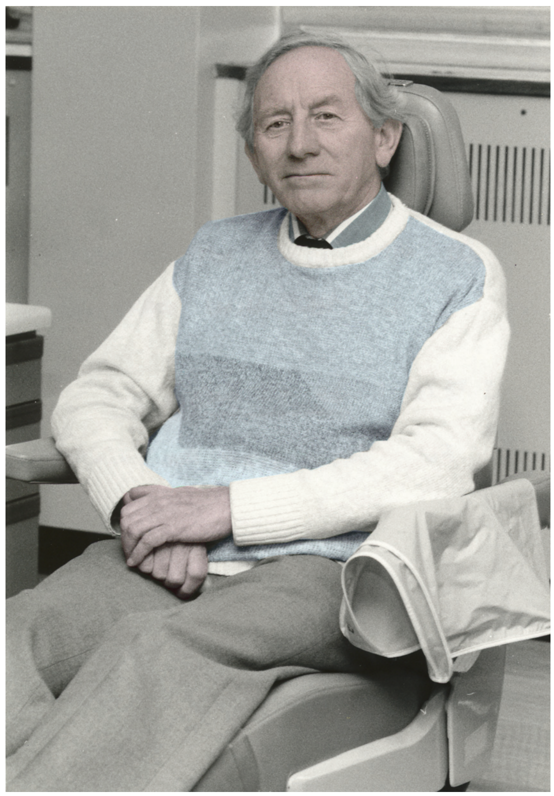
Section I
The Patient



"I'm ready when you are."

Chapter 1
The Patient – His Limitations and Expectations

The provision of high-quality restorative dentistry depends upon the dentist:

- Making an accurate diagnosis
- Devising a comprehensive and realistic treatment plan
- Executing the treatment plan to a high technical standard
- Providing subsequent continuing care

There is a very strong tendency, particularly in the field of fixed prosthodontics, for the dentist to become over-interested in the technical execution of treatment. There is a vast range of materials and equipment to stimulate this interest and compete for his attention. It is perhaps inevitable that dentists can become obsessive about types of bur or root canal file, the pros and cons of various materials and the precise techniques of restoration.

This is not to decry such interest because a high standard of technical execution is essential for the longevity of restorations. However, technical execution must be seen in the context of the four-point sequence listed above. Without a sound diagnosis and treatment plan, even the best technical execution will be doomed to failure.

A major influence on the formulation of the treatment plan is:

- The Patient (Frontispiece)

It is usually by his own volition that he seeks restorative advice and treatment, and he usually brings with him certain problems and limitations that influence treatment planning and the delivery of care.

Each patient also attends with strong preconceptions based on his previous experience of dentistry. This could be good or bad, with a single traumatic episode being able to reverse many years of cooperation. The patient will have some idea of what dentistry could or might do for him, and what he wants from his dentist. Some of his concepts could well be limited or unambitious, and education has a major role to play here. Conversely, sometimes his concepts could be over-ambitious, complex bridgework for instance, and here re-education is often necessary to bring him down to the practical and feasible.

It might be that the dentist has the skills and technical facilities to perform advanced procedures, but before he puts bur to tooth, he must stop and ask whether this is really what *this* patient needs and wants. If the answer is no, then to proceed is an act of pure selfishness that might also be regarded as negligent!

Certainly the dentist may have certain treatment goals for all his patients – no pain or caries, healthy periodontium, complete occlusion – but the way in which he prescribes and delivers his care has to be tempered by the patient's aspirations for his own mouth and his readiness to accept care.

A prolonged treatment plan could be very inconvenient to a shift worker or to a mother with young children or those with no personal transport. It might create restorations that will be beyond the maintenance capacity of the lazy or disinterested, or those with inadequate washing facilities.

Perhaps the patient is a reluctant attender, extremely apprehensive of dental care and its possible discomforts, and will require some form of therapeutic help just to get the simple things done. The short, unambitious treatment plan is more likely to succeed here, and if the patient's confidence can be obtained, the more complex treatment could be provided later.

Advanced restorations require skill and facilities, and these have to be paid for, either by the state or by the patient. Both have limited resources and both deserve value for money. Committing resources to an ambitious treatment plan should involve judgement on the likely lifespan of the restorations in that

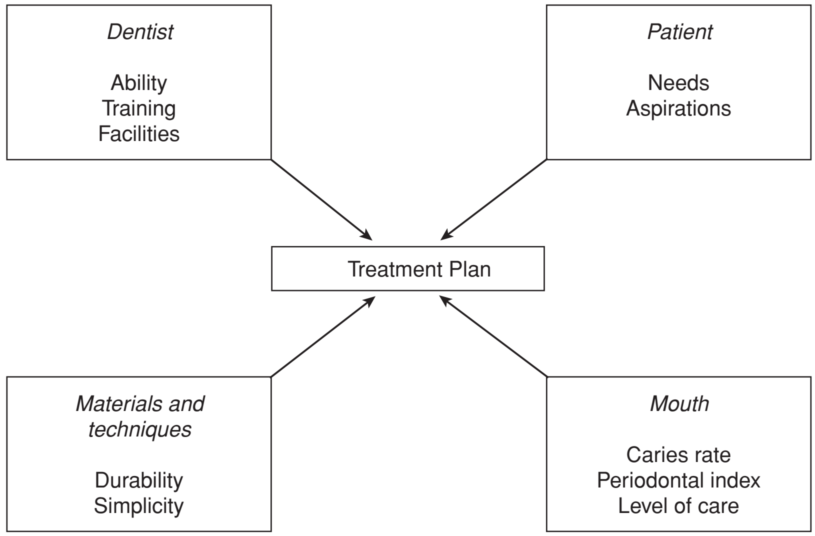


Fig. 1.1 Influences on the formulation of a treatment plan.

particular mouth and its conditions, and whether the expense is justifiable – *cost benefit analysis*.

The intra-oral conditions bring as much influence to bear. The caries rate, the number of missing teeth, the periodontal condition, the presence of dentures and the quality of previous restorative work all act as limitations to the scope of the treatment plan. All of us like to provide our best work for those who will appreciate it and look after it. Disinterest on the dentist's part is created by the appearance of large plaque deposits and evidence of little care.

The other side of the equation is what may be available and this relates to the dentist's skills and training, the materials and techniques at his disposal, and the facilities available for providing care (Fig. 1.1). These, in turn, could well modify or even dictate the patient's aspirations – a clean, well-equipped and efficient practice would indicate a good level of care to the average patient, whilst the reverse could well lower his expectations.

The dentist should offer only what is realistically available and work within his own limitations. It is certainly no disgrace to say that certain options are beyond your capabilities and it is possible to consider referral to an appropriate specialist. It could also be that the options the patient has aspirations towards are those with a lower success rate, and it is sensible to tell him this frankly.

There is considerably more awareness of the cosmetic possibilities of modern dentistry and thus demand for new materials and techniques. Much of this is expensive and has not been fully evaluated over a sufficient period for total confidence in its durability. The patient deserves a proper explanation about the reservations there are about particular lines of treatment.

The provision of restorative treatment is a complex arrangement wherein the patient, the dentist, the technical support and the materials must be in harmony to produce a satisfactory result. The limitations of one element will inevitably change the effects of the others. It is important to remember that the treatment is only as good as its weakest link – don't let that be you!

The key to success throughout is communication – listen and learn from what the patient says, explain what can be done for him, and then decide jointly on what should be done. If you are not sure, do not commit yourself, but delay the decision and take advice from your colleagues or even your local consultant.

This book begins by talking about how to find out what's wrong with the patient and what does he want done about it, coupled with the limitations the patient brings to formulating a treatment plan and then to executing it.

Section II
The Restoration and Its Environment

Chapter 5
Applied Biology of the Teeth

The techniques for the restoration of tooth structure require a detailed knowledge of the tissues against which the material is to be placed. The purpose of this chapter is to describe the hard tissues of the human tooth and their relationship with their environment. The implications for restorative dentistry of enamel and dentine structure and pulp physiology are discussed.

Introduction

Caries is a microbially initiated disease causing localised destruction of mineralised tissues in the body, including bone. For the purpose of this book only caries of the teeth will be considered and the signs of presence of the disease will be described as the localised destruction of enamel, dentine and more briefly, of cementum. As is the case with other pathological conditions, a clear understanding depends upon a knowledge of the basic structure of the tissues involved.

Enamel Structure and Chemistry

Enamel is the outer protective covering of the crown of the tooth and is an extremely hard, brittle, white, shiny substance. It is composed basically of billions of crystals of hydroxyapatite that are roughly octagonal in cross section with a diameter of about 360 nm. The length of the crystals has proved difficult to determine but they are thought to be long and ribbon-like, extending for some distance through the enamel. The crystals are tightly packed together so that organic matrix lying between them is minimal, constituting only about 2% by weight of the enamel but much more than this by volume. Between the crystals are therefore micropores or pores, the size of which can be measured with some accuracy, and changes in these spaces is one of the methods of indicating the presence of carious attack. Under these conditions the enamel is said to have developed increased porosity. The methods available for such studies will be discussed in Chapter 6.

Prisms

The crystals of enamel are not randomly arranged but are grouped together to form rods or *prisms* of material, extending from the enamel–dentine junction to the surface of the tooth. In the original English literature the preferred term is that of ‘prisms’ whereas in more recent writings the term ‘rod’ is preferred and in fact induces a clearer image of the structure in the mind of the reader. Because the remainder of this book will use the word ‘prism’, the old-fashioned term will be used here.

Each prism has a mean cross-sectional diameter of about 5 μm but because the surface area of the outer enamel is greater than that of the enamel–dentine junction the prisms tend to increase in diameter from the junction to the outer surface. The cross-sectional shape of the prisms has been variously described as octagonal to fish scale or keyhole shaped but this depends to some extent on the angle of section through the prisms. The keyhole concept is the classical construction in human enamel and is shown diagrammatically in Fig. 5.1. The broad part of the keyhole is often referred to as the head and the narrow part as the tail. There is controversy as to what constitutes the boundary of each prism. Current research suggests that prism boundaries may be formed both by sudden changes in hydroxyapatite crystal orientation and by an increased concentration of *organic matrix*.

Matrix

The nature of the organic matrix has received much attention but because of its small amount has proved difficult to analyse with certainty. In the immature tooth the matrix consists of two distinct proteins, amelogenin and enamelin, and during maturation

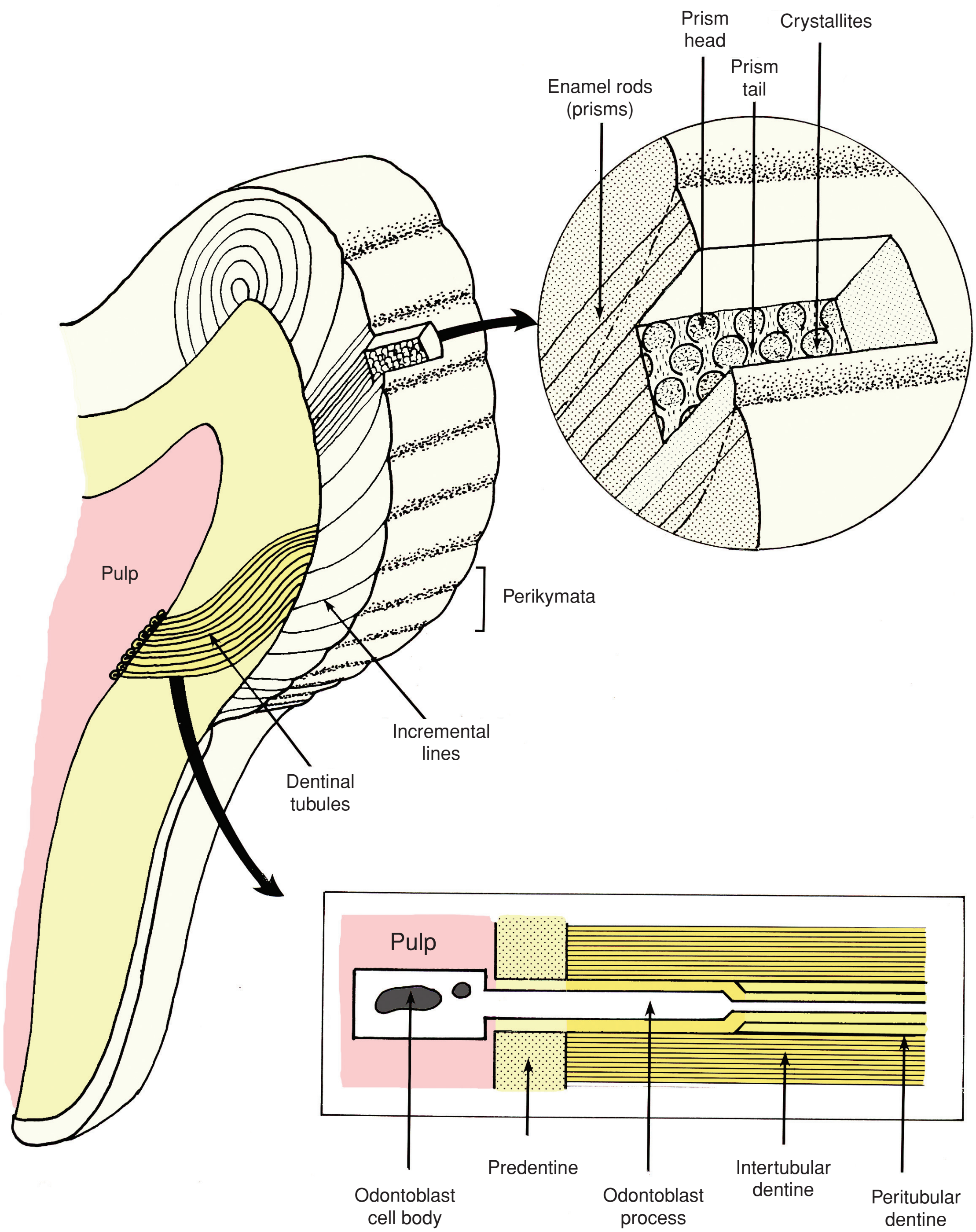


Fig. 5.1 Schematic diagram of the structure of a tooth showing the main features of enamel and dentine.

much of the amelogenin is removed. The cells responsible for secreting and maturing the enamel during development are the *ameloblasts* and they migrate outwards from the putative enamel–dentine junction for a distance equal to the thickness of the enamel at that point on the tooth.

When the ameloblasts have completed their secretory activity, the final thickness of the enamel is determined and this cannot be altered throughout life, since the ameloblasts then degenerate. In principle, enamel is a dead tissue which cannot repair itself. However, we will see later that chemically speaking some repair or re-structuring of enamel is possible.

Incremental nature

The enamel is laid down by the ameloblasts in increments, arranged rather like the layers in an onion over each cusp of the tooth. In cross section, these appear as concentric rings through the enamel and are known as *incremental lines* or brown striae of Retzius (Fig. 5.1). Each line represents the point that the ameloblasts had reached at a particular time in their functional activity. The incremental line is not pigmented as the name brown striae would suggest but is probably caused by a slight change in direction and diameter of the enamel prisms. These incremental lines reach the surface of the tooth at an acute angle and there is evidence that they modify the progression of caries in the natural lesion.

Surface structure

Although the enamel prisms have been depicted as extending from the junction out to the surface, in practice this is often not the case. Many of the prisms in certain parts of the tooth and in certain teeth stop short of the surface. The surface layers of the tooth are therefore made up of *aprismatic enamel* that may have been produced because the activity of the ameloblasts changes before they cease secretory activity. Too little attention has been paid to this outer layer on the teeth and it is conceivable that it may be related to caries susceptibility and is certainly of importance when etching and bonding techniques are considered.

Ionic exchange

Once the teeth have erupted, ionic interchange is possible between the crystals of the enamel and ions in the surrounding environment. For example, the calcium ions may be exchanged for strontium and the hydroxyl part of the molecule may be replaced by fluoride which appears to protect the tooth against carious attack. Epidemiological studies have shown that newly erupted teeth may be more susceptible to caries than teeth in more mature individuals, so that great efforts are now made by restorative dentists to prevent so far as possible the commencement of carious attack which will become much less likely in the older individual.

Morphology of Teeth

The overall shape and detailed morphology of the teeth varies considerably between teeth and even within tooth types. Thus, the incisors are quite different in shape to the canines, premolars and molars and in different individuals premolars may themselves vary somewhat in shape. These factors are important in restorative dental procedures and should be studied in greater depth in standard texts of tooth morphology. It is usual in current dental practice to distinguish to some extent between restorative procedures in deciduous teeth and permanent teeth and this is because there are structural differences between them, the most important of which are the relative size of the teeth, the thickness of the enamel and underlying dentine, the relative size of the pulp chambers which are larger in deciduous teeth and the bulbosity of the enamel of deciduous teeth at the cervical margin. However, there is evidence accruing recently that the structure of the enamel of deciduous and permanent teeth may differ and this may affect the rate of progression of caries. For instance, it has been shown using microradiographic techniques that deciduous teeth are somewhat less well mineralised than their permanent counterparts. This may account for their whiter appearance since more porous enamel tends to be less translucent so that the yellowness of the underlying dentine does not show through so clearly.

Dentine Structure, Chemistry and Sensitivity

Dentine

The bulk of the structure of the tooth, both crown and root, is made up of a less well mineralised but more flexible tissue known as dentine. This also is composed of hydroxyapatite crystals but in a less concentrated form than in enamel. The majority of the crystals are arranged more or less parallel to the enamel–dentine junction but in the three-dimensional sense are much more random than those in enamel. They are laid down in a matrix composed of *glycosaminoglycans*, in which have been laid down *collagen fibrils* secreted by the odontoblast cells in their movement inwards from the enamel–dentine junction towards the future pulp. The matrix of dentine therefore consists of a rather dense, rubbery material, the general shape of which is retained even after removal by acids of all of the mineral component. Whilst caries of enamel results in cavitation and loss of the material, at least initially in dentine a rubbery, stained matrix may be retained for some time.

Odontoblast processes

As the odontoblasts migrate inwards from the junction towards the pulp they leave behind them a cell process which becomes enclosed in a tubule incorporated into the matrix. The dentine is therefore permeated by millions of cell processes radiating out from the odontoblasts through the whole thickness of the dentine at least in the younger tooth. These processes may have side communicating branches so that a syncitium of cells is formed. When the dentine mineralises, crystals are laid down in the ground substance and fibres of the matrix but are not laid down in the cell processes. In the mature dentine, therefore, the cell processes are contained in mineralised tubules running through the dentine. With increasing age these tubules narrow by the deposition of mineralised material in their walls (intra-tubular dentine) and there is still disagreement as to whether mature dentine possesses viable cell processes throughout the length of its tubules.

Dentinal tubules

Although these tubules radiate from the pulp to the enamel–dentine junction, they do not travel in straight lines. In the longitudinal plane they tend to follow a sigmoid curve from the outer dentine towards the pulp so that the cell body is placed more apically than the periphery of the process (Fig. 5.1). This arrangement has some clinical significance which will be discussed later.

Mineralisation

Unlike enamel, dentine matrix does not mineralise as soon as it is produced. There is a delay between laying down the matrix and its mineralisation in the form of calcospherites which finally coalesce to produce a more or less homogeneously mineralised tissue. In some parts of the tooth a failure in this fusion of calcospherites seems to occur. Firstly, in the coronal portion large non-mineralised, star-shaped spaces are left in many teeth following an incremental line below the enamel–dentine junction. These defects are known as *interglobular spaces* and the cell processes of the odontoblasts run straight through them. Their significance in relation to spread of caries is not known. At the periphery of the root just below the cementum, much smaller defects in mineralisation are observed, known as the *granular layer of Tomes*. No clinical significance has been ascribed to this structure.

Secondary dentine

As the odontoblasts migrate pulpally they lay down the adult form of the tooth completing the root some $2^1/_2$ to $3^1/_2$ years after eruption of the tooth. If they were to continue at this rate of production of dentine then clearly the pulp chamber would be obliterated within a few years of establishment of the dentition. Once the mature outline of the tooth has been completed the odontoblasts slow down and although continuing to migrate inwards, do so at a rate enabling the pulp chamber to survive into old age. The dentine laid down in the initial stages of tooth development is known as *primary dentine* and that laid down after the odontoblasts have slowed is known as *regular secondary dentine*. As we will see in Chapter 6, the odontoblasts may change their rate of production of dentine and its type under the influence of carious attack.

Dentine sensitivity

In order to enable dentine to react in this manner it must be responsive to outside stimulus and many patients who have suffered cavity preparation under inadequate anaesthesia will testify that this is the case. The exact mechanism is still not clear, largely because technical problems of fixation and examination of tissue remain unsolved. The pulp is well supplied by nerves, both non-medullated (controlling blood vessel tone) and medullated (capable of transmitting common sensation and pain). These latter nerves have endings in a plexus close to the odontoblast cell bodies and also have nerve endings on the cell bodies themselves. There is clear evidence that some of these nerve fibres extend some distance into the dentine and have presumably been incorporated into it during its formation. About 1 in 2000 tubules appear to contain nerve fibres but only for quite short distances. It is interesting to consider that this so-called sparse innervation is probably greater than that found in the fingertips! As has been already stated, there is some doubt as to whether living odontoblastic cell processes extend throughout the thickness of the dentine in the mature tooth. If they do, then loss of enamel may result in osmotic changes at the peripheral end of the processes, thus resulting in fluid exchange and distortion of the processes. This event may be transmitted along the process and then converted by transduction into nerve impulses either at the inner third of the processes themselves or at the cell body region. If the cell processes do not extend throughout the thickness of the dentine then it is conceivable that fluid balance changes in the outer part of the tubules may initiate distortion of the processes resulting in impulses eventually to the nerve plexus.

Enamel–Dentine Junction

The junction between the enamel and the dentine lies on the original basement membrane separating the enamel organ on the outside from the papilla or mesodermal tissue on the inside at an early stage of tooth development. In most human teeth it is not a flat sheet but is deformed into a crater-like appearance producing on section the appearance of scallops. The concavities of these scallops face towards the enamel and the convexities towards the dentine. That is to say the outer surface of the dentine, if the enamel were to be removed, appears like the surface of the moon with irregularly shaped craters. The inner surface of the enamel is composed of convexities fitting into these craters. This has the effect of increasing the surface area between the two tissues. In some parts of the human tooth, particularly near to the neck of the tooth, the enamel–dentine junction may be more or less flat.

Smear Layer

During restorative procedures, removal of decayed enamel and dentine and extension of the cavity for prevention, retention and access may be carried out using hand instruments such as chisels and hatchets but is more commonly done using rotary instruments of various types and speeds. Rotating instruments may result in smearing of the crystal and organic content of both enamel and dentine over the cut surface. This smearing may be a purely physical effect or may be engendered by heat at the point of cutting and grinding. Hand instruments, however sharp, may also cause heavy smearing on the enamel surface especially on the floor of an approximal box. The clinical implications of the smear layer will be discussed later.

The Pulp

The pulp and the dentine cannot be separated either anatomically or functionally. Anatomically, the cell bodies of the dentinal processes lie in the peripheral region of the pulp and the *odontoblast cells* and their processes are therefore intimately associated both with dentine and pulp tissue. Functionally, the reaction of both dentine and pulp to external stimuli is dependent upon both the cell processes and bodies of the odontoblasts and therefore reaction is a combined function of both tissues. The three-dimensional shape of the *pulp chamber* varies in different teeth. Thus, in an upper incisor the coronal part of the pulp chamber is somewhat flattened buccolingually and broad mesiodistally and the radicular portion of the pulp chamber is roughly triangular in shape and conical in length. In multirooted teeth such as the molars the form of the pulp chamber is obviously much more complex. It is important for the restorative dentist to appreciate the general form of the pulp chamber in each tooth type, although variations exist even between teeth of similar notation. A standard text on tooth morphology will provide this information. It has already been stated that the relative size and shape of pulp chambers in deciduous teeth is larger than that in permanent teeth and therefore exposure of the pulp chamber is considered by many to be a greater hazard in deciduous dentitions.

The healthy pulp is of a jelly-like consistency having a ground substance of glycosaminoglycans in which is interspersed a loose and sparse network of collagen fibres. These collagen fibres are produced and maintained by fibroblasts which are the commonest cell type in the healthy pulp. There are also macrophages, pluripotential histiocytes and occasional monocytes. There is a complicated vascular supply consisting of arteries entering the apical foramen and dividing into an extensive network of arterioles, particularly in the peripheral parts of the pulp. These arterioles connect directly with venules so that arterio-venous shunts exist. There is an extensive capillary plexus particularly in the region of the odontoblast cell bodies at the periphery of the pulp. Although difficult to demonstrate, there is an adequate lymphatic drainage from the pulp and veins and lymphatics leave together through the apical foramina. Innervation of the pulp has already been discussed in relation to sensitivity of the dentine.

The Periodontium

The tooth is supported in its bony socket by a specialised connective tissue – the *periodontal ligament*. At the cervical margin or neck of the tooth it is continuous with the connective tissue underlying the *gingivae*. At the apex, it is continuous with the tooth pulp. It bridges the gap between the root cementum and the alveolar bone and is approximately 0.2 mm in width. It is composed of fibres in a gel-like ground substance that contains nerves, blood vessels and cells.

Fibres

Most of the fibres in the ligament are Type I collagen, although some Type II collagen and specialised oxytalan and elastin fibres are present in small amounts. The collagen fibres are arranged in bundles which pursue a complex wavy course. At their cementum end the bundles are smaller in diameter than at their alveolar bone end. They form branching networks around the neurovascular bundles but no single fibre bundles appear to traverse the whole distance from tooth to bone. The collagen bundles are incorporated into bone and cementum in the same way as are tendons, that is to say, in the form of mineralised Sharpey's fibres. The fibre bundles are 'crimped' along their course and the fibre bundles overlap each other. It has been suggested that this allows response to loading under occlusal forces. The functional activity of the ligament will be described later. The fibre bundles are arranged in specific named groups associated with the gingival, crestal, radicular, apical and interradicular portions of the tooth. Their arrangement is shown diagrammatically in Fig. 5.2.

The oxytalan fibres lie parallel to the length of the tooth root and are attached to cementum at one end. They have been implicated in both tooth eruption and support and may be involved in support of blood vessels.

Ground substance

The major components are hyaluronic acid, glycoproteins and proteoglycans. Hyaluronic acid and the polysaccharide components of proteoglycans are glycosaminoglycans. Water content is about 70%.

Vasculature

The periodontal ligament is well supplied with blood vessels that are mainly derived from the superior alveolar branches of the maxillary artery or from the inferior alveolar artery in the mandible. There may be other sources deriving from the buccal, masseteric or lingual arteries in the mandible or from the palatal or facial arteries in the maxilla. The veins drain into larger veins in the inter-alveolar bone and usually do not follow the route of the arteries. Within the ligament itself the blood supply is most extensive in the cervical part and least extensive in the middle third. Most of the vessels enter the ligament as perforating arteries from the intra-bony vessels and they run parallel to the long axis of the tooth, passing between the principal fibre bundles of the ligament. Many branches arise from these vessels and they form a capillary plexus that is more complex at the bone surface than at the cementum surface of the ligament. There appear to be arterio-venous shunts in the cervical part of the ligament and these resemble renal glomeruli. There is some evidence that in older patients, the vascularised spaces are larger and encroach upon areas previously occupied by fibres and bone.

The actual rate of blood flow has not yet been reliably determined but is controlled by both α- and β-adrenoreceptors, allowing both constriction and dilation of vessels.

There are lymphatics present, although not in great numbers, and they tend to follow the venous drainage.

Nerves

These are derived from either the superior or inferior dental nerves. Some of the bundles of nerve fibres run from the apical region of the periodontium towards the cervical margin of the tooth. They are joined by nerves passing through foramina in the bone to enter the ligament horizontally. Large fibres are myelinated and terminate in specialised nerve endings that are associated with mechanoreceptor activity. These monitor forces on teeth and may be involved in reflex jaw opening and masticatory control. Small fibres

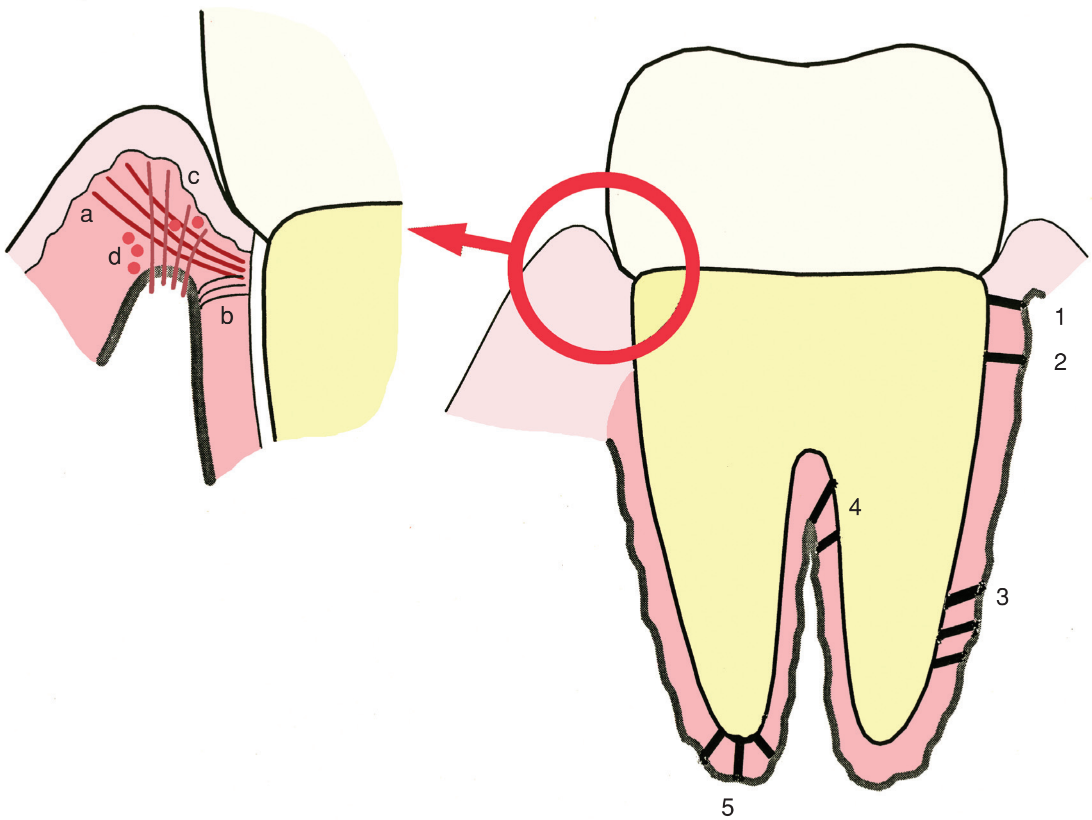


Fig. 5.2 Schematic diagram of the structure of the periodontium. Principal fibre groups: (1) alveolar crest, (2) horizontal, (3) oblique, (4) inter-radicular, (5) apical. Gingival ligament groups: (a) dentogingival, (b) dentoperiosteal, (c) alveogingival, (d) circular.

terminate as free nerve endings associated with appreciation of pain. Autonomic nerves are present and they control regional blood flow in the ligament.

Cells

Most of the cells of the ligament are fibroblasts. They are responsible for the unusually high 'turnover' rate in this tissue resulting in the fibres being constantly synthesised, removed and replaced. The fibroblasts are spindle shaped, large cells and they align themselves along the length of the fibre bundles. They are able to both produce and remove collagen fibres so that diseases affecting their function can seriously damage the ligament.

Some of the epithelial cells (Hertwig's sheath) responsible for mapping out the shape of the tooth root remain in the ligament as cell 'rests' and they may subsequently proliferate to produce periodontal cysts.

There are undifferentiated cells of mesodermal origin and it is probable that they can differentiate into any type of mesodermal cell in the ligament.

Since the ligament is bounded on the tooth surface by cementum and the outer surface by alveolar bone, there are cementoblasts and osteoblasts present. Bone remodels readily so that osteoclasts are seen in the ligament. Cementum is much more stable so that in adult teeth (but not deciduous) cementoclasts are rarely seen.

Response to movement and load

Clearly, the ligament is responsible for the support of the teeth and attaches the tooth to the bone. There is

Section II

still debate, however, as to how the ligament functions during normal physiological activities such as eruption or response to loading in an axial or tangential direction. It has been suggested that the ligament may contract during eruption, that migration or contraction of fibroblasts may occur, or that pressure may be exerted by vascular or fluid elements. The evidence is complex and largely derived from experiments on rodent teeth. It seems that the vascular theories are the most probable.

Mesial drift or movement of erupted teeth towards the mid-line has been attributed to activity in the periodontal tissues. At the present time there is conflicting evidence and physiological mesial movements in response to tooth loss or wear cannot be fully explained.

In respect of functional loading on the teeth there is also controversy. The weight of evidence suggests that the ligament does not behave purely as a suspensory ligament but that it behaves in a viscoelastic manner. It is now thought that all the components act together like a hydraulic shock absorber. In this case the fibres, ground substance, blood in the vessels and tissue fluids are all important. The system is very complex and is as yet imperfectly understood.

Age Changes in Teeth

It is sometimes difficult to distinguish between changes occurring in tissues due to age and changes occasioned usually in the older person because of increased exposure to external stimulation. This is particularly so in the case of the hard tissues of the teeth.

Enamel

In the case of enamel, although it is in principle a non-reactive tissue, most of the changes that occur as age progresses are due to ionic exchange between the external environment and the tooth. These have been described earlier. They may result in an enamel with a slightly changed refractive index so that the colour of a person's tooth may change somewhat with age, usually becoming rather darker. The small but important organic content of the teeth, especially in relation to lamellae, may also take up staining as life progresses contributing to this change in colour. Because enamel is non-replaceable in bulk, certain parts of the tooth tend to become worn as age progresses. Whilst not a true age change, this phenomenon of surface loss is often used by anthropologists to age individuals although considerable information is required as to the diet responsible for the wear pattern.

Dentine

In the case of dentine there do seem to be changes more directly associated with age. There is evidence that the amount of intra-tubular mineralisation increases with age and this occurs from the periphery of the odontoblast tubules working inwards towards the pulp. The effect of this is to produce sclerotic dentine where the refractive index and homogeneity of the tissue is more uniform. This phenomenon occurs particularly under regions of surface wear or caries in the crown but is strikingly evident in the apical part of the tooth, spreading upwards from the apex to, in old age, two-thirds or more of the way along the root. On tooth section, this *sclerotic dentine* gives a transparent appearance to the root dentine and its extent provides a standard method of ageing dead bodies in forensic investigations. Its clinical significance will be discussed later.

The pulp

The pulp, although reducing in size as age progresses, may also change in consistency. It is reported that the fibrous content of the pulp increases relatively with age and there is evidence that the number of viable odontoblasts reduces.

Cementum

Cementum was a tissue of lesser interest to restorative dentists in the past but with the advent of interest in root caries may assume a greater importance in the future. It is for this reason that the tissue structure has not been discussed in detail. It has been reported recently that incremental lines in cementum may be related to seasonal changes and therefore may be used to age an individual. Whilst this seems a possibility in hibernating animals, the prospect seems unlikely in the human tooth.

The Microenvironment of the Tooth

When the tooth erupts into the mouth any cellular remnants on its surface are quickly lost. This brings the enamel surface in direct contact with the saliva, some of the proteins of which are instantaneously deposited on the enamel surface.

Saliva

Flow rates of *saliva* are at a maximum during masticatory activity and there is also a diurnal rhythm. It is not clear whether salivary flow rates are reduced to zero during sleep but they are certainly very low. Saliva contains anti-bacterial agents and is also of some importance in the initial digestion of food. This is brought about by its content of amylase. It is also functionally necessary for the sense of taste since substances can affect the taste buds only when in solution. To the restorative dentist, apart from the physical problems of dealing with it clinically, saliva is largely viewed as a protective medium for the teeth. It contains mucus mainly secreted by the submandibular and sublingual glands and it is this mucus which forms the protein coating on newly erupted teeth. It is a self-cleansing material since it washes the teeth following meals and as already mentioned it has some anti-bacterial and possibly anti-viral activity (secretory IgA). Two features of saliva, however, are of great interest to the restorative dentist. Firstly, saliva is an excellent buffer, largely due to its content of bicarbonates and to some extent its proteins. A buffer is a substance which tends to prevent changes in pH. During mealtimes when perhaps acid substances are ingested or when the products of breakdown of food produces acid, the buffers in saliva tend to neutralise this acid. The increased flow of saliva at mealtimes produces increased buffering activity. Secondly, saliva is supersaturated with calcium and phosphate ions. It is therefore largely the source of ionic interchange between the microenvironment of the mouth and the tooth itself. Fluorides may be contained in saliva and may be concentrated by plaque forming on the surface of teeth.

Dental plaque

Plaque is a bacterial deposit on the protein pellicle of the tooth and its ecology is complex and variable. In most people it consists of a basic bacterial flora of the streptococcus mutans type perhaps along with lactobacilli. In older plaque, filamentous organisms of the actinomyces type become apparent. Many of these organisms, particularly streptococcus mutans, breakdown refined carbohydrates producing extracellular glycans and large amounts of acid. As will be seen later, the relationship of the numbers and types of various micro-organisms to the prevalence of caries is an extremely difficult problem and it must be remembered that caries is a multifactorial disease and studies of any one factor may be unrewarding. As an illustration of this point it is known that plaque on the surface of teeth is capable of concentrating fluorides so that in an external environment of one part per million there may be eight to ten parts per million in the plaque. This concentration of fluoride may be toxic to some bacteria, although there is evidence that many bacteria combine the fluoride and remain metabolically active. The suggestion has been made that the presence of some young plaque capable of concentrating fluoride may be useful to the tooth surface in that interchange with the surface hydroxyapatite crystals may be aided. Most clinicians, of course, would recommend removal of plaque, thereby denying the production of low pH and the formation of carious lesions.

Restorative Implications

In our descriptions of enamel, dentine, saliva and plaque, the reader will have detected that the information is rarely academic but is necessary for a full understanding of the process of carious attack and of the dentist's ability to prevent or repair it. Important aspects of basic dental science and clinical restorative dentistry will be emphasised by a few examples.

Enamel prisms

The reader will have appreciated that the detailed orientation of the enamel prisms is complex since it varies in different parts of the tooth. In the cuspal region the prisms follow a wavy and complex course, probably adding to the strength of this part of the enamel. In the cervical region they may slope towards the cervical margins and in deciduous teeth, may be more horizontal in this part of the tooth.

Surface preparation

It is important that unsupported prisms are not left since these may be extremely friable and the restorative dentist seeks to ensure that the periphery of his preparation lies along the general direction of the prisms. This produces maximum strength and reduces the likelihood of future fracture at the periphery of his restoration. Clinical practice must be tempered with common sense and it is recognised by most restorative dentists that sometimes the load on a particular part of a restoration part is minimal and it may not be necessary to follow these guidelines. The same principles apply to the preparation of the surface of a cavity and attempts are often made to avoid leaving loose enamel crystals present even though these are invisible to the operator. Thus, some operators advocate the cleaning and disinfection of a cavity before placing a restoration. It is probably less important in relation to enamel than to dentine unless bonding techniques are anticipated, in which case the prisms of the enamel must be exposed in order to produce a good key for the bond. This latter consideration may be important not only in relation to finishing cavity margins but in preparing surfaces of enamel where bonding to unprepared enamel is required.

Remineralisation

It will be clear from the description of enamel that in biological terms it is a non-healing tissue. This is why most approaches to dental caries in the past have been not so much treatment as repair of an untreatable defect. This has now changed and it has become established that at least in the early stages of carious attack demineralisation or increased pore spacing in enamel may be repaired to some extent by removing the attacking medium and allowing the super-saturated nature of saliva to take its effect or if necessary by applying super-saturated remineralisation solutions to the early carious lesion. It is now well recognised that caries is not a continuous process but is a start–stop phenomenon. It seems logical to assume therefore that the condition in its early stages is reversible and this fact forms the basis for most restorative, preventive and early treatment regimes.

Saliva and plaque

The importance of saliva and its consequent plaque formation on teeth has already been touched upon. Current opinion holds that removal of plaque by adequate oral hygiene procedures, especially during the first two decades of life, will prevent or markedly reduce the prevalence of caries. Extensive restorative procedures are therefore contra-indicated in patients unable to control their plaque formation and initially the prevention of caries in children and eventually the management of established caries in adults depends as much upon oral hygiene procedures, diet and fluoride application as upon excellent technical restorative procedures.

Secondary dentine

Odontoblastic processes in their tubules follow a sigmoid course as they traverse towards the pulp. This is especially the case in the radicular part of the tooth. This means that the cell bodies associated with a particular tubule are much more apically placed than the carious attack at the periphery of the tubule. Any reactive secondary dentine will therefore not be developed directly at the base of the cavity but will be placed more apically. This is important to recognise since the protective effect of secondary dentine distancing the attack from the pulp is useful in the apical portion of the cavity but exposure of the pulp is much more likely more cervically.

Progress of caries

The rate of progression of caries through enamel and dentine is not known with precision but it appears to take 3–4 years for an early lesion to progress through enamel. It is then believed that the rate of progression through dentine is much more rapid. Clinically, it is obvious that when the lesion reaches dentine it spreads laterally along the enamel–dentine junction and this may be a reflection of the lower mineral content of the dentine and also of the inter-connecting lateral processes of the odontoblastic processes. The importance clinically is that caries has to be followed laterally at the enamel–dentine junction, thereby producing undermined enamel which will need to be removed subsequently.

Dentine sensitivity

The question of reaction of dentine to external stimuli is one of the most important factors in aiding the dentist in his control of carious attack. We have already noted that progress of caries through dentine is more rapid than through enamel but this is limited by the fact that the dentine will react to attack producing irregular secondary dentine, sometimes known as tertiary dentine. Perhaps the interesting question concerning the sensitivity of dentine is not how it is brought about but why it is necessary in the first place. Sensation in most parts of the body is a defence mechanism, allowing the organism to withdraw from noxious stimuli. A patient cannot readily withdraw the teeth, although they might conceivably seek to place unpleasant foods in another portion of the mouth. It may be that the sensitivity of dentine is concerned more with trophic mechanisms controlling the health of the pulpal tissue and may be associated in some way with the response of the odontoblast and their processes to outside stimuli. A major difference between dentine and enamel is that the former is capable of responding to carious attack or wear or fracture of the tooth and has a potential for healing. This will be discussed in greater depth in Chapter 6, but the living nature of the odontoblastic processes, cell bodies of the odontoblasts and the continuing ability of the tissue to lay down pre-dentine mineralising into dentine, enables the tissue to respond to loss of tooth substance by walling off the vulnerable pulp tissue.

Section IV
Fixed and Removable Prosthodontics

Chapter 18

Diagnosis and Treatment Planning for Fixed and Removable Prosthodontics

Here we consider the possible consequences on the remaining dentition of the loss of teeth, whether to replace them or not and the general approach to the choice of a prosthetic replacement.

Consequences of Tooth Loss

No matter how good our preventive programmes and conservation skills, teeth will still be lost as a result of caries, periodontal disease and traumatic injuries. The consequences of the loss of a tooth or several teeth will vary from patient to patient, but in general the following are possible:

- Tilting, drifting and rotation of adjacent teeth
- Overeruption of opposing teeth – loss of occlusal stability
- Increased plaque accumulation and periodontal disease
- Abnormal sites for carious lesions
- Damage to remaining teeth due to increased function – tooth wear
- Loss of masticatory efficiency
- Loss of aesthetics
- Speech problems
- Alveolar resorption
- Loss of support for soft tissues

The principal effects are summarised in Fig. 18.1.

Loss of occlusal stability

The extent to which this may occur depends upon the original tooth relationships. The teeth around a single unit space may well have stable contacts such that no deterioration occurs (Fig. 18.2). In other cases, there may be slight changes in tooth position resulting in less than perfect relationships but not necessarily requiring restoration of the missing teeth (Fig. 18.3).

However, overeruption and drifting may be dramatic (Fig. 18.4). The changes in tooth positions may lead to abnormal functional relationships such as non-working interferences in protrusion and lateral excursions, and pre-centric prematurities. Space for tooth replacement may be restricted.

Loss of masticatory efficiency

Whilst the loss of a single tooth is unlikely to have any significant effect on mastication, the loss of two or more in the same quadrant would probably require the patient to modify his chewing pattern to maintain effective function. It is unlikely that this would be noticed and, even with many missing posterior teeth, the vast majority of patients will continue with a normal diet.

However, once a substantial amount of posterior support is lost, mastication will be transferred to the anterior teeth that have a narrow occlusal table making them unsuitable for grinding. The consequence will often be tooth wear or *tooth surface loss* (see Chapter 25). A typical case of anterior tooth surface loss following loss of posterior teeth is shown in Fig. 18.5.

Increased plaque accumulation – caries and periodontal disease

The opening of contacts by tilting, drifting and rotation into an edentulous space may encourage food packing and plaque accumulation that in turn may initiate or increase the progress of periodontal inflammation. The same applies to the overerupted tooth where embrasures and contact relations are changed to an unfavourable relationship for natural plaque control.

Tilted teeth may be more vulnerable to periodontal breakdown due to unfavourable loading from the occlusion.

Caries too may be initiated by plaque accumulation in poorly accessible areas, but of course this disease

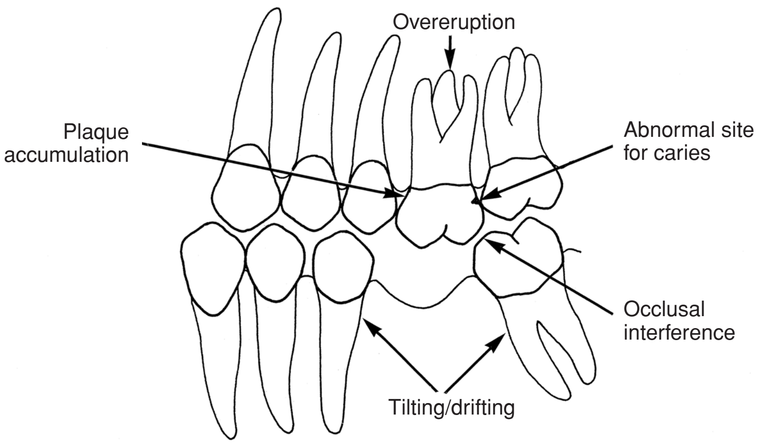


Fig. 18.1 Schematic diagram of the consequences of tooth loss.

also requires a carbohydrate substrate. Therefore, the overall caries rate will be of importance in predicting the initiation of new carious lesions. In the event of new caries, because the contact area of an overerupted tooth will be resited to an area of thinner enamel, the tooth can be more vulnerable to carious spread.

These effects are not absolutely certain and other factors such as the patient's diet and plaque control effectiveness will be important. In a mouth with a low caries rate and good oral hygiene the effects of tilting, rotation and drifting may be minimal.

Aesthetics, speech, alveolar resorption and soft tissue collapse

Losing a front tooth clearly affects aesthetics but a posterior tooth is not usually considered essential for good looks. This of course varies according to the social perceptions of the patient's social group or occupation. Perhaps an actor or public speaker may be more concerned about the loss of a premolar or molar.

Speech may be affected, particularly in respect of anterior tooth loss. There may be lisping or spitting on speaking. However, these effects are not often found because of the general ability of the patient to adapt to such changes.

Alveolar resorption is a natural consequence of tooth loss, there being no need for the bone if there is no tooth and periodontium to support. Both intra- and extraoral soft tissues may collapse or spread into the space. The tongue will spread laterally and the perioral soft tissues may collapse inwards. This latter effect may affect aesthetics considerably, particularly in middle age and after, when muscle tone is reduced.

Fig. 18.2 Edentulous spaces at |4 and |6 where tooth relationships have remained stable.

Effects of tooth loss – summary

As with many other biological processes the effects of tooth loss are often unpredictable. Although the list of possible problems is large, many patients do not exhibit any of these and in others the effects may be minimal. Clearly, the more teeth that are lost, the greater the possibility of problems. The most important are those that could induce further pathology and deterioration of the remaining dentition.

The Replacement of Missing Teeth

This section must open with the statement that *not every missing tooth needs to be replaced*. This might

(a) (b)

Fig. 18.3 Slight deterioration of occlusal relationships around missing molars but not indicating tooth replacement.

come as a shock to a well-motivated patient who has invested much time and trouble in attending for prolonged but ultimately unsuccessful endodontic therapy, only to learn that the resulting space will remain unfilled!

Such a patient needs to be informed that all methods of replacing missing teeth carry with them the possibility of causing further damage to the dentition and other problems.

On the other hand, there are obviously several potential benefits to be gained from tooth replacement:

- Restored aesthetics
- Restored function
- Prevention of deterioration of the remaining dentition

Of these, the patient will be highly motivated to the restoration of aesthetics but might need some convincing as to the value of the other two, particularly the last. From the treatment planning viewpoint, the restoration of function and the maintenance of the remaining dentition will need to be balanced against the possible harm that may be induced by the provision of a prosthesis (see later).

Missing teeth may be replaced by:

Fixed prostheses – bridgework

which may be

Resin retained (*adhesive*)
Crown retained (*conventional*)
Endosseous implant retained

Removable prostheses – partial or complete dentures

which may be

Tooth borne
Tissue borne
Implant borne
All three combined

The detailed indications, contraindications, design and construction aspects of the above will be considered in the subsequent chapters (Chapters 19–26) but the general aspects of each will be considered here.

The choice of prosthesis

Once the decision to replace a missing tooth or teeth has been made, many factors will be involved in choosing the appropriate prosthesis:

General factors

- Patient aspirations and motivation
- Age and general health of the patient
- Ability and training of the dentist
- Ability and training of the technician
- Clinical and laboratory facilities available
- Economic factors

Intraoral factors

- Restorative condition of the dentition, in particular the abutment teeth
- Number of missing teeth and their location
- Tooth relationships – the occlusion
- Periodontal condition, caries and oral hygiene

(a)

(b)

(c)

Fig. 18.4 Edentulous spaces with associated deterioration of occlusal stability which has restricted the space for replacement of the missing teeth.

Fig. 18.5 Loss of posterior support has resulted in anterior tooth surface loss due to changes in chewing pattern.

- The presence of an existing partial denture
- Alveolar bone volume and position

General factors

The patient

The patient's prime position in the formulation of a treatment plan was discussed in Chapter 1 and these same principles apply here. A patient with low motivation, who is unable to attend regularly or who cannot for whatever reason be treated 'normally', should have a simple treatment plan. In the context of the choice of a prosthesis, this will usually mean a partial denture.

There should be no general upper age limit affecting the choice between a bridge and a partial denture but age may bring with it some restrictions that affect the delivery of dental care. The influence of the medical history in the drafting of a treatment plan and its delivery was discussed in Chapter 4.

Young patients will have immature dentitions with large pulps and unstable gingival margin position and will not usually be suitable for bridgework. Also, they may be involved in contact sports that again would contraindicate bridgework. Continuing growth contraindicates implants.

The dentist, the technician and their facilities – The construction of fixed prostheses requires excellent clinical and technical skills and appropriate facilities. Whilst some aspects of the construction of partial dentures require similar skills, in general this line of treatment is usually simpler and less demanding. It may also be that the consequences of a poorly constructed partial denture will be less harmful to the dentition than those of a poorly constructed bridge. At least the partial denture can be removed for cleaning and the tooth preparation for it is usually minimal.

Economic factors including state or private insurance schemes influence the delivery of advanced restorative care to a large degree. Endosseous implant retained prostheses are outside the scope of some schemes and are outside the financial resources of many patients. Fixed bridgework is also affected, though to a lesser extent, whilst partial dentures sometimes seem to be regarded as the bargain basement treatment; this attitude somewhat devalues the skills and techniques required for their proper construction.

Intraoral factors

Restorative condition of the dentition, in particular the abutment teeth

The provision of any prosthesis should be against a background of a stable and well-restored dentition. The presence of active caries or periodontal disease ought to preclude the construction of a prosthesis that should wait until intraoral conditions are suitable. A prosthesis may aggravate a pre-existing condition and make things worse.

However, delaying the construction of a prosthesis may not always be possible, for example when the patient requires the restoration of aesthetics. In these circumstances it is necessary to make a prediction of the outcome of the pre-prosthetic periodontal and restorative therapy. If this prediction is guarded, it would be acceptable to construct a simple intermediate partial denture whilst the mouth is being stabilised. If the dentist has more confidence in the outcome then provisional bridgework could be constructed pending stabilisation of the rest of the mouth.

The condition of the abutment teeth is a major consideration in the choice of prosthesis. Bridgework requires biologically and structurally sound teeth of good prognosis to support and retain it. Each tooth should have a healthy periodontium, even though this can be reduced through previous periodontal disease. The pulp should be unquestionably vital or the tooth should be properly root filled with no apical pathology. There should be enough sound dentine or enamel to support the chosen retainer.

Whilst the abutment teeth are also important in the support and retention of a partial denture, the alveolar ridge can often be used to supplement them. Their condition therefore will not be as critical as it is for bridgework.

Teeth alongside implant retained crowns or bridges should be sound and well restored.

The number of missing teeth and their location

In general, a single missing tooth is best replaced by means of a bridge, all other factors being equal. Even in the presence of moderate periodontal disease there is evidence to suggest that a bridge creates less unfavourable conditions for plaque control than does a partial denture. Single tooth restoration endosseous implants (Chapter 23) offer better success rates than a bridge and do not need the preparation of an abutment tooth. However, cost and a surgical operation may inhibit their use.

An edentulous space resulting from two missing adjacent teeth bounded by remaining teeth could be restored by bridgework, either attached to an implant or to the adjacent teeth. Where the space is of three or more teeth, the partial denture becomes the more reliable simple option with implants providing better results at higher cost. Here there may be insufficient adjacent teeth to support a bridge adequately or the technical difficulties in construction may limit the treatment plan.

Where the edentulous space is unbounded at one end, i.e. a free end saddle, the restorative options will be further limited, again if implants are not possible. A bridge may be used to restore one tooth as a distal cantilever design but to restore more will inevitably require a partial denture.

Several missing teeth, each in different areas of the dental arch, could be replaced by several independent bridges, but usually the most cost-effective and simple option is to make a partial denture.

Tooth relationships, the occlusion

As will be discussed in Chapter 20, the design of a simple bridge involving two or more abutments requires that these teeth be aligned roughly parallel. The construction of a bridge on malaligned teeth is not impossible, but is more difficult technically. The greater the disruption to the normal tooth relationships, the more a partial denture is indicated. Irregularities of the occlusal plane will also compromise the design of a bridge and if these are difficult or impossible to correct then usually a partial denture is preferable.

Periodontal condition, caries and oral hygiene

As was stated above, all prostheses should be placed into stable and pathology-free mouths. In the face of poor oral hygiene, all types of prosthesis are likely to fail. It is a matter of some clinical judgement as to whether intraoral conditions will deteriorate more where there is a dirty bridge compared to a dirty partial denture present. The counsel of perfection is to only place a prosthesis in a mouth that is properly maintained by both the patient and by the dentist and where active caries and periodontal disease have been eliminated.

In relation to implant retained prostheses, the presence of periodontal disease is a significant contraindication. There is considerable potential for periodontal infection to spread to the implant sites and cause problems.

The presence of an existing partial denture

When a further tooth is lost in close association to an existing denture, the simplest approach is to add another artificial tooth to the denture. The mixing of a denture and bridgework in the same arch may lead the patient to dispense with the denture and to rely on the bridgework alone. This is true particularly of an anterior bridge combined with a partial denture replacing posterior teeth; having an anterior tooth on the denture is a great motivator to proper denture wearing.

Alveolar bone volume and position

These will be affected by the extent of post-extraction resorption which may in large edentulous areas continue for many years. The series of sectioned models (Fig. 18.6) shows the results of resorption in the upper incisor region. Resorption in this area and indeed the whole maxilla proceeds from the outer aspects of the alveolar ridge thus reducing its diameters. In contrast the resorption in the mandible proceeds from the inside and therefore the diameters of the lower arch increase. In an edentulous patient, this has implications for the construction of complete dentures (Chapter 26).

The lower model in Fig. 18.6 has little resorption and this represents favourable circumstances for the placement of a bridge pontic onto the alveolar ridge. This may be seen in Fig. 18.7 where a single tooth pontic is represented in its restorative position. The tooth inclination is good from an aesthetic viewpoint and, as will be seen in later chapters, the alveolar mucosa will mimic gingival tissue. A removable prosthetic replacement could also be made in this site and, because of the volume of bone, a labial flange would not be required and the artificial tooth or teeth would be *gum fitted*.

Clearly, the volume of bone seen in Fig. 18.7 would be favourable for the siting of implants.

The worst case shown in Fig. 18.8 has insufficient bone for implants and when an incisor or incisors are placed in the correct aesthetic and functional position there will be a large gap between the alveolar ridge and the teeth which can only be filled effectively by a denture base.

Where there is moderate resorption as in the middle model in Fig. 18.6, the replacement could be by a bridge, but there would be a need to make up the missing bone demonstrated in Fig. 18.9 by using pink ceramic. A denture base could also provide an effective replacement.

The angle of an implant placed into an area of reduced bone may also create unfavourable aesthetics. Figure 18.10 shows the moderately resorbed ridge with the outline of an implant placed in the maximum volume of bone. The *emergence angle* will mean that the abutment will need to be at an angle to the implant for the crown to be in a functional position and therefore the aesthetics will be poor. To create good aesthetics the implant will need to be further forward and angled palatally and this can only be done by ridge augmentation prior to implant placement (see Chapter 22).

This same principle applies to the siting of implants in other areas of alveolar resorption where vital structures such as nerves, blood vessels and the maxillary antrum would be vulnerable to damage.

Fig. 18.6 Alveolar resorption. Sections of maxillary models showing the progression of alveolar resorption over several years from the lower model where there is little resorption, the middle model where there is moderate resorption and the upper model where there is much resorption.

Fig. 18.7 Correct central incisor position on an alveolar ridge with minimal resorption.

Fig. 18.8 Correct central incisor position on a grossly resorbed ridge. The resorbed bone is replaced by denture base.

The functional and aesthetic siting of bridge pontics or implant retained crowns in areas of considerable resorption is difficult. The model in Fig. 18.11 shows an incisor that has its tip in the correct position. However, it has been angled to bring its neck into contact with the resorbed alveolus. Such an arrangement was made in the case shown in Fig. 18.12 that has a large anterior bridge. The angle of the incisors creates poor aesthetics and was presumably constructed in this way because the position of the tips was set by the lower incisor occlusion and the necks by the alveolus. Figure 18.13 shows the alveolus after the bridge was removed and the amount of resorption

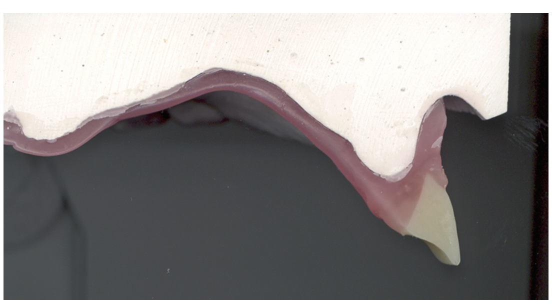


Fig. 18.9 Correct central incisor position on a moderately resorbed ridge. A bridge would need the resorbed bone to be replaced by pink ceramic. A denture base does this.

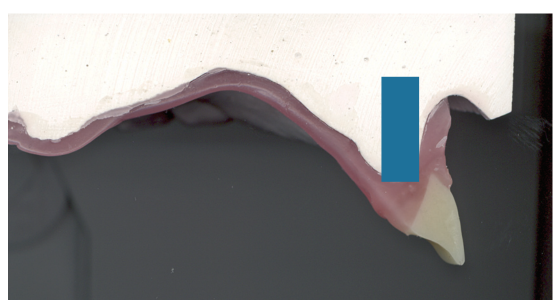


Fig. 18.10 The outline of an implant has been superimposed on the remaining bone in Fig. 18.9. The aesthetics would be poor if an implant retained crown was made in these circumstances.

Fig. 18.11 Incorrect incisor position on a ridge with much resorption. The acute angulation leads to poor aesthetics.

can be seen. The management of this case is discussed in Chapter 21.

Deleterious Effects of Dental Prostheses

There is no doubt that the placement of a prosthesis, whether this is fixed or removable, brings with it certain disadvantages. Principal amongst these is the possibility of causing further deterioration of the dentition. The possible deleterious effects are:

- Recurrent caries
- Loss of pulp vitality
- Tooth wear
- Periodontal disease
- Soft tissue infection and damage
- Alveolar bone infection

These effects will vary in incidence and magnitude according to the type and design of the prosthesis. Their management will be discussed in Chapters 29 and 30.

Fixed bridgework

The construction of a bridge requires tooth preparation to accommodate the retainers. In the case of resin-retained bridgework this preparation is minimal and this type of bridge is likely to have less untoward effects on the dentition. Where conventional bridges are made, the retainers are usually full crowns and here there is the potential for loss of vitality as a

Fig. 18.12 Large anterior bridge with poor aesthetics caused by the incorrect incisor angulation.

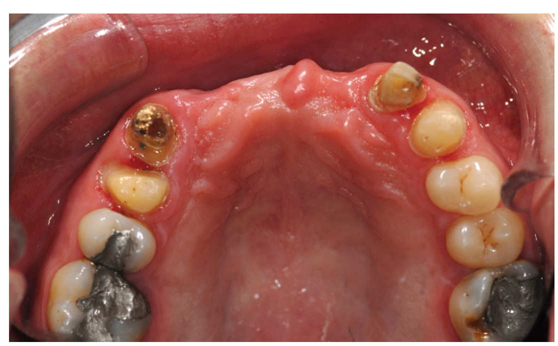


Fig. 18.13 Alveolar ridge with the bridge removed showing bone loss.

result of the trauma of the preparation. If the abutment tooth has already been carious and restored this potential is increased.

The retainer margins, no matter how well fitting, and the pontic/retainer embrasure spaces introduce plaque traps that require special oral hygiene measures to be performed by the patient. The consequences of plaque accumulation may be periodontal disease and, in the presence of a substrate, recurrent caries.

Damage to opposing teeth is possible if ceramic on the bridge is in functional contact with them. The ceramic is harder than enamel and, if poorly glazed or rough, will cause rapid tooth surface loss.

Bridge abutment teeth may transmit unfavourable twisting forces to the periodontium. If the periodontium is already inflamed these forces may accelerate periodontal breakdown. On the other hand, if the periodontium is healthy, it appears that supporting a bridge does not bring any untoward effects (see Chapter 20).

Implant-retained prostheses

Damage to local vital structures (nerves, blood vessels, antrum) is possible during placement. The endosseous implant is also a potential entry point for bacteria and 'peri-implant' infection of the soft tissues and bone is possible (Chapter 23).

Partial dentures

The contact areas of clasps and denture base to the surrounding teeth are sites for plaque accumulation and its consequences of caries and periodontal disease. Movement of the denture base, particularly tipping and rotation may accelerate periodontal breakdown in the presence of active periodontal disease.

Stagnation under a denture base may create conditions favourable to the establishment of infection by Candida albicans (thrush) leading to denture-induced stomatitis.

Continuing care and replacement

All restorative work brings the requirements of continued maintenance and monitoring by the dentist and scrupulous oral hygiene by the patient.

Perhaps of even greater importance is the realisation that eventually repair and replacement will be necessary for most restorations. This does not reflect upon the standards of care but a realistic appreciation to be conveyed to the patient that nothing lasts forever. General wear and tear and changes in the oral cavity may lead to local or general failure of restorations.

All other things being equal, i.e. that no pre-existing problem, such as a questionable root filling, exists then the life expectancy for a bridge would be between 10 and 15 years and a removable partial denture perhaps 10 years. Even during that time minor problems such as the fracture of a component or even major repairs such as root canal therapy through a retainer may be necessary.

Because of their complexity of construction, implant retained prostheses require even more intense maintenance. Failure of joints and superstructure components is possible as well as the basic failure of the implant itself.

A very positive commitment to continuing care in relation to any prosthesis is required by both the patient and the dentist. Effective oral hygiene and attendance for regular review is the patient's role in this.

Shortened dental arch

Bearing in mind the above description of the deleterious effects of dental prostheses, a philosophy of non-replacement of lost posterior teeth has evolved, known as the *shortened dental arch*. Whilst this concept could be applied to any missing molar teeth, it has come to refer to dentitions that have no teeth distal to the second premolars in all four quadrants, i.e. all the molar teeth have been lost and deliberately not replaced. This arrangement has also been termed a *premolar dental arch* or a *premolarised occlusion* (Fig. 18.14).

Fig. 18.14 A case with shortened dental arches.

There is clinical evidence to support the concept in that patients have been observed to function adequately with such a reduced occlusal table and the possible deleterious effects of a prosthesis on the premolar teeth, in particular tipping and periodontal problems, are prevented.

Loss of occlusal stability of the premolars due to distal drifting and wear has been shown to be small and the poorer aesthetics of missing molars has not been considered a problem.

The concept may also be applied if the premolar arch is not intact, particularly if the second premolars are missing. These teeth may be replaced, all other factors being equal, by distally cantilevered units attached to the remaining teeth or endosseous implants. The biomechanics of this type of arrangement must be considered. It is suggested that the distally cantilevered unit is restricted to one premolar only to reduce tipping forces and if several teeth are involved in the prosthesis that it is constructed from gold alloy and acrylic resin to allow flexure.

Treatment Planning for Prosthodontics – Summary

The loss of natural teeth may result in the deterioration of the remaining dentition and affect the patient adversely.

The provision of a prosthesis will restore aesthetics and function as well as playing a part in maintaining the dentition.

The prosthesis, however, may cause deterioration in its own right and the decision to restore the edentulous space must take into account both the advantages and the disadvantages of the treatment.

The choice of prosthesis is based on a complete assessment of both the patient and the intraoral conditions and many factors must be considered with the condition of the mouth itself being of principal concern.

The active cooperation of the patient in both the provision of the prosthesis and its subsequent maintenance is of paramount importance to its success.