3

Dental healthcare

Derrick Garwood

It is now reasonable to expect a set of permanent teeth to last a lifetime. This contrasts starkly with the situation only a generation ago, when it was widely accepted that teeth would have to be extracted and replaced by dentures well before old age.

Loss of teeth, other than by accident, is caused by two different pathological processes: dental caries and periodontal disease. Today, these are very rarely life-threatening, although dental treatment may produce adverse effects in susceptible individuals. Certain pre-existing medical conditions dramatically increase the risks of treatment. For example, haemophiliacs are at risk of severe haemorrhage after dental procedures. Subacute bacterial endocarditis may occur in individuals with a history of rheumatic fever or valvular heart disease, as a result of a bacteraemia following extractions, calculus removal (scaling), or other invasive dental procedures. Dental healthcare in susceptible individuals is, therefore, extremely important. However, for most people, dental disease is more of a social embarrassment and inconvenience than a serious health risk; at worst, it may reduce the quality of life if many teeth are lost.

In terms of the effects of dental disease on the community, its treatment is costly and results in loss of time from school or work. Unfortunately, most expenditure is on the treatment of established disease rather than disease prevention. In the UK, millions of teeth are extracted every year. Some extractions are unavoidable (e.g. to reduce overcrowding), but the overwhelming majority are a direct result of dental disease. An even greater number of teeth undergo some form of restorative treatment. A dedicated commitment to prevention by the individual is of far greater benefit than treatment.

The link between dental caries and diet has long been recognised. The incidence of dental caries increased significantly after the seventeenth century with the greater consumption of refined carbohydrates, particularly sugars. The prevalence in developing countries has until recently been low compared with western nations, but is now increasing as western-style diets are adopted. Conversely, the high prevalence in western nations reached a peak in the 1960s, but is now declining as a result of improved dental health education and the use of fluoride, especially in fluoride-containing toothpastes (*see* Anatomy and morphology *below*).

Surveys were conducted in the UK in 1973, 1983 and 1993 to assess the dental health of children. The results show that over 20 years, the total decay experience of children has fallen dramatically (Downer, 1994):

- by 55% at five years of age
- by 82% at eight years of age
- by 75% at 12 years of age
- by 74% at 14 years of age.

In 1973, just 7% of children of 12 years of age had no experience of permanent tooth decay; by 1993 this figure had risen to 50%. However, marked regional inequalities remain, with much higher caries rates in Northern Ireland and Scotland than in England. It also appears that the rate of decline has levelled out in children of five years of age, so there is still room for improvement.

Periodontal disease is responsible for the loss of more teeth than dental caries. Although generally considered a disease of adults, it also occurs

in children. Surveys of the dental health of adults in the UK have shown that the majority of people aged over 35 with some natural teeth exhibit evidence of periodontal disease. As the incidence of caries decreases, and the number of teeth that are retained consequently increases, periodontal disease will assume even more importance as a cause of tooth loss. In the past, periodontal disease was thought to be a normal process of ageing, but this is not the case; it is totally preventable.

Dental healthcare is not new; people have attempted to clean their teeth with various abrasive substances throughout history. Ancient Egyptians used mixtures of burnt egg shells, myrrh, ox hoof ashes and pumice; ancient Greeks used granulated alabaster stone, coral powder, emery, pumice, rust and talcum; and the Romans used bones, hooves, horns, shells and myrrh. Mouthwashes have also been used throughout history, and ancient Chinese writings advocate the use of urine to treat periodontal disease. Toothbrushes or toothpicks in a variety of forms have been employed for thousands of years.

Modern dental healthcare products have evolved as understanding of the mechanism and prevention of dental disease has increased. These products have traditionally been sold through community pharmacies, so the pharmacist can make a significant contribution to dental health education. However, a sound knowledge of the properties, actions and uses of the products is essential, together with a basic understanding of dental anatomy and the aetiology of dental disease and its prevention. These subjects and the pharmacist's role are discussed below.

This chapter is concerned only with diseases that affect the teeth and gums. For diseases of other tissues in the oral cavity, the reader is referred to Disorders of the ear, nose, and oropharynx in Harman (1990).

Dental anatomy and physiology

The oral cavity is the area between the cheeks, lips, hard and soft palates, and the pharynx; the floor of the oral cavity is formed by the tongue and its associated muscles. The structures surrounding the oral cavity have important roles in:

- masticating food
- initiating digestion by salivary enzymes
- swallowing food, fluid and saliva
- respiration
- speech.

Gingivae

The gingivae (gums) cover the alveolar ridges: bony horseshoe-shaped projections of the maxillae (upper jaw bone) and mandible (lower jaw bone). The gingival epithelium is continuous with the mucous membrane of the inner surface of the lips and cheeks, and with the epithelium of the hard palate and the floor of the oral cavity. Healthy gingivae are coral pink with a stippled surface, whereas the oral mucous membrane is red. Folds of soft tissue (called fraena) run between the alveolar ridges and the lips and cheeks. Gingival connective tissue forms a collar around each tooth, and is attached to the tooth surface by junctional epithelium. There is a shallow trough (the gingival crevice, Figure 3.1) between the crest of gingival tissue and the tooth, which in health is between 0.5 and 1 mm in depth.

Teeth

The teeth are supported on the upper and lower alveolar ridges, and are important structures required for mastication. They also profoundly affect speech, and facial appearance and expression.

Anatomy and morphology

Each tooth consists of the crown, which projects through the gingivae into the oral cavity, and one or more roots, which anchor the tooth in its socket (*see* Figure 3.1). The different types of teeth (Figure 3.2) reflect their varied functions:

- incisors are chisel-shaped and used for cutting into food
- canines have a pointed surface (the cusp) for tearing and shredding food

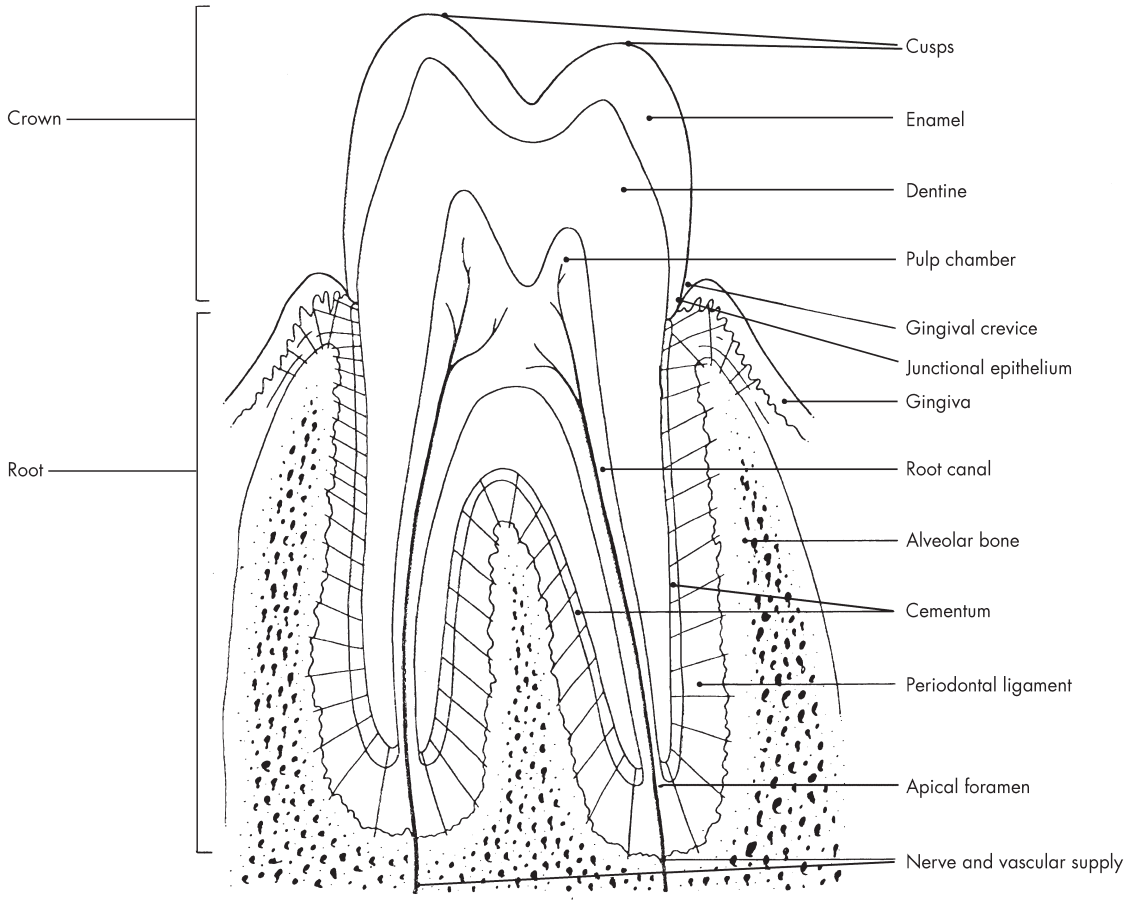


Figure 3.1 Section through a molar to show the anatomy of a typical tooth.

- premolars (bicuspids) have two cusps for chewing food
- molars have four cusps for crushing and grinding.

The cusps of premolars and molars are separated by fissures, and the whole biting surface of these teeth is called the occlusal surface. Other surfaces include:

- the palatal surface – the surface of upper teeth nearest the palate
- the lingual surface – the surface of lower teeth facing the tongue
- the labial surface – the surface of incisors and canines facing the lips
- the buccal surface – the surface of premolars and molars facing the cheeks.

The surfaces facing adjacent teeth are also important because of their association with dental caries and early periodontal disease (*see* Dental disease *below*). For effective mastication, each tooth should meet its opposing tooth in the other jaw; if one of the pair is missing, the remaining tooth is less effective because it has nothing to work against.

Incisors, canines and premolars have only one root, with the exception of the upper first premolar, which usually has two. Lower molars usually have two roots and the upper molars three, except the third molars, which may have one, two or three.

The principal component of a tooth is dentine. In the crown, this is covered with enamel; in the root, it is covered with cementum.

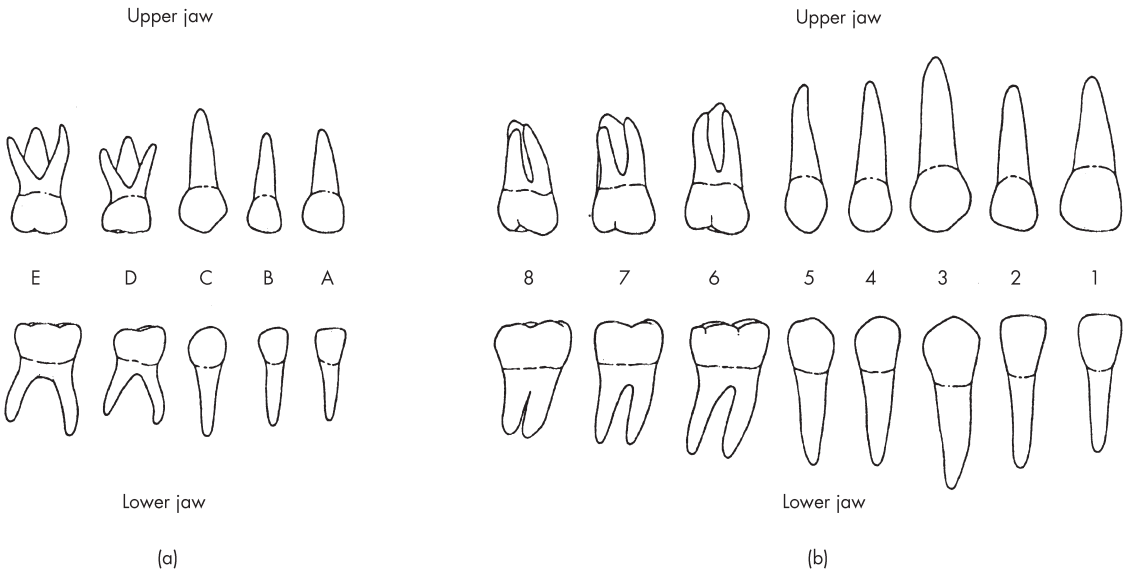


Figure 3.2 Morphology of teeth: (a) Primary dentition (b) Permanent dentition (*see* Table 3.1 for key to identification of teeth).

Dentine surrounds a cavity containing pulp; in the crown, the cavity is termed the pulp chamber; in the root, it becomes the root canal.

Dentine

Dentine is a hard yellowish substance consisting of calcium hydroxyapatite, water and an organic matrix of collagen and mucopolysaccharides. It is sensitive to touch and extremes of temperature, although the exact reason for this is not known. Dentine is deposited continuously throughout life, gradually reducing the size of the pulp cavity. This normal physiological process proceeds at a relatively slow rate compared with the secondary deposition of dentine following loss of tooth substance (e.g. as a result of dental caries, excessive wear or cavity preparation).

Enamel

Enamel is the hardest substance in the animal kingdom, and consists mainly of calcium hydroxyapatite; the remainder is water and an organic matrix similar to keratin. The primary function of enamel is to protect teeth from the forces of mastication, which would otherwise eventually wear them away. Enamel also insulates teeth from heat, cold and other pain-producing stimuli. However, it is brittle and requires the support of dentine; if this support is lost (e.g. as a result of caries) it readily fractures. Enamel is thinnest where it approaches the root, but at the cusps (or edges of incisors) it may be up to 2.5 mm thick. Its colour is governed by its thickness, and it appears lightest and almost translucent at the tooth tip. Where the enamel layer is thin, the tooth appears yellow because the dentine beneath shows through. Colour, however, does not indicate the strength of teeth, which tend to darken with age.

Cementum

Cementum is softer than dentine. It is a bone-like substance consisting of calcium hydroxyapatite and an organic matrix of collagen and mucopolysaccharides. It is laid down continuously, and the thickness may treble throughout life; some cementum is resorbed, but these areas are repaired by further deposition. Cementum attaches the tooth to the socket by means of the periodontal ligament (*see below*).

Pulp

Pulp is composed of loose areolar connective tissue richly supplied with blood vessels, lymphatic vessels and nerves, which reach it via the apical foramen. The nerve supply consists of sympathetic nerves and sensory nerves, but as the only sensory receptors are pain receptors, all stimuli are perceived as pain. Pulp becomes more fibrous and less vascular with age, and is reduced in overall size as dentine is laid down (*see above*). These changes reduce the sensitivity of teeth with age.

Periodontal ligament

A tooth is suspended firmly in its socket by the periodontal ligament, which connects the cementum to the underlying bone. Its function is to support the tooth, and protect both tooth and bone from excessive pressures during chewing and biting. The periodontal ligament is composed of collagenous fibrous connective tissue, with a rich vascular supply to provide essential nutrients to the cementum. Its nerve supply includes both touch and pain receptors, which are important in controlling mastication. Cementoblasts and osteoblasts are also present, and are responsible for laying down new cementum and bone, respectively, throughout life.

Dentition

The term dentition refers to the natural teeth and their position in the alveolar ridges. In humans, there are two dentitions: the primary dentition (deciduous teeth, baby teeth or milk teeth) and the permanent dentition. There are 20 primary and 32 permanent teeth (Table 3.1).

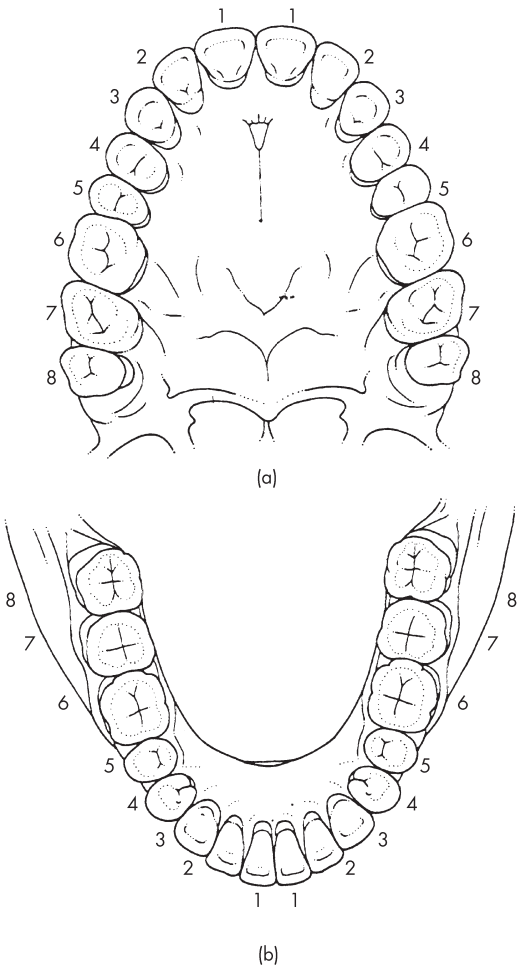


Figure 3.3 Permanent dentition: (a) Upper jaw (b) Lower jaw (*see* Table 3.1 for key to identification of teeth).

Table 3.1 The dentitions

(a) Primary dentition	(b) Permanent dentition
A (1) central incisor	1 central incisor
B (2) lateral incisor	2 lateral incisor
C (3) canine	3 canine
D (4) first molar	4 first premolar
E (5) second molar	5 second premolar
	6 first molar
	7 second molar
	8 third molar (wisdom tooth)

Dental notation

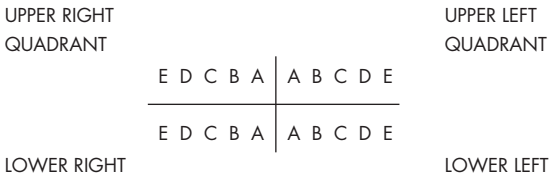
Two different systems are used to identify the teeth in their positions in the alveolar ridges. In both systems, the two dental arches are divided into four quadrants: the upper left and right, and the lower left and right (Figure 3.3).

Traditionally, a tooth has been identified by specifying the quadrant in which it is situated and the number or letter of the tooth itself; for example, the upper right six or the lower left D. Note, however, that it is always assumed that the observer is facing the patient, causing lateral inversion – as

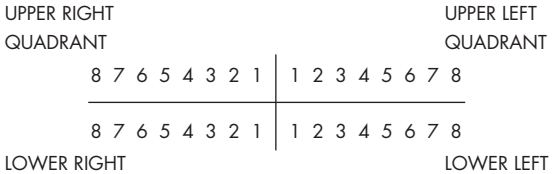
in a mirror. Thus the upper left six is written as ⌊6 and the upper right C as C⌋ (Figure 3.4).

Today, the International Tooth Numbering System is becoming accepted all over the world as the standard system of tooth identification. In this system, each quadrant is assigned a number (Table 3.2).

A tooth is denoted by specifying its quadrant number and then its individual number. In this system, the deciduous teeth are given the numbers 1 to 5, not the letters A to E. Thus, the upper left six now becomes 26, and the upper right C becomes 53 (Figure 3.5). In speech, these are referred to as 'two-six' and 'five-three', not 'twenty-six' and 'fifty-three'.



(a) Primary dentition

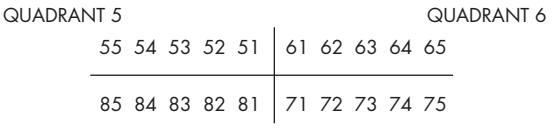


(b) Permanent dentition

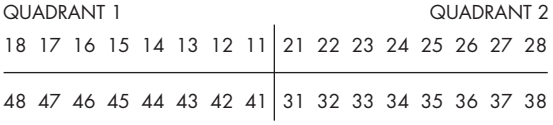
Figure 3.4 Traditional notation system.

Table 3.2 Quadrants in the International Tooth Numbering System

1	upper right quadrant, permanent dentition
2	upper left quadrant, permanent dentition
3	lower left quadrant, permanent dentition
4	lower right quadrant, permanent dentition
5	upper right quadrant, deciduous dentition
6	upper left quadrant, deciduous dentition
7	lower left quadrant, deciduous dentition
8	lower right quadrant, deciduous dentition



(a) Primary dentition



(b) Permanent dentition

Figure 3.5 The International Tooth Numbering System.

Tooth development

Teeth usually start erupting at about six months of age with the emergence of the central incisors, followed at about eight months of age by the lateral incisors. The first molars appear at about 12 months of age, the canines at about 18 months of age, and the second molars at about 24 months of age, although there is wide individual variation. As a general rule, lower teeth tend to erupt before the corresponding upper teeth.

Contrary to popular belief, there is little evidence to suggest that the eruption of teeth in children causes systemic illness. As teeth begin to erupt, the shape of the jaw bone changes. Premature loss of primary teeth may adversely affect the subsequent spacing of the permanent teeth and the shape of the jaws.

Teeth are mineralised before eruption, so they are hard enough to withstand the rigours of mastication immediately. Secondary maturation takes place after eruption; this is an important process in increasing their resistance to dental caries (*see* Dental disease *below*). Fluoride is particularly important in this process (*see* Prevention of dental disease *below*).

Teeth may become stained during development as a result of:

- systemic administration of some drugs (e.g. tetracyclines)
- ingestion of high levels of fluoride (*see* Prevention of dental disease *below*)
- systemic illness (e.g. chickenpox or measles).

These are intrinsic stains and cannot be removed from the tooth substance. Pathological lesions (e.g. dental caries or pulp necrosis, *see* Dental disease *below*) may cause intrinsic stains in developed teeth.

The entire set of primary teeth is lost between six and 12 years of age, and replaced by the permanent dentition. This permanent set is not, however, completed until adulthood. The first permanent teeth to erupt are the first molars at about six years of age, followed by the central incisors at about seven years of age. The lateral incisors appear at about eight years of age, and the canines, first premolars and second premolars between nine and 11 years of age. The second molars erupt at about 12 years of age, and the third molars (wisdom teeth) between about 17 and 21 years of age. Human evolution has resulted in a jaw that may be too small to accommodate the full dentition. In many cases, the third molars do not erupt fully but remain impacted; if they cause pain and infection, they must be surgically removed. In some cases, third molars fail to develop at all.

Saliva

Approximately 0.5 to 1.5 litres of saliva is secreted each day. There are three pairs of salivary glands: the sublingual and submandibular glands in the floor of the oral cavity, and the parotid glands (the largest) below each external auditory meatus. Salivary flow is affected by various factors (e.g. age, sex, nutritional and emotional state, time of day and season of the year). Over 50% of unstimulated saliva (resting saliva) is secreted from the submandibular glands, whereas more than 50% of stimulated saliva comes from the parotid glands.

Saliva is formed from serum and composed of water (99.5%) containing dissolved proteins and inorganic ions. The proteins include glycoproteins (mucin), albumins, globulins and enzymes. One major protein component is the enzyme amylase, which initiates digestion of starch in the oral cavity. Antibacterial enzymes are also present. The watery and mucinous character of saliva is important in:

- lubricating the mucous membranes of the oral cavity
- facilitating chewing and swallowing
- assisting speech.

The inorganic component includes bicarbonate, calcium, chloride, magnesium, phosphate, potassium, sodium and sulphate.

The proportions of the different components vary with the source of the saliva and also with the flow rate. This has the effect of changing the pH of submandibular saliva from 6.47 (flow rate of 0.26 mL/minute) to 7.62 (flow rate of 3.0 mL/minute), and of parotid saliva from 5.8 (flow rate of 0.1 mL/minute) to 7.8 (flow rate of 3.0 mL/minute).

Saliva helps maintain oral hygiene and prevent dental disease in several ways:

- the bicarbonate and phosphate content acts as a buffer in acidic environments
- antibacterial enzymes (e.g. lysozyme and lactoperoxidase) control oral bacteria
- inorganic components help re-mineralise tooth enamel and prevent dental caries
- water and mucin assist the tongue in clearing food debris and bacteria from the gingivae and teeth.

Saliva is continuously secreted to keep the mucous membranes moist, but the flow increases dramatically in response to stimulation by food. Heavy secretion of saliva continues after food has been swallowed, to clean the mouth and buffer any acidic components.

Reduced secretion of saliva causes a dry mouth (xerostomia). This may result from certain medical conditions (e.g. anaemia or diabetes mellitus) or as a side-effect of some drugs (e.g. adrenergic neurone blocking drugs, antidepressants, antihistamines, antimuscarinics, anxiolytics, diuretics, hypnotics or lithium). Sympathetic stimulation in response to fear or anxiety causes the glands to stop secreting, giving a characteristic lack of saliva. Radiotherapy to the head and neck can also reduce salivary flow, although it usually returns to normal after a period of months.

Dry mouth may be relieved by administering Artificial Saliva DPF, an inert, slightly viscous, aqueous liquid containing sodium chloride, hypromellose '4500', benzalkonium chloride, saccharin sodium, thymol, peppermint oil,

spearmint oil and amaranth solution. Alternative formulations may be used, and several commercial preparations are available. Frequent sips of cool drinks and sucking pieces of ice or sugar-free pastilles may also be of value.

Dental disease

Two distinct dental diseases may ultimately result in loss of teeth: dental caries and periodontal disease. Both diseases can occur at any age, but dental caries is generally more prevalent in children, and periodontal disease in adults. The aetiology of each disease is different, but the common factor is the presence of bacteria in dental plaque.

Plaque

Plaque is a film of soft material that forms on the teeth, gingivae, restorations and orthodontic appliances. It is composed predominantly of micro-organisms, but other constituents include:

- dietary carbohydrates
- organic acids formed by the bacterial metabolism of carbohydrates
- glucans (dextrans) resulting from the metabolism of dietary carbohydrates by streptococci
- proteins (including enzymes) from saliva
- leucocytes
- toxins from Gram-negative bacteria.

The first stage of plaque formation is the development of the salivary pellicle, a thin layer of mucoproteins derived from the glycoproteins of saliva. Mucoproteins are unstable in solution and adsorb to hydroxyapatite in tooth enamel. Pellicle formation begins immediately after cleaning the teeth, and the whole of the crown, except areas exposed to friction, becomes covered. The pellicle readily takes up extrinsic stains (*see below*). These are not necessarily harmful to the teeth, but are unattractive and generally considered socially unacceptable. The pellicle is very quickly colonised by commensal bacteria to form plaque.

Streptococcus spp. are usually the first bacteria to form colonies on the salivary pellicle, after about three to eight hours. *Streptococcus mutans* is of particular importance. *Actinomyces* spp. may also be found at this stage. After 24 hours, other species, including Gram-negative anaerobes, are attracted and start to multiply. The bacterial composition continues to become more complex, and the earlier species of colonising microorganisms assume less importance. Plaque reaches its mature state after about seven days. Micro-organisms make up about 70%, although the exact composition varies from one area of the oral cavity to another, depending upon the micro-environment and accessibility for cleaning. Mature plaque has a different role from new plaque in the aetiology of dental disease.

Food is not essential for plaque formation, but the presence of dietary sugars, especially sucrose, increases its rate of formation and thickness. Bacteria utilise sugars as an energy substrate, producing extracellular mucilaginous polysaccharides (glucans), which provide the plaque matrix and facilitate the firm adhesion of plaque to the tooth surface.

Plaque is highly tenacious and can only be removed from the teeth by mechanical means (*see* Prevention of dental disease *below*). It forms rapidly over all tooth surfaces after cleaning, and is virtually always present in areas that are difficult to clean. Plaque can only be detected during the initial stages of formation by using disclosing agents (*see* Prevention of dental disease *below*). However, if deposits are allowed to build up, it becomes clearly visible. In the early stages of development, plaque is thought to be cariogenic; mature plaque, however, is more likely to influence the development of periodontal disease.

Staining of the salivary pellicle or plaque may occur. Such extrinsic stains can be removed and should not be confused with permanent intrinsic stains that are part of the tooth substance (*see* Anatomy and morphology *above*). The commonest extrinsic stain is tar from tobacco, usually found on the lingual surfaces of the lower teeth and ranging in colour from light brown to black. The degree of staining generally reflects the standard of oral hygiene rather than the amount of tobacco smoked. Brown-black

stains may occur following use of chlorhexidine mouthwashes, and plaque may become stained a dull yellow by food dyes. Children sometimes have black or green stains; these are thought to be derived from chromogenic bacteria.

Calculus

Dental calculus (tartar or scale) is mineralised plaque, which may occur in any area of the mouth. Prevalence is high in most populations and increases over 30 years of age. Calculus is composed of inorganic salts (70%) plus organic material and micro-organisms (30%). Composition varies with location and the age of the calculus. The organic constituents are similar to those of plaque, and the micro-organisms comparable to those in mature plaque.

Plaque acts as an organic matrix for calculus formation, although the exact mechanism is unknown; it is possible that a plaque component acts as a seeding agent. Calculus provides a hard, rough surface for the formation of more plaque, which is difficult to remove and may itself become calcified; in this way, incremental layers of calculus are built up. Calculus formation usually begins between two and 14 days after the start of plaque development, but may be as early as four to eight hours in some individuals, and does not appear to be dependent on diet.

Calculus above the gingival margin (supragingival calculus) is formed from the minerals in saliva. It is especially prevalent opposite the ducts of the principal salivary glands (i.e. on the lingual surface of lower front teeth and the buccal surface of upper molars). Supragingival calculus is moderately hard and usually white or pale yellow, although it may become stained by tar from tobacco or pigments from food.

Subgingival calculus occurs below the gingival crest. It contains fewer micro-organisms than supragingival calculus, is difficult to remove, very hard, and stained a dark colour by the breakdown products of blood. Previously thought to cause periodontal disease, subgingival calculus is now considered to be merely an indicator of its presence. However, calculus does influence the development of periodontal disease by virtue of the plaque deposits present on its surface.

Dental caries

Definition and aetiology Dental caries destroys the mineralised portion of the tooth, and is one of the most common diseases in western society; prevalence in the UK is particularly high. Once established, the disease process is irreversible; unless treated, it leads inexorably to destruction of the tooth.

Dental caries is a disease of the modern world. Numerous studies have demonstrated that a high sugar diet is implicated in its aetiology, although the exact mechanism remains unclear. However, it is known that sugars alone do not cause dental caries; it is the combination of sugars in the oral cavity and plaque on the teeth. Dietary sugars dissolved in saliva readily diffuse into plaque, where bacteria (particularly streptococci in early plaque) ferment them to produce organic acids (e.g. lactic acid). These acids demineralise tooth enamel and dentine. Bacteria then invade, causing infection and inflammation. The infection progressively destroys the dentine until the pulp is reached. If unchecked, this eventually results in pulp death. Infection then spreads through the apical foramen to the apical part of the periodontal ligament and an abscess may result.

The frequency of sugar consumption has a greater influence than the quantity consumed (National Dairy Council, 1995). However, the quantity consumed is important in increasing plaque thickness and the rate of formation (*see* Plaque *above*). The incidence of caries is higher in children and adolescents than in adults because secondary maturation of dental enamel gradually increases its resistance to acid attack. Fluoride also increases the resistance of enamel.

Several host factors may influence the initial development of caries or the rate of decay. The structure of teeth varies between individuals, and the presence of deep fissures and pits predisposes to caries formation. The chemical composition of enamel also varies, and some people have teeth that are more resistant to acid attack than others. Crowded or badly aligned teeth render good

plaque control difficult; the resultant stagnation areas are more susceptible to caries.

Although dental caries may attack any surface of the tooth, more than 50% of lesions affect the occlusal surfaces of back teeth, with marginally more occurring in the upper arch than the lower. First molars appear to be more susceptible than other teeth, whilst the lowest prevalence is in lower incisors and canines. There are three types of caries:

- Pit and fissure caries
  Lesions that occur in pits and fissures are the most common type of caries. The initial break in the enamel is seen as a small black pit, which may extend into dentine. The underlying dentine is destroyed more quickly than enamel, and eventually a bluish-white area appears around the initial pit. The enamel collapses as more of the underlying dentine is destroyed, and the later stages are marked by an open cavity.
- Smooth surface caries
  Smooth surface caries is the least common. It can occur on any smooth surface, but particularly on the proximal surfaces between teeth. Lingual surfaces are affected less frequently than buccal or labial surfaces. The lesion initially appears chalky-white, becoming gradually rougher as the enamel starts to break down. The subsequent stages are the same as in pit and fissure caries.
- Cervical caries
  Cervical caries is more common in older people. It attacks exposed dentine at the neck of the tooth, where the crown meets the root. As there is no enamel at this point, an open cavity is formed from the beginning. The subsequent stages are as described above under pit and fissure caries.

On average, it takes about two years for a cavity to be clinically visible in permanent teeth, although there is wide individual variation. The time span may be as short as three months in primary teeth.

Rampant caries ('dummy' caries or 'bottle' caries) occurs in infants allowed to suck comforters (dummies) coated with sugary substances (e.g. honey, jam or undiluted fruit syrups). Drinking concentrated sweetened liquids from feeding bottles produces the same effect. Such practices allow prolonged contact between the teeth and sugar, resulting in severe and extensive caries affecting several teeth, particularly the upper incisors.

The properties of saliva (e.g. mineral composition, viscosity and rate of production) vary between individuals, affecting their susceptibility to caries. Saliva is the body's natural means of cleaning and buffering the oral cavity. It is also involved in the re-mineralisation of enamel, which can reverse early dental caries (*see below*). Xerostomia, caused by a reduction in salivary secretion (*see* Anatomy and morphology *above*), is associated with an increased incidence of caries.

Symptoms The initial stages of dental caries are asymptomatic. Pain is first felt when dentine is exposed during the open-cavity stage, although there is wide variation in the degree of pain experienced. Short-term pain on exposure to heat, cold or sweet substances during the early stages of decay indicates that prompt treatment may save the pulp from irreversible damage.

Inflammation of the pulp (pulpitis) produces swelling of the pulp tissue in an enclosed area. This sometimes results in a throbbing pain that is exacerbated by heat and relieved by cold. Pain lasting for some time (e.g. up to 20 minutes) indicates that damage to the pulp is irreversible. Severe pain that is unconnected with any stimuli or disturbs sleep signifies extensive decay. If untreated, the pain eventually subsides once pulp necrosis occurs, because of degeneration of the nerve supply. However, the infection may spread through the apex and cause inflammation of adjacent tissues. A periapical abscess may then occur, which can be extremely painful during the acute phase as pressure builds up in the enclosed space around the apical foramen. The pain is exacerbated by pressure on the tooth and subsides once the pus has discharged.

Treatment Early dental caries is reversible because minerals present in saliva allow re-mineralisation of the enamel to take place. The organic matrix is still intact at this stage, which allows the deposition of further crystals. Once the matrix collapses, this is impossible.

Re-mineralisation is more likely to be successful if further acid attack is kept to a minimum by strict plaque and dietary sugar control. Fluoride is highly beneficial in re-mineralisation (*see* Prevention of dental disease *below*), as it converts the inorganic hydroxyapatite in enamel to the more resistant fluorapatite.

Irreversible caries may require a variety of treatments, including:

- restorations (fillings)
- root canal treatment (endodontics)
- crowns or bridges
- extraction.

Analgesics may be given for pain relief until dental treatment is available, but controlling the pain does not in any way control the disease, and dental referral should not be delayed longer than necessary. For measures to prevent dental caries, *see* Prevention of dental disease *below*.

Periodontal disease

Definition and aetiology Periodontal disease encompasses several inflammatory disorders which affect the supporting structures of the teeth. It is one of the most common conditions in the world, affecting the vast majority of people at some stage in their lives. Chronic periodontal disease is slow, insidious and usually painless, but the eventual result may be destruction of the underlying bone. It causes the loss of more teeth than dental caries because the supporting structures cannot be repaired as effectively as teeth can be restored.

Like dental caries, periodontal disease is caused by plaque bacteria. However, diet is not thought to be an important factor in its development, and dental caries is not a cause; completely undecayed teeth can be affected. Plaque deposits around the gingival margin and within the gingival crevice are most important in the aetiology of periodontal disease.

Where inflammation is confined to the gingivae, the condition is called gingivitis. Spread of inflammation to the periodontal ligament and alveolar bone is termed periodontitis. Chronic gingivitis precedes chronic periodontitis, but does not always lead to it. The reason why some cases progress and others do not is not known. Prevention of chronic gingivitis therefore prevents chronic periodontitis. Gingivitis may also be an acute condition, but, unlike chronic gingivitis, this is always painful.

Chronic gingivitis

Definition and aetiology Chronic gingivitis is the result of inflammatory changes produced in the gingivae by endotoxins and enzymes from plaque bacteria. Undisturbed plaque deposits may cause the initial inflammatory reaction within two to four days.

Some medical conditions (e.g. diabetes mellitus, leukaemias and scurvy) may increase the risk of chronic gingivitis. The precise mechanism for this is unknown, but it may be a result of altered host response to bacterial products (e.g. toxins and enzymes). Administration of some drugs (e.g. cyclosporin, nifedipine, oral contraceptives or phenytoin) may also predispose to gingivitis. In some cases, these may cause severe gingival hyperplasia in which the gingivae cover most of the crown of the tooth. Any disorder or drug which reduces salivary secretion increases the susceptibility to chronic gingivitis (*see also* Dental caries *above*).

People who habitually keep their lips apart, particularly when asleep, show a greater incidence of inflammation of the anterior gingivae, most likely as a result of excessive drying of the tissues. Smokers are also more susceptible; it is not certain whether this is caused by tobacco smoke or poor oral hygiene, which has been shown to be greater in smokers than non-smokers.

Pregnant women are more susceptible to gingivitis ('pregnancy gingivitis') as a result of hormonal changes affecting connective tissues, including those of the gingivae. Some pregnant women may even complain of loose teeth. Scrupulous oral hygiene will prevent pregnancy gingivitis, and the tissues revert to normal after parturition. Puberty is also commonly associated with an increased incidence of gingivitis; again it is not clear whether this is associated with hormonal changes or poor standards of oral hygiene.

Symptoms Inflammation results in oedema, causing the gingival crevice to deepen and

pockets to develop between the gingivae and the teeth. At this stage, these are called 'false pockets'; they should not be confused with the true periodontal pockets of chronic periodontitis (*see below*). The epithelium of the crevice becomes ulcerated. Subgingival plaque accumulates in the deepened crevices, and bacterial products produce further inflammation. A vicious cycle is set up, which causes the crevices to enlarge further.

In the presence of gingivitis, gingival crevicular fluid exudes through the junctional epithelium into the gingival crevice. This cannot be detected by the patient, but can be measured using crevicular strips (small filter paper strips), and is an indicator of the extent of inflammation. Crevicular fluid contains immunoglobulins (IgA, IgG and IgM) and neutrophils (polymorphonuclear leucocytes), which may exert a protective effect.

The outward symptoms of chronic gingivitis are mild, so many sufferers do not realise they have the condition. Established chronic gingivitis is marked by changes in appearance: the gingivae become reddened, glossy, soft and swollen. Halitosis may also be present. Pain is usually absent, although abrasive food or vigorous toothbrushing may produce discomfort. The main symptom, bleeding gums, is all too often attributed to toothbrushing trauma and ignored.

Treatment Mild chronic gingivitis can be treated by good plaque control (*see* Prevention of dental disease *below*). The only dental treatment required may be oral hygiene instruction, but it is wise to refer patients to their dentist. In many cases, scaling is necessary. This involves the removal of plaque and calculus from the crown and exposed root surfaces. The surfaces are then polished to remove any rough areas that may attract plaque accumulations. For measures to prevent chronic gingivitis, *see* Prevention of dental disease *below*.

Chronic periodontitis

Definition and aetiology Chronic periodontitis, which is always preceded by chronic gingivitis, results in irreversible damage to the periodontal ligament and alveolar bone. It is rare in children under 13 years of age, but becomes more common from the late teens onwards. It is the most common cause of loss of teeth in patients over 30 years of age.

Symptoms Inflammation spreads through the gingival crevice and eventually destroys the periodontal ligament, with the junctional epithelium moving downwards onto the root. A true periodontal pocket is formed and gingival recession may occur, exposing the coronal portion of the root. As periodontal pockets deepen, plaque and debris can collect within them, exacerbating the inflammatory process. The depth of the pockets may be measured using a dental probe and indicates the progression of the disease. Further spread of inflammation to the supporting bone causes resorption, which eventually loosens the teeth.

Many symptoms of chronic gingivitis are present. As the periodontal pockets deepen, however, the swelling and reddening of the gingivae may subside, leading to the mistaken belief by the patient that the gingivitis has resolved. In fact, inflammation is still present, but is now much deeper in the tissues. Chronic periodontitis eventually causes extensive damage that is largely irreversible, and patients should seek treatment at the earliest opportunity (Figure 3.6).

Treatment Treatment of chronic periodontitis is similar to that of chronic gingivitis (*see above*). It involves thorough scaling and polishing, usually over several appointments. Root planing to clean the roots and remove infected cementum is usually necessary. In severe cases, where periodontal pockets are very deep, surgery may

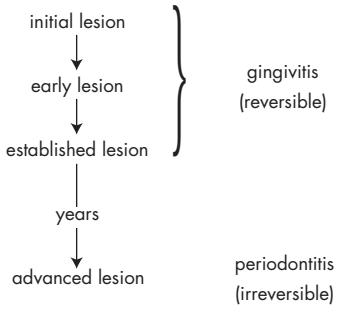


Figure 3.6 The chronological progression of gingivitis to periodontitis.

be required to reshape the gums and facilitate routine plaque removal by the patient. In the last few years, it has become possible to replace lost alveolar bone by sophisticated techniques (e.g. periodontal bone grafting and guided tissue regeneration), but these are highly specialised and not widely available.

Chlorhexidine mouthwash or gel may be useful to control plaque deposition, but is no substitute for toothbrushing. It is not recommended for long-term use, may stain the teeth, and should be restricted to the treatment phase.

Treatment of chronic periodontitis may be a long process, and is heavily dependent on improved home dental care by the patient. Oral hygiene measures alone will not arrest chronic periodontitis, but serve as a valuable adjunct to periodontal treatment and are essential to prevent further disease. Corrective measures (e.g. restorations or orthodontic procedures) in areas prone to plaque accumulation may also be beneficial. For measures to prevent chronic periodontitis, *see* Prevention of dental disease *below*.

Periodontal abscess

Definition and aetiology A periodontal abscess may develop from a periodontal pocket which becomes blocked with exudate or a foreign body (a lateral periodontal abscess). Alternatively, infection of the pulp may spread through the apical foramen (periapical periodontal abscess).

Symptoms Both types of periodontal abscess present with a throbbing pain, exacerbated by pressure on the tooth involved. Gingivae in the area of the abscess become red and swollen; this may spread to surrounding tissues (e.g. the cheeks or lips). Once pus has discharged, the acute phase subsides and, if untreated, often leads to a painless chronic abscess which may continue to exude pus. Abscesses cause further resorption of the surrounding bone.

Treatment Treatment of periodontal abscesses may involve drainage, mouthwashes and administration of antibiotics. Root canal therapy, extraction or periodontal surgery may subsequently be required.

Juvenile periodontitis

Definition and aetiology Juvenile periodontitis (periodontosis) is a chronic periodontal disease occurring in adolescents and young adults. Its development appears to be independent of the level of oral hygiene. The cause of this severe chronic periodontal disease is not known, although it has been suggested that the bacterial flora in the mouths of sufferers may be excessively virulent.

Symptoms The features of juvenile periodontitis appear similar to chronic periodontitis, but its early onset and associated bone loss make it a more serious condition. Pain is usually absent unless a lateral periodontal abscess develops. The most common presenting features are drifting of teeth and localised periodontal pockets. These are usually only apparent during dental examination; radiographs may also show severe bone loss. The disease often progresses relentlessly despite dental intervention, and the prognosis for affected teeth is not good.

Treatment Treatment is similar to that for chronic periodontitis, but more follow-up examinations are required to monitor progress of the disease. Periodontal surgery is not always successful. Treatment may have to rely on strict plaque control measures plus frequent scaling, root planing and polishing. Chlorhexidine solution is only of value if it can penetrate the periodontal pockets, which in juvenile periodontitis are very deep; use of a syringe with a suitable nozzle may be required.

Primary herpetic gingivostomatitis

Definition and aetiology Primary herpetic gingivostomatitis is an acute gingivitis occurring mainly in children between six months and five years of age. It is caused by a primary infection with herpes simplex virus type 1 (HSV 1). On recovery, the virus lies dormant in the ganglia of the trigeminal nerve and produces latent herpes labialis (cold sores) in response to various stimuli (e.g. emotional disturbance, fever, menstruation, sunlight or local trauma).

Symptoms Symptoms include fever, malaise, gingivitis, pharyngitis and generalised adenopathy. Vesicles appear all over the oral cavity and on the lips, rupturing to form excessively painful ulcers. Accompanying symptoms may include profuse salivation and halitosis. The child appears unwell, irritable, unable to eat, and has a high temperature.

Treatment The condition is self-limiting, and untreated ulcers heal without scarring within 14 to 21 days. Treatment is not generally given for primary HSV 1 infection, but measures that may be taken to relieve the discomfort include paracetamol for pain, bland mouthwashes and soft food. Chlorhexidine mouthwash or gel may be of value as an alternative to toothbrushing until the pain subsides. Where secondary infection occurs, systemic antibiotics may be necessary.

Acute ulcerative gingivitis

Definition and aetiology Acute ulcerative gingivitis (acute necrotising ulcerative gingivitis, trench mouth or Vincent's disease) is an acute, destructive, ulcerative condition affecting the gingivae. It occurs most commonly between 14 and 30 years of age. The micro-organisms most often present are fusiform bacilli and spirochaetes, but the evidence suggests that these are not the causative agents. Predisposing factors are stress, worry, and fatigue. After an initial attack there is a strong tendency for recurrence.

Symptoms Acute ulcerative gingivitis is of sudden onset, usually begins in the gingival papillae, and may extend throughout the gingivae. It is characterised by general malaise, marked gingival bleeding, inflammation and swelling. Fever is generally absent, but the pain may be so severe as to render eating and talking impossible. Halitosis and excessive salivation are also common. Characteristic 'punched-out' grey ulcers, which bleed readily, often develop at the crest of the gingival papillae. These ulcers develop a pseudomembrane composed of a necrotic grey slough.

Treatment Treatment comprises the administration of metronidazole or nimorazole in conjunction with local debridement of necrotic and infected tissue. Hydrogen peroxide mouthwashes may be used between dental appointments, and the patient should be fully instructed in good oral hygiene procedures. All patients should be followed up regularly as tissue destruction may make subsequent plaque removal difficult in some areas.

Tooth wear

Definition and aetiology Recent evidence suggests that tooth wear is now a significant problem in both children and adults (Smith, Bartlett and Robb, 1997). It is rarely possible to differentiate between the different aetiological factors, but the dental profession is particularly concerned about dental erosion. This may be defined as the progressive loss of hard dental tissues caused by the action of acids on the teeth, without the involvement of bacteria.

Erosion may result from occupational exposure to acid fumes or chronic contact with gastric acid as a result of frequent vomiting or oesophageal reflux. However, the frequent ingestion of dietary acids, in the form of carbonated drinks and fruit juices, is now considered to be of major importance, particularly in children. The extent of the problem was measured by the 1993 Child Dental Health Survey. 52% of children of five and six years of age had erosion of the deciduous incisors, and the permanent teeth of more than 30% of those of 14 years of age were affected (Office of Population Censuses and Surveys, 1994).

Prevention and treatment Prevention consists of reducing the frequency of contact with the causative agent, where this can be identified. Teeth that are severely worn may require extensive restoration work.

Gingival recession

Definition and aetiology Gingival recession may occur in healthy mouths, even in the young. Recession can take place around teeth that have a thin bone covering, teeth that are subject to excessive biting forces or where there are bony defects. Trauma produced by

over-zealous toothbrushing may exacerbate this process.

Symptoms The gingivae are pushed back and the underlying cementum is worn away to expose dentine. This may cause increased sensitivity and pain, particularly on exposure to heat, cold or sweet substances. Gingival recession can increase the risk of developing root caries.

Treatment The primary cause of recession should be eliminated where possible. For example, selective grinding by the dentist is an effective way of equalising biting forces and reducing excessive loading on an individual tooth. Desensitising toothpastes (*see* Prevention of dental disease *below*) may be used to reduce the sensitivity of the dentine. Topical application of such a toothpaste directly to the sensitive area may also be beneficial. Fluoride varnishes may be applied by the dental surgeon to promote remineralisation of the exposed dentine. The patient should be encouraged to adopt a less vigorous toothbrushing technique to prevent further recession.

Halitosis

Definition and aetiology Halitosis (bad breath) is characterised by an offensive breath odour. It is highly prevalent and is a source of social embarrassment to many.

Halitosis is often a symptom of periodontal disease. However, abnormal breath odours are produced by elimination of certain substances via the lungs, and may be a symptom of systemic disease (e.g. ketones in uncontrolled diabetes mellitus or ammoniacal compounds in uraemia). However, in the majority of cases, halitosis results from anaerobic bacterial putrefaction in the oral cavity and is not caused by systemic disease. Malodorous breath may also arise following smoking, alcohol consumption or ingestion of certain foods (e.g. garlic).

Treatment Halitosis may be controlled by minimising the oral bacterial population. All measures advocated to reduce the level of gum disease and hence bleeding (*see* Prevention of dental disease *below*) will also improve breath odour.

Mouthwashes (*see* Prevention of dental disease *below*) are often used to freshen the breath, although their value in treating halitosis is questionable.

Prevention of dental disease

Dental disease may not be life-threatening, but it can severely affect the quality of life. Loss of many or all the permanent teeth necessitates the use of dentures, which can create a different set of problems. For the young, the social stigma of wearing dentures is now much greater than in the past, when the wholesale loss of teeth was common.

Lost teeth which are not replaced by dentures create problems for the remaining teeth, and may even alter the shape of the jaw. Adjacent teeth tend to tilt or drift into the gaps, which may alter the biting pattern. Loss of one tooth from a complementary pair may limit chewing movements because the remaining tooth has nothing to bite against, and it often over-erupts. There is also the psychological aspect of altered appearance, because gaps in the permanent dentition are not generally considered attractive. Premature loss of primary teeth may affect the spacing of the subsequent permanent teeth and influence jaw development.

Decayed teeth may be restored if treated in time, but scrupulous dental healthcare is essential to save them from further damage. Secondary caries may form around the margins or underneath a filling if bacteria and sugar can gain access. Should this occur, the tooth must be refilled. Subsequent fillings are larger, and eventually the tooth may need to be crowned or even extracted.

It is absolutely essential that the gingivae are in peak condition before advanced dentistry is carried out, because the position of the gingival margins is used as a reference point. Inflamed gingivae may be swollen and cover more of the crowns of the teeth than normal. If the inflammation subsequently subsides following improvements in dental healthcare, the margins

may recede to a more normal position and, for example, expose the edges of crowns and bridges.

Almost all dental disease is completely preventable, but this requires a high degree of motivation on the part of the individual. The only passive measure available is water fluoridation, which reduces the incidence of dental caries but not periodontal disease. Both caries and chronic periodontal disease are painless conditions until the later stages, by which time irreversible damage has already occurred. Many people are unable to appreciate that a problem exists if there are no outward signs and symptoms. Consequently, they cannot easily be convinced of the need to take preventive measures. This represents one of the greatest barriers to be overcome in dental health education.

Plaque control

Plaque control is the basis of prevention of dental disease. Plaque bacteria, particularly those of mature plaque, are responsible for the vast majority of periodontal disease; therefore, prevention is aimed at keeping the level of plaque to an absolute minimum. The role of plaque in dental caries is more complex because it is the combination of sugar and plaque that results in tooth decay (*see* Dental disease *above*). Theoretically, if plaque were removed from the teeth immediately before consuming sugar, dental caries would not develop. However, for most people this is totally impractical. It is also unlikely that the teeth are ever completely plaque-free, because plaque forms extremely rapidly after cleaning, and some areas are inaccessible. Prevention of caries must, therefore, combine both good plaque control and sugar control.

The most effective means of removing plaque from teeth is with a toothbrush; invariably, toothpaste is used as well. Regular toothbrushing is begun by many people when young and continued throughout life. However, in many cases, the brushing regimen is inadequate for complete plaque control. Some areas of the dentition cannot be reached by a toothbrush, and additional methods (e.g. dental floss or interproximal brushes) must also be employed.

Disclosing agents

Plaque cannot readily be seen on teeth, making it difficult to convince an unwilling or sceptical person of its presence. A disclosing agent that stains plaque should be recommended. Various proprietary disclosing tablets and fluids are available. Some can distinguish between new and mature plaque, staining each a different colour. Re-application after brushing serves to illustrate the effectiveness of brushing technique and highlight areas where improvements may be required. Patients should be advised to smear white soft paraffin on their lips, to prevent discoloration by the dye contained in the disclosing agent.

Toothbrushing

Toothbrush design

Selecting a toothbrush can be daunting when faced with the vast array of designs available, backed up by impressive claims from manufacturers. In reality, there is no general consensus of opinion on the best design for a toothbrush, and the ultimate selection is based on personal preference. However, certain factors may help when making a choice.

Nylon bristles are preferable to natural bristles because they do not absorb fluids or harbour micro-organisms as readily, and the control of bristle quality during manufacture is easier. Natural bristle toothbrushes also have the disadvantage that they become soft (and therefore less effective) when wet. Multi-tufted, small bristles are better than fewer, larger bristles. Rounded ends to the filaments generally offer no major advantage over cut ends, although they may prevent soft tissue injury by over-enthusiastic toothbrushers.

Soft-texture brushes are less efficient in removing plaque than medium brushes, but may be of value for those with sensitive teeth, painful gum dis-orders or gingival recession. Hard brushes should be avoided because they may cause gingival trauma or recession. The brush-head should be small enough to reach awkward areas, but not so small that effective plaque removal requires prolonged brushing. A medium-sized brush-head with multi-tufted nylon bristles of medium texture is probably the best choice for most adults.

Interproximal brushes or brushes shaped like miniature bottle brushes may be required for extremely awkward areas (e.g. badly aligned teeth or bridges) or large interdental spaces.

Electric brushes can be particularly valuable for people with mental or physical disabilities. When used by the able-bodied, there is no evidence that they are intrinsically superior to manual toothbrushes, but they can achieve effective plaque removal much more quickly. Many people, especially children, find them pleasant to use, and are therefore more likely to maintain a satisfactory oral hygiene regime. Rechargeable electric toothbrushes are considered preferable to battery-operated brushes, which lose torque quickly.

Toothbrushes should be renewed relatively frequently. A worn toothbrush cannot effectively remove plaque, but there is no simple means of detecting when a toothbrush is past its prime. It has been estimated that the lifespan of a toothbrush being used correctly is probably only a few weeks.

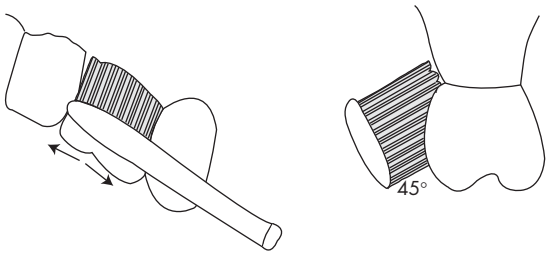


Figure 3.7 The Bass method.

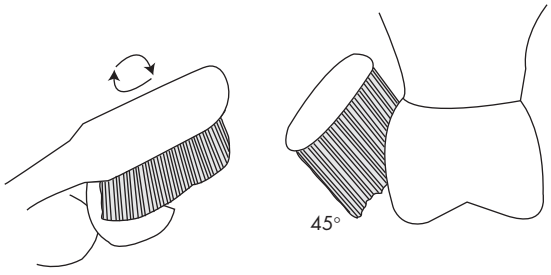


Figure 3.8 The Charters method.

Toothbrushing technique

The aim of toothbrushing is to remove plaque and food debris; it can also deliver the topical fluoride in toothpastes to the teeth. Toothbrushing technique has been the subject of much argument and many suggestions have been put forward. However, different dentitions may require different techniques; any technique that results in good plaque control without causing damage to the teeth or soft tissues can be regarded as satisfactory.

Two of the most frequently recommended techniques are the Bass and Charters methods. In the Bass method, the head of the brush is applied at an angle of 45° to the long axis of the teeth and pressed in an apical direction against the gingival margin (Figure 3.7). It is then moved anteroposteriorly with short vibratory strokes. In order to gain adequate access to the lingual surfaces of the anterior teeth, the brush must be turned into a vertical position. This method effectively removes soft deposits located above and below the gingival margin.

In the Charters method, the head of the brush is applied to the teeth at an angle of 45° to the occlusal plane (Figure 3.8), and jiggled back and forth in a circular motion. It is particularly useful if the interdental papillae have receded, leaving the proximal surfaces of the teeth accessible to the toothbrush.

Whichever technique is used, the most important factor in toothbrushing is that every accessible surface of every tooth should be thoroughly cleaned during each session. Many people concentrate on the buccal and labial surfaces, but forget the lingual and occlusal surfaces. It is helpful to divide the dentition into sections and concentrate on one section at a time. Patients who are concerned about their toothbrushing technique should be referred to their dental surgeon for evaluation.

Toothbrushing frequency

The most widely accepted routine is once in the morning and once at bedtime. Some authorities also advocate brushing the teeth after lunch, but this is probably not practical for many people. The thoroughness of plaque removal is more important than the frequency; nothing is gained by several cursory attempts at toothbrushing throughout the day.

Toothbrushing before bed is important to

prevent the reduced salivary flow during sleep allowing the build-up of thick plaque deposits. Therefore, removing as much plaque and debris as possible before sleeping considerably reduces overnight plaque levels. Theoretically, the best time to brush teeth would be before eating, because sugar is only cariogenic in the presence of plaque. In practice, plaque is unlikely to be completely removed, so it is probably best to recommend toothbrushing after meals, to remove plaque and sugars together.

However, toothbrushing should be avoided immediately after consuming acidic foods or drinks, and after vomiting. This is because at this point the enamel is particularly delicate, being in the first stages of acid attack. After approximately 30 minutes, the enamel is stabilised as a result of re-mineralisation.

Toothpaste

A toothpaste (dentifrice) is applied with a toothbrush to clean the teeth, but the action of the toothbrush is far more important than the toothpaste. It has even been suggested that toothpaste is not necessary for plaque removal. However, toothbrushing with water alone is of little benefit in stain removal. Toothpastes also polish the tooth surfaces, and plaque forms less readily on smooth surfaces than rough surfaces. Many people like the freshening effect toothpaste has in the mouth, particularly first thing in the morning.

Toothpastes are composed of the following ingredients:

- humectants, which prevent the toothpaste drying out, control microbial growth and provide a vehicle for the other ingredients
- abrasives, which polish the tooth surface and remove debris, plaque and stains
- surface-active agents, which loosen debris and facilitate its removal
- binders and thickeners, which prevent separation of the aqueous and non-aqueous constituents and thicken the formulation
- flavourings, which improve consumer acceptability, thereby increasing the likelihood of patients maintaining good plaque control
- colourings, used to improve appearance and consumer acceptability.

Toothpastes may act as vehicles for active ingredients. About 95% of all toothpastes sold in the UK contain fluoride (*see below*) in the form of sodium fluoride or sodium monofluorophosphate (MFP). The fluoride content of toothpaste is usually about 0.1%. Fluoride-containing toothpastes deliver fluoride to the enamel surface, which is extremely important in preventing dental decay. Desensitising toothpastes contain various compounds to block the perception of painful stimuli by dentine. Chlorhexidine (*see below*) inhibits plaque formation on the teeth and is included in toothpaste indicated for the control of gingivitis.

Most people cover the entire brush head with toothpaste, which is far in excess of the quantity needed. All that is required is an amount the size of a pea. Too much toothpaste generates a lot of foam and induces a premature desire to spit and rinse. For many people, this signals the end of toothbrushing. Ingestion of too much fluoride toothpaste by children, who swallow much more than adults, could possibly result in fluorosis, particularly if fluoride supplements are also being administered.

Dental floss and interdental woodsticks

Dental floss and interdental woodsticks are used to remove plaque from the areas between the teeth (embrasures) where a toothbrush cannot reach. These areas should be cleaned regularly, but not every time the teeth are brushed; once a day should be sufficient.

Dental floss

Dental floss is available in waxed or unwaxed forms; the choice is one of personal preference. Unwaxed floss splays out in contact with the tooth surface and may be more efficient at removing plaque. It may also be easier to pass through tight interdental spaces. However, the loose threads may tear against the margins of fillings, in which case waxed floss may be preferable. Dental tape, which is wider than dental floss, is also available, and special types of floss are manufactured for cleaning bridges. Correct use of floss may remove some subgingival plaque.

A long piece of floss (approximately 30 cm) should be wound around the first two fingers of each hand, leaving approximately 10 cm in

between. The floss is held taut and carefully inserted into the space between two teeth. It is then held firmly against one of the teeth and carefully moved vertically up and down to remove the plaque. This is repeated for the tooth on the other side of the space. On no account should the floss be moved horizontally between the teeth; this can severely damage the gingivae. The procedure is repeated until all the teeth have been thoroughly cleaned.

An alternative method of using dental floss involves tying a length of floss (approximately 15 cm) into a loop. The lower teeth are cleaned by holding the floss between both index fingers. The left thumb and right index finger are used to clean the upper left quadrant, and the right thumb and left index finger to clean the upper right quadrant.

Interdental woodsticks

Interdental woodsticks should not be used without proper instruction from a dentist as they can cause tissue damage. They are less effective than floss and do not remove subgingival plaque; they should not be used where teeth are closely positioned.

Interdental spaces can be cleaned by inserting and manipulating the woodstick, taking care to follow the normal contour of the interdental papillae (Figure 3.9). The mouth must be clean and the gingivae healthy; rubbing inflamed gingivae over subgingival calculus will exacerbate periodontal disease. Regular use of woodsticks can improve the shape of the interdental papillae and reduce food stagnation.

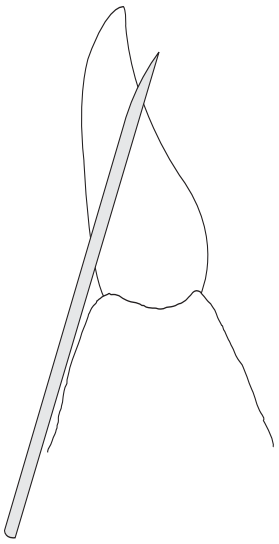


Figure 3.9 The woodstick should follow the gingival contour.

Water irrigation

Water irrigation units direct jets of water at and between the teeth, and are promoted for plaque removal. However, plaque is an extremely sticky, tenacious substance and is unlikely to be removed by water alone. Water irrigation units are ineffective in removing stains from tooth surfaces. It is also possible that the water jet could force bacteria into the crevicular epithelium and the underlying connective tissue. Any resultant bacteraemia would pose a serious risk for patients susceptible to bacterial endocarditis (e.g. those with a history of rheumatic fever).

Mouthwashes

Mouthwashes are liquid preparations containing many of the same constituents as toothpastes (*see above*). Essential differences are the exclusion of abrasives and thickening agents. They may, in addition, contain antibacterial agents, astringents, demulcents or ethanol. Antibacterial mouthwashes may help control gingivitis, but not periodontitis; however, the evidence is not conclusive, except for chlorhexidine. Mouthwashes do assist in the removal of debris, tenacious mucus and purulent secretions, and in the cleansing of traumatised areas (e.g. aphthous ulcers).

Patients using mouthwashes to treat oral lesions should be referred to their doctor or dental surgeon if the condition persists for more than seven days; severe cases should be referred immediately. Anti-plaque mouthwashes intended to loosen plaque before toothbrushing have been developed, although the evidence for their effectiveness is inconclusive.

Chlorhexidine

Chlorhexidine is a cationic antibacterial agent available in a mouthwash or dental gel. Chlorhexidine gluconate has proven activity against plaque

bacteria and prevents the build up of plaque deposits. However, it is not an effective substitute for toothbrushing, except for short-term use in painful oral conditions (*see* Dental disease *above*). In some cases, chlorhexidine stains the teeth a blackish colour along the gingival margins.

Hydrogen peroxide
The antimicrobial action of hydrogen peroxide is negligible.

Sodium chloride
A sodium chloride mouthwash can be prepared by dissolving half a teaspoon of salt in a tumblerful of warm water, or by diluting Compound Sodium Chloride Mouthwash BP in an equal volume of warm water. It is particularly useful in promoting healing (e.g. of extraction sockets and aphthous ulcers) and establishing the drainage of pus.

Sodium bicarbonate
Sodium bicarbonate may be used as a 2% solution to rinse the mouth. Its alkalinity makes it an effective mucolytic agent, but it does not have any antibacterial action.

Prevention of dental caries

Dietary management

Dental caries is unlikely to be prevented by plaque control alone; a reduction in sugar consumption is also important. Soft, sticky foods release sugars over a long period of time by clinging to tooth surfaces. Also, different sugars affect pH to varying degrees: lactose and galactose cause a smaller fall in pH than glucose, maltose, sucrose or fructose. There is no difference in cariogenic potential between refined and unrefined sugars, or some 'natural' (e.g. honey) and processed products. All should be avoided as far as possible. Fruits and vegetables are a preferred alternative to cakes, biscuits, puddings, confectionery and any other foods with a high sugar content.

Animal studies suggest that complex carbohydrates may be cariogenic, although to what extent is not known. However, suggesting that these should also be avoided would contradict the advice given to prevent other disorders. A compromise must be made so that the health of the body as a whole is considered. Thus, it is recommended that the frequency of carbohydrate consumption, rather than the amount, should be reduced. If snacks are eaten between meals, they should consist of non-sticky savoury rather than sticky sweet foods, but it must be borne in mind that sugar is also present in many processed savoury foods.

Non-cariogenic sugar substitutes may be used, although it is probably wiser to attempt to do without sweet foods and drinks. Sugar alcohols (e.g. sorbitol, mannitol and xylitol) are available; they are not as cariogenic as sugars because plaque bacteria are less able to utilise them as substrates to produce energy. However, large quantities cause osmotic diarrhoea, and the daily intake should not exceed 50 to 80 g. Hydrogenated glucose syrups are licensed for use in the UK, and available evidence suggests that they are less cariogenic than sucrose.

Fluoride

In the early 1900s, it was noted that the inhabitants of certain areas of America had mottled teeth. This was eventually found to be caused by increased levels of fluoride in the local drinking water; the condition was therefore called fluorosis. These people had a lower prevalence of dental caries than the population as a whole. Similar observations were made in the UK and elsewhere; children living in areas supplied with water containing a high level of natural fluoride had healthier teeth than those in areas whose water had a low fluoride content. The role of fluoride in the prevention of dental caries was investigated; worldwide epidemiological studies confirmed that caries is reduced in areas where the water supply contains at least 1 mg/L (1 ppm) of fluoride. However, concentrations of fluoride above 1 mg/L may cause fluorosis. Fluoride is also present in many foodstuffs, but significant amounts are found only in tea and the bones of sea-fish.

There is a strong anti-fluoridation lobby in the UK, which objects to fluoridation of water supplies on the grounds that it is dangerous, unnecessary, uneconomic and of negligible benefit. Careful and controlled studies have refuted all

these claims, and fluoridated water has been shown to be safe and effective. However, most of the UK population does not benefit from fluoridated water supplies. This contrasts starkly with other nations (e.g. Russia and the USA) where fluoridation is widespread; it is mandatory in the Republic of Ireland.

Fluoride is effective both topically and systemically (Duckworth, 1993). The topical effect is now considered more important as the greatest concentrations of fluoride are found at the tooth surface. There are several theories to explain the mode of action of fluoride. The most popular is that the calcium hydroxyapatite in enamel is replaced by calcium fluorapatite. This has a lower critical pH and therefore increases the resistance of enamel to acid attack. Fluoride is also important in re-mineralisation and the reversal of early caries, especially smooth surface caries. Fluoride can block the enzymes of plaque bacteria and may inhibit the metabolic conversion of sugars to acids. Application of topical fluoride can re-mineralise enamel and completely reverse the development of early carious lesions; it may also arrest, or slow down, the progress of later lesions. There is some evidence that the presence of systemic fluoride during tooth development results in a smoother, less fissured morphology that is less susceptible to caries.

Oral fluoride supplements containing sodium fluoride may be given to children living in areas where the level of fluoride in the water is less than 1 ppm. Pharmacists should check the level with the water authority, and issue the following guidelines when selling fluoride supplements. Doses are expressed as the amount of fluoride ion to be taken daily. These guidelines are for temperate climates; the dose may be less in tropical climates where more water is consumed.

- Fluoride level less than 300 µg/L (0.3 ppm)
  six months to two years of age – 250 µg
  two to four years of age – 500 µg
  more than four years of age – 1000 µg
- Fluoride level of 300 to 700 µg/L (0.3 to 0.7 ppm)
  less than two years of age – no supplementation required
  two to four years of age – 250 µg
  more than four years of age – 500 µg
- Fluoride level above 700 µg/L (0.7 ppm)
  no supplementation required.

These doses take into account the small amount of fluoride ingested during toothbrushing. Two divided doses should be administered each day to avoid the plasma concentration peaking at a value that could cause fluorosis. However, this requires a high degree of motivation, and once daily administration (preferably in the evening) is an effective compromise; forgotten doses should not be doubled the following day. Fluoride tablets should be sucked or dissolved in the mouth rather than swallowed whole, to allow a topical as well as a systemic effect. In the UK, fluoride supplementation is now considered unnecessary for infants under six months of age, irrespective of local water concentrations.

Additional protection may be provided for those at increased risk of caries by the use of fluoride rinses or the application of fluoride gels. Rinses may be used daily or weekly. A concentration of 0.05% sodium fluoride may be used for daily rinsing, and of 0.2% for weekly or fortnightly rinsing. The mouth should be rinsed for one minute; the rinse should not be swallowed, and eating and drinking should be avoided for 15 minutes after use. Gels must be applied by a dental surgeon, usually twice a year; extreme caution is necessary to prevent any excess from being swallowed. Less concentrated gels have recently become available for home use. Fluoride varnishes may also be applied by the dental surgeon; they are particularly valuable for young or disabled children as the varnish adheres to the teeth and sets in the presence of moisture.

It should be borne in mind that fluoride does not confer complete protection, and minimal sugar consumption, together with good plaque control, is still essential to prevent dental decay.

Dental intervention

It cannot be emphasised too strongly that the most important preventive measures are those routinely undertaken by the individual at home. However, regular visits to the dental surgeon are necessary to identify early caries, some of which may be reversed. For lesions that cannot be

reversed, restorative treatment limits the amount of tooth tissue lost. X-ray examination is essential to detect some cavities, especially those between teeth, and will also show early periodontal bone destruction.

Some individuals are more susceptible to caries than others. Some of the factors responsible may be outside their control (e.g. those that are genetically inherited or occur during tooth development, *see* Dental disease *above*). The risks may be minimised by strict attention to oral hygiene and use of fluoride products. However, dental intervention may be necessary to ensure effective plaque control (e.g. orthodontic procedures, which involve moving teeth into more favourable positions under mild pressure, or extractions to reduce overcrowding). Orthodontic appliances provide a surface for plaque build-up and can irritate the gingivae. They may increase susceptibility to dental disease, and must be kept scrupulously clean.

Fissures on the occlusal surfaces of molars and premolars are most prone to dental caries. Here, fluoride is less effective in preventing caries than in other areas of the tooth (*see above*). Deep fissures may be treated with proprietary sealants. This involves filling the fissures and pits with a plastic substance. If applied properly, no decay should occur as long as the sealant remains in place. Sealants should be applied as soon as possible after eruption. The method is painless but time-consuming, and may be difficult if a child is unco-operative.

Regular dental check-ups are also important for adults. The dental surgeon is able to offer advice and training in good plaque control techniques. It is generally recommended that routine check-ups should take place every six months, although some young children may benefit from visits every four months. Adults with good plaque control may only need an annual check-up. It must be stressed that regular dental check-ups are not a substitute for good oral hygiene.

Prevention of dental disease in children

In children, caries is more of a problem than periodontal disease, so dental healthcare measures should be directed towards reducing tooth decay. However, the practices and habits adopted during childhood will also combat periodontal disease if continued into adulthood.

Instilling good dietary habits (*see above*) is absolutely essential in the early years, together with fluoride supplementation (*see above*), if necessary. Parents should not add sugar to feeding bottles or coat dummies with sweet substances. Children should be discouraged from adding sugar to foods or drinks (e.g. cereals, fruit, tea or coffee). A taste for savoury foods should be encouraged because, once attained, a 'sweet tooth' is very difficult to eliminate.

Toothbrushing should be started as soon as the first tooth erupts, and the child encouraged to take an active part as soon as possible. Reasons for cleaning the teeth should be explained, and the presence of plaque demonstrated using a disclosing agent. Children's toothbrushes with small heads and short handles should be employed. Use of dental floss is not usually necessary in children, and would be difficult because of lack of manual dexterity. However, flossing should be started as soon as possible in adolescence. Thumbsucking should be actively discouraged, because it may alter the alignment and spacing of the front teeth.

Children should be introduced to the dental surgeon at an early age, certainly by the time all the primary teeth have erupted. Good oral hygiene practices reduce the necessity for treatment and ensure that a child builds a good relationship with the dental surgeon right from the start.

Care of dentures

Anyone who wears a complete set of dentures may assume that it is too late to worry about dental healthcare. However, plaque accumulates on dentures in exactly the same way as on natural teeth, and must be removed regularly to avoid mucosal inflammation. Removal of plaque and food debris also reduces the likelihood of bacterial putrefaction and the resultant offensive mouth odours. Plaque on dentures is subject to the same risks of staining (e.g. from

coffee, tea, tobacco or red wine) as natural teeth. Regular cleaning will maintain an attractive appearance. Partial dentures must be kept scrupulously clean in order to preserve the remaining natural teeth. Dentures should always be cleaned out of the mouth, once or twice a day. They are not usually worn at night, when they should be placed in water to prevent them drying out and distorting.

Dentures are generally made of acrylic materials that are softer than enamel, so equipment and products designed for natural teeth should never be used. Some partial dentures are metal: chrome-cobalt alloy is most commonly used. Denture brushes resemble nail brushes on long handles. There is very often a thick tuft of bristles on the opposite side of the head, which can be used to clean awkward areas. Toothpastes specifically designed for dentures should be used and highly abrasive cleansers avoided, because of the risks of scratching; household bleach, disinfectants or antiseptics should never be used. Alternatively, brushing with soap and water can be just as effective. Disclosing solutions may be used to detect plaque on dentures and assess the thoroughness of cleansing routines in exactly the same way as for natural teeth.

Tablets or powders that release oxygen when dissolved in water may be used to soak the dentures to remove plaque; a stronger acidic cleanser may be required for stubborn stains. Soaking, however, is no substitute for brushing and can lead to 'crazing' of the acrylic surface; minute cracks develop which make the denture appear dull and render it much more susceptible to staining. Metal components may corrode in certain solutions, and the manufacturer's instructions should always be consulted before soaking. Some dentures have soft linings; the dental surgeon should be consulted about the safest way to clean these.

Dentures must be handled with great care; they should be cleaned over a bowl of water or a soft surface in case they are dropped. Denture repair kits are available to carry out emergency repairs, but should only be used as a very last resort; the slightest misalignment or excess of repair material can make a denture unwearable. Household adhesives should never be used; the dentures should be taken to a dental surgeon or dental technician for professional repair as soon as possible.

Once a tooth has been lost, the surrounding alveolar bone gradually resorbs, the rate varying dramatically between individuals. Dentures rest on the alveolar ridge and extensive bone loss results in a poor fit. Loose dentures affect eating and speaking; the effects may be severe enough to make the wearer withdraw socially. Eating may also be painful, because uneven contact means that the soft gingivae are excessively loaded in some areas. The hard palate provides a wide surface over which biting forces are distributed, whereas lower dentures can only cover the alveolar ridge, because the floor of the oral cavity is taken up by the tongue and its associated muscles. Consequently, lower dentures tend to be more difficult to wear than upper dentures. Denture fixatives, usually containing karaya gum or tragacanth, are used by many people to increase retention. However, anyone having problems should be referred to their dental surgeon.

The risk of developing oral lesions is increased in some systemic disorders. Pharmacists should always enquire about any underlying condition when a patient presents with denture problems (e.g. there is an increased incidence of oral candidiasis in diabetics). A dry mouth may also make wearing dentures difficult and uncomfortable, so pharmacists should be aware of the conditions and drugs that reduce salivary secretion (*see* Dental diseases *above*). Patients may need to be referred to their doctor as well as their dental surgeon.

New dentures may take getting used to, especially if the patient has not worn dentures before. They may produce gum discomfort and even sores or ulcers. Unless the symptoms are extremely mild, patients should be referred to their dental surgeon as the dentures may require adjustment. In the meantime, an oral preparation containing a local anaesthetic may be applied to the affected area.

The fit of dentures is rarely satisfactory for more than five years, and they must be renewed periodically. Denture wearers should visit their dental surgeon every one to three years (every six

months if they have partial dentures) to have their dentures checked and the fit re-evaluated.

The role of the pharmacist

Pharmacists have traditionally been involved in selling dental products to the public, and are therefore ideally positioned to reinforce health education messages from the dental profession and other dental healthcare authorities. In addition, pharmacists can recognise disorders of the oral cavity and refer patients to general practitioners or dental surgeons as appropriate. Dental healthcare is essential for a healthy lifestyle, and should be placed equally among other forms of lifestyle modification. Pharmacists should not take over the role of dental health education from dental surgeons, but rather augment it. Much can be achieved by dental surgeons and pharmacists liaising. This also ensures that pharmacists endorse the dental healthcare advice given by the dental profession.

In most cases, the sale of dental healthcare products is a passive process. It would not be practical to become actively involved in every sale, but pharmacists may perceive that a problem exists (e.g. by noticing repeat purchases of mouthwashes or a customer's difficulty in selecting a toothbrush or toothpaste). Dental healthcare products should be positioned so that pharmacists can observe customers, and therefore offer help when necessary. In large pharmacies, locating the dental healthcare section close to the dispensary serves to raise the status of dental products in the eyes of the public from mere toiletries to essential healthcare items.

Pharmacists should be aware of the importance of sugar control in the prevention of dental caries, and therefore only counter-prescribe non-cariogenic liquid medicines, particularly for children. Mouth and throat lozenges may contain cariogenic sugars, and this should be pointed out to patients. Pharmacists have little control over medicines supplied on prescription unless generic items are requested. However, a discussion with local doctors to make them aware of any sugar-free alternatives may be valuable. Pharmacists should also check the manufacturer's information to see if alternative diluents to syrup may be used when dispensing reduced-strength preparations.

Whenever the opportunity arises, pharmacists should stress:

- the insidious and painless nature of dental disease
- prevention is better than cure
- complete prevention is totally feasible
- regular dental check-ups are essential at any age.

It should also be emphasised that periodontal disease is not a normal ageing process, but a pathological disease that can be prevented by good oral hygiene. Children should be encouraged to adopt good habits from as early an age as possible.

Pharmacists should be familiar with diseases and drugs that may increase the susceptibility to dental caries or periodontal disease (*see* Dental diseases *above*), and offer counselling on preventive measures where appropriate. It is imperative, however, that pharmacists do not compromise patients' confidence in prescribed medicines, or increase their anxiety over a disease state. The discussion needs to be handled with tact and sensitivity, maintaining a positive attitude throughout and emphasising there is nothing difficult about good dental heathcare. Sometimes, there is no alternative to a prescribed medicine, and the patient's medical health may seem more important than their dental health. Neither should be compromised at the expense of the other and, in most cases, dental health can be maintained with good plaque and sugar control. If a patient is over-anxious, pharmacists should discuss the matter with the patient's doctor and dental surgeon in an attempt to resolve the difficulty. Pregnant women are prone to gingivitis and should be counselled that good plaque control will minimise problems. It is also essential that pregnant women and children do not take tetracyclines, as these may cause intrinsic discoloration of children's permanent teeth during the developmental stages.

There may be occasions when patients consult pharmacists about dental problems. Anyone with dental pain should always be referred to a dentist, because it may be difficult to establish the cause, and usually only a dentist will be able to carry out the treatment necessary to alleviate the patient's

discomfort. If patients are unable to obtain emergency treatment from their own dental surgeon, pharmacists should supply the address and telephone number of the nearest emergency dental service. Analgesics may be administered in the meantime, but it must be stressed that the problem does not disappear with the pain, and dental treatment must be sought at the earliest available opportunity. The belief that placing an aspirin tablet against the offending tooth will relieve toothache should be firmly discouraged, because of the risk of extensive mucosal ulceration; aspirin is of greater benefit in pain relief if taken systemically.

Some patients may have been given the all-clear by their dentist, or told that their problem is due to gingival recession and exposure of the root surface. In this case, pharmacists can recommend one of the proprietary brands of desensitising toothpaste, preferably one containing fluoride. It should be explained that two or three weeks' conscientious brushing is required before these toothpastes exert their maximum effect.

Most people have mouth ulcers occasionally. Aphthous ulcers are the ordinary mouth ulcers that appear singly or in small numbers, often at times of stress. Various proprietary remedies are on the market, some of which contain a local anaesthetic to render the ulcers less painful. Pharmacists should recommend an appropriate product, as well frequent hot salty mouthwashes, which often have a beneficial effect.

A patient with mouth ulcers need only be referred to a dental surgeon if the ulcers are:

- particularly large
- last more than ten days or so
- repeatedly occur in the same place, which implies that they could be traumatic in origin (e.g. caused by a sharp tooth or rough filling)
- widespread or in large clusters, especially in young children, which could indicate infection with herpes simplex virus
- associated with an objectionable taste or halitosis
- caused by dentures.

A number of emergency kits are available for patients to insert their own temporary fillings and temporarily cement crowns that have become detached. These are a good interim measure, but often require a high degree of manual dexterity on the part of the patient. At all costs, patients should be dissuaded from using household glues to re-cement a crown. The result can be painful and cause difficult and expensive dental problems.

Teeth which have been knocked out in an accident may be successfully re-implanted; however, they may not survive a lifetime, or may discolour and require crowning. Such teeth should be placed in a clean container of milk and immediately taken by the patient to the dental surgeon. On no account should the teeth be washed, rinsed or cleaned in any way. It is vital that there is the minimum delay possible in seeking treatment. If the tooth has fallen onto a dirty surface, the patient may require immunisation against tetanus.

People who visit a dental surgeon have been sufficiently motivated to make an appointment. However, many people never see a dental surgeon, but buy dental healthcare products. Others may not follow any sort of oral hygiene regimen, but still visit a pharmacy for other reasons. Pharmacists, therefore, can interact with significantly more people than dental surgeons, and should take advantage of this situation whenever possible. The impact of any educational material (e.g. books, leaflets or posters) in a pharmacy is potentially greater than in a dental surgery, and pharmacists would do well to include dental health information among their displays.

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Useful addresses

British Dental Association (BDA)
64 Wimpole Street
London W1M 8AL
Tel: 020 7935 0875

British Fluoridation Society
Sandlebrook
Mill Lane
Alderley Edge
Cheshire SK9 7TY
Tel: 01565 873936

British Society for Disability and Oral Health
Department of Sedation and Special Care Dentistry
Floor 26, Guy's Tower
London SE1 9RT
Tel: 020 7955 5000 Ext. 3047

General Dental Council
37 Wimpole Street
London W1M 8DQ
Tel: 020 7887 3800

The Oral and Dental Research Trust
Keats' House
36 St. Thomas Street
London SE1 9RN
Tel: 020 7955 4699

FDI World Dental Federation
7 Carlisle Street
London W1V 5RG
Tel: 020 7935 7852