4 Considerations for removable prostheses

INTRODUCTION

Once the patient has agreed to the provision of a removable prosthesis, there are a number of factors to consider. In the main, these will be specific for each patient. However, there are some that are general and which relate to clinical common sense. For example, not all prostheses should be considered as 'definitive'. Some are clearly intended to help diagnosis, some to be of short duration, and some for a specific therapeutic purpose. Examples of some of these are given in Table 4.1.

It is perhaps unrealistic to consider any prosthesis as being 'permanent', and in the interests of clarity clinicians ought to be aware of the fact that, on occasions, it is useful to consider prostheses as being:

- Preliminary to definitive treatment, or
- Definitive treatment.

The execution of the design of a removable prosthesis should be thorough, irrespective of its intended duration, and the notion that any prosthesis 'is only a temporary denture' is to be deprecated.

To avoid repetition, this chapter will deal with the planning processes for removable prostheses in broad terms, and the considerations for all of the categories of prostheses listed in Table 4.1 will be covered under one umbrella.

Table 4.1 Types of prosthesis according to their intended purpose

Intended nature of prosthesis	Example
Diagnostic	Occlusal splints (? 'bite-freeing')
Short duration	Immediate-insertion prostheses Training dentures Manchester veneers (McCord et al., 1992)
Therapeutic	Training plates for patients who retch
Definitive	Any prosthesis intended to be in place for more than 6 months without any required reline or addition

STAGES IN PLANNING REMOVABLE PROSTHESES

Outlining the saddles

When the factors listed in Chapter 2 have been considered and the agreed option is a removable prosthesis, the clinician has to decide which of the missing teeth are to be replaced and which saddles are to be restored. For example, in Figure 4.1a, there is only one saddle and one tooth to be replaced (albeit for a short time) with a removable prosthesis; this part of the decision-making process is relatively straightforward. In Figure 4.1b, there are several teeth to be replaced and several saddles. Not all of the teeth and not all of the saddles *need* to be replaced, as this might result in unnecessary tooth involvement with the denture and, in addition, may compromise appearance and retention (see below). In Figure 4.1c, however, no teeth may be being replaced but, as an occlusal splint is required, the prosthesis will cover an entire dental arch. The decision to restore a saddle or not will inevitably simplify or complicate the design, as has been referred to above.

Most textbooks on removable partial prosthodontics suggest that this stage of the denture design process should be performed as the commencement of a logical sequence. This has much merit as a teaching or training method, but in reality the decision on whether to restore an edentulous area ought to have been made concurrent with the decision of how to restore the missing tooth/teeth. We consider that all graduate clinicians ought to be aware of the need to plan holistically, and that it is good practice to formulate a tentative denture design concurrent with the formulation of the treatment plan. In this way, the three clinical options illustrated in Figure 4.1 may be made at the chairside; the clinician may alter the design after reflective thought, and having the benefit of articulated casts and following thorough cast analysis. The latter makes ultimate sense, as no prosthesis should be planned without considering the patient's intermaxillary relationships: sometimes, for example, there is no space for a prosthesis, and a predefinitive stage may be required (Fig. 4.2).

Deciding on the nature of the support

Over the years, a variety of clinicians have offered suggestions for classifications of dentures based on support. For any classification to be useful, it should be:

- Consistent

a

b

c

Fig. 4.1 (a) This maxillary cast has one edentulous area and one tooth is missing from that area. (b) There are several edentulous areas and some have more than one tooth missing. (c) No teeth are missing here, but a prosthesis has been prescribed to serve as a splint.

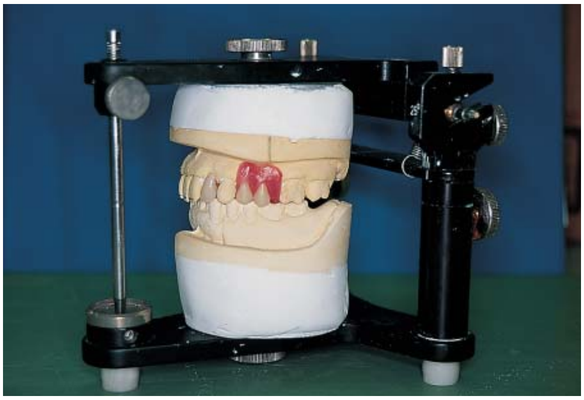


Fig. 4.2 The articulated casts should be examined to check for available space.

Fig. 4.3 This mandibular denture is tissue-borne and has 'sunk' into the tissues.

- Unambiguous
- Generally accepted.

According to Osborne and Lammie (1974), however, a classification of partial dentures should do more than the above and ought to suggest the main problem involved in the particular case. For this reason no one classification is ideal, and perhaps the most useful is that outlined, in one form or another, by Beckett (1953), Craddock (1956) and Osborne and Lammie (1974):

- Class I: Denture supported by mucosa and underlying bone
- Class II: Denture supported by teeth
- Class III: Denture supported by a combination of mucosa and tooth-borne means.

We consider that this classification should now be extended to include a further type, namely:

- Class IV: Denture supported by implants (see Chapter 5).

It must be realized that this classification is not ranked in order of precedence but could perhaps be considered in order of complexity of planning. For this reason, the support options will be discussed in the above order.

Class 1 Dentures (deriving their support from mucosa and underlying bone)

Wills and Manderson (1977) and Picton and Wills (1978) clarified some misconceptions on the displacement and deformation properties of oral mucosa with their research on primates. They determined that the effects of loading mucosa over a long period were to compress it by up to 45% of its original thickness and, further, that its recovery was viscoelastic in nature. These findings were confirmed by the research of Kydd and Daly (1982). The time required for recovery from the displacing forces has also been found to increase with age. What this clearly means, however, is that prostheses which derive their support from mucosa and the underlying bone will inevitably do two things:

- Displace mucosa
- Result in further loss of alveolar bone (this is perhaps of greater importance).

From the above, it is clear that in mandibular dentures especially, mucosa-borne partial prostheses ought to be considered as a last resort, or possibly as a transitional phase to complete dentures (Fig. 4.3). More latitude exists in the maxilla, however, where the hard palate affords additional support, but this is often abused (Fig. 4.4).

Class II Dentures (deriving their support from teeth)

Tooth-supported prostheses gain their support from the teeth via the supreme qualitative and quantitative support agent, namely the periodontal membrane. Pressure down the long axis of the tooth imparts tension in the periodontal

Fig. 4.4 Poor planning of the upper denture has resulted in gum-stripping. An added complication was that the opposing teeth erupted, causing major problems of space.

membrane, which in turn helps to maintain alveolar bone. Clearly this is the most desirable form of support and should be used whenever practicable. It has traditionally been taught that dentures may gain tooth support from incisal rests, occlusal rests or cingulum rests. This reflects on less holistic prosthodontics than may be currently practised, and Table 4.2 suggests a more detailed outline of tooth-derived support.

The statements in the foregoing paragraph indicate that, theoretically, support derived from teeth is more desirable than any other single form of support, and this is a scientifically established fact. However, on occasion the clinician has a need to be empirical and to prescribe what is most appropriate for the patient. For example, a patient who has been treated for chronic periodontal disease may have lost considerable bony support, and a cast metal framework utilizing occlusal rests and cast cobalt chromium clasp assemblies may impart inappropriate forces on a tooth (see pp 42–44).

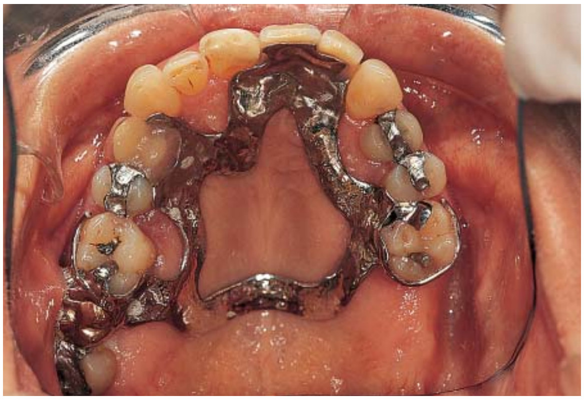
It should be redundant to state that there is no place nowadays for wrought occlusal rests – they cannot offer an acceptably accurate fit and therefore cannot transfer occlusal loads in a satisfactory manner.

Class III Dentures (deriving their support from a combination of mucosa and tooth-borne means)

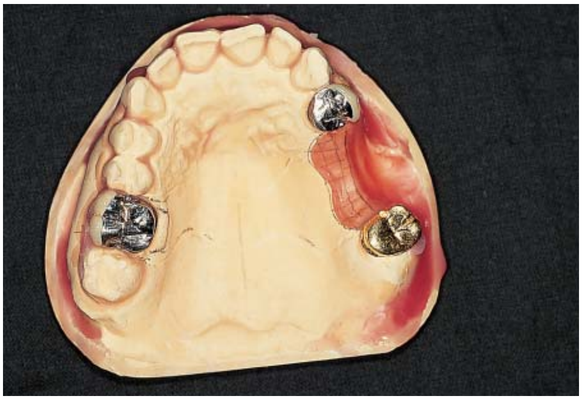
It is perhaps no coincidence that clinicians and patients alike have embraced the shortened dental arch philosophy. The option to do nothing or to

Table 4.2 Possible means of tooth support

Details of tooth support	Description
Occlusal rest	Typically a saucer-shaped depression in a natural tooth prepared to house a metal casting, although if a parallelometer is used a metal/metalloceramic crown may be waxed-up to receive a wedged-box inlay preparation (Figs 4.5a and b)
Incisal rest	Less common nowadays, as most western European and North American patients do not find the appearance acceptable (Fig. 4.6)
Cingulum rest	A common supporting element which has the double advantage of providing good reciprocation to a direct retainer on the same tooth. Typically, this is created through the use of a tapered fissure bur and presents a positive ledge in the cingulum (Fig. 4.7). Cingulum rests may also be created or acquired via adhesive techniques, when composite resin or a metal alloy may be added to the surface of a tooth
Milled crown	Offers the potential for good support down the long axis of the supporting tooth and, if planned well, prevents coverage of the gingivae by the major connector (Fig. 4.8)
Overdenture	May be a decoronated tooth, which has usually undergone endodontic treatment. May or may not have a precision attachment on or in the root face



a



b

Fig. 4.5 (a) Form of occlusal rests on abutment teeth to provide occlusal contact and engender stability to the denture. (b) Milled occlusal rests on crowned abutment teeth.

Fig. 4.6 Incisor rests have been included in this denture but the appearance has been compromised.

Fig. 4.8 Milled crown, shoulder clear.

Fig. 4.7 Cingulum rests have been milled to fit into a shoulder on the crowns of the canines.

use a fixed prosthesis to replace one dental unit (e.g. by cantilevering one unit from the terminal abutment) is seen as being less problematic than providing a removable prosthesis to replace several missing teeth. From the clinician's viewpoint this is because of the very real and problematic differences between the two supporting elements, and from the patient's perspective because of intensive tissue coverage.

Extrapolating the results of Wills and Manderson (1977) and Wills et al. (1980), the clear fact emerges that, long after abutment teeth have returned to their resting positions (after mastication, for example), the mucosa will remain displaced; this displacement is of the order of 20 times that of the teeth even on the basis of a maximally covered saddle. It will be self-evident to state that mucosa under minimally covered saddles will be displaced even more than under maximally covered saddles.

This support differential is thus problematic, and the inherent tendency for a prosthesis to demonstrate rocking (instability) has resulted in philosophies of clasping which were based on homeostatic principles of stress-breaking, whereas others were based on more biological principles (Kratochvil, 1963; Krol, 1973). The 1983 Symposium on Restoration of the Partially Dentate Mouth (Bates et al., 1984) effectively refuted the stress-breaker concept, and the philosophy of clasping in this type of prosthesis is now more biologically friendly (see below). Another complicating factor to bear in mind, arising from the disparity in the supporting agents, is the need to consider antirotation devices, and this will also be considered later.

Class IV Dentures (deriving their support from implants)

Implant-supported prostheses will be considered in Chapter 5.

Deciding on the form of the major connector

As presented in many textbooks, the next stage of the design process is to consider how the prosthesis will be retained. It became clear in the planning stages of this book that the authors tend to consider the major connector next, and thus we offer this as the next stage of the design of the removable prosthesis. Just as in a fixed prosthesis, where the bounded saddle is restored with a tooth/teeth forming the pontic, so in a removable prosthesis we use a component called not a pontic but a major connector. This must be rigid and capable of transferring occlusal and masticatory loads to the supporting elements of the denture without adversely affecting these denture-bearing tissues. The types of major connector in common use are listed in Table 4.3.

These are merely descriptions of the form of the component. The decision on the nature of the material (from which the connector is produced) must be based on the clinical findings and the future needs of the patient. If the prosthesis is intended to be an immediate denture, or if it is to be a splint to treat temporomandibular dysfunction symptoms, then the material of choice will invariably be poly(methyl)methacrylate (PMMA). If smaller areas of coverage are intended and the major connector is required to be intrinsically strong, then a metal alloy is indicated. The most common alloy in clinical usage is cobalt-chromium, although type IV gold alloys may be used. More recently, titanium alloys have been recommended, but the technical requirements of the latter are more rigorous than the former two, and so more

Table 4.3 Common major connectors

Maxillary	Mandibular
Palatal plate (Fig. 4.9)	Lingual plate (Fig. 4.15)
Palatal strap (Fig. 4.10)	Lingual bar (Fig. 4.16)
Anterior or posterior palatal bar (Fig. 4.11)	Sublingual bar (Fig. 4.17)
Skeletal design (Fig. 4.12)	Kennedy bar, i.e. a lingual bar plus a continuous clasp (Fig. 4.18)
Horseshoe design (Fig. 4.13)	Labial bar
Labial bar (Fig. 4.14)	

Fig. 4.9 Palatal plate.

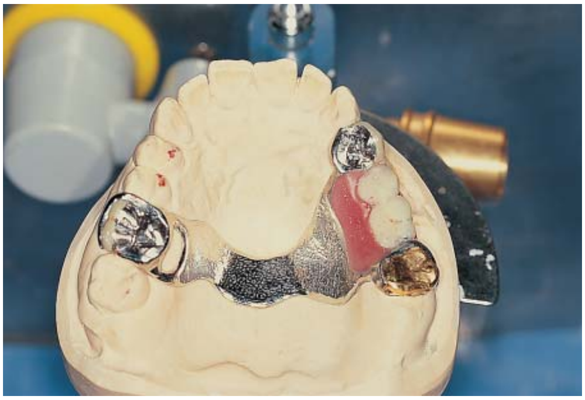


Fig. 4.10 Palatal strap.

Fig. 4.13 Horseshoe design.

Fig. 4.11 Posterior palatal bar.

Fig. 4.14 Labial bar.

Fig. 4.12 Skeletal design.

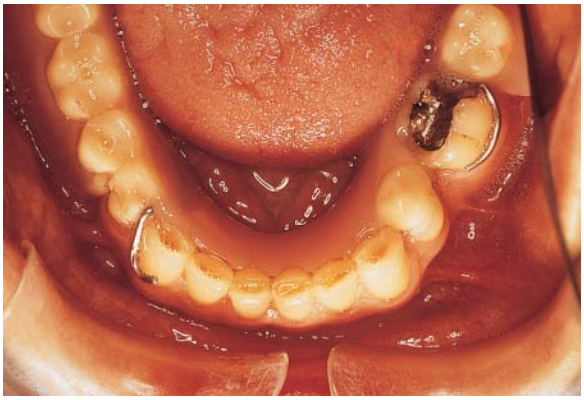


Fig. 4.15 Lingual plate.

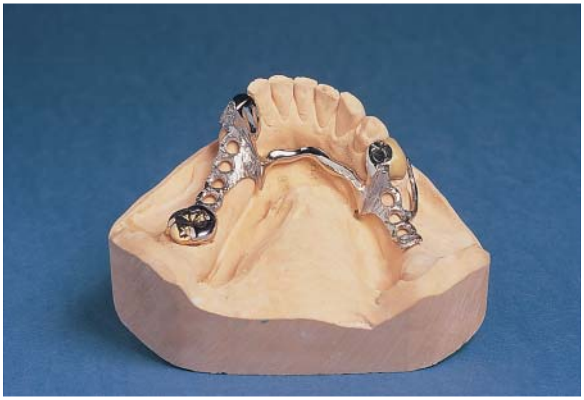


Fig. 4.16 Lingual bar.

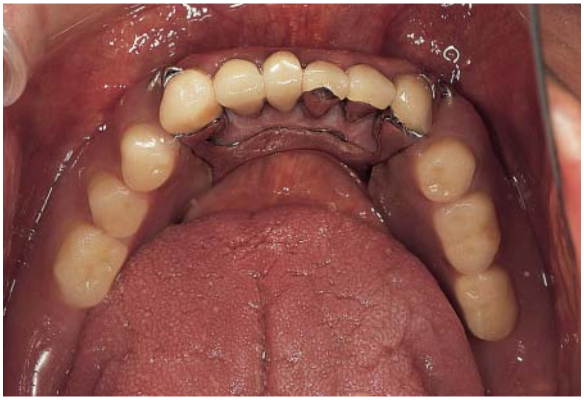


Fig. 4.17 Sublingual bar.

Fig. 4.18 Kennedy bar.

clinical testing is required before they enjoy the popularity of the cobalt-chromium alloys.

Deciding on how the prosthesis will be retained

Irrespective of whether it is to be fixed or removable, the clinician must plan to ensure that the prosthesis resists movement away from the tissues that support it. Fixed prostheses gain support from the height and 'parallelism' of the abutment tooth preparations plus the cement/luting material. In the case of removable prostheses, retention is achieved in a variety of ways, and these are listed in Table 4.4. Not included here is neuromuscular control, principally because this is not quantifiable; nor can it be guaranteed that all patients develop it well.

Although some patients are able to control their dentures without the aid of any retainer or adhesive, we do not consider that any clinician can provide a prosthesis without direct retainers and be confident that it will be adequately retained. Equally, it is generally considered that it

Table 4.4 Direct retainers

Type of direct retainer	Clinical examples
Clasps	Gingivally approaching Occlusally approaching
Precision attachments	Intracoronal attachment Extracoronal attachment Studs Bars Others
Planned use of undercuts not on buccal or lingual of teeth	Guide planes Use of bony undercuts, e.g. labial undercuts in anterior bounded saddles
Use of resilient materials	Resilient materials, e.g. silicone rubber to engage undercuts
Denture adhesives	Usually resorted to by patients, but may be suggested by clinician in certain situations

is impossible to attain a peripheral seal (to assist retention) where partial dentures are concerned. However, it is suggested that, in certain situations, the provision of a peripheral seal is possible.

Clasps

The type or form of clasp is generally selected after surveying the cast. Surveying is generally performed at right-angles to the occlusal plane in the first instance, as this is the likely path of displacement. Surveyors are basically simple instruments which enable a cast to be analysed with respect to tooth contour. Not all surveyors are bulky, and the authors recommend that practitioners use a simple one (Fig. 4.19).

Surveying will identify three principal factors:

- The presence of undercuts
- The contour of the undercuts relative to the gingival margin
- The depth of the undercuts.

Clearly, the absence of undercuts will suggest that no direct retention from clasps is available, and some method whereby retention may be achieved needs to be incorporated. This could be done relatively easily by the addition of composite resin

Fig. 4.19 A simple surveyor for surgeries.

Fig. 4.20 Some composite has been added to the buccal aspect of the lower right canine to provide an undercut.

(Fig. 4.20) or by a crown or, if a crown already exists, by creating a dimple in the crown (Figs 4.21), taking care not to perforate it. The contour of the undercuts relative to the gingivae will determine if the clasp is to be gingivally approaching or occlusally approaching. As the health of the periodontium must not be compromised, it is clear that clasp arms and clasp tips should be clear of the gingival margins of abutment teeth.

The depth of the undercut is determined via undercut gauges, three of which are in current use, namely 0.25 mm, 0.5 mm and 0.75 mm. As all direct retainers, especially clasps, work by making the retaining element deform, the deformation must be controlled, and it is this component that determines, fundamentally, the material used for the direct retainer.

For example, in large undercuts more flexible clasps are required, and these will inevitably be wrought in nature; for 0.25 mm undercuts less flexibility is required and cast cobalt-chromium may be used. However, the clinician should be mindful of the application of biomaterials science when he/she considers the material, and this is particularly relevant here. Bates (1965) and Prabowa (1995) have referred to the need for a minimal length of cast cobalt-chromium for flexibility. This is 14 mm; as no premolar tooth is 14 mm in length mesiodistal, there is no scientific basis for making cast cobalt-chromium clasp arms *which are occlusally approaching* on premolar teeth. If it is not possible to have gingivally approaching

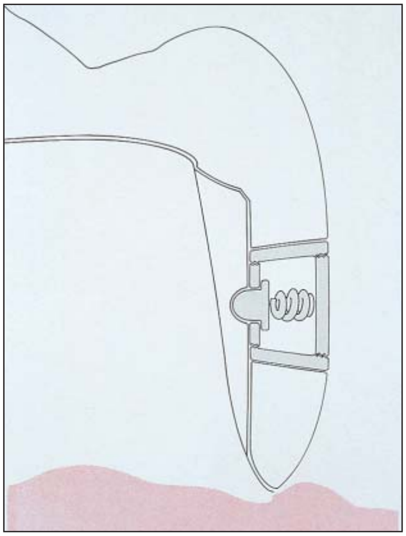


Fig. 4.21 A thimble crown has an indent on the buccal aspect, into which a precision attachment is placed. Alternatively, a clasp arm could be placed into the created undercut.

Fig. 4.22 Dental D clasp. Note its proximity to the gingival margin.

clasps then some other form of direct retention is indicated. This is because short clasps tend to deform permanently or to fracture because the elastic deformation of cobalt-chromium in these circumstances is inadequate.

Reference was made earlier to the analysis of articulated casts, and the clinician ought to be aware of the three-dimensional nature of clasp assemblies. This is particularly true when occlusal rests are part of the assembly. Careful analysis of the articulated cast will enable the clinician to see whether there is space for the occlusal rest and/or clasp arms; if no space exists, tooth preparation is required, for which informed consent must be obtained (see Fig. 1.9c).

The importance of appearance should also be considered, and this is why a tooth-coloured polymeric material was introduced (Dental D). It is not clear whether this material demonstrates the desired qualities to act as a direct retainer, and the advantages of its colour should never be to the detriment of the patient's tissues (Fig. 4.22).

Precision attachments

According to *The Glossary of Prosthodontic Terms* (Academy of Prosthodontics, 1999), a precision attachment is: 'a device which comprises of two or more components which is machined or fabricated for the purposes of providing retention to a prosthesis'. Typically, there are five types of precision attachment and they are listed in Table 4.5.

For further details, readers are referred to standard textbooks (e.g. Preiskel, 1979), although further examples of precision attachments will be discussed in the chapter on implant-retained and supported prostheses.

Planned use of undercuts not on buccal or lingual aspects of teeth

Reference has been made to the need to analyse articulated casts and to survey for undercuts at right-angles to the occlusal plane. Unfortunately, certain clinical conditions conspire to complicate planning, and this is particularly true where anterior bounded saddles exist, and also where posterior free-end saddles exist. These situations may result in diminished retention, and they may also reduce the potential for an aesthetic result (Figs 4.31, 4.32). In both cases a second survey is required (giving a dual survey) to eliminate the undercut areas and provide paths of insertion (and thus of withdrawal) which are not the same as the natural path of displacement (Fig. 4.33). In essence, the second survey determines a plane of insertion, and this is termed a **guide plane.** Guide planes may need to be created by inten-

Table 4.5 A simple classification of precision attachments, with examples of each type

Type of precision attachment	Example	General comment
Intracoronal	Pin-slot (Fig. 4.23) Chayes	Inherently requires loss of tooth tissue and needs a minimum of 5 mm height from base of floor of cavity to the marginal ridge
Extracoronal	Ceka (Fig. 4.24) Dalla-bona	May be resilient or non-resilient. Also requires width and height (5 mm)
Stud	Dalbo Rotherman (Fig. 4.25)	Need to be aware of the potential for bulk and to plan common paths of withdrawal
Bar	Dolder-type (Fig. 4.26) Hader-type (Fig. 4.27) `	The type of bar used may impart the potential to rotate about the bar axis; space requirements are also important, and if an RPD is being used the wax trial denture should be assessed prior to fabricating the bar
Other	Hinges (Fig. 4.28) Spring-loaded ball (Fig. 4.29) Split-pin and tube (Fig. 4.30)	May be problematic to repair Useful but not for free-end saddles Useful in some sectional denture cases

Fig. 4.23 Pin-slot in interproximal grooves.

Fig. 4.24 Ceka extracoronal attachment.

tional modification of tooth contour or by planned contour of fixed restorations (Fig. 4.34). This is the basis of the RPI system advocated by Kratochvil (1963), and modified by Krol in 1973, as a solution to the problems of free-end saddles.

R stands for the occlusal rest, which is placed on the mesial of the terminal abutment tooth. **P** stands for the guide plane, which enhances retention and ought to reduce rotating movements on the tooth. **I** stands for the I-bar, which is the principal direct retainer.

Reciprocation for this I-bar, which should be on the distobuccal aspect of the tooth, is achieved via the mesially placed occlusal rest. Again, further details are available in standard textbooks of prosthodontics.

A more sophisticated philosophy concerns a rotational path of insertion. This was reviewed by Krol and Finzen (1988) (Fig. 4.35).

Fig. 4.25 Rothermann eccentric attachments.

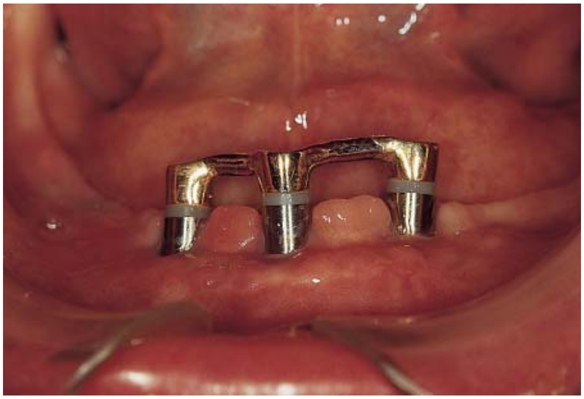


Fig. 4.26 Dolder bar.

Fig. 4.27 Hader bar in a planned hybrid prosthesis.

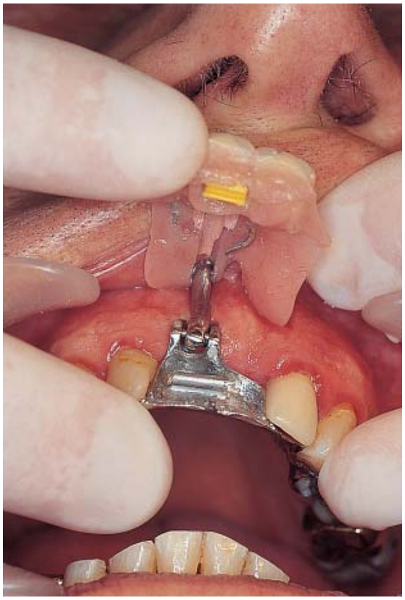


Fig. 4.28 Hinges in upper RPD.

Use of resilient materials

Two statements have already been made in this chapter which now need to be reviewed. The first was that, in theory, it is not possible to achieve a peripheral seal with a removable prosthesis. The second was the definition of a precision attachment (see above). Precision attachments are generally metallic, although some use polymeric components, e.g. rubber O-rings in stud attachments, and we offer the option of using traditional silicone rubber resilient base materials as retaining agents. Typical examples are where only two teeth remain in the arch. The patient is reluctant to lose the remaining teeth and the clinician may be apprehensive about extracting them. Conventional wisdom would indicate that the teeth may not have a lengthy prognosis and we offer the option of utilizing the remaining teeth and achieving a peripheral seal by enveloping them with a velum of silicone rubber (Fig. 4.36). This option is not suggested for every case, but only where the onset of edentulousness is perceived to be 2–3 years away. It must be pointed out to the patient that the resilient material will require to be replaced typically on an annual basis, much as the rubber component of the O-ring is.

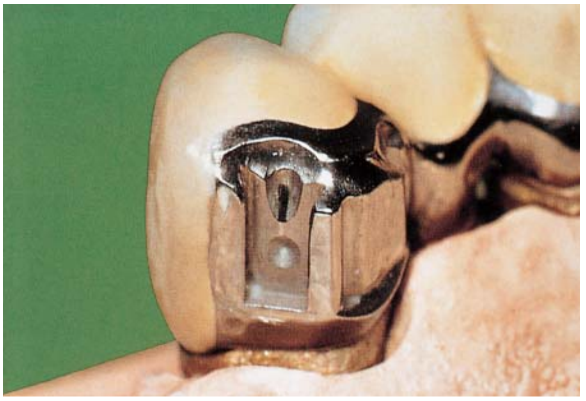


Fig. 4.29 A spring-leaded ball attachment would fit into this prepared receptacle in the matrix.

Fig. 4.30 Split-pin in tube. The tube is incorporated into the denture tooth.

Fig. 4.31 Poor aesthetics, anterior saddle.

Fig. 4.32 Poor aesthetics, Kennedy I (modification).

Fig. 4.33 Better result for Figure 4.31.

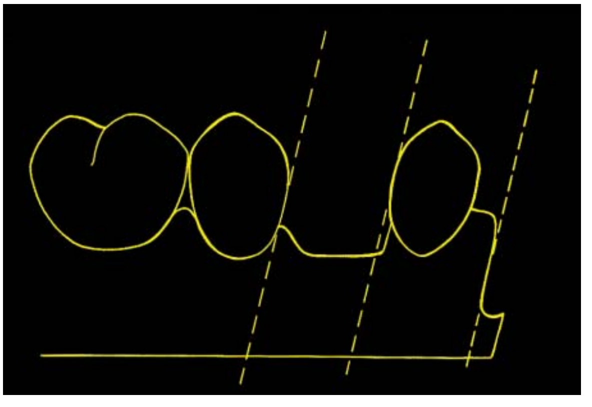


Fig. 4.34 The use of guide planes will improve retention and should enhance appearance.

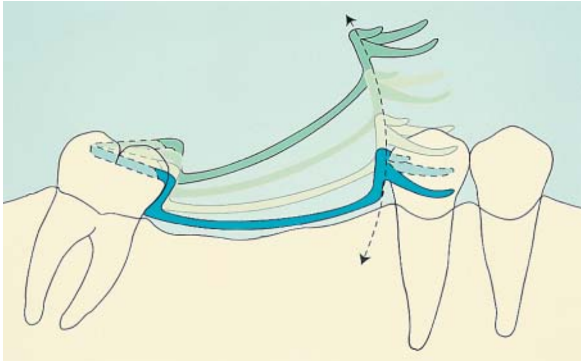


Fig. 4.35 Rotational path of insertion.

Fig. 4.36 Molloplast B has been added to engage the undercut on the distal of the abutment teeth (arrowed).

Use of denture adhesives

Most clinicians, if they are truthful, will confess that they have had to resort to recommending denture adhesives. This is typical in the case of complete dentures, as the potential for caries and other plaque-associated disease is enhanced if denture adhesives are worn in removable prostheses (Berg, 1991); nevertheless, patients will often resort to the use of denture adhesives if retention and stability are poor.

Planning for stability

If RPDs are to be worn with comfort and if they are to achieve their functional goals, then they ought to be as stable as possible during that function. Clearly, in mucosa-borne and in some tooth- and mucosa-borne RPDs, some fine movement of the denture bases over the saddle areas will occur. The principal area of concern is rotational movement. The element in an RPD that counteracts rotational movement is called **indirect retention,** and is achieved by one or more indirect retainers that reduce the tendency for a denture base to move in an occlusal direction about a fulcrum line.

An indirect retainer has been defined (Academy of Prosthodontics, 1999) as: 'the component of a removable partial denture that assists the direct retainer(s) in preventing displacement of the distal extension base by functioning through lever action on the opposite side of the fulcrum line when the denture base moves away from the tissues in pure rotation around the fulcrum line'.

The definition is not all-embracing, as indirect retainers may be incorporated in Kennedy IV dentures, where the saddle is, by definition, anteriorly placed.

The indirect retainer, in addition to resisting rotation of the saddle away from the tissues, also prevents the remainder of the denture, on the other side of the fulcrum, from traumatizing the tissues.

Some writers consider the fulcrum axis to be between the clasp tips; in the case of Kennedy 1 or 2 dentures (Kennedy, 1928), where the RPI system is used, this is essentially impossible and here the axis of rotation will be around the occlusal rests on the terminal abutment teeth (Fig. 4.37). In practice, the two axes tend to be so close to each other that the difference is of no practical significance.

It can be seen from Figure 4.37, therefore, that indirect retainers are supporting elements and serve to further stabilize the denture; failure to provide an indirect retainer will have the dual disadvantages of not resisting rotation and, by virtue of the rotation, will cause 'gum-stripping' by the denture.

Review of design with hygiene and maintenance in mind

After the clinician has drawn the design of the intended RPD on the study cast (Fig. 4.38) he/she

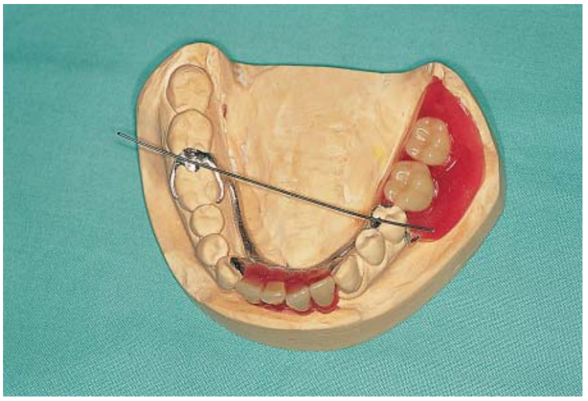


Fig. 4.37 The axis of rotation of this denture is indicated by the metal wire. This wire lies across the occlusal rests, and also coincides with the position of the clasp tip on the lower left premolar.

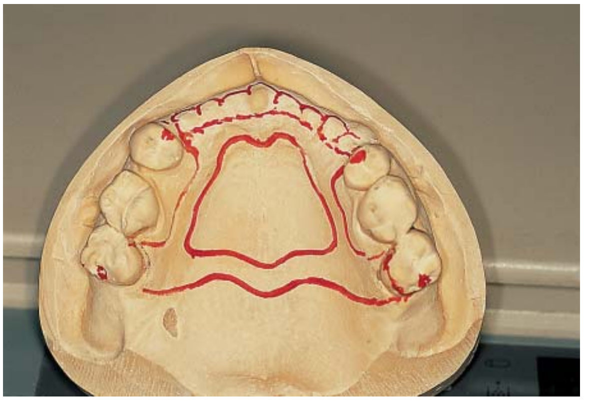


Fig. 4.38 Design drawn on cast.

should then review the design with an objective mind, to determine whether the RPD will be manageable by the patient, that it satisfies guidelines governing the health of tissues (e.g. 3 mm biological width or clearance from the free gingival margins), and that maintenance is relatively easy. For example, there is no point in designing an elaborate sectional denture if the patient does not have the dexterity to insert or remove it.

From the above, if the RPD is to be successful, then the clinician has a duty to plan removable prostheses appropriately for each patient. For this reason, the clinician should not abdicate responsibility by requesting the technician merely to make a prosthesis. No self-respecting clinician would prescribe a drug for a patient, without checking that it was appropriate to do so, yet many dentists request removable prostheses to be designed and processed by technicians who have never seen the patient and who have no real knowledge of the hard and soft dental tissues in the vicinity of the prostheses.

The simple template suggested in this chapter is recommended to enable the clinician to plan the most appropriate prosthesis for the patient.

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