth preparation, temporary restoration may be performed.

The prepared tooth, ready for placement of restorative materials, is generally called a **tooth preparation**. Materials used may be gold, amalgam, dental composites, resin-reinforced glass ionomers, porcelain or any number of other materials.

Preparations may be intracoronal or extracoronal.

- **Intracoronal preparations** are those preparations which serve to hold restorative material within the confines of the structure of the crown of a tooth. Examples include all classes of cavity preparations for composite or amalgam, as well as those for gold and porcelain inlays. Intracoronal preparations are also made as female recipients to receive the male components of Removable partial dentures.
- **Extracoronal preparations** are those preparations which serve as a core or base upon which or around which restorative material will be placed to bring the tooth back into a functional or aesthetic structure. Examples include crowns and onlays, as well as veneers.

In preparing a tooth for a restoration, a number of considerations will come into play to determine the type and extent of the preparation. The most important factor to consider is decay. For the most part, the extent of the decay will define the extent of the preparation, and in turn, the subsequent method and appropriate materials for restoration.

Another consideration is unsupported tooth structure. In the photo at right, unsupported enamel can be seen where the underlying dentin was removed because of infiltrative decay. When preparing the tooth to receive a restoration, unsupported enamel is removed to allow for a more predictable restoration. While enamel is the hardest substance in the human body, it is particularly brittle, and unsupported enamel fractures easily.

### *Direct restorations*

This technique involves placing a soft or malleable filling into the prepared tooth and building up the tooth before the material sets hard. The advantage of direct restorations is that they usually set quickly and can be placed in a single procedure. Since the material is required to set while in contact with the tooth, limited energy can be passed to the tooth from the setting process without damaging it. Where strength is required, especially as the fillings become larger, indirect restorations may be the best choice.

### Indirect restorations

This technique of fabricating the restoration outside of the mouth using the dental impressions of the prepared tooth. Common indirect restorations include inlays and onlays, crowns, bridges, and veneers. Usually a dental technician fabricates the indirect restoration from records the dentist has provided of the prepared tooth. The finished restoration is usually bonded permanently with a dental cement. It is often done in two separate visits to the dentist. Common indirect restorations are done using gold or ceramics.

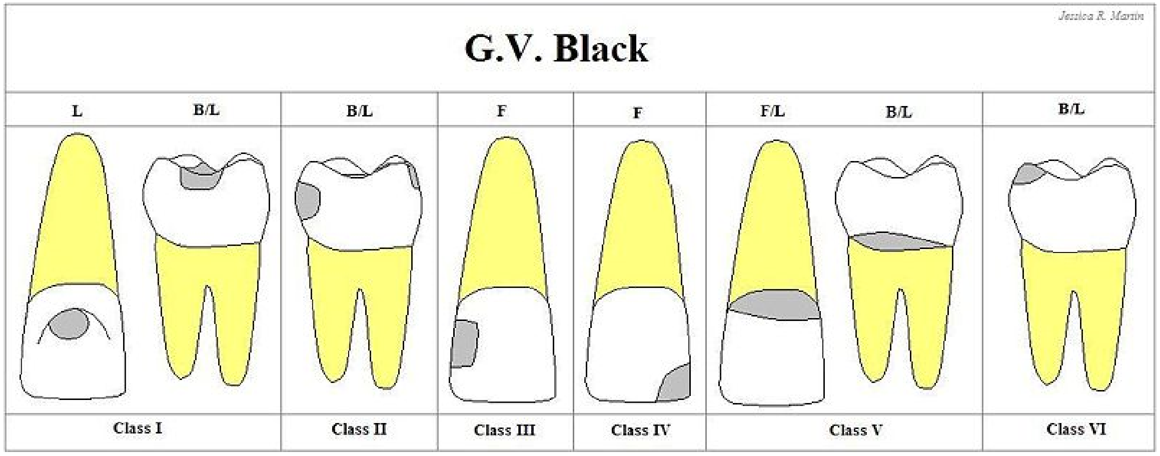
While the indirect restoration is being prepared, a provisory/temporary restoration is sometimes used to cover the prepared part of the tooth, which can help maintain the surrounding dental tissues.

Removable dental prostheses (mainly dentures) are considered by some to be a form of indirect dental restoration, as they are made to replace missing teeth. There are numerous types of precision attachments (also known as combined restorations) to aid removable prosthetic attachment to teeth, including magnets, clips, hooks and implants which could be seen as a form of dental restoration.

The CEREC method is a chairside CAD/CAM restorative procedure. An optical impression of the prepared tooth is taken using a camera. Next, the specific software takes the digital picture and converts it into a 3D virtual model on the computer screen. A ceramic block that matches the tooth shade is placed in the milling machine. An all-ceramic, tooth-colored restoration is finished and ready to bond in place.

Another fabrication method is to import STL and native dental CAD files into CAD/CAM software products that guide the user through the manufacturing process. The software can select the tools, machining sequences and cutting conditions optimized for particular types of materials, such as titanium and zirconium, and for particular prostheses, such as copings and bridges. In some cases, the intricate nature of some implants requires the use of 5-axis machining methods to reach every part of the job.

## *Restoration classifications*




GV Black Classification of Restorations

Greene Vardiman Black classified the fillings depending on their size and location.

- Class I Caries affecting pit and fissure, on occlusal, buccal, and lingual surfaces of posterior teeth, and Lingual of anterior teeth.
- Class II Caries affecting proximal surfaces of molars and premolars.
- Class III Caries affecting proximal surfaces of centrals, laterals, and cuspids.
- Class IV Caries affecting proximal including incisal edges of anterior teeth.
- Class V Caries affecting gingival 1/3 of facial or lingual surfaces of anterior or posterior teeth.
- Class VI Caries affecting cusp tips of molars, premolars, and cuspids.

## *Materials used in dental restorations*

### Metals and metallic alloys

Amalgam filling

These metals are mostly used for making crowns, bridges and dentures. Pure titanium could be successfully incorporated into bone. It is biocompatible and stable.

Precious metallic alloys

- gold (high purity: 99.7%)
- gold alloys (with high gold content)
- gold-platina alloy
- silver-palladium alloy
- titanium

Base metallic alloys

- cobalt-chromium alloy
- nickel-chrome alloy

Amalgam

- Silver amalgam

Amalgam is widely used for direct fillings, mainly for posterior teeth, and completed in single appointment. Cast gold is used for indirect restorations. Amalgam leaches tiny amounts of mercury and while some concerns have been raised, there is currently no evidence that any of this mercury remains in the body nor that dangerous levels are ever reached .

Direct Gold

- Gold

Although rarely used, due to expense and specialized training requirements, gold foil can be used for direct dental restorations.

### Tooth colored

Dental composites are also called white fillings, used in direct fillings. Crowns and in-lays can be made in the laboratory from dental composites. These materials are similar to those used in direct fillings and are tooth coloured. Their strength and durability is not as high as porcelain or metal restorations and they are more prone to wear and discolouration.

## Composite resin

Dental composites, also called white fillings, are a group of restorative materials used in dentistry. As with other composite materials, a dental composite typically consists of a resin-based matrix, such as a bisphenol A-glycidyl methacrylate (BISMA) resin like urethane dimethacrylate (UDMA), and an inorganic filler such as silicon dioxide silica. Compositions vary widely, with proprietary mixes of resins forming the matrix, as well as engineered filler glasses and glass ceramics. The filler gives the composite wear resistance and translucency. A coupling agent such as silane is used to enhance the bond between these two components. An initiator package begins the polymerization reaction of the resins when external energy (light/heat, etc.) is applied. A catalyst package can control its speed. This is not recommended for molars.

After tooth preparation, a thin glue or bonding material layer is applied. Composites are then filled layer by layer and photo-polymerising each using light. At the end the surface will be shaped and polished.

## Glass ionomer cement

A glass ionomer cement (GIC) is one of a class of materials commonly used in dentistry as filling materials and luting cements. These materials are based on the reaction of silicate glass powder and polyalkeonic acid. These tooth-coloured materials were introduced in 1972 for use as restorative materials for anterior teeth (particularly for eroded areas, Class III and V cavities).

As they bond chemically to dental hard tissues and release fluoride for a relatively long period, modern-day applications of GICs have expanded. The desirable properties of glass ionomer cements make them useful materials in the restoration of carious lesions in low-stress areas such as smooth-surface and small anterior proximal cavities in primary teeth. Results from clinical studies also support the use of conventional glass ionomer restorations in primary molars. They need not be put in layer by layer, like in composite fillings.

## Porcelain (ceramics)

*Full-porcelain* (ceramic) dental materials include porcelain, ceramic or glasslike fillings and crowns (a.k.a jacket crown, as a metal-free option). They are used as in-lays, on-lays, crowns, and aesthetic veneers. A veneer is a very thin shell of porcelain that can replace or cover part of the enamel of the tooth. Full-porcelain (ceramic) restorations are particularly desirable because their color and translucency mimic natural tooth enamel.

Another type is known as *porcelain-fused-to-metal*, which is used to provide strength to a crown or bridge. These restorations are very strong, durable and resistant to wear, because the combination of porcelain and metal creates a stronger restoration than porcelain used alone.

One of the advantages of computerized dentistry (CAD/CAM technologies) is that it enabled the application of *zirconium-oxide* ($ZrO_2$). The introduction of this material in restorative and prosthetic dentistry is most likely the decisive step toward the use of full ceramics without limitation. With the exception of zirconium-oxide, existing ceramics systems lack reliable potential for the various indications for bridges without size limitations. Zirconium-oxide with its high strength and comparatively higher fracture toughness seems to buck this trend. With a three-point bending strength exceeding 900 megapascals, zirconium-oxide can be used in virtually every full ceramic prosthetic solution, including bridges, implant supra structures and root dowel pins.

Previous attempts to extend its application to dentistry were thwarted by the fact that this material could not be processed using traditional methods used in dentistry. The arrival of computerized dentistry enables the economically prudent use of zirconium-oxide in such elements as base structures such as copings and bridges and implant supra structures. Special requirements apply to dental materials implanted for longer than a period of thirty days. Several technical requirements include high strength, corrosion resistance and defect-free producibility at a reasonable price.

Ever more stringent requirements are being placed on the aesthetics of teeth. *Metals* and porcelain are currently the materials of choice for crowns and bridges. The demand for full ceramic solutions, however, continues to grow. Consequently, industry and science are increasingly compelled to develop full ceramic systems. In introducing full ceramic restorations, such as base structures made of sintered ceramics, computerized dentistry plays a key role.

## Comparison

- Composites and Amalgam are used mainly for direct restoration. Composites can be made of color matching the tooth, and surface can be polished after filling.

- Amalgam fillings expand with age, possibly cracking the tooth and requiring repair and filling replacement. But chance of leakage of filling is less.

- Composite fillings shrink with age and may pull away from the tooth allowing leakage. If leakage is not noticed early recurrent decay may occur.

- Fillings have a finite lifespan: an average of 12.8 years for amalgam and 7.8 years for composite resins. Fillings fail because of changes in the filling, tooth or the bond between them. Secondary caries formation can also affect the structural integrity the original filling. Fillings are recommended for small to medium sized restorations.

- Porcelain and Gold are used for indirect restorations like crowns and partial coverage crowns (onlays). Some types of porcelains are hard, but can cause wear on opposing teeth. They are brittle and are not always recommended for molar restorations. A new material called lithium disilicate (ips.emax) is indicated for use on molars for crowns and onlays now because it is fracture resistant compared to other porcelains used for dental restorations.

## Experimental

In 2010, researchers reported that they were able to stimulate mineralization of an enamel-like layer of fluorapatite *in vivo*.

### *Restoration of dental implants*

Dental implants, are anchors placed in bone, usually made from titanium or titanium alloy. They can support dental restorations which replace missing teeth. Some restorative applications include supporting crowns, bridges, or dental prostheses.

# Chapter 2

# Dental Restorative Materials

**Dental restorative materials** are specially fabricated materials, designed for use as dental restorations (fillings), which are used to restore tooth structure loss, usually resulting from but not limited to dental caries (dental cavities). There are many challenges for the physical properties of the ideal dental restorative material.

## *Restorative material development*

The goal of research and development is to develop the ideal restorative material. The ideal restorative material would be identical to natural tooth structure, in strength adherence and appearance. The properties of an ideal filling material can be divided into four categories: physical properties, biocompatibility, aesthetics and application.

### Physical properties

Requisite physical properties include low thermal conductivity and expansion, resistance to different categories of forces and wear like attrition and abrasion and resistance to chemical erosion. There must also be good bonding strength to the tooth. Everyday masticatory forces and conditions must be withstood without fatiguing.

### Biocompatibility

Biocompatibility refers to how well the material coexists with the biological equilibrium of the tooth and body systems. Since fillings are in close contact with mucosa, tooth, and pulp, biocompatibility is very important. Common problems with some of the current dental materials include chemical leakage from the material, pulpal irritation and less commonly allergy. Some of the byproducts of the chemical reactions during different stages of material hardening need to be considered.

### Aesthetics

Filling materials ideally would match the surrounding tooth structure in shade, translucency, and texture.

### Application

Dental operators require materials that are easy to manipulate and shape, where the chemistry of any reactions that need to occur are predictable or controllable.

## *Direct restorative materials*

The chemistry of the setting reaction for direct restorative materials is designed to be more biologically compatible. Heat and byproducts generated cannot damage the tooth or patient, since the reaction needs to take place while in contact with the tooth during restoration. This ultimately limits the strength of the materials, since harder materials need more energy to manipulate.

### Amalgam

Amalgam is a metallic filling material composed from a mixture of mercury (from 43% to 54%) and powdered alloy made mostly of silver, tin, zinc and copper commonly called the amalgam alloy. Amalgam does not adhere to tooth structure without the aid of cements, or techniques which lock in the filling, using the same principles as a dovetail joint. Amalgam is still used extensively in many parts of the world because of its cost effectiveness, superior strength and longevity. However their metallic colour is not aesthetic and tooth coloured alternatives are continually emerging with increasingly comparable properties. Due to the known toxicity of the element mercury, there is some controversy about the use of amalgams. *Amalgam: The most popular amalgam was a mixture of silver, tin and mercury. According to the authors of the article *" It set very hard and lasted for many years, the major contradiction being that it oxidized in the mouth, turning teeth black. Also the mercury contained in the amalgam was thought at that time to be harmful."* as explained in the pre-eminent dental textbook of that century, The Principles and Practice of Dental Surgery by Chapin A. Harris A.M., M.D., D.D.S.. More recent dental texts strongly support the use of amalgam; "In summary, dental amalgam is a highly successful material clinically and is very cost effective, but alternatives such as cast gold and esthetic restorative materials are now very competitive in terms of frequency of use. Many argue, however, that the use of amalgam must be strongly supported given its large public health benefit in the United States and many other countries."

### Composite resin

*Composite resin* fillings (also called white fillings) are a mixture of powdered glass and plastic resin, and can be made to resemble the appearance of the natural tooth. They are strong, durable and cosmetically superior to silver or dark grey colored amalgam fillings.

Composite resin fillings are usually more expensive than amalgam fillings. Bis-GMA based materials contain Bisphenol A, a known endocrine disrupter chemical, and may contribute to the development of breast cancer. PEX-based materials do not.

Most modern composite resins are light-cured photopolymers, meaning that they harden with light exposure. They can then be polished to achieve maximum aesthetic results. Composite resins experience a very small amount of shrinkage upon curing, causing the material to pull away from the walls of the cavity preparation. This makes the tooth slightly more vulnerable to microleakage and recurrent decay. There are handling techniques combined with material selection,which minimize or eliminate microleakage.

In some circumstances, less tooth structure can be removed compared to preparation for other dental materials such as amalgam and many of the indirect methods of restoration. This is because composite resins bind to enamel (and dentin too, although not as well) via a micromechanical bond. As conservation of tooth structure is a key ingredient in tooth preservation, many dentists prefer placing materials like composite instead of amalgam fillings whenever possible.

Generally, composite fillings are used to fill a carious lesion involving highly visible areas (such as the central incisors or any other teeth that can be seen when smiling) or when conservation of tooth structure is a top priority.

The bond of composite resin to tooth, is especially affected by moisture contamination and cleanliness of the prepared surface. Other materials can be selected when restoring teeth where moisture control techniques are not effective.

## Glass Ionomer Cement

These fillings are a mixture of glass and an organic acid. Although they are tooth-colored, glass ionomers vary in translucency. Although glass ionomers can be used to achieve an aesthetic result, their aesthetic potential does not measure up to that provided by composite resins.

The cavity preparation of a glass ionomer filling is the same as a composite resin; it is considered a fairly conservative procedure as the bare minimum of tooth structure should be removed.

Conventional glass ionomers are chemically set via an acid-base reaction. Upon mixing of the material components, there is no light cure needed to harden the material once placed in the cavity preparation. After the initial set, glass ionomers still need time to fully set and harden.

Glass ionomers do have their advantages over composite resins:

1. They are not subject to shrinkage and microleakage, as the bonding mechanism is an acid-base reaction and not a polymerization reaction.

2. Glass ionomers contain and release fluoride, which is important to preventing carious lesions. Furthermore, as glass ionomers release their fluoride, they can be "recharged" by the use of fluoride-containing toothpaste. Hence, they can be used as a treatment modality for patients who are at high risk for caries. Newer formulations of glass ionomers that contain light-cured resins can achieve a greater aesthetic result, but do not release fluoride as well as conventional glass ionomers.

Glass ionomers are about as expensive as composite resin. The fillings do not wear as well as composite resin fillings. Still, they are generally considered good materials to use for root caries and for sealants.

### Resin modified Glass-Ionomer Cement (RMGIC)

A combination of glass-ionomer and composite resin, these fillings are a mixture of glass, an organic acid, and resin polymer that harden when light cured. (The light activates a catalyst in the cement that causes it to cure in seconds.) The cost is similar to composite resin. It holds up better than glass ionomer, but not as well as composite resin, and is not recommended for biting surfaces of adult teeth.

In general, resin modified glass-ionomer cements can achieve a better aesthetic result than conventional glass ionomers, but not as good as pure composites.it has its own setting reaction.

### Compomers

Again a combination of Composite resin and glass ionomer technology, however with the focus lying towards the composite resin end of the spectrum. Has better mechanical and aesthetic properties than RMGIC but worse wear and requires a bonding system to be used. Although compomers release fluoride, they do so at such a low level that it is not deemed effective, and unlike glass ionomer and RMIC cannot act as a fluoride reservoir.

## *Indirect Restorative materials*

### Porcelain (ceramic)

Porcelain fillings are hard, but can cause wear on opposing teeth. They are brittle and are not always recommended for molar fillings.

### Gold

Gold fillings have excellent durability, wear well, and do not cause excessive wear to the opposing teeth, but they do conduct heat and cold, which can be irritating. There are two categories of gold fillings, cast gold fillings (gold inlays and onlays) made with 14 or 18 kt gold, and gold foil made with pure 24 kt gold that is burnished layer by layer. For years, they have been considered the benchmark of restorative dental materials. Recent advances in dental porcelains and consumer focus on aesthetic results have caused demand for gold fillings to drop in favor of advanced composites and porcelain veneers and crowns. Gold fillings are sometimes quite expensive, although they do last a very long time, which can mean gold restorations are less costly and painful in the long run. It is not uncommon for a gold crown to last 30 years.

### Other historical fillings

Lead fillings were used in the 18th century, but became unpopular in the 19th century because of their softness. This was before lead poisoning was understood.

According to American Civil War-era dental handbooks from the mid-19th century, since the early 19th century metallic fillings had been used, made of lead, gold, tin, platinum, silver, aluminum, or amalgam. A pellet was rolled slightly larger than the cavity, condensed into place with instruments, then shaped and polished in the patient's mouth. The filling was usually left "high", with final condensation — "tamping down" — occurring while the patient chewed food. Gold foil was the most popular and preferred filling material during the Civil War. Tin and amalgam were also popular due to lower cost, but were held in lower regard.

One survey of dental practices in the mid-19th century catalogued dental fillings found in the remains of seven Confederate soldiers from the U.S. Civil War; they were made of:

- Gold foil: Preferred because of its durability and safety.
- Platinum: Was rarely used because it was too hard, inflexible and difficult to form into foil.
- Aluminum: A material which failed because of its lack of malleability but has been added to some amalgams.
- Tin and iron: Believed to have been a very popular filling material during the Civil War. Tin foil was recommended when a cheaper material than gold was requested by the patient, however tin wore down rapidly and even if it could be replaced cheaply and quickly, there was a concern, specifically from Harris, that it would oxidise in the mouth and thus cause a recurrence of caries. Due to the blackening, tin was only recommended for posterior teeth.
- Thorium: Radioactivity was unknown at that time, and the dentist probably thought he was working with tin.
- Lead and tungsten mixture, probably coming from shotgun pellets. Lead was rarely used in the 19th century, it is soft and quickly worn down by mastication, and had known harmful health effects.

## *Failure of dental restorations*

Fillings have a finite lifespan: an average of 12.8 years for amalgam and 7.8 years for composite resins. One advantage of gold restorations is longevity, because gold can outlast other materials by three to five times longer. When describing other materials, dentists talk in terms of years of service, whereas with cast gold, dentists speak of decades of service. To achieve the greatest longevity, gold dental work must be done with sufficient skill and precision, so discerning patients should seek gold dentists with quality training, experience and expertise.

Fillings fail because of changes in the filling, tooth or the bond between them.

Amalgam fillings expand with age, possibly cracking the tooth and requiring repair and filling replacement. Composite fillings shrink with age and may pull away from the tooth allowing leakage. Quality dental gold is the most biocompatible material used in dentistry today, being non-corrosive and hypo-allergenic. Dental gold's wear rates and coefficient of thermal expansion is very similar to tooth enamel, which minimizes gaps, leakage or repair due to expansion differentials over time.

As chewing applies considerable pressure on the tooth, the filling may crack, allowing seepage and eventual decay in the tooth underneath. Gold margins do not break or chip even when thinned and polished, and can achieve microscopic gaps even smaller than the diameter of bacterium that cause tooth decay.

The tooth itself may be weakened by the filling and crack under the pressure of chewing. That will require further repairs to the tooth and replacement of the filling. On the other hand, less tooth structure is removed when preparing teeth for gold dental restoration, which leaves the tooth stronger and healthier.

Gold restorations, if done properly, could last the lifetime of a patient. As life expectancies increase, thoughtful dental material choices become even more important to reduce the number of times that fillings and other restorations must be replaced. Repeated repairs to teeth can lead to pulpal inflammation and necrosis, root canal therapy and the eventual necessity for crowns in lieu of fillings. Restoring a tooth only once, with highly durable, non-toxic, biocompatible materials like gold, can be very appealing to discerning patients, and be less costly and painful in the long run.

If fillings leak or if the original bond is inadequate, the bond may fail even if the filling and tooth are otherwise unchanged.

## *Evaluation and regulation of dental materials*

The Nordic Institute of Dental Materials (NIOM) evaluates dental materials in the Nordic countries. This research and testing institution are accredited to perform several test procedures for dental products. In Europe, dental materials are classified as medical devices according to the Medical Devices Directive. In USA, the U.S. Food and Drug Administration is the regulatory body for dental products.

## Chapter 3

# Endodontics, Periodontology and Prosthodontics

## Endodontics

An endodontist operating on his patient.

**Endodontics** (from the Greek *endo* "inside"; and *odons* "tooth") is one of dental specialties recognized by the American Dental Association, Royal College of Dentists of Canada, and Royal Australasian College of Dental Surgeons, and deals with the tooth pulp and the tissues surrounding the root of a tooth. Endodontists perform a variety of procedures including root canal therapy, endodontic retreatment, surgery, treating cracked teeth, and treating dental trauma. Root canal therapy is one of the most common procedures. If the pulp (containing nerves, arterioles, venules, lymphatic tissue, and fibrous tissue) becomes diseased or injured, endodontic treatment is required to save the tooth.

## *Training*

### Australia

Australian programs are accredited by the Australian Dental Council (ADC) and are 3 years in length and culminate with either a Master degree (MDS) or a Doctor of Clinical Dentistry degree (DClinDent). Fellowship can then be obtained with the Royal Australasian College of Dental Surgeons, FRACDS (Endo).

### Canada

Canadian programs are accredited by the (CDAC) and are a minimum of two years in length to a maximum of 8 years in length and usually culminate with a master (MSc or MDent) degree. Graduates are then eligible to sit for the Fellowship exams with the Royal College of Dentists of Canada (FRCD (C)).

### USA

In the United States after a dentist finishes their dental degree they must undergo 2-3 additional years of postgraduate training to become an endodontist. The American Dental Association (CODA) accredited programs are a minimum of two years in length. Following successful completion of this training the dentist becomes Board eligible to sit the American Board of Endodontology examination. Successful completion of board certification results in Diplomate status in the American Board of Endodontology.

# Periodontology

| Periodontist | |
|---|---|
| **Occupation** | |
| **Type** | Specialty |
| **Activity sectors** | Dentistry |
| **Description** | |
| **Education required** | dental degree |
| **Fields of employment** | Hospitals, Private Practices |

**Periodontology** or **Periodontics** (from Greek *peri* "around"; and *odons* "tooth") is the specialty of dentistry that studies supporting structures of teeth, diseases, and conditions that affect them. The supporting tissues are known as the periodontium, which includes the gingiva (gums), alveolar bone, cementum, and the periodontal ligament. A professional who practises this speciality field of dentistry is known as a **periodontist**.

## *Periodontal disease*

Periodontal diseases take on many different forms but are usually a result of a coalescence of bacterial plaque biofilm accumulation of the gingiva and teeth, combined with host immuno-inflammatory mechanisms and other risk factors which lead to destruction of the supporting bone around natural teeth. Untreated, these diseases lead to alveolar bone loss and tooth loss and, to date, continue to be the leading cause of tooth loss in adults.

## *Training*

Before applying to any postgraduate training program in periodontology one must first complete a dental degree.

### USA

The American Dental Association (CODA) accredited programs are a minimum of three years in length. According to the American Academy of Periodontology, US trained Periodontists are specialists in the prevention, diagnosis and treatment of periodontal diseases and oral inflammation, and in the placement and maintenance of dental implants. Following successful completion of post-graduate training a periodontist becomes Board eligible for the American Board of Periodontology examination. Successful completion of board certification results in Diplomate status in the American Board of Periodontology.

### Australia

Australian programs are accredited by the Australian Dental Council (ADC) and are 3 years in length and culminate with either a Master degree (MDS) or a Doctor of Clinical Dentistry degree (DClinDent). Fellowship can then be obtained with the Royal Australasian College of Dental Surgeons, FRACDS (Perio).

### Canada

Canadian programs are accredited by the (CDAC) and are a minimum of two years in length and usually culminate with a master (MSc or MDent) degree. Graduates are then eligible to sit for the Fellowship exams with the Royal College of Dentists of Canada (FRCD (C)).

### *India*

Periodontics is offered as a specialization field of dentistry in India. Periodontists attend a Master of Dental Surgery (M.D.S) program affiliated with dental schools in India. The minimum qualification required for the M.D.S degree is a Bachelor of Dental Surgery (B.D.S) degree.

### *United Kingdom*

The British Society of periodontology exists to promote the art and science of periodontology. Their membership includes specialist practitioners, periodontists, general dentists, consultants and trainees in restorative dentistry, clinical academics, dental hygienists and therapists, specialist trainees in periodontology and many others.

# Prosthodontics

| Prosthodontist | |
|---|---|
| **Occupation** | |
| **Names** | Prosthodontist |
| **Type** | Specialty |
| **Activity sectors** | Dentistry |
| **Description** | |
| **Education required** | dental degree |
| **Fields of employment** | Hospitals, Private Practices |

**Prosthodontics**, also known as **dental prosthetics** or **prosthetic dentistry**, is one of nine dental specialties recognized by the American Dental Association, Royal College of Dentists of Canada, and Royal Australasian College of Dental Surgeons. Prosthodontics is the dental specialty pertaining to the diagnosis, treatment planning, rehabilitation and maintenance of the oral function, comfort, appearance and health of patients with clinical conditions associated with missing or deficient teeth and/or oral and maxillofacial tissues using biocompatible substitutes.

According to the American College of Prosthodontists, a prosthodontist is a dentist who:

1. Specializes in the esthetic (cosmetic) restoration and replacement of teeth.
2. Receives three to four years of additional training after dental school.
3. Restores optimum appearance and function to your smile. The treatment planning and restoration of implants, temporomandibular joint disorder, and rehabilitation of occlusion with prostheses all fall under the field of prosthodontics.

## *Training*

### Australia

Australian programs are accredited by the Australian Dental Council (ADC) and are 3 years in length and culminate with either a Master degree (MDS), a Master of Dental Science (MDSc) or a Doctor of Clinical Dentistry degree (DClinDent). Fellowship can then be obtained with the Royal Australasian College of Dental Surgeons, FRACDS (Pros).

### Canada

Canadian programs are accredited by the (CDAC) and are a minimum of three years in length and usually culminate with a master (MSc or MDent) degree. Graduates are then eligible to sit for the Fellowship exams with the Royal College of Dentists of Canada (FRCD (C)).

In Canada, prosthodontics speciality programs are available at University of Montréal, University of Toronto and UBC.

### USA

The American College of Prosthodontists (ACP)  ensures standards are maintained in the field. Becoming a prosthodontist requires an additional three years of postgraduate specialty training after obtaining a dental degree. Training consists of rigorous clinical and didactic preparation in the basic sciences, head and neck anatomy, biomedical sciences, biomaterial sciences, function of occlusion (bite), TMD (Temporomandibular joint disorder), and treatment planning and experience treating full-mouth reconstruction cases, and esthetics. Due to this extensive training, prosthodontists are required to treat complex cases, full-mouth rehabilitation, TMJ related disorders, congenital disorders, and sleep apnea by planning and fabricating various prostheses. There are only 3,200 prosthodontists in comparison to 170,000 general dentists in the United States. Prosthodontists have been consistently ranked at 6th or 7th positions by Forbes among America's most competitive and highest salaried jobs,

Board certification is awarded through the American Board of Prosthodontics (ABP) and requires successful completion of the Part I written examination and Part 2, 3 and 4 oral examinations. There are approximately 1000 diplomates so far, thus making them highly qualified. The written and one oral examination may be taken during the 3rd year of speciality training and the remaining two oral examinations taken following completion of speciality training. Board eligibility starts when an application is approved by the ABP and lasts for six years. Diplomates of the ABP are ethically required to have a practice limited to prosthodontics. Fellows of the American College of Prosthodontists (FACP) are required to have a dental degree, have completed three years of prosthodontic speciality training, and be board certified by the ABP.

According to the ADA, specialties are recognized in those areas where advanced knowledge and skills are essential to maintain or restore oral health (Principles of Ethics and Code of Professional Conduct). Not all areas in dentistry will satisfy the requirements for specialty recognition. However, the public and profession benefit substantially when non-specialty groups develop and advance areas of interest through education, practice and research. Acknowledged by the profession, the contributions of such and their endeavors are encouraged. There is no such thing as "Cosmetic Dentistry" and the American Dental Association does not recognize "Cosmetic Dentistry" as a speciality. Prosthodontics is the only dental speciality under which the concentration of cosmetic/esthetic dentistry falls. General dentists may perform some simple cosmetic procedures. However, there are questions regarding whether it is ethical for general dentists to treat "smile makeovers" or complex cosmetic and full-mouth reconstruction cases, as they are not qualified to address the complex needs of the patient. (Felton D. Ethics, Dentistry, and the Prosthodontist. J of Prosthodont. 2009;18(4):291-291.), Likewise, there is no specialty recognized by the ADA for dental implants.

## *Maxillofacial prosthodontics/prosthetics*

Maxillofacial prosthetics is a sub-specialty or often called as super-specialty of prosthodontics. All Maxillofacial Prosthodontists are prosthodontists first and then attain a fellowship training (1 year) exclusively in Maxillofacial Prosthetics. Maxillofacial prosthodontists treat patients who have acquired and congenital defects of the head and neck (maxillofacial) region due to cancer, surgery, trauma, and/or birth defects. Maxillary obturators, Speech-aid prosthesis (formerly called as Pharyngeal/Soft Palate Obturators) and Mandibular-Resection prostheses are the most common prostheses planned and fabricated by Maxillofacial Prosthodontists. Other types of prostheses include artificial eyes, nose and other facial prostheses fabricated in conjunction with an anaplastologist.

Treatment is multidisciplinary involving oral and maxillofacial surgeons, plastic surgeons, head and neck surgeons, ENT doctors, oncologists, speech therapists, occupational therapists, physiotherapists, and other healthcare professionals.

To be qualified as a Maxillofacial Prosthodontist in the United States, an additional year of training is required following completion of the certificate for speciality training in prosthodontics. Due to their extensive training in prosthetic reconstruction, breadth of knowledge and capability of handling most types of complex cases, Maxillofacial Prosthodontists are often referred to as "Bullet-Proof" dentists.

### *Conditions and treatment modalities*

- Akers' Clasp
- Amalgam (dentistry)
- Bisphosphonate-associated osteonecrosis of the jaws
- Bridge (dentistry)
- Bruxism
- Centric relation
- Commonly used terms of relationship and comparison in dentistry
- Crown (dentistry)
- Crown lengthening
- Crown-to-root ratio
- Curve of spee
- Dental implant
- Dental Phobia
- Dental Surgery
- Dentures
- Edentulism
- Fixed prosthodontics
- Head and neck anatomy
- Inlays and onlays
- Obiismist
- Occlusal trauma
- Occlusion
- Removable partial dentures
- RPI
- Temporomandibular joint disorder

## Chapter 4

# Bridge (Dentistry)

A three unit porcelain fused to metal bridge (PFM) made by a dental technician.

A **semi-precision attachment** between teeth #3 and #4, with the female on #4. Note the **lingual buttons** extending, in the photo, upward on #2 (on the left) and downward on #4. These are used to grasp the crowns with a hemostat and make them easier to handle. They can also be used to aid in removal of the crown in case there is an excessive amount of retention during the try-in. They are cut off prior to final cementation.

The proximal surfaces of the pre-solder index abutment and pontic, showing lab-processed grooves for added retention of the GC pattern resin.

The abument and pontic joined with GC pattern resin in a solder index and reinforced with an old bur (lying horizontally across the occlusal surface of the copings).

A **bridge**, also known as a **fixed partial denture**, is a dental restoration used to replace a missing tooth by joining permanently to adjacent teeth or dental implants.

There are different types of bridges, depending on how they are fabricated and the way they anchor to the adjacent teeth. Conventionally, bridges are made using the indirect method of restoration however, bridges can be fabricated directly in the mouth using such materials as composite resin.

A bridge is fabricated by reducing the teeth on either side of the missing tooth or teeth by a preparation pattern determined by the location of the teeth and by the material from which the bridge is fabricated. In other words, the abutment teeth are reduced in size to accommodate the material to be used to restore the size and shape of the original teeth in a correct alignment and contact with the opposing teeth. The dimensions of the bridge are defined by Ante's Law: "The root surface area of the abutment teeth has to equal or surpass that of the teeth being replaced with pontics".

The materials used for the bridges include gold, porcelain fused to metal, or in the correct situation porcelain alone. The amount and type of reduction done to the abutment teeth varies slightly with the different materials used. The recipient of such a bridge must be careful to clean well under this prosthesis.

When restoring an edentulous space with a fixed partial denture that will crown the teeth adjacent to the space and *bridge* the gap with a **pontic**, or "dummy tooth", the restoration is referred to as a **bridge**. Besides all of the preceding information that concerns single-unit crowns, bridges possess a few additional considerations when it comes to case selection and treatment planning, tooth preparation and restoration fabrication.

### *Case selection and treatment planning*

When a single tooth requires a crown, the prosthetic crown will in most instances rest upon whatever tooth structure was originally supporting the crown of the natural tooth. However, when restoring an edentulous area with a bridge, the bridge is almost always restoring more teeth than there are root structures to support. For instance, in the photo at right, the 5-unit bridge will only be supported on three abutment teeth. To determine whether or not the abutment teeth can support a bridge without failure from lack of support from remaining root structures, the dentist employs **Ante's rule**—which states that the roots of abutment teeth must have a combined surface area in three dimensions that is more than that of the missing root structures of the teeth replaced with a bridge. When the situation yields a poor prognosis for proper support, double abutments may be required to properly conform to Ante's rule.

When a posterior tooth intended for an abutment tooth already possesses an intracoronal restoration, it might be better to make that bridge abutment into an inlay or an onlay, instead of a crown. However, this may concentrate the torque of the masticatory forces onto a less enveloping restoration, thus making the bridge more prone to failure.

In some situations, a cantilever bridge may be constructed to restore an edentulous area that only has adequate teeth for abutments either mesially or distally. This must also conform to Ante's rule but, because there are only abutments on one side, a modification to the rule must be applied, and these bridges possess double abutments in the majority of cases, and the occlusal surface area of the pontic is generally decreased by making the pontic smaller than the original tooth.

## Tooth preparation

As with preparations for single-unit crowns, the preparations for multiple-unit bridges must also possess proper taper to facilitate the insertion of the prosthesis onto the teeth. However, there is an added dimension when it comes to bridges, because the bridge must be able to fit onto the abutment teeth simultaneously. Thus, the taper of the abutment teeth must match, to properly seat the bridge. This is known as requiring **parallelism** among the abutments.

When this is not possible, due to severe tipping of one of more of the abutments, for example, an **attachment** may be useful, as in the photo at right, so that one of the abutments may be cemented first, and the other abutment, attached to the pontic, can then be inserted, with an arm on the pontic slipping into a groove on the cemented crown to achieve a span across the edentulous area.

## Restoration fabrication

Full dental bridge being machined using WorkNC Dental CAD/CAM software.

As with single-unit crowns, bridges may be fabricated using the lost-wax technique if the restoration is to be either a multiple-unit FGC or PFM. Another fabrication technique is to use CAD/CAM software to machine the bridge. As mentioned above, there are special considerations when preparing for a multiple-unit restoration in that the relationship between the two or more abutments must be maintained in the restoration. That is, there must be proper parallelism for the bridge to seat properly on the margins. Sometimes, the bridge does not seat, but the dentist is unsure whether or not it is only because the spatial relationship of the two or more abutments is incorrect, or whether the abutments do not actually fit the preparations. The only way to determine this is to section the bridge and try in each abutment by itself. If they all fit individually, it must have simply been that the spatial relationship was incorrect, and the abutment that was sectioned from the pontic must now be reattached to the pontic according to the newly confirmed spatial relationship. This is accomplished with a **solder index**.

The proximal surfaces of the sectioned units (that is, the adjacent surfaces of the metal at the cut) are roughened and the relationship is preserved with a material that will hold on to both sides, such as GC pattern resin. With the two bridge abutments individually seated on their prepared abutment teeth, the resin is applied to the location of the sectioning to reestablish a proper spatial relationship between the two pieces. This can then be sent to the lab where the two pieces will be soldered and returned for another try-in or final cementation.

## Chapter 5

# Dental Composite


Dental composites.

**Dental composite resins** are types of synthetic resins which are used in dentistry as restorative material or adhesives. Synthetic resins evolved as restorative materials since they were insoluble, aesthetic, and insensitive to dehydration and were inexpensive. It is easy to manipulate them as well. Composite resins are most commonly composed of Bis-GMA monomers or some Bis-GMA analog, a filler material such as silica and in most current applications, a photoinitiator. Dimethacrylates are also commonly added to achieve certain physical properties such as flowability. Further tailoring of physical properties is achieved by formulating unique concentrations of each constituent.Unlike

Amalgam which essentially just fills a hole, composite cavity restorations when used with dentin and enamel bonding techniques restore the tooth back to near its original physical integrity.

### History of use

Initially, composite restorations in dentistry were very prone to leakage and breakage due to weak compressive strength. In the 1990s and 2000s, composites were greatly improved and are said to have a compression strength sufficient for use in posterior teeth. Today's composite resins have low polymerization shrinkage and low coefficients of thermal shrinkage, which allows them to be placed in bulk while maintaining good adaptation to cavity walls. The placement of composite requires meticulous attention to procedure or it may fail prematurely. The tooth must be kept perfectly dry during placement or the resin will likely fail to adhere to the tooth. Composites are placed while still in a soft, dough-like state, but when exposed to light of a certain blue wavelength, they polymerize and harden into the solid filling. It is challenging to harden all of the composite, since the light often does not penetrate more than 2–3 mm into the composite. If too thick an amount of composite is placed in the tooth, the composite will remain partially soft, and this soft unpolymerized composite could ultimately irritate or kill the tooth's nerve. The dentist should place composite in a deep filling in numerous increments, curing each 2–3 mm section fully before adding the next. In addition, the clinician must be careful to adjust the bite of the composite filling, which can be tricky to do. If the filling is too high, even by a subtle amount, that could lead to chewing sensitivity on the tooth. A properly placed composite is comfortable, aesthetically pleasing, strong and durable, and could last 10 years or more. (By most North American insurance companies 2 years minimum)

The most desirable finish surface for a composite resin can be provided by aluminum oxide disks. Classically, Class III composite preparations were required to have retention points placed entirely in dentin. A syringe was used for placing composite resin because the possibility of trapping air in a restoration was minimized. Modern techniques vary, but conventional wisdom states that because there have been great increases in bonding strength due to the use of dentin primers in the late 1990s, physical retention is not needed except for the most extreme of cases. Primers allow the dentin's collagen fibers to be "sandwiched" into the resin, resulting in a superior physical and chemical bond of the filling to the tooth. Indeed, composite usage was highly controversial in the dental field until primer technology was standardized in the mid to late 1990s. The enamel margin of a composite resin preparation should be beveled in order to improve aesthetics and expose the ends of the enamel rods for acid attack. The correct technique of enamel etching prior to placement of a composite resin restoration includes etching with 30%-50% phosphoric acid and rinsing thoroughly with water and drying with air only. In preparing a cavity for restoration with composite resin combined with an acid etch technique, all enamel cavosurface angles should be obtuse angles. Contraindications for composite include varnish and zinc oxide-eugenol. Composite resins for Class IIs were not indicated because of excessive occlusal wear in the 1980s and early 1990s. Modern bonding techniques and the increasing unpopularity of amalgam filling material have made composites more attractive for Class II restorations. Opinions vary, but composite is regarded as having adequate longevity and wear characteristics to be used for permanent Class II restorations (although amalgam has proved to last considerably longer and have reduced leakage and sensitivity when compared to Class II composite restorations).

### *Composition*

Dental composite resin.

As with other composite materials, a dental composite typically consists of a resin-based oligomer matrix, such as a bisphenol A-glycidyl methacrylate (BISGMA) or urethane dimethacrylate (UDMA), and an inorganic filler such as silicon dioxide (silica). Compositions vary widely, with proprietary mixes of resins forming the matrix, as well as engineered filler glasses and glass ceramics. The filler gives the composite wear resistance and translucency. A coupling agent such as silane is used to enhance the bond between these two components. An initiator package (such as: camphorquinone (CQ), phenylpropanedione (PPD) or lucirin (TPO)) begins the polymerization reaction of the resins when external energy (light/heat, etc.) is applied. A catalyst package can control its speed.

### Advantages

The main advantage of a direct dental composite over traditional materials such as amalgam is improved aesthetics. Composites can be made in a wide range of tooth colors allowing near invisible restoration of teeth. Composites are glued into teeth and this strengthens the tooth's structure. The discovery of acid etching (producing enamel irregularities ranging from 5-30 micrometers in depth) of teeth to allow a micromechanical bond to the tooth allows good adhesion of the restoration to the tooth. This means that unlike silver filling there is no need for the dentist to create retentive features destroying healthy tooth. The acid-etch adhesion prevents micro leakage; however, all white fillings will eventually leak slightly. Very high bond strengths to tooth structure, both enamel and dentin, can be achieved with the current generation of dentin bonding agents.

### Disadvantages

Composite resin restorations have several disadvantages: They are technique-sensitive meaning that without meticulous placement they may fail prematurely. They take up to 50% longer to place than amalgam fillings and are thus more expensive. In addition clinical survival of composite restorations placed in posterior teeth has been shown to be significantly lower than amalgam restorations.

Survival and reasons for failure of amalgam versus composite posterior restorations placed in a randomized clinical trial.

### Direct dental composites

Direct dental composites are placed by the dentist in a clinical setting. Polymerization is accomplished typically with a hand held curing light that emits specific wavelengths keyed to the initiator and catalyst packages involved. When using a curing light, remember that the light should be held as close to the resin surface as possible, a shield should be placed between the light tip and the operator's eyes, and that curing time should be increased for darker resin shades. Light cured resins provide denser restorations than self-cured resins because no mixing is required that might introduce air bubble porosity.

Direct dental composites can be used for:

- Filling gaps (diastemas) between teeth using a shell-like veneer or
- Minor reshaping of teeth

- Partial crowns on single teeth

### *Indirect dental composites*

This type of composite is cured outside the mouth, in a processing unit that is capable of delivering higher intensities and levels of energy than handheld lights can. Indirect composites can have higher filler levels, and are cured for longer times. As a result, they have higher levels and depths of cure than direct composites. For example, an entire crown can be cured in a single process cycle in an extra-oral curing unit, compared to a millimeter layer of a filling.

As a result, full crowns and even bridges (replacing multiple teeth) can be fabricated with these systems. A stronger, tougher and more durable product is likely.

Indirect dental composites can be used for:

- Filling cavities in teeth, as fillings, inlays and/or onlays
- Filling gaps (diastemas) between teeth using a shell-like veneer or
- Reshaping of teeth
- Full or partial crowns on single teeth
- And even bridges spanning 2-3 teeth

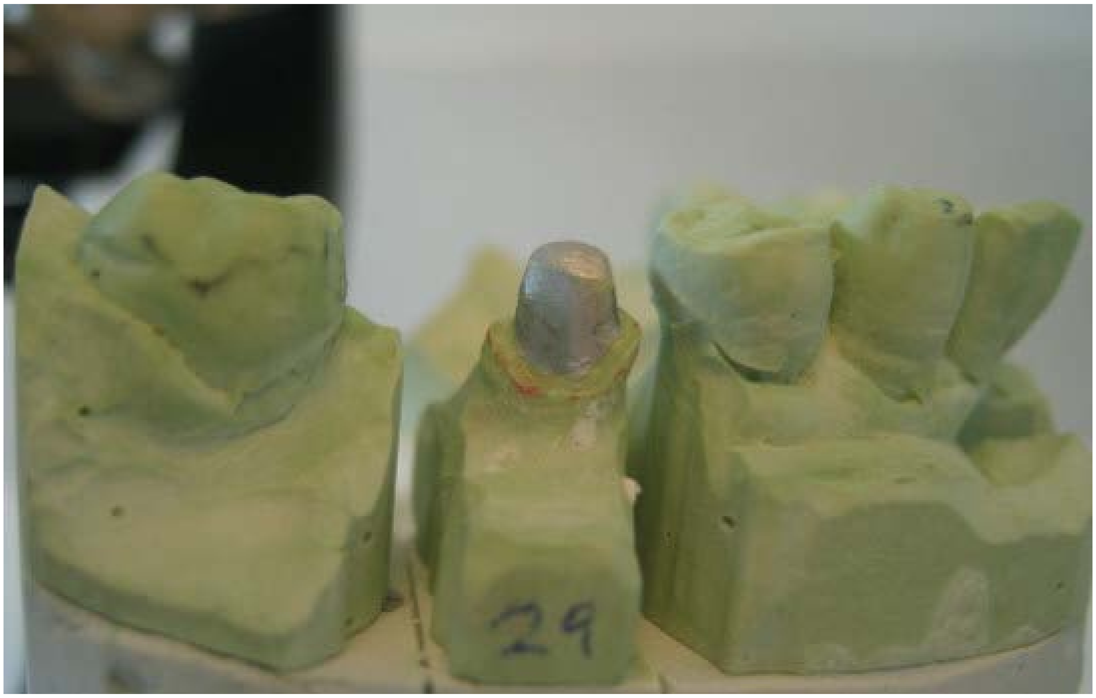
### *Composite shrinkage*

Composite resins have a notorious reputation for shrinking upon curing, however, uses as a dental restorative material focus on low shrinkage composites. Composite shrinkage can be reduced by altering the molecular and bulk composition of the resin. For example, *UltraSeal XT Plus* uses Bis-GMA without dimethacrylate and was found to have a shrinkage of 5.63%, 30 minutes after curing. On the other hand, this same study found that *Heliomolar*, which uses Bis-GMA, UDMA and decandiol dimethacrylate, had a shrinkage of 2.00%, 30 minutes after curing. In the field of dental restorative materials, reduction of composite shrinkage is a "hot topic". Soon to be introduced are patent pending, is a safe, non-leaching antimicrobial agent which minimizes recurrent decay of the tooth and reduces the harmful effects of micro-organisms and which some may cause gingivitis and periodonttitis (periodontal disease).

# Chapter 6

# Crown (Dentistry)


A **porcelain-fused-to-metal crown** for tooth #29 on its stone model. It is now ready to be cemented into the patient's mouth. The prosthetic crown does not extend distally to tooth #31 (molar to the left in photo) because the span is too large, as tooth #30 is missing. This edentulous area, together with a much larger one across the arch in the area of teeth #18-21, will be restored with a removable partial denture.



The stone model die for the same PFM crown on tooth #29. Notice how much tooth structure has been removed in order to facilitate placement of a crown. The original dimensions of the tooth approach if not duplicate the contours of the restoration in the photo above. The silvery paint on the stone die of tooth #29 is a **die spacer**, placed to allow for a minute amount of space between the tooth structure and the internal surface of the crown, which will later fill with cement upon final insertion of the crown into the mouth.

A **crown** is a type of dental restoration which completely caps or encircles a tooth or dental implant. Crowns are often needed when a large cavity threatens the ongoing health of a tooth. They are typically bonded to the tooth using a dental cement. Crowns can be made from many materials, which are usually fabricated using *indirect methods*. Crowns are often used to improve the strength or appearance of teeth. While unarguably beneficial to dental health, the procedure and materials can be relatively expensive.

The most common method of crowning a tooth involves using a dental impression of a prepared tooth by a dentist to fabricate the crown outside of the mouth. The crown can then be inserted at a subsequent dental appointment. Using this *indirect method* of tooth restoration allows use of strong restorative materials requiring time consuming fabrication methods requiring intense heat, such as casting metal or firing porcelain which would not be possible to complete inside the mouth. Because of the expansion properties, the relatively similar material costs, and the aesthetic benefits, many patients choose to have their crown fabricated with gold.

As new technology and materials science has evolved, computers are increasingly becoming a part of crown and bridge fabrication, such as in CAD/CAM Dentistry.

## *Other reasons to restore with a crown*

There are additional situations in which a crown would be the restoration of choice.

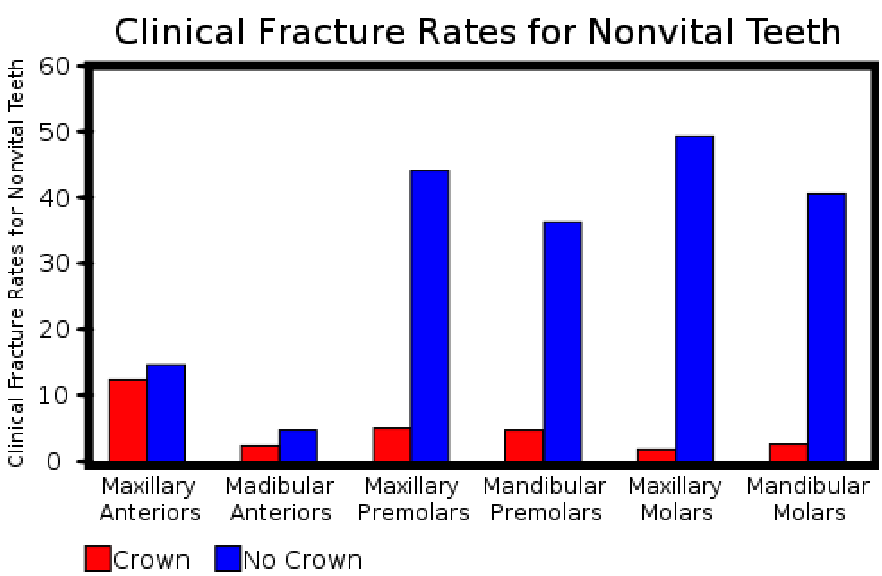
### Implants

Dental implants are placed into either the maxilla or mandible as an alternative to partial or complete edentulism. Once placed and properly integrated into the bone, implants may then be fitted with a number of different prostheses:

- crowns or bridges
- precision attachments for either removable partial dentures, complete dentures or a hybrid sort of prosthetic appliance.

### Endodontically treated teeth

When teeth undergo endodontic treatment, or root canal therapy, they are devitalized when the nerve and blood supply are cut off and the space which they previously filled, known as the "pulp chamber" and "root canal", are thoroughly cleansed and filled with various materials to prevent future invasion by bacteria. Although there may very well be enough tooth structure remaining after root canal therapy is provided for a particular tooth to restore the tooth with an intracoronal restoration, this is not suggested in most teeth. The vitality of a tooth is remarkable in its ability to provide the tooth with the strength and durability it needs to function in mastication. The living tooth structure is surprisingly resilient and can sustain considerable abuse without fracturing. Consequently, after root canal therapy is performed, a tooth becomes extremely brittle and is significantly weaker than its vital neighbors.




Fractures of endodontically treated teeth increase considerably in the posterior dentition when cuspal protection is not provided by a crown.

The average person can exert 150-200 lbs. of muscular force on their posterior teeth, which is approximately nine times the amount of force that can be exerted in the anterior. If the effective posterior contact area on a restoration is 0.1 $mm^2$, over 1 million PSI of stress is placed on the restoration. Therefore, posterior teeth (i.e. molars and premolars) should in almost all situations be crowned after undergoing root canal therapy to provide for proper protection against fracture (mandibular premolars, being very similar in crown morphology to canines, may in some cases be protected with intracoronal restorations). Should an endodontically treated tooth not be properly protected, there is a chance of it succumbing to breakage from normal functional forces. This fracture may well be difficult to treat, such as a "vertical root fracture" . Anterior teeth (i.e. incisors and canines), which are exposed to significantly lower functional forces, may effectively be treated with intracoronal restorations following root canal therapy if there is enough tooth structure remaining after the procedure.

## Surveyed crown

Another situation in which a crown is the restoration of choice is when a tooth is intended as an abutment tooth for a removable partial denture, but is initially unfavorable for such a task. If the abutment teeth onto which the RPD is supposed to clasp do not possess the proper dimensions or features required, these aspects can be built into what is known as a **surveyed crown**.

## Aesthetics

A fourth situation in which a crown would be the restoration of choice is when a patient desires to have his or her smile aesthetically improved but when **partial coverage** (i.e., a veneer/laminate) is not an option for one or more reasons. If the patient's occlusion does not permit for a mildly-retentive restoration, or if there is too much decay or a fracture within the tooth structure, a porcelain or composite veneer may not be placed with any adequate guarantee for its durability. Similarly, a "bruxer" (someone who clenches or grinds their teeth) may produce enough force to repeatedly dislodge or irreversibly abrade any veneer a dentist can plan for. In such a case, **full coverage** crowns can alter the size, shape or shade of a patient's teeth while protecting against failure of the restoration.

Makeover shows such as *Extreme Makeover* make extensive use of crowns, as the time-frame of the makeover is too short to allow up to 18 months for orthodontic treatment for problems that might otherwise be corrected more conservatively.

### *Tooth preparation*

A full-arch vinylpolysiloxane impression of the teeth prepared for the 5-unit PFM bridge shown in the photographs below. The salmon-colored impression material used near the crown preparations is of a lower viscosity than the blue, allowing for the capture of greater detail.

Preparation of a tooth for a crown involves the irreversible removal of a significant amount of tooth structure. All restorations possess compromised structural and functional integrity when compared to healthy, natural tooth structure. Thus, if not indicated as desirable by an oral health-care professional, the crowning of a tooth would most likely be contraindicated. It should be evident, though, that dentists trained at different institutions in different eras and in different countries might very well possess different methods of treatment planning and case selection, resulting in somewhat diverse recommendations for treatment.

Traditionally more than one visit is required to complete crown and bridge work, and the additional time required for the procedure can be a disadvantage; the increased benefits of such a restoration, however, will generally offset these considerations.

## Dimensions of preparation

When preparing a tooth for a traditional crown, the enamel may be totally removed and the finished preparation should, thus, exist primarily in dentin. As elaborated on below, the amount of tooth structure required to be removed will depend on the material(s) being used to restore the tooth. If the tooth is to be restored with a full gold crown, the restoration need only be .5 mm in thickness (as gold is very strong), and therefore, a minimum of only .5 mm of space needs to be made for the crown to be placed. If porcelain is to be applied to the gold crown, an additional minimum of 1 mm of tooth structure needs to be removed to allow for a sufficient thickness of the porcelain to be applied, thus bringing the total tooth reduction to minimally 1.5 mm.

If there is not enough tooth structure to properly retain the traditional prosthetic crown, the tooth requires a build-up material. This can be accomplished with a pin-retained direct restoration, such as amalgam or a composite resin, or in more severe cases, may require a post and core. Should the tooth require a post and core, endodontic therapy would then be indicated, as the post descends into the devitalized root canal for added retention. If the tooth, because of its relative lack of exposed tooth structure, also requires crown lengthening, the total combined time, effort and cost of the various procedures, together with the decreased prognosis because of the combined inherent failure rates of each procedure, might make it more reasonable to have the tooth extracted and opt to have an implant placed.

In recent years, the technological advances afforded by CAD/CAM Dentistry offer viable alternatives to the traditional crown restoration in many cases. Where the traditional indirectly fabricated crown requires a tremendous amount of surface area to retain the normal crown, potentially resulting in the loss of healthy, natural tooth structure for this purpose, the all-porcelain CAD/CAM crown can be predictably used with significantly less surface area. As a matter of fact, the more enamel that is retained, the greater the likelihood of a successful outcome. As long as the thickness of porcelain on the top, chewing portion of the crown is 1.5mm thick or greater, the restoration can be expected to be successful. The side walls which are normally totally sacrificed in the traditional crown are generally left far more intact with the CAD/CAM option. In regards to post & core buildups, these are generally contraindicated in CAD/CAM crowns as the resin bonding materials do best bonding the etched porcelain interface to the etched enamel/dentin interfaces of the natural tooth itself. The crownlay is also an excellent alternative to the post & core buildup when restoring a root canal treated tooth.

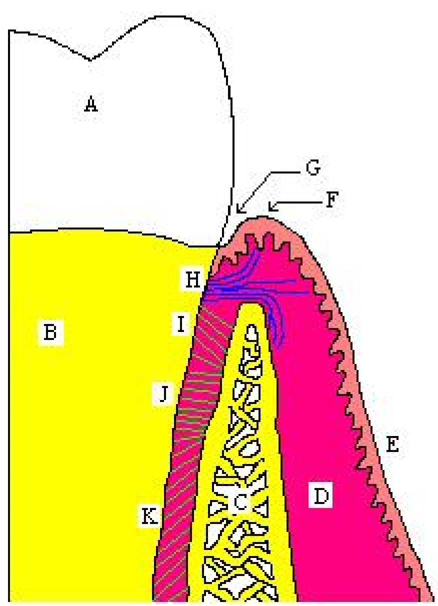
## Taper

The prepared tooth also needs to possess 3 to 5 degrees of taper to allow for the restoration to be properly placed on the tooth. The taper should not exceed 20 degrees. Fundamentally, there can be no undercuts on the surface of the prepared tooth, as the restoration will not be able to be removed from the die, let alone fit on the tooth. At the same time, too much taper will severely limit the grip that the crown has on the prepared tooth, thus contributing to failure of the restoration. Generally, 6º of taper around the entire circumference of the prepared tooth, giving a combined taper of 12º at any given sagittal section through the prepared tooth, is appropriate to both allow the crown to fit yet provide enough grip.

## Margin

The most coronal position of untouched tooth structure (that is, the continual line of original, undrilled tooth structure at or near the gum line) is referred to as the **margin**. This margin will be the future continual line of tooth-to-restoration contact, and should be a smooth, well-defined delineation so that the restoration, no matter how it is fabricated, can be properly adapted and not allow for any openings visible to the naked eye, however slight. An acceptable distance from tooth margin to restoration margin is anywhere from 40-100 μm. However, the R.V. Tucker method of gold inlay and onlay restoration produces tooth-to-restoration adaptation of potentially only 2 μm, confirmed by scanning electron microscopy; this is less than the diameter of a single bacterium.

Naturally, the tooth-to-restoration margin is an unsightly thing to have exposed on the visible surface of a tooth when the tooth exists in the aesthetic zone of the smile. In these areas, the dentist would like to place the margin as far apical (towards the root tip of the tooth) as possible, even below the gum line. While there is no issue, per se, with placing the margin at the gumline, problems may arise when placing the margin too subgingivally (below the gumline). First, there might be issues in terms of capturing the margin in an impression to make the stone model of the prepared tooth. Secondly, there is the seriously important issue of biologic width. Biologic width is the mandatory distance to be left between the height of the alveolar bone and the margin of the restoration, and if this distance is violated because the margin is placed too subgingivally, serious repercussions may follow. In situations where the margin cannot be placed apically enough to provide for proper retention of the prosthetic crown on the prepared tooth structure, the tooth or teeth involved should undergo a crown lengthening procedure.



The natural tooth's crown *(A)* meets the root *(B)* at the cementoenamel junction, and it is roughly at this point that the gingival attachment begins at the base of the gingival sulcus *(G)*. The margin of the prosthetic crown may not violate the 2 mm of biologic width from the base of this sulcus to the height of the alveolar bone *(C)* if complications are to be avoided.

There are a number of different types of margins that can be placed for restoration with a crown. There is the chamfer, which is popular with full gold restorations, which effectively removed the smallest amount of tooth structure. There is also a **shoulder**, which, while removing slightly more tooth structure, serves to allow for a thickness of the restoration material, necessary when applying porcelain to a **PFM coping** or when restoring with an **all-ceramic crown**. When using a shoulder preparation, the dentist is urged to add a bevel; the shoulder-bevel margin serves to effectively decrease the tooth-to-restoration distance upon final cementation of the restoration.

### Ferrule effect

A very important consideration when restoring with a crown is the incorporation of the **ferrule effect**. As with the bristles of a broom, which are grasped by a ferrule when attached to the broomstick, the crown should envelop a certain height of tooth structure to properly protect the tooth from fracture after being prepared for a crown. This has been established through multiple experiments as a mandatory continuous circumferential height of 2 mm; any less provides for a significantly higher failure rate of endodontically-treated crown-restored teeth. When a tooth is not endodontically treated, the remaining tooth structure will invariably provide the 2 mm height necessary for a ferrule, but endodontically treated teeth are notoriously decayed and are often missing significant solid tooth structure. Because they are weaker after the additional removal of tooth structure that occurs during a root canal procedure, endodontically treated teeth require proper protection against vertical root fracture. Contrary to what some dentists believe, a bevel *is not* at all suitable for implementing the ferrule effect, and beveled tooth structure may not be included in the 2 mms of required tooth structure for a ferrule. Some have speculated that a shoulder preparation on an all ceramic crown that will be bonded in place may have the same effect as a ferrule.

## *Adequate and appropriate restoration of tooth structure*

As crowns are fabricated indirectly (outside of the mouth) free of the encumbrances of saliva, blood, and tight quarters, they can be made to fit more precisely than restorative materials placed directly (inside the mouth). In regards to marginal adaptations (the circumferential seal which keeps bacteria out), anatomically correct contacts (touching adjacent teeth properly so food will not be retained), and proper morphology, the indirect fabrication of the restorations are unprecedented. Indirectly fabricated crowns may be fabricated one of two ways. In the traditional sense, the tooth in question is prepared, a mold is taken, a temporary crown is placed and then the patient leaves. The mold is then sent to a dental laboratory whereby a model is constructed from the mold, and a crown is created on the model (usually out of porcelain, ceramic, gold, or porcelain/ceramic fused to metal) to replace the missing tooth structure. The patient returns to the dental office a week or two later and then the temporary is removed and the crown is fitted and cemented in place. Alternatively, a crown may be indirectly fabricated utilizing technology and techniques relating to CAD/CAM Dentistry, whereby the tooth is prepared and computer software is used to create a virtual restoration which is milled on the spot and bonded permanently in place an hour or two later.

## *3/4 and 7/8 crowns*

There are even restorations that fall between an onlay and a full crown when it comes to preservation of natural tooth structure. In the past, it was somewhat common to find dentists who prepared teeth for **3/4 and 7/8 crowns**. Such restorations would generally be fabricated for maxillary second premolars or first molars, which might only be slightly visible when a patient smiled. Thus, the dentist would preserve healthy natural tooth structure that existed on the mesiobuccal corner of the tooth for aesthetic purposes, the remainder of the tooth would be enclosed in restorative material. Even when porcelain-fused-to-metal and all-ceramic crowns were developed, preserving *any* amount of tooth structure adds to the overall strength of the tooth. As one can imagine, though, those dentists who took issue with the increased marginal length of the onlay restoration would *surely* take issue with the purported advantages of increased remaining tooth structure when it translated into the enormously increased marginal length of a 3/4 or 7/8 crown.

## *All-ceramic restorations*

Inlays, onlays, porcelain veneers, crownlays and all varieties of crowns can also be fabricated out of ceramic materials, such as in CAD/CAM Dentistry or traditionally in a dental laboratory setting. CAD/CAM technology can allow for the immediate, same day delivery of these types restorations which are milled out of blocks of solid porcelain which matches the shade or color of the patients teeth. Traditionally, all-ceramic restorations have been made off site in a dental laboratory either out of feldspathic porcelains or pressed ceramics. This indirect method of fabrication involves molds and temporaries, but can yield quite beautiful end-results if communication between the laboratory and the dentist is sound. The greatest difference between these two differing modalities lies in the fact that the CAD/CAM route does not require temporization, while the laboratory-fabricated route does. Some argue that this lack of temporization can result in a decreased need for root canal therapy, as there is no temporary leakage between visits.

Restorations that are all-ceramic require wide shoulder margins and reductions of at least 1.0 - 1.5 mm across the occlusal (chewing) surfaces of the teeth. There are times where this reduction would be considered excessive, just as there are times when previous restorations or pathology require this much removal or more. Arguments against using all-ceramic restorations include a greater chance of fracture, when little to no enamel remains for proper adhesive bonding, or potentially when the patient clenches or grinds their teeth ("bruxes") excessively. Indications for using all-ceramic restorations include more aesthetic results, when metal compatibility issues exist, and when removal of less tooth structure is desired. All-ceramic restorations do not require resistance and retention form and consequently less surface area need be removed and the restoration will still stay in place by virtue of micromechanical and chemical bonding.

Ceramic materials such as lithium disilicate dental ceramics have recently been developed which provide greater strength and life-expectancy of dental restorations.

## *Longevity*

Although no dental restoration lasts forever, the average lifespan of a crown is around 10 years. While this is considered comparatively favorable to direct restorations, they can actually last up to the life of the patient (50 years or more) with proper care. One reason why a 10 year mark is given is because a dentist can usually provide patients with this number and be confident that a crown that the dental lab makes will last at least this long. It should be noted that many dental insurance plans in North America will allow for a crown to be replaced after only five years.

The most important factor affecting the lifespan of any restorative is the continuing oral hygiene performed by the patient. With crowns, as with most things, a poorly-made object can last well past its predicted lifetime if it is properly cared for, and even a well-made item can last only a day if handled improperly. Other factors depend on the skill of the dentist and their lab technician, the material used and appropriate treatment planning and case selection.

Full gold crowns last the longest, as they are fabricated as a single piece of gold. PFMs, or porcelain-fused-to-metal crowns possess an additional dimension in which they are prone to failure, as they incorporate brittle porcelain into their structure. Although incredibly strong in compression, porcelain is terribly fragile in tension, and fracture of the porcelain increased the risk of failure, which rises as the amount of surfaces covered with porcelain is increased. A traditional PFM with occlusal porcelain (i.e. porcelain applied to the biting surface of a posterior tooth) has a 7% higher chance of failure per year than a corresponding full gold crown.

When crowns are used to restore endodontically treated teeth, they increase the life of the tooth not only by preventing fracture of the brittle devitalized tooth but also by providing a better seal against invading bacteria. Although the inert filling material within the root canal blocks against microbial invasion of the internal tooth structure, it is actually a superior coronal seal, or marginal adaptation of the restoration in or on the crown of the tooth, which prevents reinvasion of the root canal.

## *Advantages and disadvantages*

The main disadvantages of restoration with a crown are extensive irreversible tooth preparation (grinding away) and higher costs than for direct restorations such as amalgam or Dental composite. The benefits, as described above, include long-term durability and evidence-based success as compared to other restorations or no treatment. The crowning of two fairly large molars to sling a bridge between them for a missing tooth is a costly and sometimes oversold procedure.The increased food and bacteria trapping of the underside of the bridge often offsets the benefits of the bridge element in maintaining the positions of the opposing teeth and the loss of the ease of use and mouth feel of two big natural teeth.

It is important to bear in mind that it is usually the damage to a tooth that dictates the need for a crown, and alternative treatments are usually less effective. However, it is also important to realise that even if risks and benefits are objectively analysed, their significance depends on the priorities of the patient. An example of this occurs when a patient would like to restore an edentulous area between healthy adjacent teeth. Before implants, there were three options:

- Fixed partial denture (bridge)
- Removable partial denture
- No treatment

Those who could afford it were usually told by their dentists that a bridge was their best choice, because it is much sturdier than removable dentures and requires less looking after. When implants became available, however, they were recommended as the best possible treatment, because the virgin teeth adjacent to the edentulous area no longer needed to be cut in order to fit the bridge. The affluent are thus told that a fixed partial denture is no longer desirable, now that implants are available. However, implants are significantly more expensive than a bridge, and the results are generally much less immediate.

### *Types and materials*


In order to determine the shade for the future crowns, the shade of adjacent teeth are matched to preformed shade guides. Here, the shade is determined to match best with B1. (The two maxillary central incisors have already been cut down and prepared for crowns.)

There are many different methods of crown fabrication, each using a different material. Some methods are quite similar, and utilize either very similar or identical materials.

### Metal-containing restorations

## Full gold crown

Full gold crowns (FGCs) consist entirely of a single piece of alloy. Although referred to as a *gold* crown, this type of crown is actually composed of many different types of elements, including but not limited to gold, platinum, palladium, silver, copper and tin. The first three elements listed are noble metals, while the last three listed are base metals. Full gold crowns are of better quality when they are high in noble content. According to the American Dental Association, full gold crown alloys can only be labeled as *high noble* when they contain at least 60% noble metal, of which at least 40% must be gold.

Full gold crowns are cast metal restorations that are made using the lost-wax technique. After the dentist prepares a tooth for a crown, he or she will take an impression of the prepared tooth, the adjacent teeth in the same arch and the opposing teeth in the opposing arch. With all of the necessary boundaries of the future cast crown defined in three dimensions within the impression material (i.e. the necessary height, width and depth of the crown is now recorded in impression material), the impression(s) are sent to a dental laboratory where they will be poured up in various types of dental stone or plaster. After the stone models are formed, they are ditched, died and articulated so that the laboratory technician can see how the two arches meet and properly access the tooth replicates to perform his tasks. The lab technician will then apply wax to the die (analog of the prepared tooth) and manipulate and craft the wax until he or she has built it up into what appears like and conforms to the specific dimensions of the tooth being restored. Prior to applying the wax, though, a die spacer is applied to the die. This is a thin coat of material that is painted onto the die to provide a space between the gold crown and the actual tooth structure to be filled with cement upon final cementation. A lubricant is also applied so that the wax pattern, as the wax-up of the crown is referred to, can be easily removed when completed.

The wax pattern is removed from the die and invested in a sort of plaster while connected to a short plastic stick, called a "sprue former", which will stick out of the investing plaster. The investment, as it is called now, is placed in a furnace, which will completely burn off the wax and plastic that formed the wax pattern/sprue complex. What is left is a hollow within the investment material, known as an "investment pattern". Because the sprue former stuck out a little bit from the investment material, there is a communication between the outside and the investment pattern. The investment pattern is then placed in a sort of simple centrifuge where pennyweights of gold are melted down and rapidly shot through the communication in the investment pattern, through the sprue that was formed by the sprue former, and into the hollow that used to be inhabited by the wax pattern of the crown waxed-up by the technician, thus called the lost-wax technique. After properly cooling, the single piece crown-and-sprue of gold is sectioned, and the sprue can be recycled in another casting. The crown is touched-up in the location of the sprue attachment, finished and polished to a high shine, and delivered to the dentist so that he or she can try it in the mouth, make certain it has all of the proper contacts with the adjacent and opposing teeth, and cement it to the prepared tooth.

## Porcelain-fused-to-metal crowns

Porcelain-fused-to-metal dental crowns (PFMs) have a metal shell on which is fused a veneer of porcelain in a high heat oven. The metal provides strong compression and tensile strength, and the porcelain gives the crown a white tooth-like appearance, suitable for front teeth restorations. These crowns are often made with a partial veneer that covers only the aspects of the crown that are visible. The remaining surfaces of the crown are bare metal. A variety of metal alloys containing precious metals and base metals can be used. The porcelain can be color matched to the adjacent teeth.

## Restorations without Metal

### Chairside CAD/CAM Dentistry

The CAD/CAM method of fabricating all-ceramic restorations is by electronically capturing and storing a photographic image of the prepared tooth and, using computer technology, crafting a 3D restoration design that conforms to all the necessary specifications of the proposed inlay, onlay or single-unit crown; there is no impression. After selecting the proper features and making various decisions on the computerized model, the dentist directs the computer to send the information to a local milling machine. This machine will then use its specially designed diamond burs to mill the restoration from a solid ingot of a ceramic of pre-determined shade to match the patient's tooth. After about 20 minutes, the restoration is complete, and the dentist sections it from the remainder of the unmilled ingot and tries it in the mouth. If the restoration fits well, the dentist can cement the restoration immediately. A dental CAD/CAM machine costs roughly $100,000, with continued purchase of ceramic ingots and milling burs.

Typically, over 95% of the restorations made using Dental CAD/CAM and Vita Mark I and Mark II blocks are still clinically successful after 5 years. Further, at least 90% of restorations still function successfully after 10 years. Advantages of the Mark II blocks over ceramic blocks include: they wear down as fast as natural teeth, , their failure loads are very similar to those of natural teeth, and the wear pattern of Mark II against enamel is similar to that of enamel against enamel.

### Empress

The Empress system is superficially similar to a lost-wax technique in that a hollow investment pattern is made, but the similarities stop there. A specially designed pressure-injected leucite-reinforced ceramic is then pressed into the mold by using a pressable-porcelain-oven, as though the final all-ceramic restoration has been "cast." The Empress can be utilized for anything the lost-wax technique can be used for, in addition to veneers (which would not be made of cast metal).

### In-ceram

Introduced in 1989, In-ceram, by Vita, infused the fragile new "all-ceramic crown" with glass to produce what was then thought to be a superior product.

### Procera

Procera AllCeram, owned by Nobel Biocare, is a CAD/CAM based method which produces a crown by overlaying a very durable ceramic coping of either **alumina** or **zirconia**, referred to as a "core", with Vitadur Alpha porcelain. Introduced in 1991, Procera can now be used to produce crowns, bridges and veneers.

## Chapter 7

# Dentures


Occlusal view of the same maxillary denture.

A maxillary denture.

**Dentures** are prosthetic devices constructed to replace missing teeth, and which are supported by surrounding soft and hard tissues of the oral cavity. Conventional dentures are removable, however there are many different denture designs, some which rely on bonding or clasping onto teeth or dental implants. There are two main categories of dentures, depending on whether they are used to replace missing teeth on the **mandibular arch** or the **maxillary arch**.

## *Causes of tooth loss*

Patients can become entirely edentulous (without teeth) due to many reasons, the most prevalent being removal because of dental disease typically relating to oral flora control, i.e. periodontal disease and tooth decay. Other reasons include tooth developmental defects caused by severe malnutrition, genetic defects such as *Dentinogenesis imperfecta*, trauma, or drug use.

## *Advantages*

Dentures can help patients in a number of ways:

1. **Mastication** - chewing ability is improved by replacing edentulous areas with denture teeth.

2. **Aesthetics** - the presence of teeth provide a natural facial appearance, and wearing a denture to replace missing teeth provides support for the lips and cheeks and corrects the collapsed appearance that occurs after losing teeth.

3. **Phonetics** - by replacing missing teeth, especially the anteriors, patients are better able to speak by improving pronunciation of those words containing sibilants or fricatives.

4. **Self-Esteem** - Patients feel better about themselves.

## *Types of dentures*

### Removable partial dentures

Removable partial dentures are for patients who are missing some of their teeth on a particular arch. Fixed partial dentures, also known as "crown and bridge", are made from crowns that are fitted on the remaining teeth to act as abutments and pontics made from materials to resemble the missing teeth. Fixed bridges are more expensive than removable appliances but are more stable.

### Complete dentures

Conversely, complete dentures or full dentures are worn by patients who are missing all of the teeth in a single arch (i.e. the maxillary (upper) or mandibular (lower) arch).

## *History*

Around 700BC, Etruscans in northern Italy made dentures out of human or other animal teeth. These deteriorated quickly but, being easy to produce, were popular until the mid 19th century.

The oldest useful complete denture appeared in Japan, and has been traced to the ganjyoji temple in Kii Province, Japan.。 It was a wooden denture made of Buxus microphylla, and used by Nakaoka Tei (–20 April 1538). This wooden denture had almost the same shape as modern dentures retained by suction. It also shaped to cover each condition of teeth loss. Wooden dentures were used in Japan up until the Meiji period.

London's Peter de la Roche is believed to be one of the first 'Operators for the Teeth', men who fashioned themselves as specialists in dental work. Often these men were professional goldsmiths, ivory turners or students of barber-surgeons.

The first porcelain dentures were made around 1770 by Alexis Duchâteau. In 1791 the first British patent was granted to Nicholas Dubois De Chemant, previous assistant to Duchateau, for "De Chemant's Specification", "a composition for the purpose of making of artificial teeth either single double or in rows or in complete sets and also springs for fastening or affixing the same in a more easy and effectual manner than any hitherto discovered which said teeth may be made of any shade or colour, which they will retain for any length of time and will consequently more perfectly resemble the natural teeth." He began selling his wares in 1792 with most of his porcelain paste supplied by Wedgwood. Perhaps the most famous early denture user was George Washington. He was fitted with them no later than 1764. President Washington's dentures are part of a new display on exhibit at Mount Vernon. Despite the rumors, the famous dentures are not made of wood; instead they are made of hippopotamus ivory.

In London in 1820, Claudius Ash, a goldsmith by trade, began manufacturing high-quality porcelain dentures mounted on 18-carat gold plates. Later dentures were made of Vulcanite from the 1850s on, a form of hardened rubber (Claudius Ash's company was the leading European manufacturer of dental Vulcanite) into which porcelain teeth were set, and then, in the 20th century, acrylic resin and other plastics. In Britain in 1968 79% of those aged 65–74 had no natural teeth, by 1998 this proportion had fallen to 36%.

## Fabrication of Complete Dentures

Modern dentures are most often fabricated in a commercial Dental Laboratory using a combination of a tissue shaded powder polymethylmethacrylate acrylic for the tissue shaded aspect, and commercially produced acrylic teeth available in hundreds of shapes and tooth colors.

The process of fabricating a denture usually begins with a dental impression of the maxilla or mandible. This impression is used to create a stone model that represents the arch. A wax rim is fabricated to assist the dentist or denturist with establishing the vertical dimension of occlusion. After this a bite registration is created to marry the position of one arch to the other.

Once the relative position of each arch to the other is known, the wax rim can be used as a base to place the selected denture teeth in correct position. This arrangement of teeth is tried in to the mouth so that adjustments can be made to the Occlusion. After the occlusion has been verified by the doctor with the patient, and all phonetic requirements are met, the denture is processed.

Processing a denture is usually performed in a lost-wax process whereby the form of the final denture, including the acrylic denture teeth, is invested in stone. This investment is then heated, and the wax is remove through a sprue when it melts. The remaining cavity is then either filled by forced injection or pouring of the uncured denture acrylic. After a curing period, the stone investement is removed, the acrylic is polished, and the denture is complete.

## Problems with complete dentures

Problems with dentures include the fact that patients are not used to having something in their mouth that is not food. The brain senses this appliance as "food" and sends messages to the salivary glands to produce more saliva and to secrete it at a higher rate. This will only happen in the first 12 to 24 hours, after which the salivary glands return to their normal output. New dentures can also be the cause of sore spots as they compress the soft tissues mucosa (denture bearing soft tissue). A few **denture adjustments** for the days following insertion of the dentures can take care of this issue. Gagging is another problem encountered by a minority of patients. At times, this may be due to a denture that is too loose, too thick or extended too far posteriorly onto the soft palate. At times, gagging may also be attributed to psychological denial of the denture. (Psychological gagging is the most difficult to treat since it is out of the dentist's control. In such cases, an implant supported palateless denture may have to be constructed or a hypnotist may need to be consulted). Sometimes there could be a gingivitis under the full dentures, which is caused by accumulation of dental plaque.

One of the most common problems for new full upper denture wearers is the loss of taste.

Another problem with dentures is keeping them in place. There are three rules governing the existence of removable oral appliances: **support**, **stability** and **retention**.

## *Prosthodontic principles of dentures*

### Support

**Support** is the principle that describes how well the underlying mucosa (oral tissues, including gums and the vestibules) keeps the denture from moving vertically towards the arch in question, and thus being excessively depressed and moving deeper into the arch. For the mandibular arch, this function is provided by the gingiva (gums) and the **buccal shelf** (region extending laterally (beside) from the posterior (back) ridges), whereas in the maxillary arch, the palate joins in to help support the denture. The larger the denture flanges (part of the denture that extends into the vestibule), the better the support. This last sentence requires comment and correction, it reveals some misunderstanding by the author as flanges usually provide stability and not support. Indeed, long flanges beyond the functional depth of the sulcus are a common error in denture construction, often (but not always) leading to movement in function.

### Stability

**Stability** is the principle that describes how well the denture base is prevented from moving in the **horizontal plane**, and thus from sliding side to side or front and back. The more the denture base (pink material) runs in smooth and continuous contact with the edentulous ridge (the hill upon which the teeth used to reside, but now consists of only residual alveolar bone with overlying mucosa), the better the stability. Of course, the higher and broader the ridge, the better the stability will be, but this is usually just a result of patient anatomy, barring surgical intervention (bone grafts, etc.).

### Retention

**Retention** is the principle that describes how well the denture is prevented from moving **vertically** in the opposite direction of insertion. The better the topographical mimicry of the **intaglio** (interior) surface of the denture base to the surface of the underlying mucosa, the better the retention will be (in removable partial dentures, the clasps are a major provider of retention), as surface tension, suction and just plain old friction will aid in keeping the denture base from breaking intimate contact with the mucosal surface. It is important to note that the most critical element in the retentive design of a full maxillary denture is a complete and total border seal (complete peripheral seal) in order to achieve 'suction'. The border seal is composed of the edges of the anterior and lateral aspects AND the posterior palatal seal. The posterior palatal seal design is accomplished by covering the entire hard palate and extending not beyond the soft palate and ending 1–2 mm from the vibrating line.

As mentioned above, implant technology can vastly improve the patient's denture-wearing experience by increasing stability and saving his or her bone from wearing away. Implant can also help with the retention factor. Instead of merely placing the implants to serve as blocking mechanism against the denture pushing on the alveolar bone, small retentive appliances can be attached to the implants that can then snap into a modified denture base to allow for tremendously increased retention. Options available include a metal **Hader bar** or precision balls attachments, among other things.

## Complications and recommendations

The fabrication of a set of complete dentures is a challenge for any Dentist/Denturist, including those who are experienced. There are many axioms in the production of dentures that must be understood; ignorance of one axiom can lead to failure of the denture case. In the vast majority of cases, complete dentures should be comfortable soon after insertion, although almost always at least two adjustment visits will be necessary to remove sore spots. One of the most critical aspects of dentures is that the impression of the denture must be perfectly made and used with perfect technique to make a model of the patient's edentulous (toothless) gums. The dentist must use a process called border molding to ensure that the denture flanges are properly extended. An array of problems may occur if the final impression of the denture is not made properly. It takes considerable patience and experience for a dentist to know how to make a denture, and for this reason it may be in the patient's best interest to seek a specialist, either a Prosthodontist or perhaps even a Denturist, to make the denture. A general dentist may do a good job, but only if he or she is meticulous and usually he or she must be experienced.

The maxillary denture (the top denture) is usually relatively straightforward to manufacture so that it is stable without slippage.

A lower full denture should or must be supported by 2-4 implants placed in the lower jaw for support. A lower denture supported by 2-4 implants is a far superior product than a lower denture without implants, because

1) It is much more difficult to get adequate suction on the lower jaw.
2) The functioning of the tongue tends to break that suction, and
3) Without teeth the ridge tends to resorb and provides the denture less and less stability over time. It is routine to be able to bite into an apple or corn-on-the-cob with a lower denture anchored by implants. Without implants, it is quite difficult or even impossible to do so.

In any case, implant supported dentures provide several advantages over conventional dentures. They offer improved comfort due to less irritation of the gums, confidence due to less risk of slipping out, and appearance due to less plastic required for retention purposes. Patients with implant supported dentures have increased chewing efficacy and can speak more clearly.

Some patients who believe they have "bad teeth" may think it is in their best interests to have all their teeth extracted and full dentures placed. However, statistics show that the majority of patients who actually receive this treatment wind up regretting they did so. This is because full dentures have only 10% of the chewing power of natural teeth, and it is difficult to get them fitted satisfactorily, particularly in the mandibular arch. Even if a patient retains one tooth, that will contribute to the denture's stability. However, retention of just one or two teeth in the upper jaw does not contribute much to the overall stability of a denture, since a full upper denture tends to be very stable, in contrast to a full lower denture. It is thus advised that patients keep their natural teeth as long as possible, especially their lower teeth.

Chapter 8

# Veneer (Dentistry) and Fixed Prosthodontics

## Veneer (Dentistry)

A veneer

In dentistry, a **veneer** is a thin layer of restorative material placed over a tooth surface, either to improve the aesthetics of a tooth, or to protect a damaged tooth surface. There are two main types of material used to fabricate a veneer, composite and dental porcelain. A composite veneer may be directly placed (built-up in the mouth), or indirectly fabricated by a dental technician in a dental laboratory, and later bonded to the tooth, typically using a resin cement such as Panavia. In contrast, a porcelain veneer may only be indirectly fabricated.

## History

Veneers were invented by a California dentist named Charles Pincus . At the time, they fell off in a very short time as they were held on by denture adhesive. They were, however, useful for temporarily changing the appearance of actors' teeth.

Research started in 1982 by Simonsen and Calamia  revealed that porcelain could be etched with hydrofluoric acid, and bond strengths could be achieved between composite resins and porcelain that were predicted to be able to hold porcelain veneers on to the surface of a tooth permanently. This was confirmed by Calamia  in an article describing a technique for fabrication, and placement of Etched Bonded Porcelain Veneers using a refractory model technique and Horn  describing a platinum foil technique for veneer fabrication. Additional articles have proven the long-term reliability of this technique.

Today, with improved cements and bonding agents, they typically last 10-30 years. They may have to be replaced in this time due to cracking, leaking, chipping, discoloration, decay, shrinkage of the gum line and damage from injury or tooth grinding. The cost of veneers can vary depending on the experience and location of the dentist. In the US, costs range anywhere from $1000 a tooth upwards to $2500 a tooth as of 2009. Porcelain veneers are said to be somewhat more durable and less likely to stain than veneers made of composite.,

## Indications

Veneers are an important tool for the cosmetic dentist. A dentist may use one veneer to restore a single tooth that may have been fractured or discolored, or multiple teeth to create a "Hollywood" type of makeover. Many people have small teeth resulting in spaces that may not be easily closed by orthodontics. Some people have worn away the edges of their teeth resulting in a prematurely aged appearance, while others may have malpositioned teeth that appear crooked. Multiple veneers can close these spaces, lengthen teeth that have been shortened by wear, provide a uniform color, shape, and symmetry, and make the teeth appear straight.

The problem of overuse of porcelain veneers by certain cosmetic dentists has been profiled in the book, 'Confessions of a Former Cosmetic Dentist'. The author suggests that the use of veneers for 'instant orthodontics' or simulated straightening of the teeth is harmful, especially for younger people with healthy teeth. Many cosmetic dentists agree that porcelain veneers can be used improperly and can exploit patients.

### *Alternatives*

In the past, the only way to correct dental imperfections was to cover the tooth with a crown. Today, in most cases there are several alternatives: crown, composite resin bonding or porcelain veneer or even cosmetic contouring or orthodontics

Non-permanent dental veneers are available. These dental veneers are molded to existing teeth and are removable and reusable and are made from a flexible resin material. Do it yourself at home kits are also available for the impression-taking process. Actual veneers are made in the lab and sent to the wearer through the mail.

# Fixed prosthodontics

**Fixed prosthodontics** in dentistry is a technique used to restore teeth, using fixed restorations (also referred to as indirect restorations), which include crowns, bridges, inlays, onlays, and veneers. Prosthodontists are specialist dentists who have undertaken training recognized by academic institutions in this field. Fixed prosthodontics can be used to restore single or multiple teeth, spanning areas where teeth have been lost. In general, the main advantages of fixed prosthodontics when compared to direct restorations is the superior strength when used in large restorations, and the ability to create an aesthetic looking tooth. As with any dental restoration, principles used to determine the appropriate restoration involves consideration of the materials to be used, extent of tooth destruction, orientation and location of tooth, and condition of neighboring teeth.

## *Preparation techniques*

Preparation of a tooth for a crown involves the irreversible removal of a significant amount of tooth structure. All restorations possess compromised structural and functional integrity when compared to healthy, natural tooth structure. Thus, if not indicated as desirable by an oral health-care professional, the crowning of a tooth would most likely be contraindicated. It should be evident, though, that dentists trained at different institutions in different eras and in different countries might very well possess different methods of treatment planning and case selection, resulting is somewhat diverse recommendations for treatment.

Traditionally more than one visit is required to complete crown and bridge work, and the additional time required for the procedure can be a disadvantage; the increased benefits of such a restoration, however, will generally offset these considerations.

### Dimensions of preparation

When preparing a tooth for a crown, the enamel should be totally removed and the finished preparation should, thus, exist entirely in dentin. As elaborated on below, the amount of tooth structure required to be removed will depend on the material(s) being used to restore the tooth. If the tooth is to be restored with a full gold crown, the restoration need only be .5 mm in thickness (as gold is very strong), and therefore, a minimum of only .5 mm of space needs to be made for the crown to be placed. If porcelain is to be applied to the gold crown, an additional minimum of 1 mm of tooth structure needs to be removed to allow for a sufficient thickness of the porcelain to be applied, thus bringing the total tooth reduction to minimally 1.5 mm.

If there is not enough tooth structure to properly retain the prosthetic crown, the tooth requires a build-up material. This can be accomplished with a pin-retained direct restoration, such as amalgam or a resin like fluorocore, or in more severe cases, may require a post and core. Should the tooth require a post and core, endodontic therapy would then be indicated, as the post descends into the devitalized root canal for added retention. If the tooth, because of its relative lack of exposed tooth structure, also requires crown lengthening, the total combined time, effort and cost of the various procedures, together with the decreased prognosis because of the combined inherent failure rates of each procedure, might make it more reasonable to have the tooth extracted and opt to have an implant placed.

## Taper

The prepared tooth also needs to possess a certain degree of taper to allow for the restoration to be properly placed on the tooth. Fundamentally, there can be no undercuts on the surface of the prepared tooth, as the restoration will not be able to be removed from the die, let alone fit on the tooth. At the same time, though, too much taper will severely limit the grip that the crown has while on the prepared tooth, thus contributing to failure of the restoration. Generally, 6º of taper around the entire circumference of the prepared tooth, giving a combined taper of 12º at any given sagittal section through the prepared tooth, is appropriate to both allow the crown to fit yet provide enough grip.

## Margin

The most coronal position of untouched tooth structure (that is, the continual line of original, undrilled tooth structure at or near the gumline) is referred to as the **margin**. This margin will be the future continual line of tooth-to-restoration contact, and should be a smooth, well-defined delineation so that the restoration, no matter how it is fabricated, can be properly adapted and not allow for any openings visible to the naked eye, however slight. An acceptable distance from tooth margin to restoration margin is anywhere from 40-100 nm. However, the R.V. Tucker method of gold inlay and onlay restoration produces tooth-to-restoration adaptation of potentially only 2 nm, confirmed by scanning electron microscopy; this is less than the diameter of a single bacterium.

Naturally, the tooth-to-restoration margin is an unsightly thing to have exposed on the visible surface of a tooth when the tooth exists in the esthetic zone of the smile. In these areas, the dentist would like to place the margin as far apical (towards the root tip of the tooth) as possible, even below the gum line. While there is no issue, per se, with placing the margin at the gumline, problems may arise when placing the margin too subgingivally (below the gumline). First, there might be issues in terms of capturing the margin in an impression to make the stone model of the prepared tooth. Secondly, there is the seriously important issue of biologic width. Biologic width is the mandatory distance to be left between the height of the alveolar bone and the margin of the restoration, and if this distance is violated because the margin is placed too subgingivally, serious repercussions may follow. In situations where the margin cannot be placed apically enough to provide for proper retention of the prosthetic crown on the prepared tooth structure, the tooth or teeth involved should undergo a crown lengthening procedure.

There are a number of different types of margins that can be placed for restoration with a crown. There is the chamfer, which is popular with full gold restorations, which effectively removed the smallest amount of tooth structure. There is also a **shoulder**, which, while removing slightly more tooth structure, serves to allow for a thickness of the restoration material, necessary when applying porcelain to a **PFM coping** or when restoring with an **all-ceramic crown**. When using a shoulder preparation, the dentist is urged to add a bevel; the shoulder-bevel margin serves to effectively decrease the tooth-to-restoration distance upon final cementation of the restoration.

### Ferrule effect

The single most important consideration when restoring with a crown is, undeniably, the incorporation of the **ferrule effect**. As with the bristles of a broom, which are grasped by a ferrule when attached to the broomstick, the crown should envelop a certain height of tooth structure to properly protect the tooth from fracture after being prepared for a crown. This has been established through multiple experiments as a mandatory continuous circumferential height of 2mm; any less provides for a significantly higher failure rate of endodontically-treated crown-restored teeth. When a tooth is not endodontically treated, the remaining tooth structure will invariably provide the 2mm height necessary for a ferrule, but endodontically treated teeth are notoriously decayed and are often missing significant solid tooth structure. Contrary to popular belief, endodontically treated teeth are not brittle after being devitalized according to the following study -CM Sedglay & Messer 1992 Journal of Endodontics. Contrary to what some dentists believe, a bevel *is not* at all suitable for implementing the ferrule effect, and beveled tooth structure may not be included in the 2 mms of required tooth structure for a ferrule.

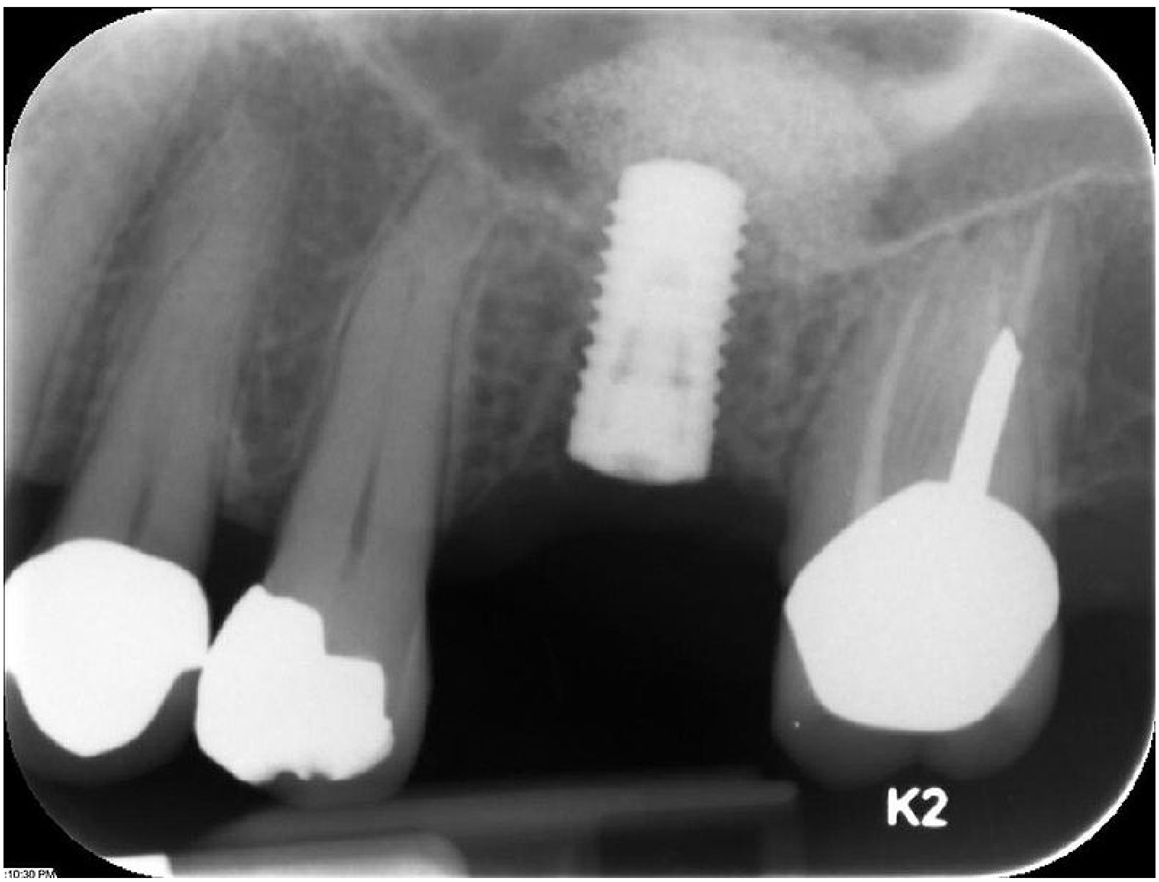
## *Restoration types*

### Crown

A crown is used to cover a tooth and may be commonly referred to as a "cap." Traditionally, the teeth to be crowned are prepared by a dentist, and records are given to a dental technician to construct the prosthesis. The records include models, which are replicas of a patient's teeth, and the impressions used to make these models. There are many different methods of crown fabrication, each using a different material. Some methods are quite similar, and utilize either very similar or identical materials. Crowns may be made of gold or other similar metals, porcelain, or a combination of the two.

Chapter 9

# Dental Implant




A Straumann-brand root-form endosseous dental implant placed in the site of the maxillary left permanent first molar with bone graft used to elevate the sinus floor

A **dental implant** is a titanium "root" used in dentistry to support restorations that resemble a tooth or group of teeth to replace missing teeth.

Virtually all dental implants placed today are **root-form endosseous implants**, i.e., they appear similar to an actual tooth root (and thus possess a "root-form") and are placed *within* the bone (*end-* being the Greek prefix for "in" and *osseous* referring to "bone"). The bone of the jaw accepts and osseointegrates with the titanium post. The osseointegration is the component of this implant procedure that makes it resemble the look and feel of a natural tooth.

Prior to the advent of root-form endosseous implants, most implants were either **blade endosseous implants**, in that the shape of the metal piece placed within the bone resembled a flat blade, or **subperiosteal implants**, in which a framework was constructed to lie upon and was attached with screws to the exposed bone of the jaws.

Dental implants can be used to support a number of dental prostheses, including crowns, implant-supported bridges or dentures. They can also be used as anchorage for orthodontic tooth movement. The use of dental implants permits unidirectional tooth movement without reciprocal action.

## *History*

The Mayan civilization has been shown to have used the earliest known examples of endosseous implants (implants embedded into bone), dating back over 1,350 years before Per-Ingvar Brånemark started working with titanium. While excavating Mayan burial sites in Honduras in 1931, archaeologists found a fragment of mandible of Mayan origin, dating from about 600 AD. This mandible, which is considered to be that of a woman in her twenties, had three tooth-shaped pieces of shell placed into the sockets of three missing lower incisor teeth. For forty years the archaeological world considered that these shells were placed after death in a manner also observed in the ancient Egyptians. However, in 1970 a Brazilian dental academic, Professor Amadeo Bobbio studied the mandibular specimen and took a series of radiographs. He noted compact bone formation around two of the implants which led him to conclude that the implants were placed during life.

In the 1950s research was being conducted at Cambridge University in England to study blood flow in vivo. These workers devised a method of constructing a chamber of titanium which was then embedded into the soft tissue of the ears of rabbits. In 1952 the Swedish orthopaedic surgeon, P I Brånemark, was interested in studying bone healing and regeneration, and adopted the Cambridge designed ‘rabbit ear chamber’ for use in the rabbit femur. Following several months of study he attempted to retrieve these expensive chambers from the rabbits and found that he was unable to remove them. Per Brånemark observed that bone had grown into such close proximity with the titanium that it effectively adhered to the metal. Brånemark carried out many further studies into this phenomenon, using both animal and human subjects, which all confirmed this unique property of titanium.

Meanwhile an Italian medical doctor called Stefano Melchiade Tramonte, understood that titanium could be used for dental restorations and after designing a titanium screw to support his own dental prosthesis, started to use it on many patients in his clinic in 1959. The good results of his clinical studies on humans were published in 1966.

Although Brånemark had originally considered that the first work should centre on knee and hip surgery, he finally decided that the mouth was more accessible for continued clinical observations and the high rate of edentulism in the general population offered more subjects for widespread study. He termed the clinically observed adherence of bone with titanium as 'osseointegration'. In 1965 Brånemark, who was by then the Professor of Anatomy at Gothenburg University in Sweden, placed his first titanium dental implant into a human volunteer, a Swede named Gösta Larsson.

Contemporaneous independent research in the United States by Stevens and Alexander led to a 1969 US patent filing for titanium dental implants.

Over the next fourteen years Brånemark published many studies on the use of titanium in dental implantology until in 1978 he entered into a commercial partnership with the Swedish defense company, Bofors AB for the development and marketing of his dental implants. With Bofors (later to become Nobel Industries) as the parent company, Nobelpharma AB (later to be renamed Nobel Biocare) was founded in 1981 to focus on dental implantology. To the present day over 7 million Brånemark System implants have now been placed and hundreds of other companies produce dental implants. The majority of dental implants currently available are shaped like small screws, with either tapered or parallel sides. They can be placed at the same time as a tooth is removed by engaging with the bone of the socket wall and sometimes also with the bone beyond the tip of the socket. Current evidence suggests that implants placed straight into an extraction socket have comparable success rates to those placed into healed bone. The success rate and radiographic results of immediate restorations of dental implants placed in fresh extraction sockets (the temporary crowns placed at the same time) have been shown to be comparable to those obtained with delayed loading (the crowns placed weeks or months later) in carefully selected cases

Some current research in dental implantology is focusing on the use of ceramic materials such as zirconia ($ZrO_2$) in the manufacture of dental implants. Zirconia is the dioxide of zirconium, a metal close to titanium in the periodic table and with similar biocompatibility properties. Although generally the same shape as titanium implants, zirconia, which has been used successfully for orthopaedic surgery for a number of years, has the advantage of being more cosmetically aesthetic owing to its bright tooth-like colour. However, long-term clinical data is necessary before one-piece $ZrO_2$ implants can be recommended for daily practice.

## *Composition*

A typical implant consists of a titanium screw (resembling a tooth root) with a roughened or smooth surface. The majority of dental implants are made out of commercially pure titanium, which is available in 4 grades depending upon the amount of carbon and iron contained. More recently grade 5 titanium has increased in use. Grade 5 titanium,

Titanium 6AL-4V, (signifying the Titanium alloy containing 6% Aluminium and 4% Vanadium alloy) is believed to offer similar osseointegration levels as commercially pure titanium. Ti-6Al-4V alloy offers better tensile strength and fracture resistance. Today most implants are still made out of commercially pure titanium (grades 1 to 4) but some implant systems (Endopore and NanoTite) are fabricated out of the Ti-6Al-4V alloy. Implant surfaces may be modified by plasma spraying, anodizing, etching or sandblasting to increase the surface area and the integration potential of the implant.

## *Training*

There is no specialty recognized by the ADA for dental implants. Implant surgery may be performed as an outpatient under general anesthesia, oral conscious sedation, nitrous oxide sedation, intravenous sedation or under local anesthesia by trained and certified clinicians including general dentists, oral surgeons, periodontists, and prosthodontists.

The legal training requirements for dentists who carry out implant treatment differ from country to country. In the UK implant dentistry is considered by the General Dental Council to be a postgraduate sphere of dentistry. In other words it is not sufficiently covered during the teaching of the university dental degree course and dentists wishing to practice in dental implantology legally need to undergo additional formal postgraduate training. The General Dental Council has published strict guidelines on the training required for a dentist to be able to place dental implants in general dental practice. UK dentists need to complete a competency assessed postgraduate extended learning program before providing implant dentistry to patients.

The degree to which both graduate and post-graduate dentists receive training in the surgical placement of implants varies from country to country, but it seems likely that lack of formal training will lead to higher complication rates.

## *Surgical procedure*

### Surgical planning

Prior to commencement of surgery, careful and detailed planning is required to identify vital structures such as the inferior alveolar nerve or the sinus, as well as the shape and dimensions of the bone to properly orient the implants for the most predictable outcome. Two-dimensional radiographs, such as orthopantomographs or periapicals are often taken prior to the surgery. Sometimes, a CT scan will also be obtained. Specialized 3D CAD/CAM computer programs may be used to plan the case.

Whether CT-guided or manual, a 'stent' may sometimes be used to facilitate the placement of implants. A surgical stent is an acrylic wafer that fits over either the teeth, the bone surface or the mucosa (when all the teeth are missing) with pre-drilled holes to show the position and angle of the implants to be placed. The surgical stent may be produced using stereolithography following computerized planning of a case from the CT scan. CT guided surgery may double the cost compared to more commonly accepted approaches.

## Basic procedure

In its most basic form the placement of an osseointegrated implant requires a preparation into the bone using either hand osteotomes or precision drills with highly regulated speed to prevent burning or pressure necrosis of the bone. After a variable amount of time to allow the bone to grow on to the surface of the implant (osseointegration), a crown or crowns can be placed on the implant. The amount of time required to place an implant will vary depending on the experience of the practitioner, the quality and quantity of the bone and the difficulty of the individual situation.

## Detail procedure

At edentulous (without teeth) jaw sites, a pilot hole is bored into the recipient bone, taking care to avoid the vital structures (in particular the inferior alveolar nerve or IAN and the mental foramen within the mandible). Drilling into jawbone usually occurs in several separate steps. The pilot hole is expanded by using progressively wider drills (typically between three and seven successive drilling steps, depending on implant width and length). Care is taken not to damage the osteoblast or bone cells by overheating. A cooling saline or water spray keeps the temperature of the bone to below 47 degrees Celsius (approximately 117 degrees Fahrenheit). The implant screw can be self-tapping, and is screwed into place at a precise torque so as not to overload the surrounding bone (overloaded bone can die, a condition called osteonecrosis, which may lead to failure of the implant to fully integrate or bond with the jawbone). Typically in most implant systems, the osteotomy or drilled hole is about 1mm deeper than the implant being placed, due to the shape of the drill tip. Surgeons must take the added length into consideration when drilling in the vicinity of vital structures.

## Surgical incisions

Traditionally, an incision is made over the crest of the site where the implant is to be placed. This is referred to as a 'flap'. Some systems allow for 'flapless' surgery where a piece of mucosa is punched-out from over the implant site. Proponents of 'flapless' surgery believe that it decreases recovery time while its detractors believe it increases complication rates because the edge of bone cannot be visualized. Because of these visualization problems flapless surgery is often carried out using a surgical guide constructed following computerized 3D planning of a pre-operative CT scan.

## Healing time

The amount of time required for an implant to become osseointegrated is a hotly debated topic. Consequently the amount of time that practitioners allow the implant to heal before placing a restoration on it varies widely. In general, practitioners allow 2–6 months for healing but preliminary studies show that early loading of implant may not increase early or long term complications. If the implant is loaded too soon, it is possible that the implant may move which results in failure. The subsequent time to heal, possibly graft and eventually place a new implant may take up to eighteen months. For this reason many are reluctant to push the envelope for healing.

## One-stage, two-stage surgery

When an implant is placed either a 'healing abutment', which comes through the mucosa, is placed or a 'cover screw' which is flush with the surface of the dental implant is placed. When a cover screw is placed the mucosa covers the implant while it integrates then a second surgery is completed to place the healing abutment.

Two-stage surgery is sometimes chosen when a concurrent bone graft is placed or surgery on the mucosa may be required for esthetic reasons. Some implants are one piece so that no healing abutment is required.

In carefully selected cases, patients can be implanted and restored in a single surgery, in a procedure labeled "Immediate Loading". In such cases a provisional prosthetic tooth or crown is shaped to avoid the force of the bite transferring to the implant while it integrates with the bone.

## Surgical timing

There are different approaches to place dental implants after tooth extraction. The approaches are:

1. Immediate post-extraction implant placement.
2. Delayed immediate post-extraction implant placement (2 weeks to 3 months after extraction).
3. Late implantation (3 months or more after tooth extraction).

According to the timing of loading of dental implants, the procedure of loading could be classified into:

1. Immediate loading procedure.
2. Early loading (1 week to 12 weeks).
3. Delayed loading (over 3 months)

## Immediate placement

An increasingly common strategy to preserve bone and reduce treatment times includes the placement of a dental implant into a recent extraction site. In addition, immediate loading is becoming more common as success rates for this procedure are now acceptable. This can cut months off the treatment time and in some cases a prosthetic tooth can be attached to the implants at the same time as the surgery to place the dental implants.

Most data suggests that when placed into single rooted tooth sites with healthy bone and mucosa around them, the success rates are comparable to that of delayed procedures with no additional complications.

### Use of CT scanning

When computed tomography, also called cone beam computed tomography or CBCT (3D X-ray imaging) is used preoperatively to accurately pinpoint vital structures including the inferior alveolar canal, the mental foramen, and the maxillary sinus, the chances of complications might be reduced as is chairtime and number of visits. Cone beam CT scanning, when compared to traditional medical CT scanning, utilizes less than 2% of the radiation, provides more accuracy in the area of interest, and is safer for the patient. CBCT allows the surgeon to create a surgical guide, which allows the surgeon to accurately angle the implant into the ideal space.

## *Complementary procedures*

Sinus lifting is a common surgical intervention. A dentist or specialist with proper training such as an oral surgeon, periodontist, general dentist, or prosthodontist, thickens the inadequate part of atrophic maxilla towards the sinus with the help of bone transplantation or bone expletive substance. This results in more volume for a better quality bone site for the implantation. Prudent clinicians who wish to avoid placement of implants into the sinus cavity pre-plan sinus lift surgery using the CBCT X-ray, as in the case of posterior mandibular implants discussed earlier.

Bone grafting will be necessary in cases where there is a lack of adequate maxillary or mandibular bone in terms of front to back (lip to tongue) depth or thickness; top to bottom height; and left to right width. Sufficient bone is needed in three dimensions to securely integrate with the root-like implant. Improved bone height—which is very difficult to achieve—is particularly important to assure ample anchorage of the implant's root-like shape because it has to support the mechanical stress of chewing, just like a natural tooth.

Typically, implantologists try to place implants at least as deeply into bone as the crown or tooth will be above the bone. This is called a 1:1 crown to root ratio. This ratio establishes the target for bone grafting in most cases. If 1:1 or more cannot be achieved, the patient is usually advised that only a short implant can be placed and to not expect a long period of usability.

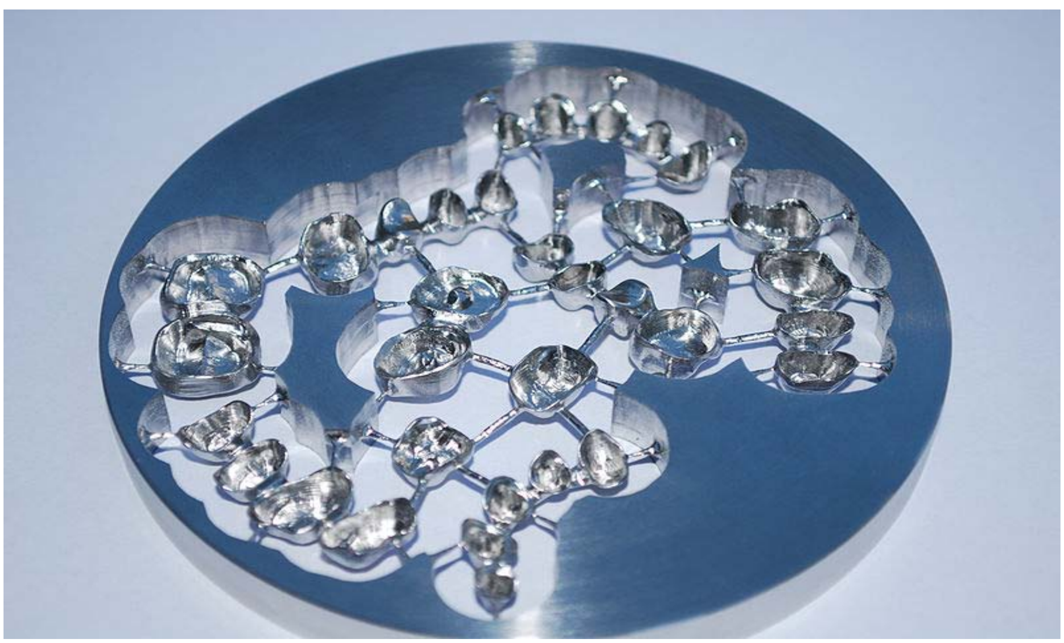
A wide range of grafting materials and substances may be used during the process of bone grafting / bone replacement. They include the patient's own bone (autograft), which may be harvested from the hip (iliac crest) or from spare jawbone; processed bone from cadavers (allograft); bovine bone or coral (xenograft); or artificially produced bone-like substances (calcium sulfate with names like Regeneform; and hydroxyapatite or HA, which is the primary form of calcium found in bone). The HA is effective as a substrate for osteoblasts to grow on. Some implants are coated with HA for this reason, although the bone forming properties of many of these substances is a hotly debated topic in bone research groups. Alternatively the bone intended to support the implant can be split and widened with the implant placed between the two halves like a sandwich. This is referred to as a 'ridge split' procedure.

Bone graft surgery has its own standard of care. In a typical procedure, the clinician creates a large flap of the gingiva or gum to fully expose the jawbone at the graft site, performs one or several types of block and onlay grafts in and on existing bone, then installs a membrane designed to repel unwanted infection-causing microbiota found in the oral cavity. Then the mucosa is carefully sutured over the site. Together with a course of systemic antibiotics and topical antibacterial mouth rinses, the graft site is allowed to heal (several months).

The clinician typically takes a new radiograph to confirm graft success in width and height, and assumes that positive signs in these two dimensions safely predict success in the third dimension; depth. Where more precision is needed, usually when mandibular implants are being planned, a 3D or cone beam radiograph may be called for at this point to enable accurate measurement of bone and location of nerves and vital structures for proper treatment planning. The same radiographic data set can be employed for the preparation of computer-designed placement guides.

Correctly performed, a bone graft produces live vascular bone which is very much like natural jawbone and is therefore suitable as a foundation for implants.

### *Considerations*



Chrome-cobalt disc with bridges and crowns for dental implants manufactured using WorkNC Dental CAD/CAM

For dental implant procedure to work, there must be enough bone in the jaw, and the bone has to be strong enough to hold and support the implant. If there is not enough bone, more may need to be added with a bone graft procedure discussed earlier. Sometimes, this procedure is called bone augmentation. In addition, natural teeth and supporting tissues near where the implant will be placed must be in good health.

In all cases careful consideration must be given to the final functional aspects of the restoration, such as assessing the forces which will be placed on the implant. Implant loading from chewing and parafunction (abnormal grinding or clenching habits) can exceed the biomechanic tolerance of the implant bone interface and/or the titanium material itself, causing failure. This can be failure of the implant itself (fracture) or bone loss, a "melting" or resorption of the surrounding bone.

The dentist must first determine what type of prosthesis will be fabricated. Only then can the specific implant requirements including number, length, diameter, and thread pattern be determined. In other words, the case must be reverse engineered by the restoring dentist prior to the surgery. If bone volume or density is inadequate, a bone graft procedure must be considered first. The restoring dentist may consult with the oral surgeon, periodontist, endodontist, or another trained general dentist to co-treat the patient. Usually, physical models or impressions of the patient's jawbones and teeth are made by the restorative dentist at the implant surgeons request, and are used as physical aids to treatment planning. If not supplied, the implant surgeon makes his own or relies upon advanced computer-assisted tomography or a cone beam CT scan to achieve the proper treatment plan.

Computer simulation software based on CT scan data allows virtual implant surgical placement based on a barium impregnated prototype of the final prosthesis. This predicts vital anatomy, bone quality, implant characteristics, the need for bone grafting, and maximizing the implant bone surface area for the treatment case creating a high level of predictability. Computer CAD/CAM milled or stereolithography based drill guides can be developed for the implant surgeon to facilitate proper implant placement based on the final prosthesis' occlusion and aesthetics.

Treatment planning software can also be used to demonstrate "try-ins" to the patient on a computer screen. When options have been fully discussed between patient and surgeon, the same software can be used to produce precision drill guides. Specialized software applications such as 'SimPlant' (simulated implant) or 'NobelGuide' use the digital data from a patient's CBCT to build a treatment plan. A data set is then produced and sent to a lab for production of a precision in-mouth drilling guide.

## *Success rates*

Dental implant success is related to operator skill, quality and quantity of the bone available at the site, and the patient's oral hygiene. The consensus is that implants carry a success rate of around 95%

One of the most important factors that determine implant success is the achievement and maintenance of implant stability. The stability is presented as an ISQ (Implant Stability Quotient) value. Other contributing factors to the success of dental implant placement, as with most surgical procedures, include the patient's overall general health and compliance with post-surgical care.

### *Failure*

Failure of a dental implant is often related to failure to osseointegrate correctly. A dental implant is considered to be a failure if it is lost, mobile or shows peri-implant (around the implant) bone loss of greater than 1.0 mm in the first year and greater than 0.2mm a year after.

Dental implants are not susceptible to dental caries but they can develop a condition called peri-implantitis. This is an inflammatory condition of the mucosa and/or bone around the implant which may result in bone loss and eventual loss of the implant. The condition is usually, but not always, associated with a chronic infection. Peri-implantitis is more likely to occur in heavy smokers, patients with diabetes, patients with poor oral hygiene and cases where the mucosa around the implant is thin.

Currently there is no universal agreement on the best treatment for peri-implantitis. The condition and its causes is still poorly understood.

Risk of failure is increased in smokers. For this reason implants are frequently placed only after a patient has stopped smoking as the treatment is very expensive. More rarely, an implant may fail because of poor positioning at the time of surgery, or may be overloaded initially causing failure to integrate. If smoking and positioning problems exist prior to implant surgery, clinicians often advise patients that a bridge or partial denture rather than an implant may be a better solution.

Failure may also occur independently of the causes outlined above. Implants like any other object suffers from wear and tear. If the implants in question are replacing commonly used teeth, then these may suffer from wear and tear and after years may crack and break up, although this is a very rare occurrence. The only way to minimize the risk of this happening is to visit your dentist for regular reviews.

In the majority of cases where an implant fails to integrate with the bone and is rejected by the body the cause is unknown. This may occur in around 5% of cases. To this day we still do not know why bone will integrate with titanium dental implants and why it does not reject the material as a 'foreign body'. Many theories have been postulated over the last five decades. A recent theory argues that rather than being an active biological tissue response, the integration of bone with an implant is the lack of a negative tissue response. In other word for unknown reasons the usual response of the body to reject foreign objects implanted into it does not function correctly with titanium implants. It has further been postulated that an implant rejection occurs in patients whose bone tissues actually react as they naturally should with the 'foreign body' and reject the implant in the same manner that would occur with most other implanted materials.

## *Contraindications*

There are few absolute contraindications to implant dentistry. However, there are some systemic, behavioral and anatomic considerations that should be assessed.

Particularly for mandibular (lower jaw) implants, in the vicinity of the mental foramen (MF), there must be sufficient alveolar bone above the mandibular canal also called the inferior alveolar canal or IAC (which acts as the conduit for the neurovascular bundle carrying the inferior alveolar nerve or IAN).

Failure to precisely locate the IAN and MF invites surgical insult by the drills and the implant itself. Such insult may cause irreparable damage to the nerve, often felt as a paresthesia (numbness) or dysesthesia (painful numbness) of the gum, lip and chin. This condition may persist for life and may be accompanied by unconscious drooling.

Uncontrolled type II diabetes is a significant relative contraindication as healing following any type of surgical procedure is delayed due to poor peripheral blood circulation. Anatomic considerations include the volume and height of bone available. Often an ancillary procedure known as a block graft or sinus augmentation are needed to provide enough bone for successful implant placement.

There is new information about intravenous and oral bisphosphonates (taken for certain forms of breast cancer and osteoporosis, respectively) which may put patients at a higher risk of developing a delayed healing syndrome called osteonecrosis. Implants are contraindicated for some patients who take intravenous bisphosphonates.

The many millions of patients who take an oral bisphosphonate (such as Actonel, Fosamax and Boniva) may sometimes be advised to stop the administration prior to implant surgery, then resume several months later. However, current evidence suggests that this protocol may not be necessary. As of January, 2008, an oral bisphosphonate study reported in the February 2008 *Journal of Oral and Maxillofacial Surgery*, reviewing 115 cases that included 468 implants, concluded "There is no evidence of bisphosphonate-associated osteonecrosis of the jaw in any of the patients evaluated in the clinic and those contacted by phone or e-mail reported no symptoms."

The American Dental Association had addressed bisphosphonates in an article entitled "Bisphosphonate medications and your oral health," In an Overview, the ADA stated "The risk of developing BON [bisphosphonate-associated osteonecrosis of the jaw] in patients on oral bisphosphonate therapy appears to be very low...". The ADA Council on Scientific Affairs also employed a panel of experts who issued recommendations [for clinicians] for treatment of patients on oral bisphosphonates, published in June, 2006. The overview may be read online at ada.org but it has now been superseded by a huge study—encompassing over 700,000 cases—entitled "Bisphosphonate Use and the Risk of

Adverse Jaw Outcomes." Like the 2008 JOMS study, the ADA study exonerates oral bisphosphonates as a contraindication to dental implants.

Bruxism (tooth clenching or grinding) is another consideration which may reduce the prognosis for treatment. The forces generated during bruxism are particularly detrimental to implants while bone is healing; micromovements in the implant positioning are associated with increased rates of implant failure. Bruxism continues to pose a threat to implants throughout the life of the recipient. Natural teeth contain a periodontal ligament allowing each tooth to move and absorb shock in response to vertical and horizontal forces. Once replaced by dental implants, this ligament is lost and teeth are immovably anchored directly into the jaw bone. This problem can be minimized by wearing a custom made mouthguard (such an NTI appliance) at night.

Postoperatively, after implants have been placed, there are physical contraindications that prompt rapid action by the implantology team. Excessive or severe pain lasting more than three days is a warning sign, as is excessive bleeding. Constant numbness of the gingiva (gum), lip and chin—usually noticed after surgical anesthesia wears off—is another warning sign. In the latter case, which may be accompanied by severe constant pain, the standard of care calls for diagnosis to determine if the surgical procedure insulted the IAN. A 3D cone beam X-ray provides the necessary data, but even before this step a prudent implantologist may back out or completely remove an implant in an effort to restore nerve function because delay is usually ineffective. Depending upon the evidence visible with a 3D X-ray, patients may be referred to a specialist in nerve repair. In all cases, speed in diagnosis and treatment are necessary.

## *Market*

In the United States and the United Kingdom, there is no exclusive specialty in 'implantology'.

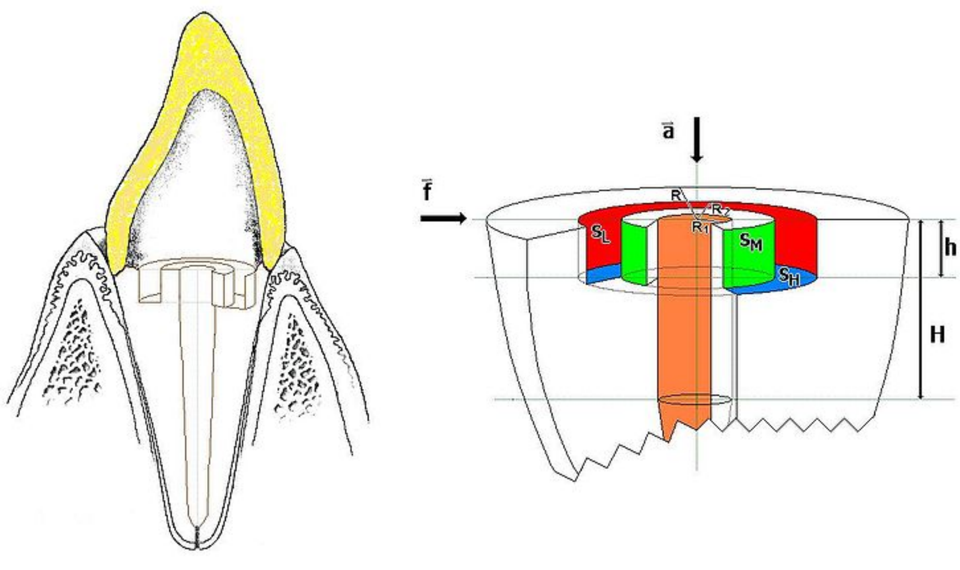
Any practitioner who carries out implant treatment, whether in the surgical insertion or the final provision of the prosthesis, must be adequately trained. Legal training requirements differ between countries.

In 2008, in the UK the General Dental Council (GDC) laid down strict training requirements for dentists involved in dental implantology. Any dentist in the UK who wishes to train in the field of dental implantology must take part in an extended learning program which covers a detailed theory syllabus, as approved by the GDC, in addition to formal supervised surgical training and mentoring. Dentists must not take part in implant dentistry in the UK until they have been approved by the training provider as having passed a formal competency assessment. Failure to comply with the GDC regulations may result in a dentist being removed from the Dental Register and hence losing the right to practice dentistry in the UK.

## Chapter 10

# Nankali Post System

The **Nankali post system** is a post-core, which is used in prosthodontology and dental restoration. This post consists of a single *smooth* or *serrated post* and core which has an additional *circle ring* around it.




A root tooth after preparation for using the Nankali-Post

Nankali-post System.

The additional single-circle ring increases the contact surface area between the core and involved hard tissue of tooth significantly. Increased contact surface area raises the level of force between to objects (remained hard tissue of tooth and post-core) followed by *declining the number of fails* in treatment.

## *General indications*

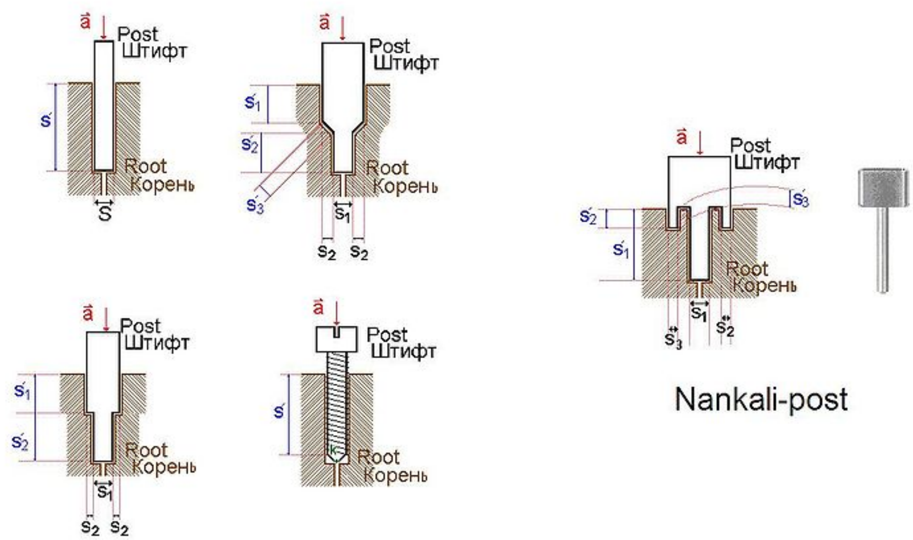
The main indications are:

- Badly damaged crown
- Trauma
- Tooth wear (erosion)
- Hypoplastic conditions
- As part of another restoration
- Combined indication
- Non-vital teeth

## *Contraindication*

- Vertical fracture along the root
- Non-treated root tooth
- Existing a pathology in apex area

## *Advantages*




Comparing the contact surface area of some different posts
with the Nankali-post

Nankali-post System.

The majority of the advantages are the same as other post and core systems; however, there are some points which make it different such as:

- **increasing the contact surface** between the hard tissue of tooth and post/core,

- **minimum required preparation** of the hard tissue,
- and declining the number of difficulties at the time of tooth preparation and most importantly suitable for treatment of those teeth, in which there is a difficulty to deepen in the root canal more than *50% of root length* , and therefore they had to be extracted before.

The post can be used for treating both single or multi-rooted teeth and also in combination with other types of prosthetics.

The insertion ring increases the level of fixation, distribute equally mastication pressure and provide appropriate condition for prosthetics.

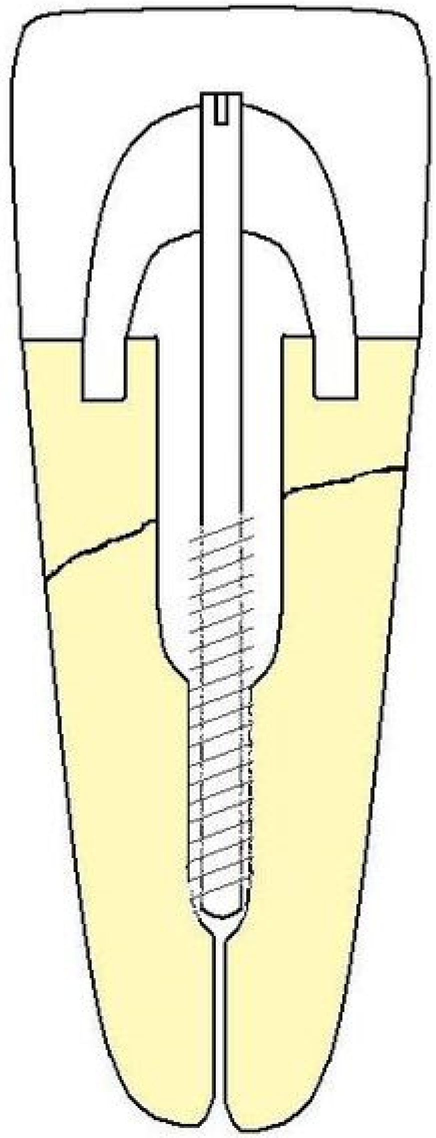
It is also recommended for using bridges, crown or other types of dental prosthetics, if a post core is required for treatment.

### *Disadvantages*

The disadvantages are as follows:

- Requires an exact casting ( an exact cast post-core is required to get the highest result, particularly, when the depth of prepared canal is less than *50% of the root length*),
- A specific bur is required,
- Increases plaque accumulation and changes in composition,
- Damage to soft tissues and remaining teeth, due to either poor denture design or lack of patient care,

### *Fractured teeth*



Schema of using the Nankali Post System for a horizontal rooth fractured tooth.

The post is suitable for those types of fractures in which the fracture line passes apical to the crown. In the first stage it is necessary to examine the patient in order to be sure that there is no sign of any fracture in the mandible or maxilla, then analyse the possibility of treatment of the fractured tooth canal. In addition, the condition of the tooth for using the bur requires to be checked as well.

In the situation of having suitable condition, after treatment and preparation of the root canal, it is possible to use this type of post-core. The root canal requires a two different sizes preparation. In this case the post and core are separate and they will be joined together in the second stage. By rotating the serrated post that is fixed to the special core the system keeps the broken parts together.

Four year observation of patients treated by this method, confirmed a '100% result' without any 'complication' in the National Medical University at the Orthopedic and Implant Stomatology Department; however, before using this type of treatment the conditions have to be analyzed carefully.

## *Treatment*

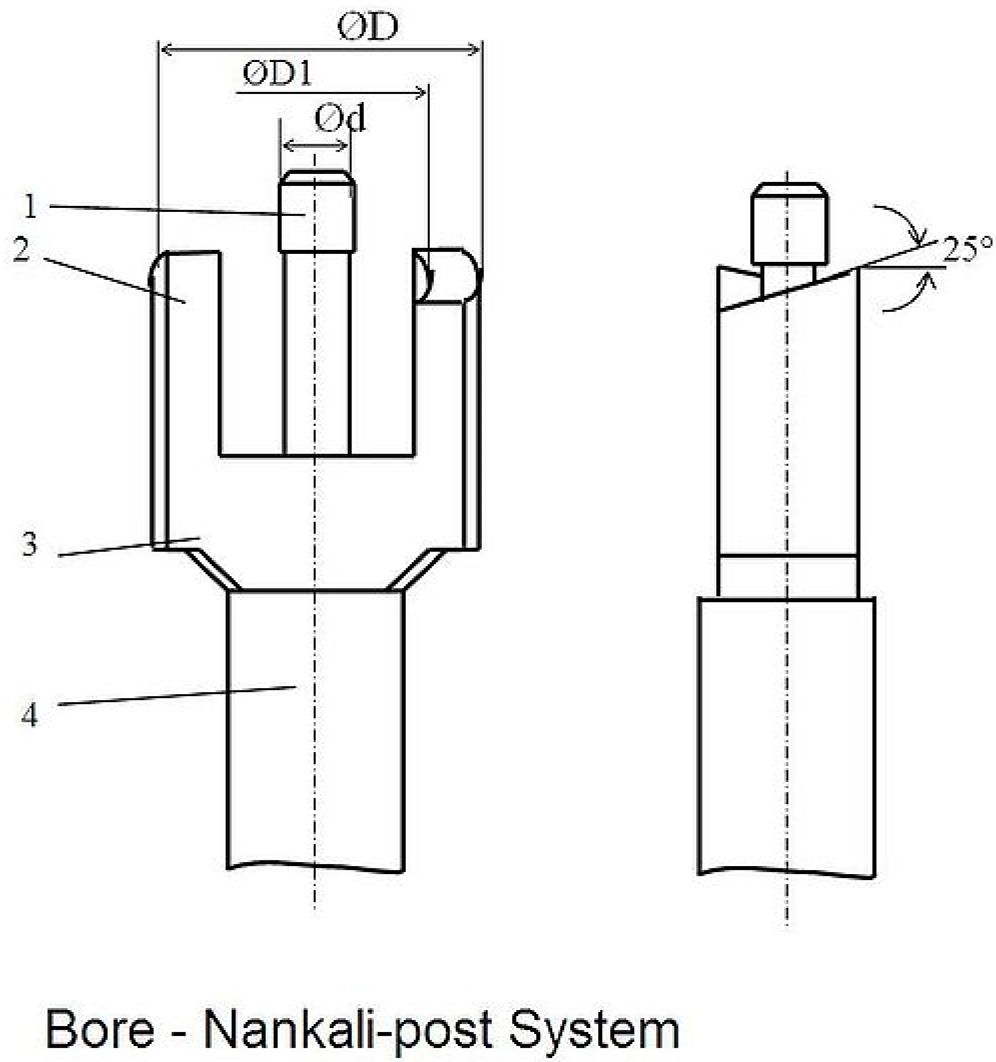
The essential requirement for using this post and core is its *bur*, which is manufactured in different sizes to produce an additional circle ring around the canal of a tooth.

The same as traditional treatment method by any post and core, the root canal is prepared using parallel-side twist drill after treating and filling canal by an inert gutta percha or similar material. Then root canal needs to be prepared with the maximum possible depth for the second stage. However, it has to be noticed that the minimum essential requirement of canal is *one third of its length*, which is necessary in roder to fix the core.

In the next stage, using the specific bur, dentist prepares an additional circle ring around the tooth canal. The post and core can then be constructed either by a direct technique or by an indirect technique. In the direct technique a pattern is fabricated in the mouth using either inlay wax or a burn out resin (e.g. Duralay) which is then sent to the laboratory for casting. For the direct technique, which is more widely used, an impression is taken using a matched plastic impression post placed in the prepared post hole.

For the post-core, it is possible to use different material such as metals or the high strong fibres which is used in dental laboratories.

***Bur***




Schema of the bur of Nankali-post System. 1-Head, 2-cutter, 3-Body, 4-Holder

The designed bur for treating teeth is a bur consisting of *a central guider* and two symmetrical cutter to produce a single-circle ring. This bur is used after preparation of the root canal similar to other posts.

The two main *advantages* of this bore are speed in preparation root canals and its accuracy. The bur is designed in *different sizes*, which make it available for using in treatment of various teeth. The depth of the prepared ring is in direct proportion with the size of bore.

One of the major problems of using this post system is its bur, which means without having the bur it is impossible to use it.

## *History*

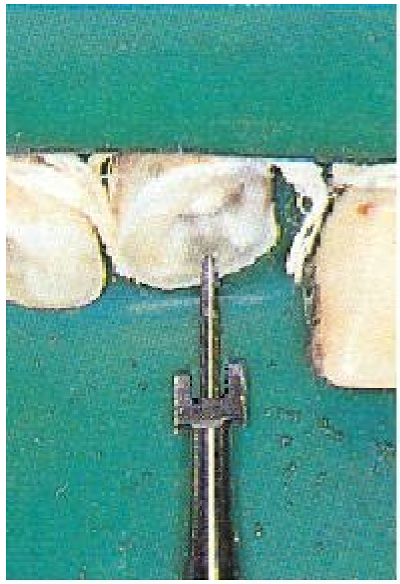
The Nankali-post was designed in 1997 in the National Medical University at the Orthopedic and Implant Stomatology Department by Dr. Ali Nankali, which (October 1999) verified by Scientific Board of National Medical University (O.O. Bogomolets) and international patent organization (УДК; 616.314-76-77:616.314.11-74:678.029.46:612.311) in Kiev/Ukraine.

Initially it was presented at the 54Th Medical Science Conference of Students & Young Scientists in 1999, that was organized by Ukraine Health Ministry and National Medical University known as O.O. Bogomolets and Society Science Students known as O.O. Kisilia. The result of presentation was published in "Young Scientists and Students / Scientific Medical Seminar in 1999".

In 1999 it was requested for the patent (УДК; 616.314-76-77:616.314.11-74:678.029.46:612.311)and became a part of research of the Orthopedic and Implant Stomatology Department of the National Medical University. This new modified post-core was under study till 2004 and then attested by the Dental Scientific Board of Ukraine.

During the four years of careful observation (2000-2004 / National Medical University in Kiev), the number of reported complication from patient, whom were treated with the Nankali-post was none.

Initially the bur and cast post-core were manufactured in the laboratory of the Orthopedic and Implant Stomatology Department of the National Medical University (O.O.Bogomolets) in Kiev.



Nankali-bore

The image of first Bur, which was used for treatment teeth by the Nankali-post System.

## Chapter 11

# Post and Core

A **post and core** is a dental restoration used to sufficiently build-up tooth structure for future restoration with a crown when there is not enough tooth structure to properly retain the crown, due to loss of tooth structure to either decay or fracture. Post and cores are therefore referred to as *foundation restorations*.

### *Treatment with a post and core*

Post and cores divide into two main groups: prefabricated and cast. Both of these systems employ a post that is placed within the **root canal** of the tooth being restored. Thus the tooth be endodontically treated. After this procedure has been completed, and the root canal(s) is/are filled with the inert **gutta percha** root canal filling material, some gutta percha is removed from the canal space, usually by a drill bit that prepares and shapes the root canal. The space that exists coronal to the remaining gutta percha, called the **post space** is now available within which to place a post. It is desirable to leave sufficient root filling material in the apical area to maintain an apical seal.

## *Post space and associated length of post*

The post on the left is a tapered post, the one on the right is a parallel post.

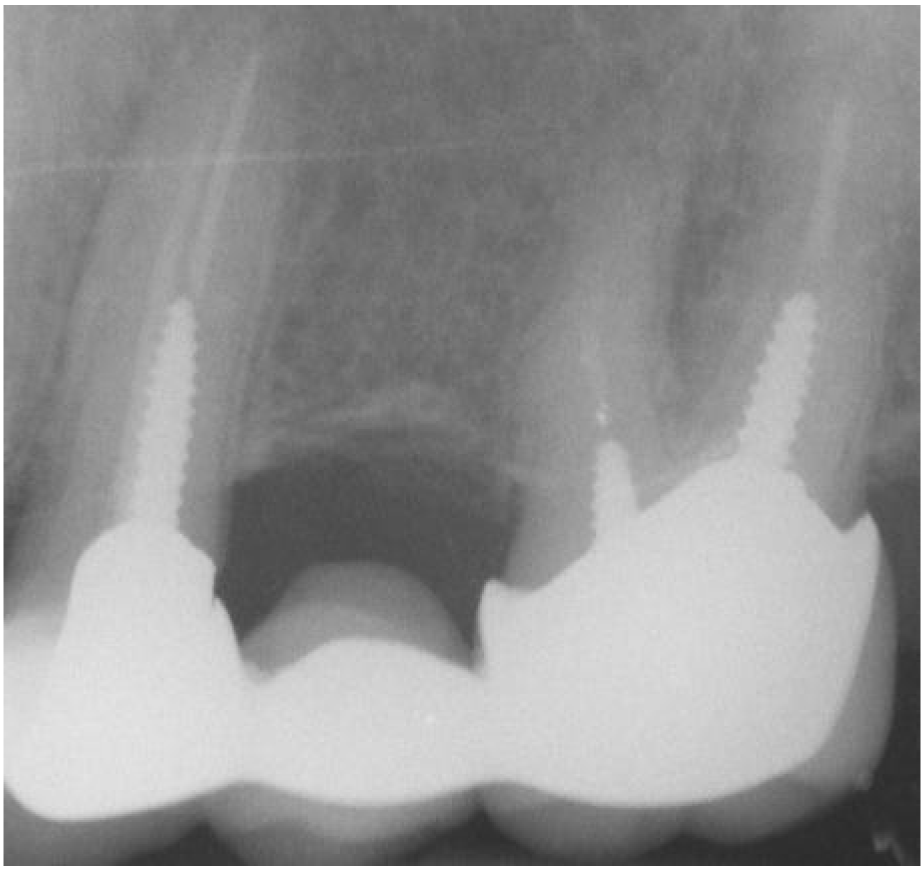
In post and core fabrication, it is desirable that the post descend at least two third of the length of root canal (or not less than the height of the crown) in order to provide sufficient retention.

Basically, it is important to leave at least 5 mm of gutta percha at the apex of the root canal, even at the expense of a longer post, because it is within the apical 5 mm of the root canal that the apical delta anastomose with the exterior surface of the root. Should these lateral canals not be blocked with the gutta percha and the cement used to place the gutta percha, the chances of microleakage and percolation of microbes is drastically increased, thereby increasing the likelihood of an **endodontic failure**.

It is not necessarily the length of the post within the root canal that provides for retention of the core, and thus the eventual crown, but rather the length of post that will exist within root structure *that exists within surrounding bone*. If the post is 16 mm long, but only extends 4 mm into root structure that is surrounded by solid bone, the restoration will have a poor prognosis. This consideration of crown-to-root ratio is essential when evaluating the tooth for a crown lengthening procedure.

In the picture at right, the two teeth on the extreme left and right are the ones under discussion. The two teeth in the middle have been endodontically treated, but do not have post and cores.

## Prefabricated post and cores



Maxillary posterior teeth restored with prefabricated screw posts.

Prefabricated post and cores take less time to place, as they do not involve any lab work and can be inserted immediately upon the decision to utilize them, once the endodontic therapy has been completed and the post space cleared of gutta percha. After the prefabricated post is properly cemented into the post space, a core material, such as Dental composite, can be packed around the cemented post. After the material has been cured or has had a chance to set and properly formed into a crown preparation, an impression can be taken for the fabrication of a prosthetic crown.

Metal prefabricated post systems are being superseded by fibre-reinforced composite resin post systems which offer improved resistance to untreatable fracture of tooth substrate such as vertical root fracture.

### Cast post and cores

In cases where the post space is not a good match for a prefabricated post, a cast post and core can be custom fabricated for the tooth. A **resin pattern** is produced by placing a preformed plastic "burnout" post into the post space and a resin material, such as Duralay resin, is used to build up the tooth to the proper dimensions. When this is completed, the pattern resin/plastic post is removed from the tooth structure and attached to a **sprue** former, much in the same way as a is done with the wax pattern of a crown, and a single-unit cast post and core can thus be fabricated out of gold, titanium or another metal using the **lost-wax technique**. Alternatively an impression can be taken of the post space and dental arch using a plastic post and a polyvinylsiloxane impression material, and this used to constuct a suitable post in the dental laboratory.

## *Post design*

There are many types of post designed available for cast post and cores, utilizing various combinations of the following properties:

- **parallel** vs. **tapered**
- **smooth-sided** vs. **serrated** vs. **threaded**
- **post only** vs. **with additional single-circle ring**

The best design for a post to decrease the risk of failure is the *narrowest & longest smooth, parallel post that one can fit into the post space*. Utilizing the longest possible post ensures that the forces transmitted from the crown are distributed over as much of the root as possible. Using the narrowest diameter post ensures that as much natural tooth structure as possible is left to support the post and absorb the transmitted forces; the largest ideal diameter for a post is ⅓ the diameter of the root at the most apical portion of the post space. A parallel post ensures the greatest retention of the post within the canal, and is perhaps utilized with only the slightest loss of tooth structure to the internal wall of the canal. A smooth-surfaced post, although less retentive than either serrated or threaded post surfaces, transmits the least amount of force to the root structure. While both smooth and serrated posts are passive, in that they simply lie within the post space after being cemented, threaded posts actively engage the internal walls of the root canal as they are screwed in, and, while being the most retentive by far, produce such a force on the brittle root structure that they are contraindicated in most situations.

The use of a post and core does not strengthen the tooth prior to restoration with a crown; rather, it may contribute to the weakening of the tooth structure, as the forces placed upon the future prosthetic crown and core are now transmitted along virtually the entire length of the brittle, endodontically treated tooth. This inherent drawback is taken into account when the prognosis of the finished restoration is determined and explained to the patient prior to the onset of treatment. It is because of this increased risk of failure inherent in the use of post and core restorations that, when all of the independent failure rates of the many procedures needed for the restoration of the tooth are considered together (endodontic treatment, crown lengthening (when indicated), post and core & prosthetic crown), the patient is sometimes advised to have the tooth extracted and an implant placed.

The post with additional single-circle ring increases the contact surface area between the core and involved hard tissue of tooth significantly,therefore this system does not require a post with at least 2/3 of the root canal depth as its indication.

**Chapter 12**

# Removable Partial Denture and Resin Retained Bridge

## Removable partial denture

Occlusal view of a mandibular partial denture. All seven parts of an RPD are visible on this example.

Same RPD, different view.

A **removable partial denture (RPD)** is for a partially edentulous dental patient who desires to have replacement teeth for functional or aesthetic reasons, and who cannot have a bridge (a fixed partial denture) for any number of reasons, such as a lack of required teeth to serve as support for a bridge (i.e. distal abutments) or due to financial limitations.

The reason why this type of prosthesis is referred to as a *removable partial denture* is because patients can remove and reinsert them when required without professional help. Conversely, a "fixed" prosthesis can and should be removed only by a dental professional.

## *Partially edentulous conditions*

Depending on where in the mouth teeth are missing, edentulous situations can be grouped under four different categories, as defined by Dr. Edward Kennedy in his classification of partially edentulous arches.

- Class I (bilateral free ended partially edentulous)
- Class II (unilateral free ended partially edentulous)
- Class III (unilateral bounded partially edentulous)

- Class IV (bilateral bounded anterior partially edentulous)

**Kennedy Class I** RPDs are fabricated for people who are missing some or all of their posterior teeth **on both sides (left *and* right)** in a single arch (either mandibular or maxillary), and there are no teeth posterior to the edentulous area. In other words, Class I RPDs clasp onto teeth that are more towards the front of the mouth, while replacing the missing posterior teeth **on both sides** with false denture teeth. The denture teeth are composed of either plastic or porcelain.

**Class II** RPDs are fabricated for people who are missing some or all of their posterior teeth **on one side (left *or* right)** in a single arch, and there are no teeth behind the edentulous area. Thus, Class II RPDs clasp onto teeth that are more towards the front of the mouth, as well as on teeth that are more towards the back of the mouth of the side on which teeth are not missing, while replacing the missing more-back-of-the-mouth teeth **on one side** with false denture teeth.

**Class III** RPDs are fabricated for people who are missing some teeth such that the edentulous area has teeth remaining both posterior and anterior to it. Unlike Class I and Class II RPDs which are both tooth-and-tissue-borne (meaning they both clasp onto teeth, as well as rest on the posterior edentulous area for support), Class III RPDs are strictly tooth-borne, which means they only clasp onto teeth and do not need to rest on the tissue for added support. This makes Class III RPDs exceedingly more secure as per the three rules of removable prostheses that will be mentioned later, namely: **support**, **stability** and **retention**.

However, if the edentulous area described in the previous paragraph crosses the anterior midline (that is, at least both central incisors are missing), the RPD is classified as a **Class IV** RPD. By definition, a Kennedy Class IV RPD design will possess only one edentulous area.

Class I, II and III RPDs that have multiple edentulous areas in which replacement teeth are being placed are further classified with modification states that were defined by Oliver C. Applegate. Kennedy classification is governed by the most posterior edentulous area that is being restored. Thus, if, for example, a maxillary arch is missing teeth #1, 3, 7-10 and 16, the RPD would be Kennedy Class III mod 1. It would not be Class I, because missing third molars are generally not restored in an RPD (although if they were, the classification would indeed be Class I), and it would not be Class IV, because modification spaces are not allowed for Kennedy Class IV.

## *Components of an RPD*

Rather than lying entirely on the edentulous ridge like complete dentures, removable partial dentures possess clasps of metal or plastic that "clip" onto the remaining teeth, making the RPD more stable and retentive.

The parts of an RPD can be listed as follows (and are exemplified by the picture above):

- **Major Connector** (the thick metal "U" in the RPD above is a **lingual bar**, a type of major connector)
- **Minor Connector** (the small struts protruding from the lingual bar at roughly 90 degree angles)

- **Direct Retainer** (examples are in the upper left of upper photo and lower right of lower photo; the clasp arms act to hug the teeth and keep the RPD in place. The metal clasp and rest immediately adjacent to the fake teeth is also a direct retainer.)
- **Indirect Retainer** (example is the little metal piece coming off the "U" at a 90 degree angle near the top of the upper photo, which is a cingulum rest on a canine.)
  - **Physical Retainer** (this is a mesh of metal that allows the pink base material to connect to the metal framework of the RPD. Some consider physical retainers their own component (making a total of seven), while others consider them within the indirect retainer category (thus making a total of six components.)

- **Base** (the pink material, mimicking gingiva)

- **Teeth** (plastic or porcelain formed in the shape of teeth)

## *Clasp Design*

Direct retainers may come in various designs:

- **Cast circumferential clasp** (suprabulge)
  - Akers'
  - Half and half
  - Back-action
  - Ring clasp
- **Wrought wire clasp**
- **Roach clasp** (infrabulge)
  - I-bar
  - T-bar
  - Y-bar
  - 7-bar

Both cast circumferential and wrought wire clasps are *suprabulge clasps*, in that they engage an undercut on the tooth by originating coronal to the height of contour, while Roach clasps are *infrabulge clasps* and engage undercuts by approaching from the gingival.

In addition there are a couple of specific theories which include the clasp design:

- **RPI**: mesial rest, distolingual guide plate, I-bar

    - Described by Kratochvil in 1963 and modified by Kroll in 1973
    - An illustration of the RPI design function
- **RPA**: mesial rest, distolingual guide plate, Akers' clasp-style retentive arm
- **RPC**: mesial rest, distolingual guide plate, other type of cast circumferential clasp
    - So named in response to the **RPI Philosophy** introduced by Kratochvil and Kroll

# Resin retained bridge

A **resin retained bridge** is a dental prosthesis replacing a missing tooth that relies for its retention on a composite resin cement.

The resin retained bridge is a good treatment option for many missing teeth as it is relatively cheap when compared to alternatives such as dental implants, requires little or no damage to the surrounding teeth during preparation for placement, and it is well tolerated by patients. Typical success rates are quoted as being as high as 80% after 15 years in the anterior maxilla. Far lower success rates are seen in the posterior mandible. Thus case selection is important. As with any dentistry, good oral hygiene is paramount for success.

One major advantage of the resin retained bridge over a conventional bridge is the failure mode is likely to be debonding of the retainer. In conventional bridges the failure mode is likely to be complete fracture of the abutment tooth with difficult to manage sequelae, possibly requiring root canal treatment. With a resin retained bridge the prosthesis can usually be cleaned off and rebonded in position with minimal inconvenience to the patient.

The resin retained bridge has gone through a number of iterations. Perhaps the best known is the Maryland bridge. Other designs used in the past include the Rochette bridge .

The resin retained bridge requires a very specific set of design principles.

The wing or retainer must be rigid and is usually fabricated from a metal alloy. The inner surface must fit closely to the abutment tooth. The intaglio is treated in some way to enhance the micromechanical adhesion between the prosthesis and the composite resin cement. In the past various methods have been used, ranging from metal-weave patterns to tin plating. The modern resin retained bridge retaining wing is usually sandblasted with an alumina powder.

The pontic is usually made from dental porcelain. The whole restoration is thus a porcelian fused to metal restoration.

Current cement brands commonly used for this procedure include Panavia, Nexus. All are either auto cure or dual cure to ensure complete polymerisation of the resin under the wing. Great care must be taken during cementation to avoid contamination of the operative field as this will lower the bond strength of the cement and lead to premature failure. For this reason rubber dam is often advocated for placement, though this can bring its own difficulties.

The resin retained bridge is increasingly being used in modern dentistry as an alternative to more destructive treatments. This has been driven by the advent of evidence based dentistry showing the benefits to patients of reduced tooth preparation and the importance of an intact enamel structure for the longterm health of the teeth. The resin retained bridge is currently in favour in the United Kingdom for these reasons.

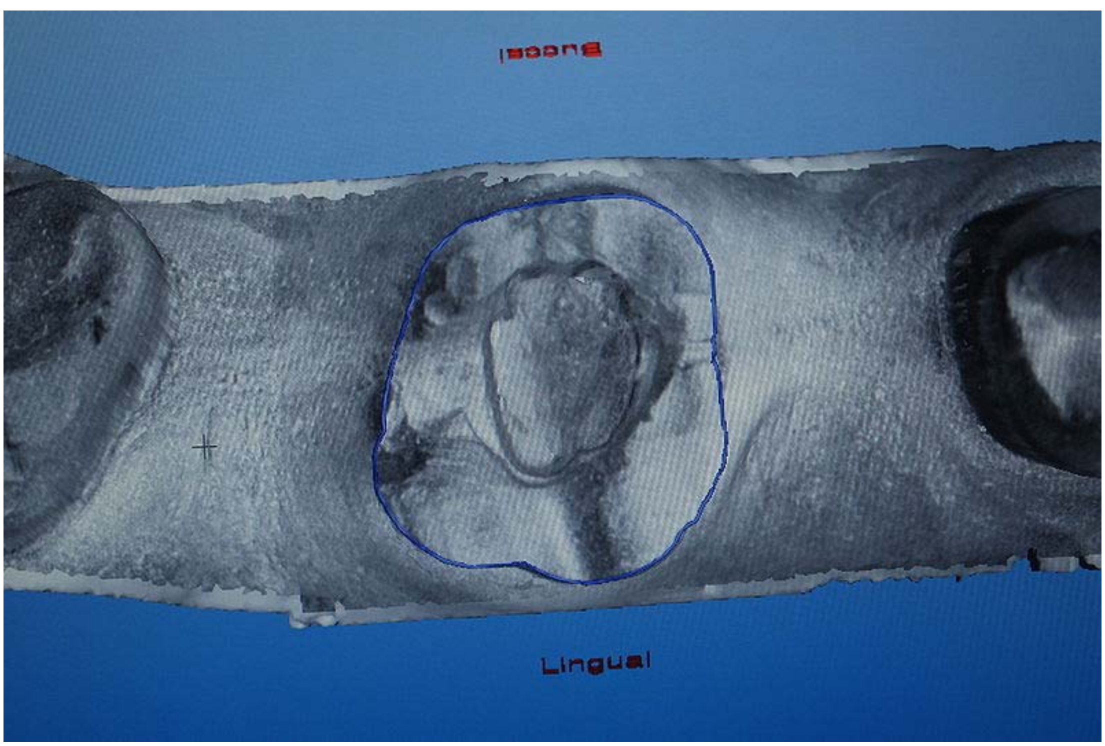
Chapter 13

# Crownlay

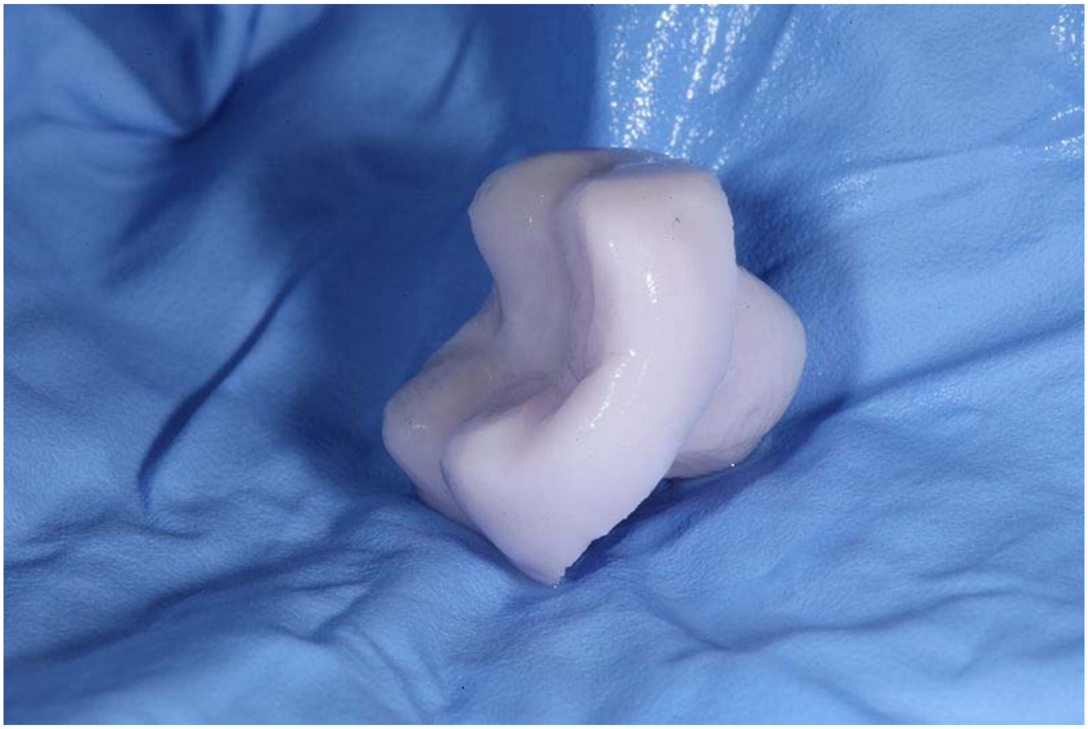
A **crownlay** is a type of dental restoration.

## *Description*

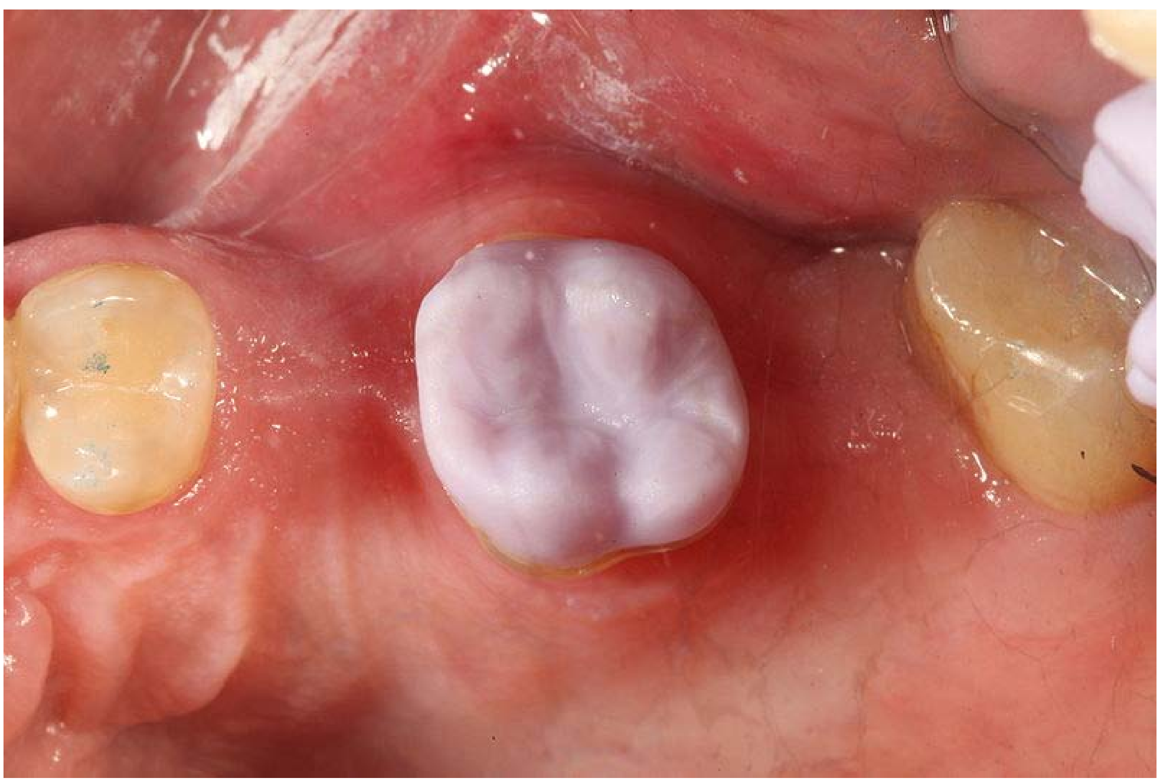
A crownlay is a hybrid dental restoration typically placed over a endodontically treated treated tooth that is more conservative than a normal full coverage crown, but less conservative than a normal onlay. Crownlays incorporate an extension of extra restorative material on the underside of the restoration into the excavated pulp chamber following root canal therapy, taking advantage of the extra surface area afforded in this space on the interior aspect of the preparation, thereby sparing the external walls from needing as much tooth reduction. The use of a crownlay results in the conservation of more healthy, natural tooth structure than is otherwise possible.




Root canal treated molar prepared for CAD/CAM crownlay



crownlay milled



### *Usage*

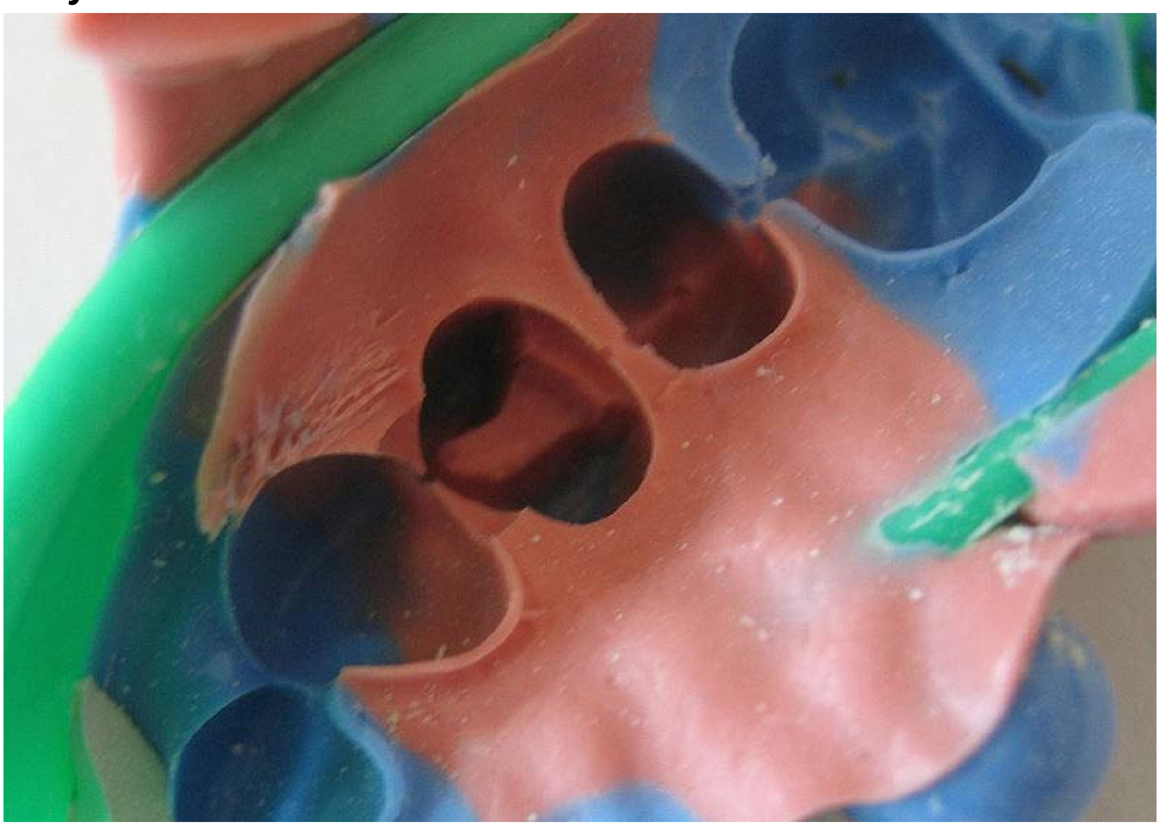
Crownlays are typically used in place of traditional post and core restorations. Post and core buildups are essentially rods of restorative material made out of titanium, stainless steel or resin that glean extra surface area against the internal walls of root canal-treated teeth when there is little to no tooth left above the gumline to hold a normal crown or onlay in place. The post and core buildup serve to aid in retention of a traditional crown but increase the likelihood of root fracture because chewing forces are directed vertically along the hollowed out and subsequent weaker remnants of the internal surfaces of an endodontically (root canal treated) tooth. Crownlays are typically constructed from milled, monolithic blocks of solid porcelain which not only very intimately fit the prepared tooth, but are acid etched and bonded into place using very strong resin materials, decreasing the need for physical retention.

## Chapter 14

# Inlays and Onlays

In dentistry, an **inlay** is an indirect restoration (filling) consisting of a solid substance (as gold or porcelain) fitted to a cavity in a tooth and cemented into place. An **onlay** is the same as an inlay, except that it extends to replace a cusp. Crowns are onlays which completely cover all surfaces of a tooth.

### *Inlays*



An impression of preparation for restoration with a **DO gold inlay** on tooth #5. The "DO" designation indicates that the gold serves as a restoration for the distal and occlusal surfaces of the tooth. This tooth was prepared and the inlay will be fabricated according to the **R.V. Tucker** method of gold inlay preparation. Notice how the line angles of the impression for the inlay are very sharp and precise; this is achieved using carbon-tipped stainless steel instruments. The salmon-colored polyvinylsiloxane impression material is less viscous than the blue and is able to capture better detail for the tooth being restored.

Sometimes, a tooth is treatment planned to be restored with an intracoronal restoration, but the decay or fracture is so extensive that a direct restoration, such as amalgam or composite, would compromise the structural integrity of the restored tooth by possibly undermining the remaining tooth structure or providing substandard opposition to occlusal (i.e. biting) forces. In such situations, an indirect gold or porcelain inlay restoration may be indicated. The following documents the indirect (out of the mouth) fabrication of a **gold inlay**. When an inlay is used, the tooth-to-restoration margin may be finished and polished to such a super-fine line of contact that recurrent decay will be all but impossible. It is for this reason that some dentists recommend inlays as the restoration of choice for pretty much any and all filling situations. While these restorations might be ten times the price of direct restorations, the superiority of an inlay as a restoration in terms of resistance to occlusal forces, protection against recurrent decay, precision of fabrication, marginal integrity, proper contouring for gingival (tissue) health, ease of cleansing and many other aspects of restorative quality offers an excellent alternative to the direct restoration. For this reason, some patients request inlay restorations so they can benefit from its wide range of advantages even when an amalgam or composite will suffice. The only true disadvantage of an inlay is the higher cost.

An **MO gold inlay** on tooth #3, the "MO" designation indicating that the gold serves as a restoration for the mesial and occlusal surfaces of the tooth. This tooth was also restored according to the **R.V. Tucker** method. Notice how the gold appears to flow into the tooth structure, almost perfectly mimicking the natural contours and even allowing the specular reflection to continue over the margin from tooth to gold.

### *Onlays*

Additionally, when decay or fracture incorporate areas of a tooth that make amalgam or composite restorations essentially inadequate, such as cuspal fracture or remaining tooth structure that undermines perimeter walls of a tooth, an "onlay" might be indicated. Similar to an inlay, an onlay is an indirect restoration which incorporates a cusp or cusps by covering or *onlaying* the missing cusps. All of the benefits of an inlay are present in the onlay restoration. The onlay allows for conservation of tooth structure when the only other alternative is to totally eliminate cusps and perimeter walls for restoration with a crown. Just as inlays, onlays are fabricated outside of the mouth and are typically made out of gold or porcelain. Gold restorations have been around for many years and have an excellent track record. In recent years, newer types of porcelains have been developed that seem to rival the longevity of the gold. Either way, if the onlay or inlay is made in a dental laboratory, a temporary is fabricated while the restoration is custom made for the patient. A return visit is then required to deliver the final prosthesis. Inlays and onlays may also be fabricated out of porcelain and delivered the same day utilizing techniques and technologies relating to CAD/CAM Dentistry.

## Chapter 15

# Orthodontic Technology

**Orthodontic technology** is a specialty of dental technology that is concerned with the design and fabrication of dental appliances for the treatment of malocclusions, which may be a result of tooth irregularity, disproportionate jaw relationships, or both.

There are three main types of orthodontic appliances: active, passive and functional. All these types can be fixed or removable.

## *Active Appliances*

An active appliance is a device used to apply forces to the teeth to change the relationship of the teeth.

### Removable active appliances

- Expansion and Labial Segment Alignment Appliance (ELSAA)

### Fixed active appliances

- Pin and Tube Appliances
- Ribbon Arch Appliances
- Begg Lightwire Appliances
- Edgewise Appliances
- Pre-adjusted Edgwise Appliances
- Self-ligating Edgewise Appliances
- Bi Helix
- Tri Helix
- Quad Helix
- Rapid Maxillary Expansion Appliance (RME)
- pin stripe appliance

## *Passive Appliances*

Passive appliances include space maintainers and retainers

### Removable passive appliances

- Hawley Retainer
- Begg Retainer
- Vacuum Formed "Essix" Retainer

### Fixed passive appliances

- Bonded "Twistflex" Retainer
- Fixed Space Maintainer

## *Functional appliances*

Also known as dentofacial orthopaedic appliances, these appliances utilize the muscle action of the patient to produce orthodontic or orthopaedic forces. Various functional appliances have been described.

### Introduction and Definition

### Indications and Timing of Treatments and Types of Maloccusion

### Removable functional appliances

- Andresen Appliance- This is to reduce the overbite, making the molars over-erupt.

- Bionator — Bionators initially look like a sort of combined upper and lower Hawley retainer, but do not fasten to the teeth and are not used for post-brace removal treatment. Bionators are held in the mouth within the space that the teeth surround when biting. They are used to expand the palate and create space for incoming teeth.

- Biobloc — Biobloc is an appliance used to posture forward the lower jaw.

- Clark Twin Block — This appliance incorporates the use of upper and lower bite blocks to position the mandible forward for skeletal Class II correction. The appliance was first developed by Scottish Orthodontist William Clark and Orthodontic Technician James Watt in 1977. The Twin Block has become the most popular functional appliance in use in the United Kingdom and is gaining popularity across Europe and the USA.

- Bass Dynamax — This appliance is similar in principle to the Twin Block. It is based around a prefabricated modular spring, built into a maxillary (upper)occlusal splint. Two integral vertical springs make contact with a fixed lingual arch or removable lower appliance to posture the mandible (lower jaw) forward for skeletal Class II correction. This appliance was developed by London Orthodontist Neville Bass in the early twenty-first century.

- Medium Opening Activator- This is a modified version of the Andreson appliance.

## Orthodontic Headgear

Headgear.

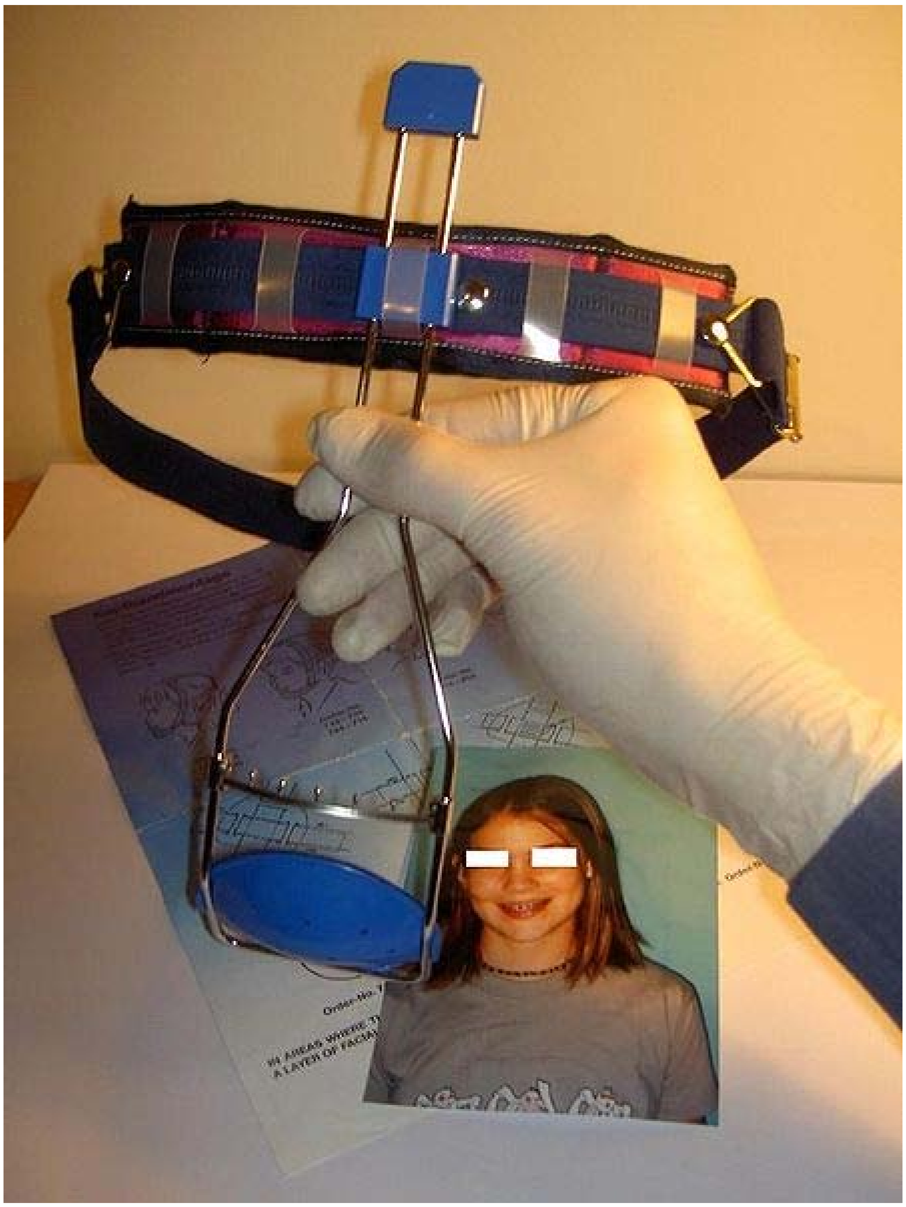
Orthodontic Headgear is a type of appliance attached to dental braces that aids in correcting more severe bite problems.

Headgear is an orthodontic appliance for the correction of Class II correction, typically used in growing patients to correct overbites by holding back the growth of the upper jaw, allowing the lower jaw to catch up.

The headgear can also be used to make more space for teeth to come in. The headgear is then attached to the molars (via molar headgear bands & tubes), and helps to push or draw them backwards in the mouth, opening up space for the front teeth to be moved back using braces and bands.

Headgear needs to be worn approximately 12 to 22 hours a day to be truly effective in correcting the overbite, and treatment is usually anywhere from 6 to 18 months in duration, depending on the severity of the overbite and how much a patient is growing.

## Orthodontic facemask and reverse-pull headgear



Facemask

Facemask or Reverse-pull Headgear is used to control the growth of the maxillary and mandibular bones during orthodontic treatment.

The appliance is used in growing patients to correct under bites (known as a Class III orthodontic problem) by pulling forward and assisting the growth of the upper jaw, allowing the upper jaw to catch up.

Facemasks or Reverse-pull Headgear needs to be worn approximately 12 to 22 hrs to be truly effective in correcting the under bite, usually anywhere from 6 to 18 months depending on the severity of the bite and how much a patient is growing.

The appliance normally consists of a frame or a centre bars that are strapped to the patients head during a fitting appointment. The frame has a section which is positioned in front of the patients mouth, which allows for the attachment of elastic or rubber bands directly into the mouth area. These elastics are then hooked onto the child's braces (brackets and bands) or appliance fitted in his or her mouth.

This creates a forward 'pulling' force to pull the upper jaw forward.

## Fixed functional appliances

- Herbst Appliance: A **Herbst Appliance** corrects overbites by holding the lower jaw in a protrusive position. It is similar to the Twin Block Appliance except that it is fixed in place and hence non-removable. This appliance is most commonly used in non-compliant patients. The Herbst appliance is very effective in correcting large overbites due to small lower jaws in patients that are growing.

- Fixed Twin Block Appliance: The Twin Block appliance is a removable appliance, and its high comfort level allows you to wear it 24 hours a day. This appliance actually is made up of two separate appliances that work together as one. The upper plate includes an optional expansion screw to widen your upper arch, if needed, as well as pads to cover your molars. The lower plate includes pads to cover your lower bicuspids. These two appliances interlock at an angle, and they move your lower jaw forward and lock it into the ideal position when you bite together. This new position, while temporary, will eventually become the permanent corrected position.