THE CLINICAL GUIDE SERIES

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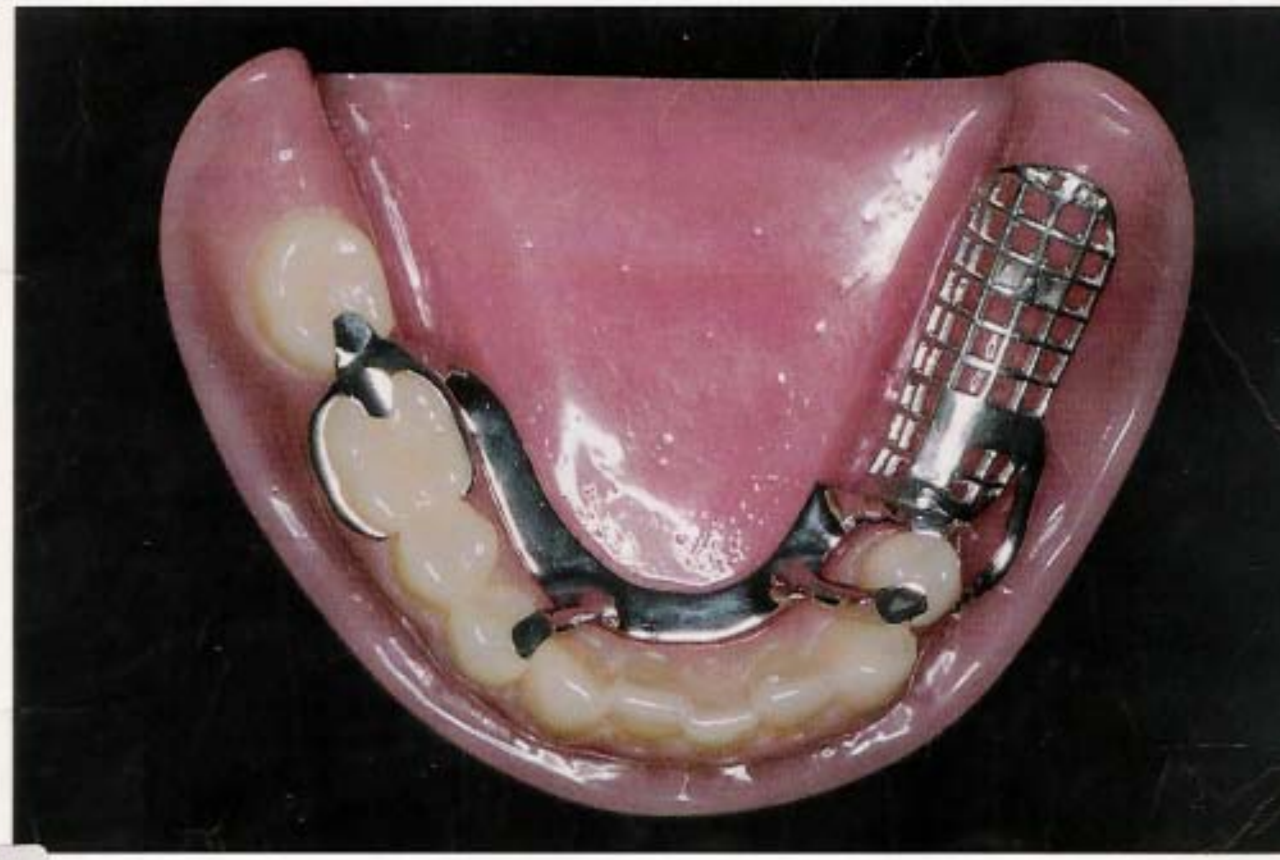
J P Ralph & P O Glantz

# A CLINICAL GUIDE TO REMOVABLE PARTIAL DENTURE DESIGN





[t]he authoritative reference for
[d]ental practitioners and students

## Preface to the first edition

Much clinical research over the last three decades has drawn attention to the tissue damage that can occur as a result of removable partial dentures being worn. In the last ten years or so the influence of removable partial dentures on plaque formation has been stressed. There is thus some evidence to support the layman's comment that 'A partial denture is a device for losing one's teeth slowly, painfully and expensively'.

Fortunately, results from other clinical studies redress the balance, indicating that treatment will be successful and that oral health can be maintained, provided that a team approach is adopted — the team comprising the clinician, the dental technician and the patient. The clinician's responsibilities include preparing the patient to accept the partial dentures, designing the dentures carefully so that the risk of damage is reduced to a minimum, undertaking the clinical work to the highest possible standard and communicating with the dental technician so that the details of design are not absent by default. The dental technician's responsibility is to ensure that the dentures are constructed accurately and that the principies of good design are followed through. All this effort is worthless unless the patient appreciates the importance of oral hygiene and prevention of disease and is prepared to put considerable effort into maintaining the mouth and the dentures.

This Atlas attempts to present in pictures and words the principles which govern successful treatment throughout the stages of patient evaluation, denture design, preparation of the mouth and construction of the dentures. We have purposely concentrated on clasp-retained partial dentures as there are other texts which deal with fixed restorations and precision attachments.

Rather than include an exhaustive list of references we have leant heavily on the book Restoration of the partially dentate mouth, edited by Bates, Neill and Preiskel, which is a record of a very successful international symposium held in London in 1982. Twelve workshops were held and the reports of these workshops brought together the literature. We feel that this volume provides a useful source of reference for those readers who wish to delve further into that literature.

We have decided to use the FDI two-digit system of tooth notation as it is now becoming more widely accepted throughout the world, probably due to the increasing use of computers. A word of explanation serves as a guide to those readers who have not used it before. The four quadrants of the mouth are denoted by the first digit of each pair of numbers, namely

| 1 | 2 |
|---|---|
| 4 | 3 |

. The second digit refers to the tooth, for example: 18 17 16 15 14 13 12 11|

Thus, 4/ (upper right first premolar) is 14.

No book can be all-embracing. There is, after all, no real substitute for experience gained by treating patients. We hope, however, that this Atlas will serve as a useful guide to clinical work and that it will encourage the team approach to the care of partially edentulous patients.

JCD
RMB
JRH
JPR

## Preface to the second edition

One of the authors (JCD) had the very good fortune to be invited to participate in a removable partial denture (RPD) 'Summit' organised by Professor Bengt Öwall at the Panum Institute, Copenhagen in June 1999. Prosthodontists from Denmark, Sweden, USA, Germany, Greece, Japan and the UK reviewed the literature, shared their clinical experience and engaged in a wide-ranging and fruitful discussion. During a remarkable three days the focus was kept firmly on aspects of RPD design likely to be significant for oral health. The conclusion was that there was still very little scientific data on which to base current concepts of RPD design. However, it was reassuring that the group exhibited a high level of agreement over the interpretation and application of what data there was, and was united in the view that hygienic aspects of RPD design are of over-riding importance compared with design aspects that are concerned primarily with mechanical requirements. It is the authors' hope and intention that this 2nd edition of our textbook clearly reflects this international consensus on the importance of basing RPD design predominantly on the need to maintain the oral health of the patient.

The 2nd edition of our book has been re-organised into two volumes to conform to the format of the successful 'Clinical Guide' series of our new publishers, the *British Dental Journal*. The material in each volume complements the other.

Several new chapters have been added to this 2nd edition, broadening significantly the scope of the book. Emphasis is placed on the important distinction between the need and the demand for RPD treatment. The dangers of over-treatment are discussed and the management options for the partially dentate patient considered. A chapter on RPDs and the elderly includes comments on the demographic processes within the population and the possible significance of the retention of at least some teeth into old age. Effective communication between dentist and dental technician is one of the cornerstones of competent RPD treatment and so another new section considers present shortcomings and how they may be overcome. Checklists of instructions to the technician conclude each of the chapters, dealing with the clinical stages of RPD treatment as an aide memoire for the dentist.

'Principles of Design' is entirely new and was developed from a collection of design rules produced for a computerised knowledge-based system, RaPiD, for the design of RPDs. This collection of rules was obtained initially from the literature and was subsequently modified in the light of comments received from prosthodontic colleagues in all the dental schools in the UK and the Republic of Ireland. The level of support each design rule received from these experts is included as a guide to the reader. Since then, further significant contributions to this knowledge base have been made by a number of prosthodontic specialists from several different countries. Their comments have been taken into account in the discussion that follows each rule. We hope that the wealth of prosthodontic knowledge and experience that this section now represents will make it of particular and lasting value to the reader.

In addition to these new chapters the remainder of the text has been extensively revised and updated. All of the line diagrams have been redrawn by one of the authors (JCD) and several new ones have been added.

JCD
RMB
JRH
JPR
P-OG
PH


## Acknowledgments for the first edition

The foundations of any atlas are the illustrations and we are greatly indebted to Miss A Durbin, Department of Medical Illustration, Leeds University and to Miss S Davenport for their expert help with the preparation of the diagrams.

We should also like to express our gratitude to Mr A J Robertson, Mr P Parkinson, and Mr D A Hawkridge of Leeds Dental School and to Mr M Sharland of Birmingham Dental School for undertaking much of the photography; to Mr F G Beanland, Mr B S Dransfield and Mr R Ruddy, Leeds, and Mr W B Hullah and Mr D Spence, Birmingham, for the technical work; to those colleagues, Dr A Harrison, Dr M J Kowolik, Dr F J Kratochvil, Mr S L Pearson, Miss K Powell and Dr R T Walker, who allowed us to include their photographs; and to Dr H J Wilson and Professor W R E Laird for helpful advice.


## Dedication for the first edition

We dedicate this book to our wives who have cheerfully endured numerous weekends disrupted by authors' meetings and who have encouraged us throughout the project, showing the greatest of patience and understanding.

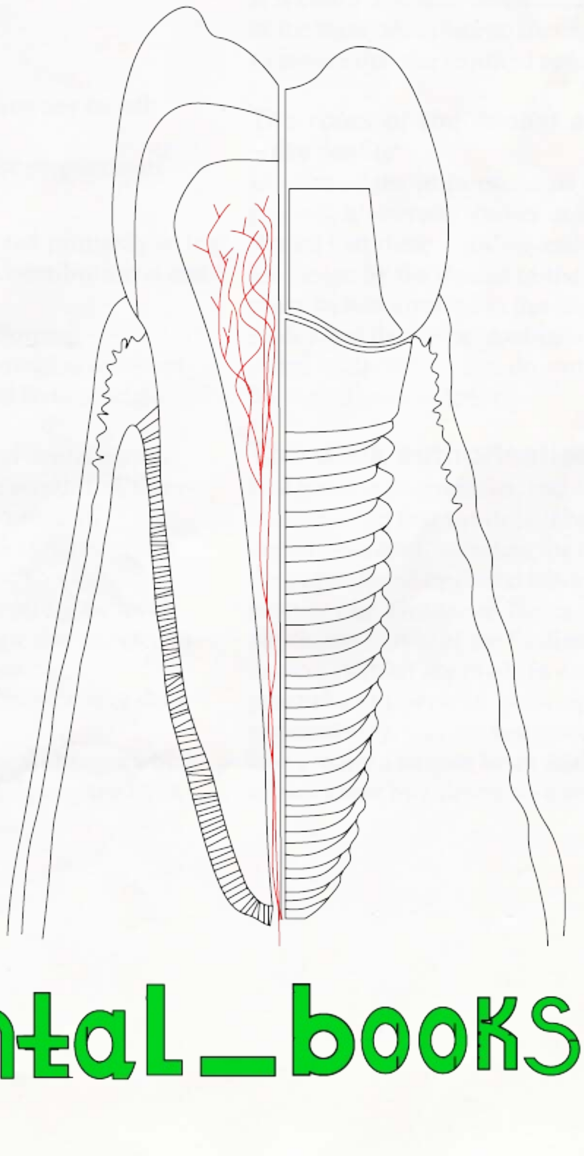

## Acknowledgments for the second edition

The authors would like to thank the following prosthodontic colleagues for their valuable contribution to the 'Principles of Design'-section: Dr C L Barclay, Dr M Barsby, Dr J N Besford, Dr M Faigenblum, Dr N J A Jepson, Dr E A MacLaughlin, Dr R I Nairn, Dr H W. Preiskel, Dr J D Walter, Dr R B Winstanley (all from the UK), Professors B Öwall and S Palmquist (Denmark), Professor E Budtz-Jorgensen (Switzerland), Professor R P Renner (USA), Professor B Wöstmann (Germany), Dr A Sofou (Greece), Dr E Mushimoto (Japan). We should also like to thank the members of the prosthodontic departments in all the dental schools in the UK and the Republic of Ireland who made contributions to the original RPD design rules survey on which Part 2 is based. We are particularly indebted to Dr M de Mattos (Brazil) who helped to design, administer and analyse the survey. We should also like to thank two colleagues who kindly allowed us to include some of their photographs: Dr A C Shortall for Figure 3.2 and Dr C L Barclay for Figures 3.6, 3.10, 3.11 and 3.12.

# Contents

# Part 1 — Procedures and general principles

Part 1 of this book considers the process of designing RPDs, discusses the principles involved and takes the reader through a logical sequence of building up the final design.



# 1 Communication between the dentist and the dental technician

## Design responsibility

### *The roles of the dentist and the dental technician – the ideal*

In order to obtain the best possible results from removable partial denture treatment, it is essential that the dentist and dental technician work together effectively as a team. Each should have a sound understanding of the role of the other so that they can collaborate in an effective fashion.

The creation of an optimal RPD design is dependant on the following factors:

- Clinical knowledge and training.
- A thorough assessment of the patient.
- Appropriate treatment planning including any mouth preparation.
- Technical expertise and knowledge of the properties of materials.

Clearly the dentist's contribution is related primarily to the first three aspects while the technician's contribution is concerned with the fourth.

The dentist's input is founded on the following:

- A knowledge of biological factors, pathological processes and the possible influence of mechanical factors on the masticatory system.
- A knowledge of the patient's medical and dental history and an ability to appreciate, and to take account of, those aspects likely to be significant in RPD treatment.
- An ability to undertake a thorough clinical examination andanalysis of the oral environment.
- An ability to modify the oral environment, e.g. by tooth preparation, periodontal and orthodontic therapy etc., to increase the effectiveness of the RPD treatment.
- An ability to design an RPD which enhances, rather than compromises, oral function.
- An ability to anticipate possible future oral changes which can then be taken into account when designing the RPD.

The technician's input is founded on:-

- The ability to translate two-dimensional design diagrams and written instructions into the three-dimensional reality of an RPD, according to accepted biological and mechanical principles.
- The knowledge of appropriate techniques and materials to produce the finished RPD.

It is clearly essential that a dialogue between the two members of the team takes place so the expertise of both can be combined to ensure that the required outcome is achieved.

### *The roles of the dentist and the dental technicians – the reality*

In spite of the importance of the dentist in the RPD design process, numerous studies in several countries have demonstrated that there is widespread delegation of the responsibility for design by the dentist to the technician. There are probably many factors involved in this abrogation of the dentist's responsibility, but there is no doubt that it results in patients being provided with RPDs that do not take account of clinical and biological circumstances.

## The work authorisation

In a number of countries, including the USA and Sweden, legislation states that the dentist has ultimate responsibility for all dental treatment, including the design and material of any prosthesis produced by dental laboratories. In the European Community the Guidance Notes for Manufacturers of Dental Appliances (1994) of the Medical Devices Agency state that these devices (RPDs) are made in accordance with a duly qualified practitioner's written prescription which gives, under his responsibility, specific design characteristics. In the USA, State laws require a written Work Authorisation Order to accompany all work sent by a dentist to a dental laboratory.

It is obviously essential for effective communication that the dentist and technician have a clear understanding of each others terminology. Clarification of the design diagram may be achieved by using a colour code to identify different RPD components or functions. Since there is no universally agreed colour code in existence, agreement between the dentist and the technician on the meaning of any code is essential. One such example is a system based on the function of the RPD components:-

- Red – support.
- Green – retention.
- Blue – bracing/reciprocation.
- Black – connection.

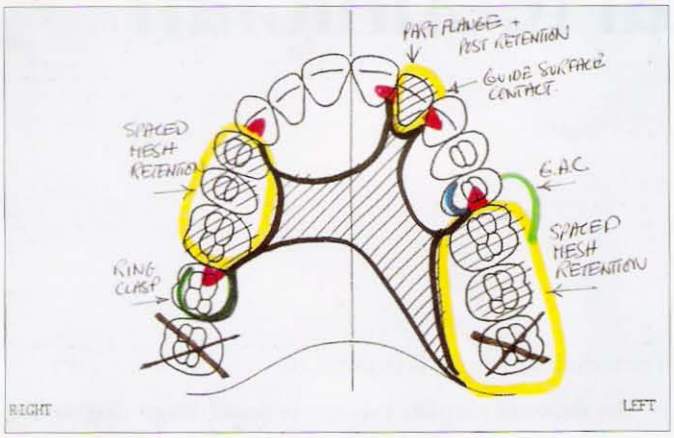



*Figure 1.1 — The design diagram*

A satisfactory work authorisation for an RPD design takes the form of an annotated diagram of the design produced after a thorough assessment of both the patient and of surveyed, often articulated, study casts.

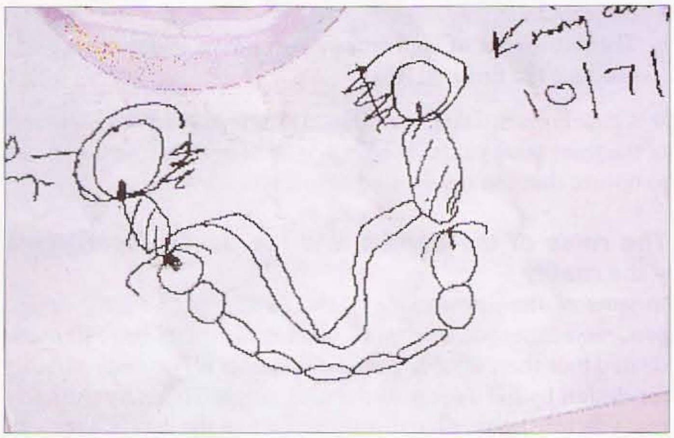



*Figure 1.2 — The design diagram*

To be an efficient means of communication between dentist and technician, the design diagram must be executed with skill and precision. If the diagram is of poor quality, as in this case, misinterpretation and inappropriate shaping and positioning of components is possible.

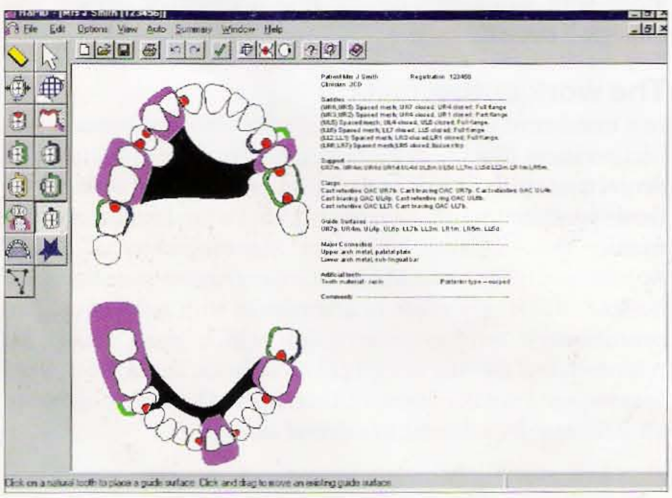


*Figure 1.3 — The design diagram*

Good quality coloured annotated design diagrams can quickly be produced using a computerised knowledge-based (or expert) system for RPD design. Design expertise incorporated in the software reacts if a mistake is made and guides the user to an acceptable design solution. The development of such computerised RPD systems introduces the possibility of on-line discussion between dentist and dental technician of RPD designs via the Internet. This form of tele-dentistry has potential as a useful new communications link between these two members of the dental team.

Clinician's name ..................

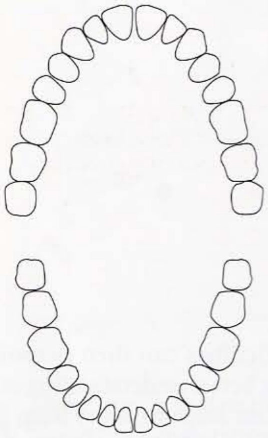
Address ..................

..................

Phone N° ..................

Fax .................. E-mail ..................

**Instructions for all stages**
*(Date instructions and strike through when obsolete.)*



This design is not valid until signed by a qualified clinician.
Clinician's signature .................. Date ..................

Clinical item disinfected? (Y / N - *delete as appropriate and enter date*)

| | | | | |
|---|---|---|---|---|
| Y / N | Y / N | Y / N | Y / N | Y / N |
| Y / N | Y / N | Y / N | Y / N | Y / N |

a

Laboratory name ..................

Address ..................

Phone N° .................. Fax ..................

E-mail .................. MDD Registration N° ..................

Patient's name ..................

Type of prosthesis (es) ..................

**Materials** U L
Acrylic resin ☐☐
Metal ☐☐

NHS ☐
Independent ☐
Private ☐

**Teeth** Shade ..................
Mould ..................
Make ..................

| **Stages** | **Date required** | **Technician** | **Quality control** |
|---|---|---|---|
| Casts – [surveyed*] | | | |
| Special tray – [spaced*, perforated*] | | | |
| Occlusal rims | | | |
| Framework try-in [with teeth*] | | | |
| Re-try | | | |
| Finish | | | |

*Delete as appropriate]

Job N° ..................

Work reviewed and accepted by –
Technician's Signature ..................
Date ..................

This is a custom made device for the exclusive use of the above named patient. When signed in this box the device conforms to the relevant essential requirements set out in Annex 1 of the Medical Devices Directives (93/42/EEC) unless stated otherwise in this document.
Technician's Signature ..................
Date ..................

Keep this device away from extremes of heat and cold.

Non-sterile device.

*Shaded areas for laboratory use only.*

b

*Figure 1.4a and b — The design diagram*

When producing a design diagram it is helpful to use a proforma, such as the example here, which includes the following information:

- Patient – name; registration number.
- Dental practice – practice address, telephone, fax, e-mail, clinician's name.
- Date of next appointment.
- Dental laboratory – laboratory address, telephone, fax, e-mail, job number; technician's name.
- RPD design diagram.
- RPD components, materials, specific instructions, e.g. type of articulator.
- Any statement required by current legislation, e.g. those stipulated by the Medical Devices Agency.

## The study cast

*Figure 1.5 — The study cast*

However well the design diagram is produced, it still suffers from the significant limitation of being a two-dimensional representation of a three- dimensional object. Designs that appear entirely satisfactory in two- dimensions can be obviously in need of modification when seen in three dimensions. Also, subsequent transfer of two-dimensional information by the technician from the paper diagram to the three-dimensional cast can lead to errors of interpretation. Therefore, it is desirable for the dentist to transfer at least the outline of the major connector from the diagram to the study cast before sending both to the technician. In many cases there can be advantages if the dentist goes further and draws on the cast details of other components such as minor connectors, guide plates, clasps and occlusal rests.

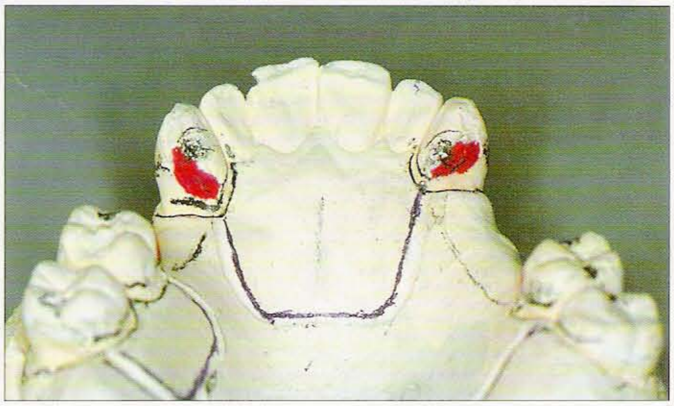


*Figure 1.6 — The study cast*

Sometimes a patient may present with an RPD that has given satisfactory service for many years but is now 'worn out'. A study cast obtained from an impression of the old denture *in situ* will provide clear details of the connector outline and sometimes also the location of other components which will provide a useful reference when designing and fabricating the replacement denture.

### *Verbal communication*

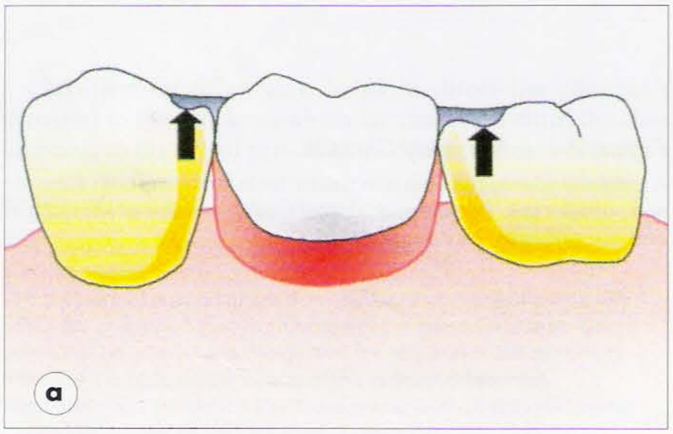
However thorough the dentist is in providing the technician with details of an RPD design together with all the supporting records, it is possible that the technician will still sometimes need additional information or clarification. Under such circumstances the value of discussing the case face to face, if the technician works on the premises, or on the telephone if the laboratory is elsewhere, cannot be underestimated.

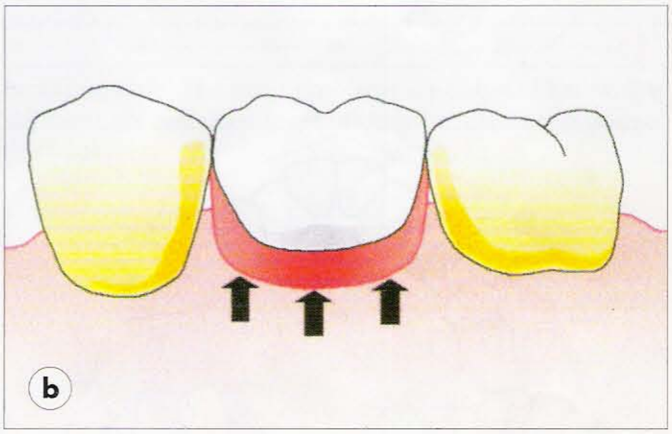
Apparently insurmountable difficulties can then evaporate. Each participant can acquire a far better understanding of the work of the other and in the process forge stronger team links and become a significantly better health-care worker as a result. Increasingly, electronic links such as E-mail and the Internet are likely to become more widely used for such communication.

# 2 Classification of the partially edentulous arch

A classification to describe and simplify the almost infinite variety of permutations of teeth and edentulous areas is desirable. It facilitates the recording of case histories and aids discussion between clinicians and communication with technicians. It may also help the clinician to anticipate the basic type of RPD design that is appropriate for a particular patient.

Classifications in current use are of two types – those that classify the RPD and those that classify the partially edentulous arch.



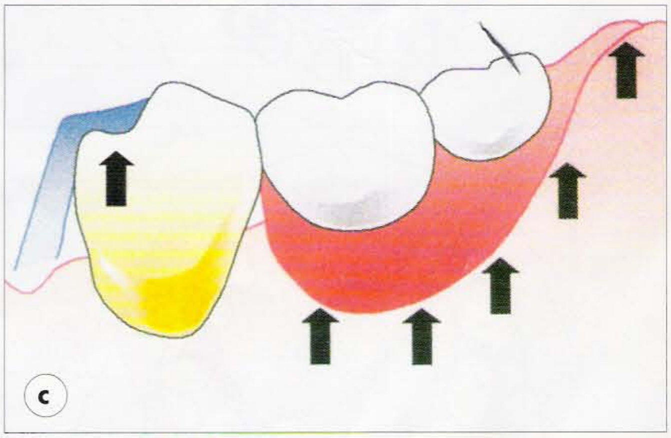




*Figures 2.1a–c — RPD classification based on support*

This example of a classification that describes RPDs is based on the nature of the support utilised by an RPD. Support can be gained from:

(a) Teeth.
(b) Mucosa
(c) Teeth and mucosa.

This concept is discussed in more detail in Chapter 5. The virtue of this classification is that it focuses attention on the problem of support, which is a particularly important aspect of RPD design. However, it does not convey any information about the number and distribution of the edentulous spaces and it is largely for this reason that the most widely used classification is that introduced by Kennedy in 1928. This is an anatomical classification that describes the number and distribution of edentulous areas present.



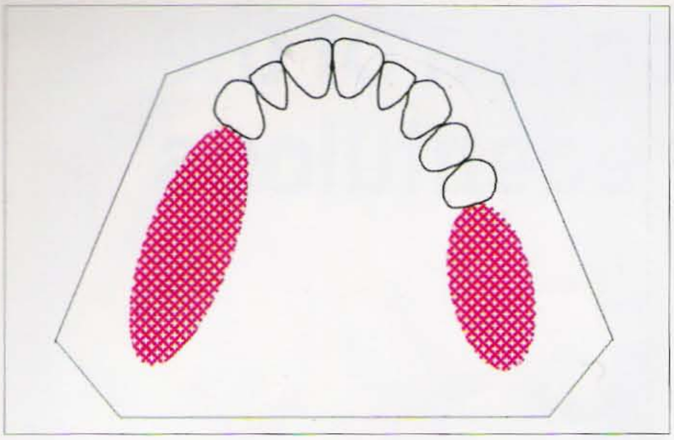


*Figure 2.2 — Kennedy Class I*

Bilateral edentulous areas located posterior to the remaining natural teeth. Denture saddles that restore such edentulous areas are described as 'distal extension saddles'.

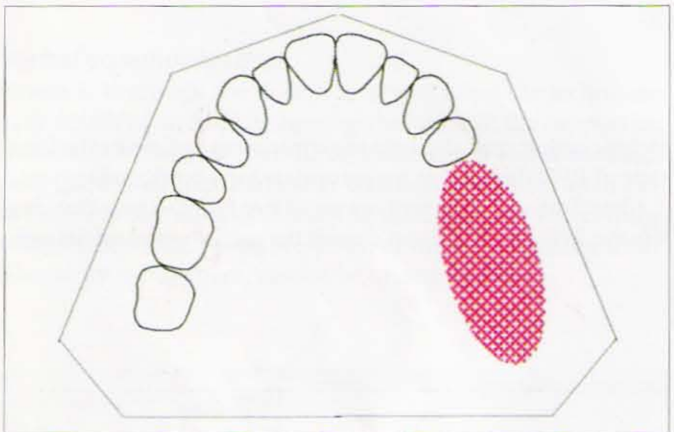


*Figure 2.3 — Kennedy Class II*

A unilateral edentulous area located posterior to the remaining natural teeth.

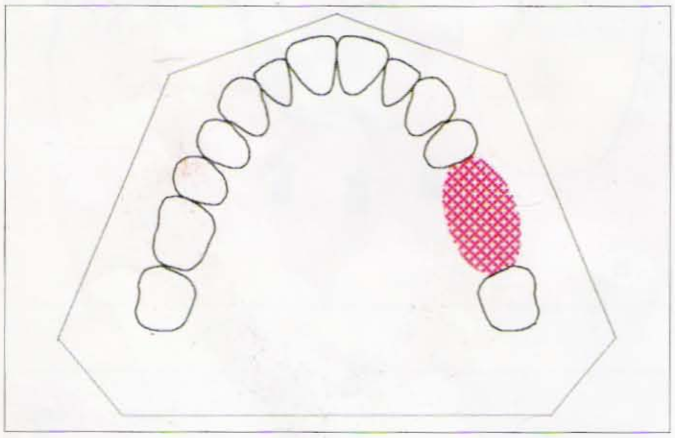


*Figure 2.4 — Kennedy Class III*

A unilateral edentulous area with natural teeth remaining both anterior and posterior to it. Denture saddles that restore this type of edentulous area are said to be 'bounded saddles'.

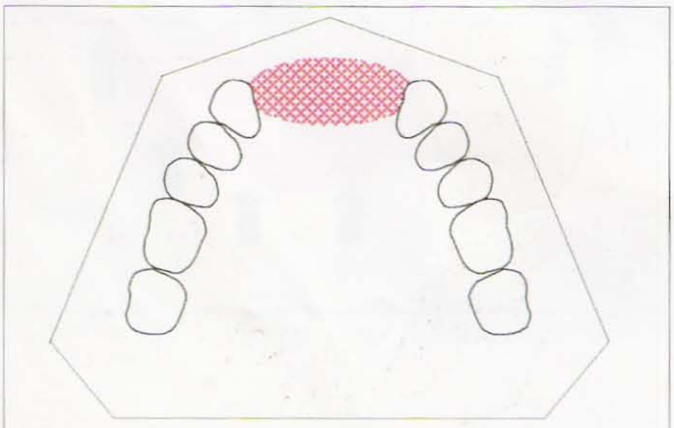


*Figure 2.5 — Kennedy Class IV*

A single edentulous area located anterior to the remaining natural teeth.

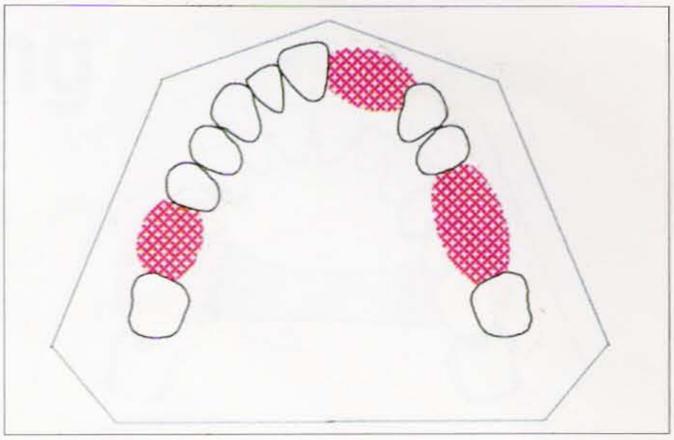


*Figure 2.6 — Modifications*

In Classes I–III any additional bounded edentulous area is referred to as a modification. This example would be described as Class III Modification 2 (there being two additional edentulous areas).

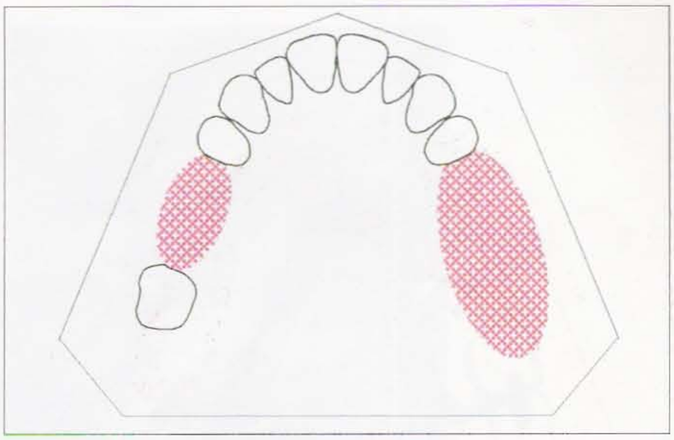


*Figure 2.7 — Modifications*

Classification is always determined by the most posterior edentulous area. For example, the classification of the arch illustrated is determined by the presence of the distal extension saddle area, not by the bounded saddle area. This example is therefore a Kennedy Class II Modification1. Because of this principle there can be no modifications to the Kennedy Class IV arch.

Classification of an arch helps to direct the clinician's thoughts to the problems which are characteristic of the class and thus to the broad principles of design which are likely to be appropriate. The main problems are outlined below. The solutions are described more fully in the relevant sections of this book.

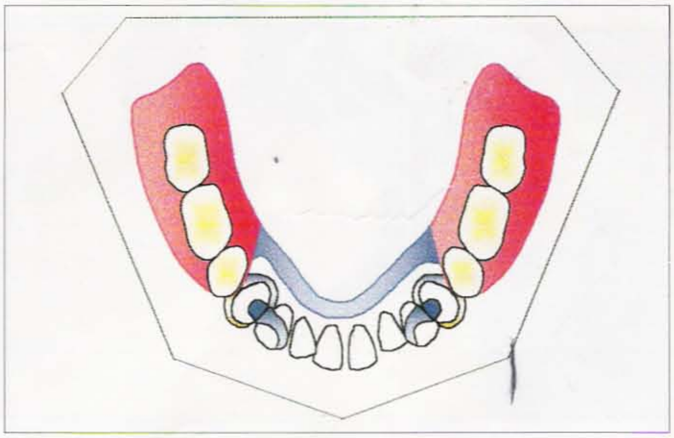


*Figure 2.8 — Kennedy Class I*

The absence of abutment teeth distally creates problems both of support and retention.

The problem of support arises from the fact that the abutment tooth offers firmer support than the mucosa of the edentulous area. Great care must be taken in the design and construction of the denture to minimise the undesirable effects of this support differential.

The other major problem is that there are no teeth posteriorly to retain the saddle against movement in an occlusal direction. Specific measures must be employed to prevent this movement. These will include utilising the principle of indirect retention (Chapter 8), here illustrated by placing mesial incisal rests on 33 and 43, and correct shaping of the buccal and lingual polished surfaces of the saddles to assist neuromuscular control.

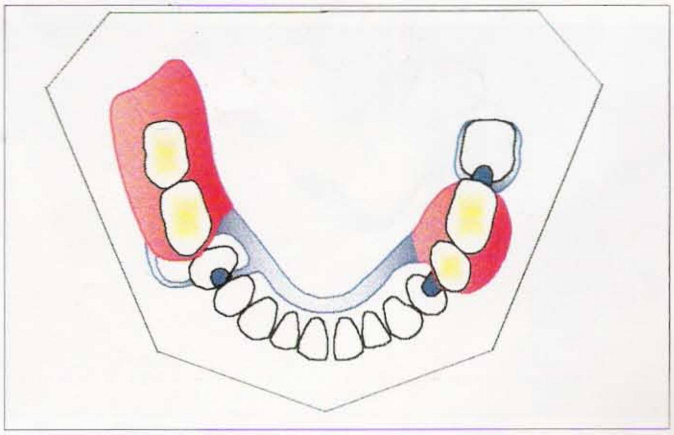


*Figure 2.9 — Kennedy Class II*

Like the Class I arch this requires a denture that is both tooth- and mucosa-supported but in this instance there is often a modification present which can be tooth-supported. Once again there is the opportunity for the distal extension saddle to move but the situation is not so critical because there are teeth on the other side of the arch with the potential to provide more effective retention.

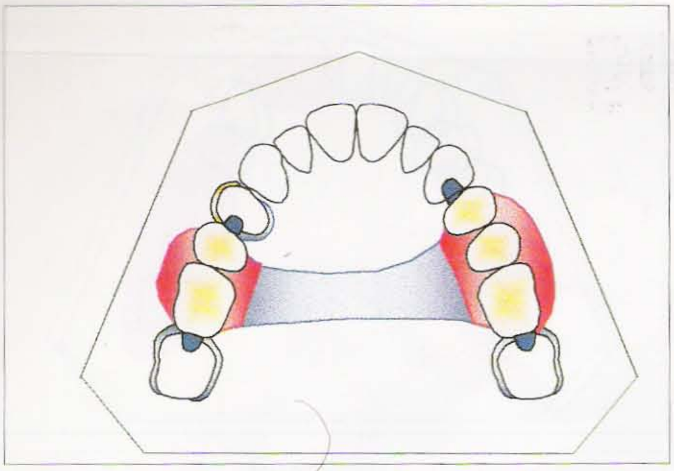


*Figure 2.10 — Kennedy Class III*

In this situation there is opportunity for the denture to be entirely supported and retained by teeth. Therefore the difficulties in producing a stable denture are likely to be less than for Classes I and II. However, it will be appreciated that complications will arise when one or more of the abutment teeth cannot be clasped because of an unsuitable contour or because a clasp would detract from the appearance, as would be the case for 23 in the illustration. Under such circumstances indirect retention, here provided by the rest on 17, may be helpful. If the denture does not replace a large number of teeth and is fully tooth-supported the connector can be reduced in size as it will not have a supportive function.

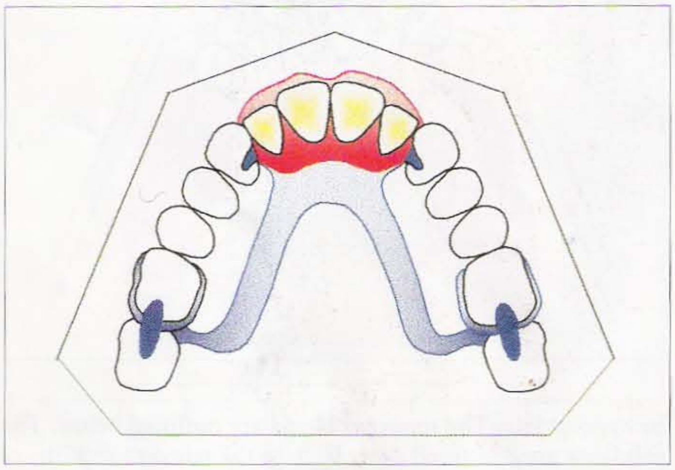


*Figure 2.11 — Kennedy Class IV*

Appearance is of paramount importance in this class. As a consequence it is rarely possible to clasp the abutment teeth. Therefore alternative means of retaining the saddle need to be sought, including the use of a labial flange. In addition the retentive clasps must be located with great care so that the benefits of indirect retention can be realised, in this instance by placing extended rests on 17 and 27.

# 3 Surveying

*Figure 3.1 — Surveying*

The surveyor was first introduced to the dental profession in 1918. This instrument, which is essentially a parallelometer, is one of the cornerstones of effective RPD design and construction. The surveyor allows a vertical arm to be brought into contact with the teeth and ridges of the dental cast, thus identifying parallel surfaces and points of maximum contour.

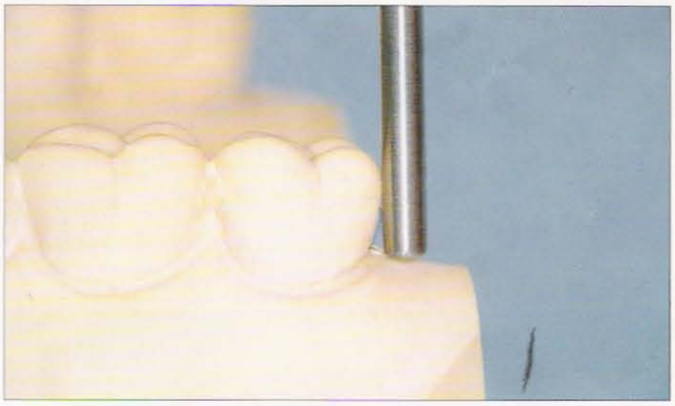
Ideally the clinician, rather than the dental technician, surveys the study cast in preparation for designing an RPD. It is this design, produced in the light of clinical knowledge and experience, which guides decisions on pre-prosthetic treatment and which is ultimately sent as a prescription to the dental technician, who constructs the denture accordingly.

There are several different attachments that may be used with the surveyor.

### *Analysing rod*

*Figure 3.2 — Analysing rod*

This metal rod is placed against the teeth and ridges during the initial analysis of the cast to identify undercut areas and to determine the parallelism of surfaces without marking the cast.



### *Graphite marker*

*Figure 3.3 — Graphite marker*

The graphite marker is moved around the tooth and along the alveolar ridge to identify and mark the position of maximum convexity (survey line) separating non-undercut from undercut areas.

When surveying a tooth, the tip of the marker should be level with the gingival margin allowing the side of the marker to produce the survey line as shown in the illustration.

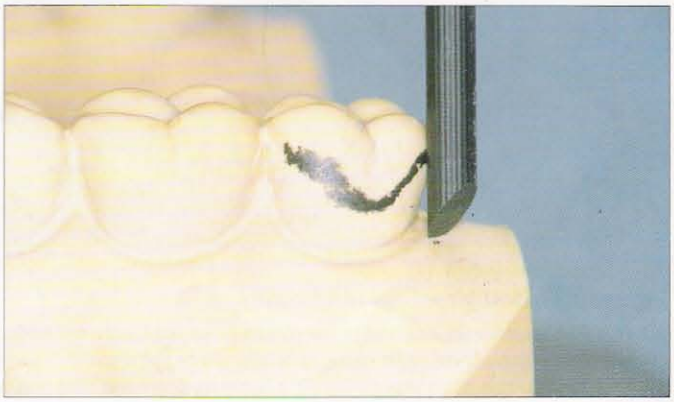


*Figure 3.4 — Graphite marker*

A false survey line will be produced if the tip of the marker is incorrectly positioned. In this example there is not, in fact, an undercut area on the tooth although an incorrect surveying technique has indicated one. If this false line is used in designing an RPD, errors will arise in the positioning of components, especially clasps.

### Undercut gauge

*Figure 3.5 — Undercut gauge*

Gauges are provided to measure the extent of horizontal undercut and are available in the following sizes: 0.25 mm, 0.50 mm and 0.75 mm. By adjusting the vertical position of the gauge until the shank and head contact the cast simultaneously, the point at which a specific extent of horizontal undercut occurs can be identified and marked. This procedure allows correct positioning of retentive clasp arms on the tooth surface as described in chapter 6.

Other, more sophisticated, types of undercut gauge are available such as dial gauges and electronic gauges. These attachments fulfil the same function as the simpler type of gauge.

### Trimming knife

*Figure 3.6 — Trimming knife*

This instrument is used to eliminate unwanted undercuts on the master cast. Wax is added to these unwanted undercut areas and then the excess is removed with the trimmer so that the modified surfaces are parallel to the chosen path of insertion. A duplicate cast is then made on which the denture is manufactured. Such a procedure eliminates the problem shown in Figure 3.7.

When elimination of undercuts is required on a cast which is not to be duplicated, a material such as zinc phosphate cement, which can resist the boiling out procedure, is used. The surveyor is used to shape the cement before it is fully set.



*Figure 3.7a and b — Trimming knife*

(a) This RPD cannot be inserted in the mouth because failure to eliminate unwanted undercut on the cast has resulted in acrylic resin being processed into the area.

(b) This denture has been processed on a correctly prepared cast and, as a result, there is no interference with insertion.

*Figure 3.8 — Trimming knife*

The trimming knife can also be used to prepare guide surfaces (Figure 3.9) on wax patterns of crowns for abutment teeth.

Before discussing the functions of a surveyor in more detail it is necessary to explain the following terms:

- Guide surfaces.
- Path of insertion.
- Path of displacement.

### *Guide surfaces (or guide planes)*

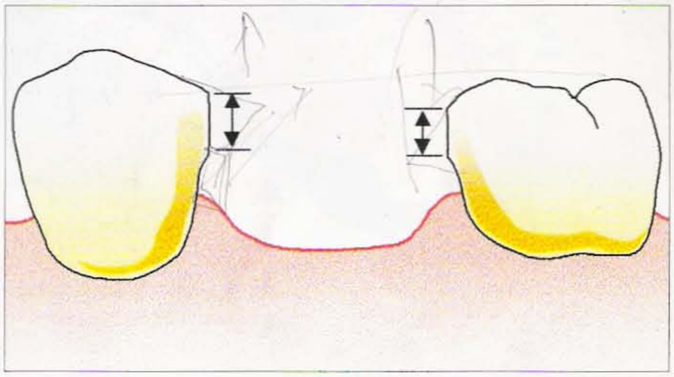


*Figure 3.9 — Guide surfaces*

Two or more parallel axial surfaces on abutment teeth which can be used to limit the path of insertion and improve the stability of a removable prosthesis. Guide surfaces may occur naturally on teeth but more commonly need to be prepared.

### *Path of insertion*

The path followed by the denture from its first contact with the teeth until it is fully seated. This path coincides with the path of withdrawal and may or may not coincide with the path of displacement (Figure 3.15). There may be a single path or multiple paths of insertion.

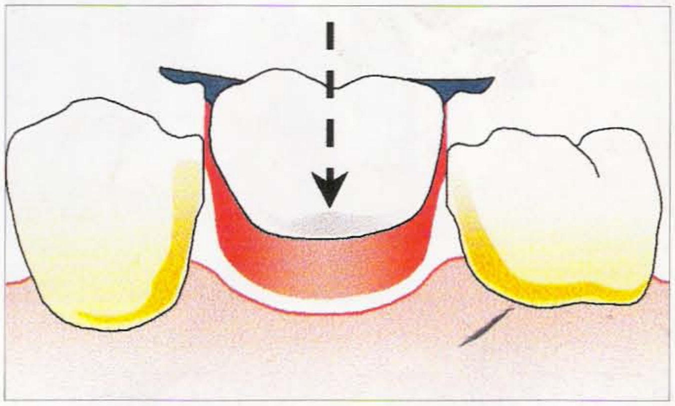


*Figure 3.10 — Path of insertion*

A single path of insertion may be created if sufficient guide surfaces are contacted by the denture; it is most likely to exist when bounded edentulous areas are present.

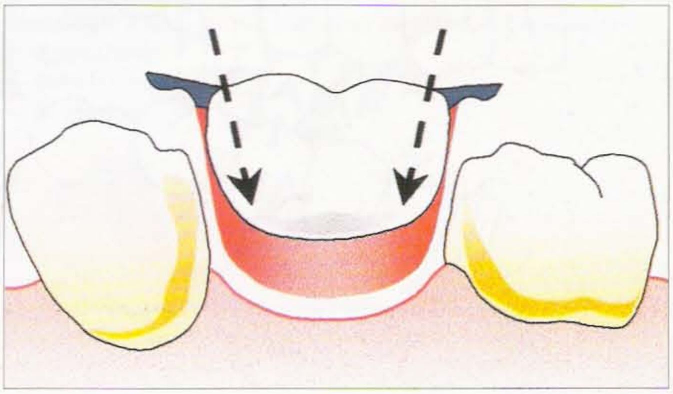


*Figure 3.11 — Path of insertion*

Multiple paths of insertion will exist where guide surfaces are not utilised, for example where the abutment teeth are divergent.

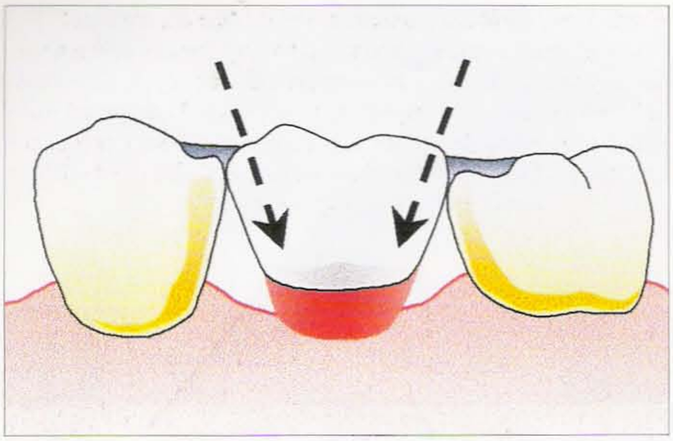


*Figure 3.12 — Path of insertion*

Multiple paths will also exist where point contacts between the saddle of the denture and the abutment teeth are employed in the 'open' design of saddle. The philosophy for this approach is discussed in chapter 4.

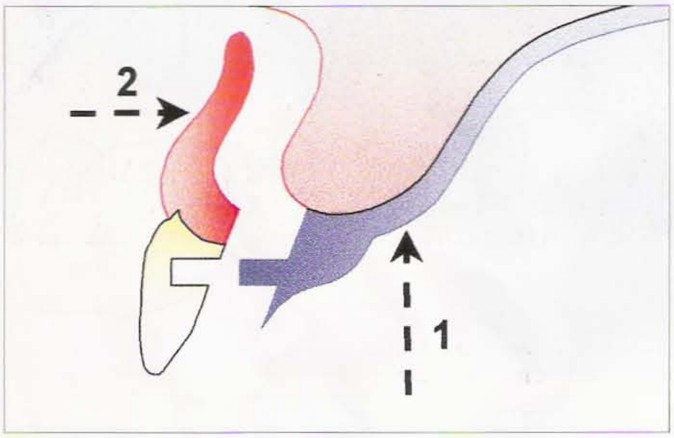



*Figure 3.13 — Path of insertion*

Two distinct paths of insertion will be employed for a sectional, or two-part denture illustrated here by a diagram in the sagittal plane of a Kennedy Class IV denture. The abutment teeth on either side of the saddle are not shown.

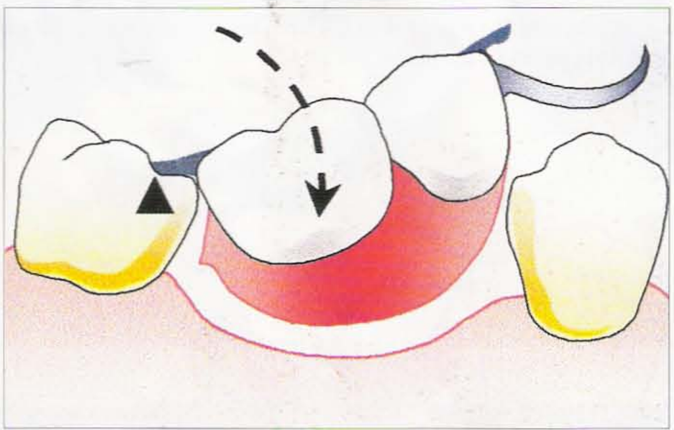
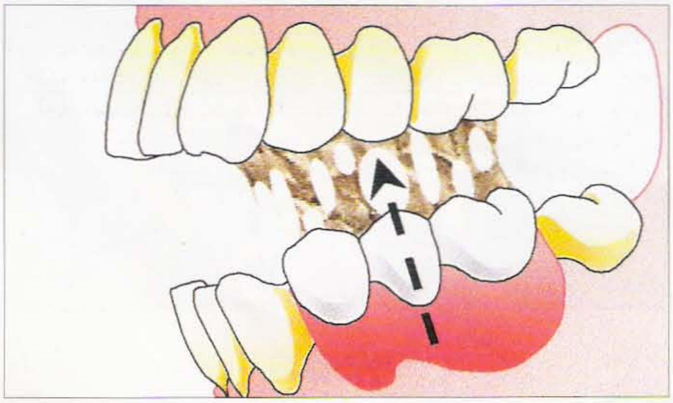


*Figure 3.14 — Path of insertion*

Occasionally a rotational path of insertion can be used.



**Path of displacement**

*Figure 3.15 — Path of displacement*

This is the direction in which the denture tends to be displaced in function. The path is variable but is assumed for the purpose of design to be at right angles to the occlusal plane.

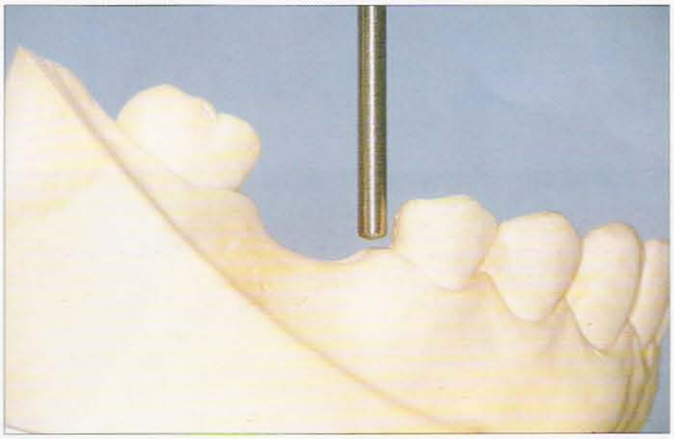
## Surveying procedure

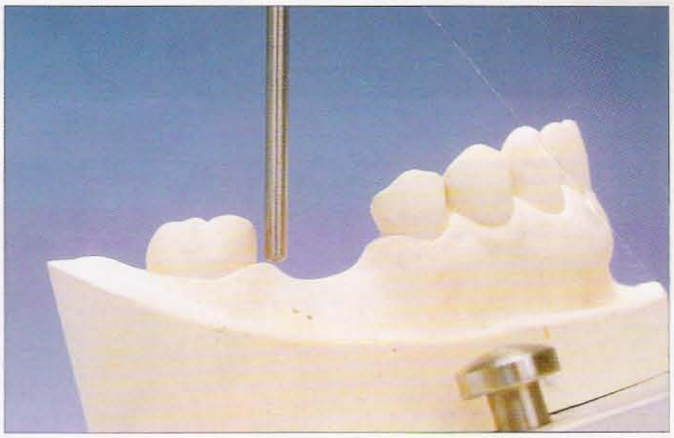
This may be divided into the following distinct phases:

- Preliminary visual assessment of the study cast.
- Initial survey
- Analysis
- Final survey.

### *Preliminary visual assessment of the study cast*

This stage has been described as 'eyeballing' the cast and is a useful preliminary to the surveying procedure proper. The cast is held in the hand and inspected from above. The general form and arrangement of the teeth and ridge can be observed, any obvious problems noted and an idea obtained as to whether or not a tilted survey should be employed.





*Figures 3.16 and 3.17 — Assessment of the study cast*

Figure 3.16 shows an anterior tilt ('heels up')

Figure 3.17 shows a posterior tilt ('heels down'). Clinical experience indicates that these are the positions of the cast that most commonly give the greatest benefit. However, a lateral tilt of the cast to right or left may also be indicated on occasion.

### *Initial survey*

*Figure 3.18 — Initial survey*

The cast is positioned with the occlusal plane horizontal. The teeth and ridges are then surveyed to identify undercut areas that might be utilised to provide retention in relation to the most likely path of displacement. The position of the survey lines and the variations in the horizontal extent of undercut associated with them should be noted. The amount of undercut can be judged approximately from the size of the 'triangle of light' between the marker and the cervical part of the tooth, or measured more precisely by using an undercut gauge. An assessment can then be made as to whether the horizontal extent of undercut is sufficient for retention purposes.

### *Analysis*

An RPD can be designed on a cast which has been surveyed with the occlusal plane horizontal (ie so that the path of insertion equals the path of displacement). However, there are occasions when tilting of the cast is indicated so that the paths of insertion and displacement differ.

Before deciding if the cast should be tilted for the final survey the graphite marker in the surveyor is changed for an analysing rod so that various positions of the cast can be examined without marking the teeth.

The analysis of the cast continues with the occlusal plane horizontal and the following aspects, one or more of which might necessitate a final survey with the cast tilted, are considered:

- Appearance.
- Interference.
- Retention.

### Appearance

*Figure 3.19 — Appearance*

When a maxillary cast, containing an anterior edentulous area, is surveyed with the occlusal plane horizontal it will often be found that there are undercuts on the mesial aspects of the abutment teeth.

If the RPD is constructed with this vertical path of insertion there will be an unsightly gap between the denture saddle and the abutment teeth gingival to the contact point.

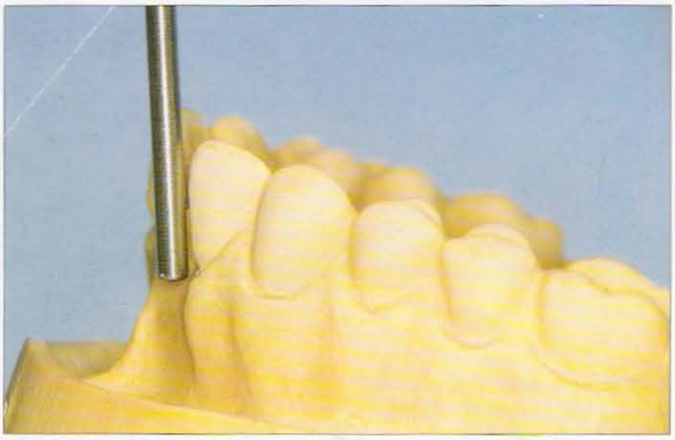
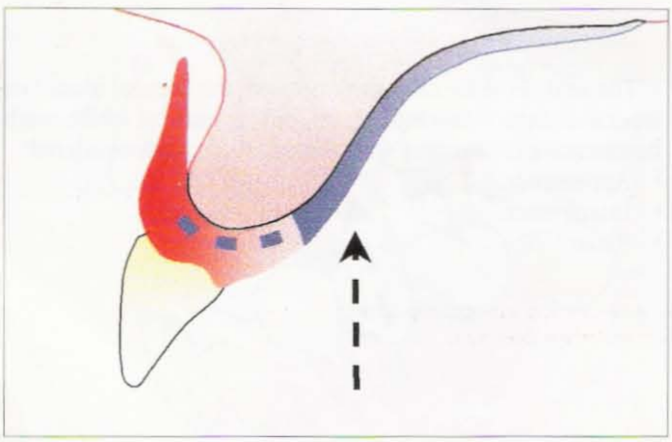


*Figure 3.20 — Appearance*

This unsightly gap can be avoided by giving the cast a posterior (heels down) tilt so that the analysing rod is parallel with the mesiolabial surface of the abutment tooth.

*Figure 3.21 — Appearance*

With this posterior path of insertion the saddle can be made to contact the abutment tooth over the whole of the mesiolabial surface and a much better appearance results.



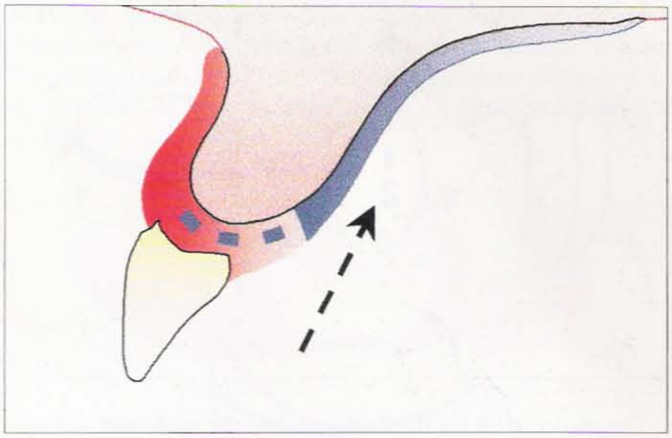
### Interference

*Figure 3.22 — Interference*

While examining the cast with the occlusal plane horizontal, it sometimes becomes apparent that an undercut tooth or ridge would obstruct the insertion and correct placement of a rigid part of the denture. By tilting the cast, a path of insertion may be found which avoids this interference. For example, if a bony undercut is present labially, insertion of a flanged denture along a path at right angles to the occlusal plane will only be possible if the flange stands away from the mucosa or is finished short of the undercut area. This can result in poor retention as well as a poor appearance.

*Figure 3.23 — Interference*

If the cast is given a posterior tilt so that the rod, and thus the path of insertion, is parallel to the labial surface of the ridge it is possible to insert a flange that fits the ridge accurately.



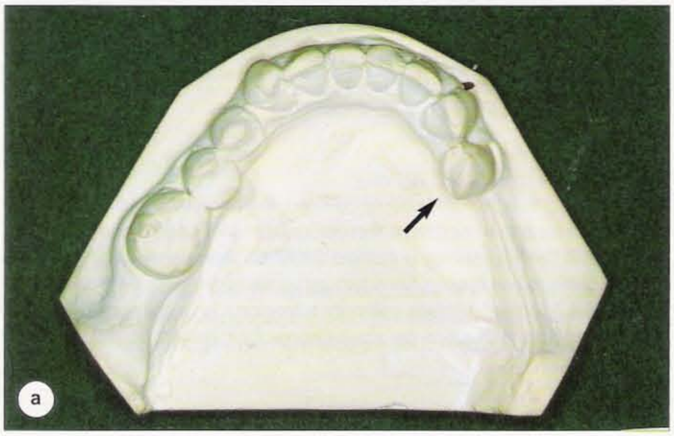
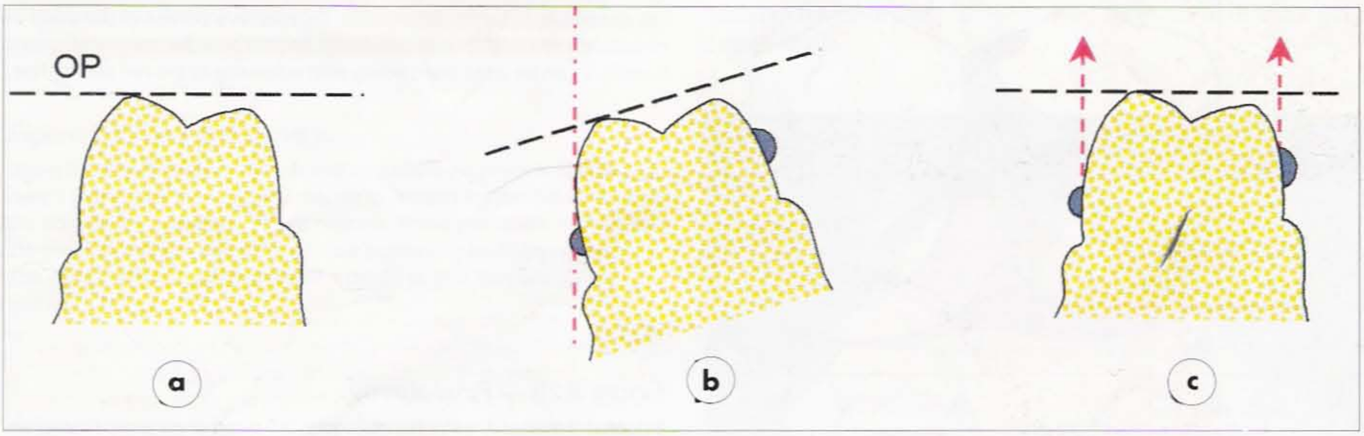


*Figure 3.24a — Interference*

Lingually tilted premolars can make it impossible to place a sublingual, or lingual, bar connector sufficiently close to the lingual mucosa. Such a problem would occur lingually to 44.

*Figure 3.24b — Interference*

Giving the cast an anterior (heels up) tilt reveals a path of insertion that avoids this interference. If interference from a tooth is present and cannot be avoided by selecting an appropriate path of insertion, consideration should be given to the possibility of eliminating the interference by tooth preparation, for example by crowning to reduce the lingual overhang.




### Retention

*Figure 3.25a–c — Retention*

To obtain retention, undercuts must be present on teeth relative to the horizontal survey. It is a misconception to believe that changing the tilt of the cast will produce retentive undercuts if none exist when the cast is horizontal.

a) No undercuts on the tooth when the occlusal plane (OP) is horizontal.

b) An apparent undercut created by tilting the cast laterally.

c) Clasp arms placed in this false undercut do not provide any resistance to movement along the path of displacement.

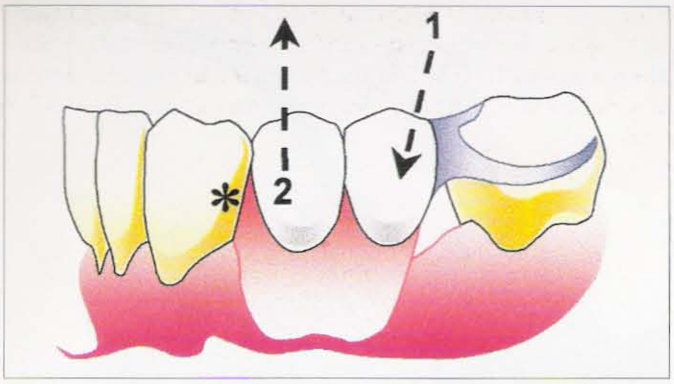



*Figure 3.26 — Retention*

The principle of tilting the cast to enhance retention is that by so altering the path of insertion (1) a rigid part of the denture can enter an area of the tooth surface or an area of the ridge which is undercut relative to the path of displacement (2).

In this example, providing retention by engaging the distal undercut (*) of the canine may well look more pleasing than a clasp arm on the same tooth.

The choice of tilt for the final survey of the study cast will usually be a compromise as the requirements of different parts of the denture may conflict. This might be the case, for example, where the appearance of a maxillary anterior saddle needs to take precedence over the optimum positioning of molar clasps. Thus a posterior (heels down) tilt would be selected for the final survey which favours appearance at the expense of clasp retention. It is of course possible to create more favourable uncercuts on the molars by tooth preparation (*A Clinical Guide to Removable Partial Dentures*, chapter 15)

### Final Survey

*Figure 3.27 — Final survey*

If it is decided that the cast should be tilted, the analysing rod is exchanged for a marker different in colour from that used in the first survey, and the final survey is carried out. It will then usually be found that the teeth to be clasped have two separate survey lines which cross each other. In order to obtain optimum retention it is necessary to understand how to position the clasps correctly in relation to the two survey lines.

The aims for optimum retention should be to provide:

- Resistance along the path of displacement.
- Resistance along the path of withdrawal.

The former can be achieved by the use of guide surfaces or clasps while the latter is provided by clasps alone. The various ways of achieving these aims are illustrated in Figures 3.28–31. In each case the red survey line has been produced with the cast tilted and is relative to the path of insertion and withdrawal while the green survey line has been produced with the cast horizontal and is relative to the path of displacement.

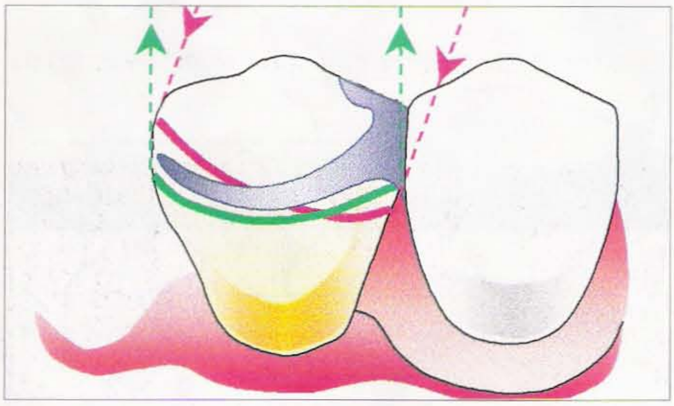


*Figure 3.28 — Final survey*

When guide surfaces are used to provide resistance to displacement of the denture in an occlusal direction, the retentive portion of the clasp needs only to resist movement along the path of withdrawal and therefore can be positioned solely with reference to the red survey line.

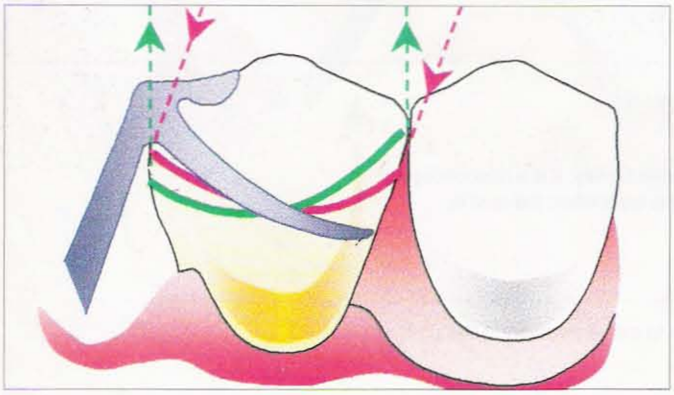


*Figure 3.29 — Final survey*

It does not matter if, as in this example, the clasp engages too deep an undercut relative to the path of displacement. Movement of the denture in an occlusal direction is prevented by contact with the guide surface, therefore permanent deformation of the clasp will not occur.

When the denture does not contact guide surfaces on the clasped tooth the clasp will have to resist movement of the denture along both the path of withdrawal and the path of displacement. The clasp will thus need to be positioned in the correct depth of undercut relative to both survey lines. The clasp will then provide the necessary retention without being permanently deformed either by insertion and removal of the denture along the planned path, or by inadvertent displacement of the denture during function. Ways of achieving this are shown in Figures 3.30 and 3.31.

*Figure 3.30 — Final survey*

A gingivally approaching clasp positioned at the cross-over point of the survey lines resists movement along both the path of withdrawal and the path of displacement without being permanently deformed by movement along either path.

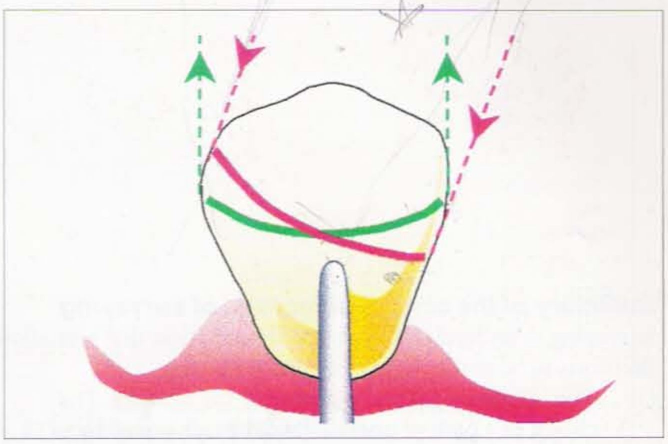
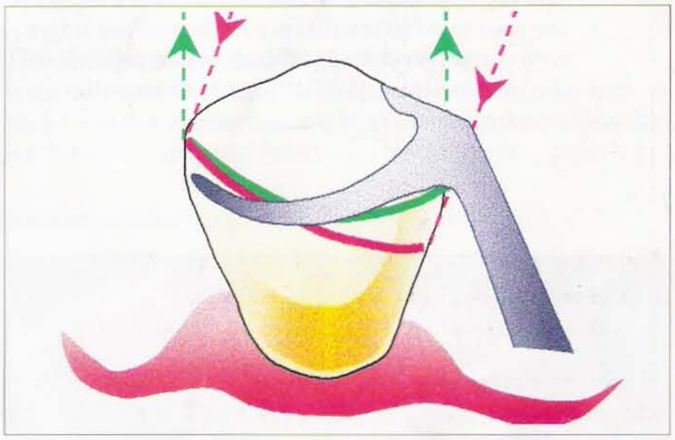


*Figure 3.31 — Final survey*

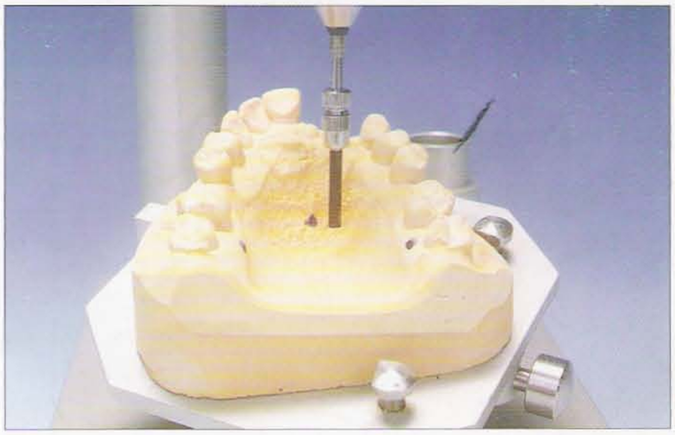
If the survey lines converge mesially or distally, the tip of an occlusally approaching clasp can engage the common area of undercut to provide resistance to movement along both paths.



If the cast has been tilted for the final survey, the degree of tilt must be recorded so that the position of the cast can be reproduced in the laboratory. There are two methods of recording the degree of tilt.

*Figure 3.32 — Final survey*

Using the tripod method, the vertical arm of the surveyor is locked at a height that allows the tip of the marker to contact the palatal surface of the ridge in the molar and incisal regions. Three points are marked with the graphite marker, one on each side posteriorly and one anteriorly. The points will then be ringed with a pencil so that they are clearly visible.



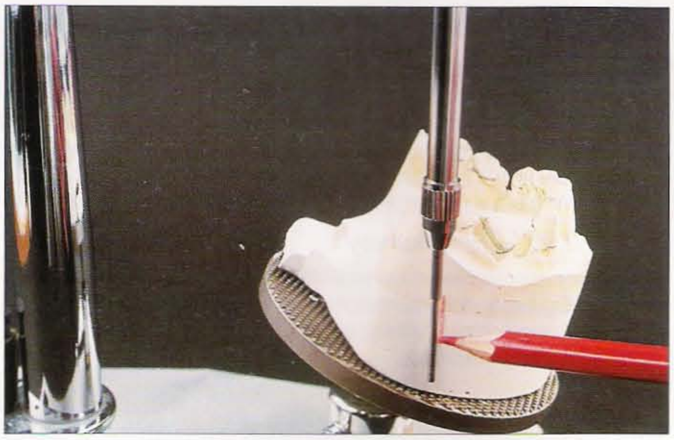


*Figure 3.33 — Final survey*
Alternatively, the analysing rod is placed against one side of the base of the cast and a line drawn on the cast parallel to the rod. This is repeated on the other side and at the back of the cast so that there are three widely spaced lines parallel to the path of insertion.

### *Summary of the clinical objectives of surveying*

Surveying is undertaken to obtain information that will allow decisions to be made concerning the following:

(1) The optimum path of insertion of the denture. The choice of a path of insertion will be influenced by:
- the need to utilise guiding surfaces to achieve a pleasing appearance.
- the need to avoid interference by the teeth or ridges with correct positioning of denture components.
- the need to utilise guide surfaces for retention.

(2) The design, material and position of clasps.

Decisions on these aspects of clasps can be arrived at from measurement of the horizontal extent of undercut on abutment teeth and the identification of sites on the teeth to provide reciprocation either from guiding surfaces or from cross-arch reciprocation (chapter 7).

# 4 Saddles

The saddle is that part of an RPD that rests on and covers the alveolar ridge and which includes the artificial teeth and gumwork. The patient naturally regards it as the most important component because it imparts both appearance and function to the denture. The clinician's major concerns are centred on:

- The design of the occlusal surface.
- The base extension.
- The design of the polished surface.
- The material for the impression surface.
- The junction between saddle and abutment tooth.

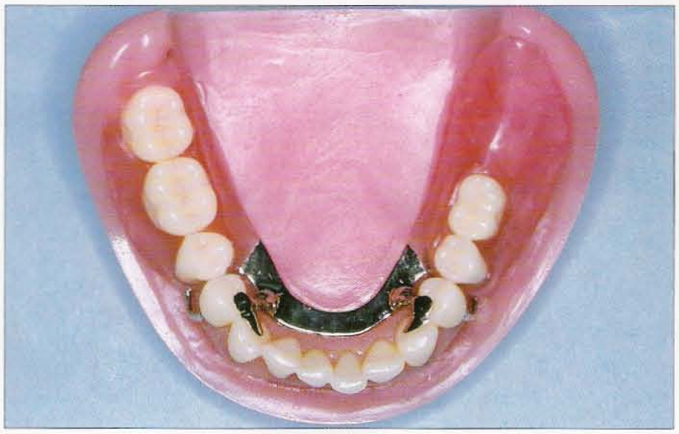
### *The design of the occlusal surface*

It is fundamentally important to position the artificial teeth in such a way that even occlusal contact in the intercuspal position is achieved and occlusal balance is created where appropriate.

*Figure 4.1 — The design of the occlusal surface*

Reducing the area of the occlusal table of posterior artificial teeth is likely to play an important part in the success of a mandibular RPD, especially if a distal extension saddle is present (see Statement 11.16). It has been shown that the reduction in area of the occlusal table, by using narrow posterior teeth or by reducing the length of the table by omitting teeth, will reduce the force to the underlying tissues during mastication. This is because penetration of the food bolus by the teeth is easier. This principle is illustrated by the artificial teeth replacing 35 and 36 and is in contrast to the teeth replacing 45, 46 and 47.

A further advantage in reducing the bucco-lingual width of the teeth is the increase in space made for the tongue that may well have spread laterally following extraction of the natural teeth. Were the space to be unduly restricted, the tongue would tend to move the denture during normal function and the patient's tolerance of the denture might be adversly affected.

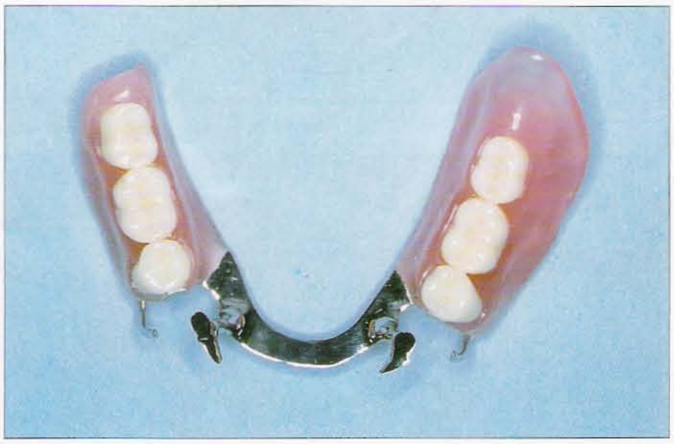


### *The base extension*

*Figure 4.2 — The base extension*

When some, or all, of the support for a saddle is gained from the mucosa and underlying bone, it is most important to ensure that the maximum possible area is covered by the base in order to distribute functional forces as widely as possible. This point is of particular relevance in the case of the distal extension saddle denture where much of the force inevitably must be transmitted through the mucosa of the saddle area.

For this reason the base of the mandibular distal extension saddle should be extended over the pear-shaped pads and into the full functional depth of the buccal and lingual sulci, as in the saddle replacing 35, 36 and 37 (also see Statement 11.17). This ensures that the maximum area of bone, including the buccal shelf, is load-bearing. If coverage is reduced, as in the other saddle, both retention and stability will suffer and the stresses will be increased, thus putting the underlying bone at risk. When a saddle is fully tooth-supported, maximum extension of the base is not required for load distribution



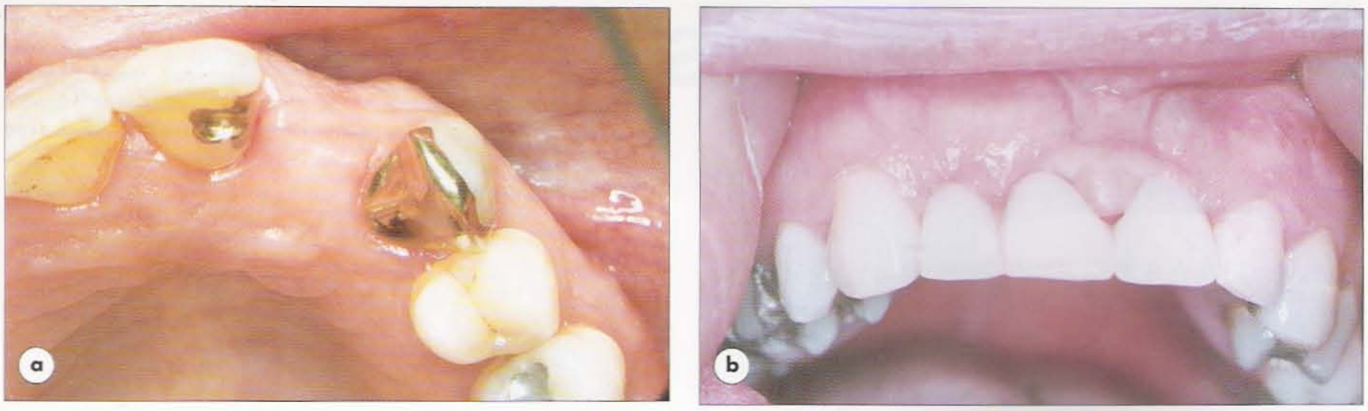
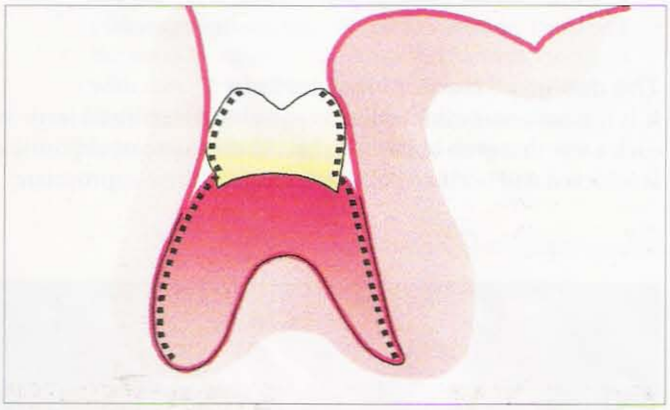


Figure 4.3a and b — The base extension

The base extension of a small tooth-supported saddle at the front of the mouth will often be governed by aesthetic requirements. In 4.3a there has been very little resorption of the ridge and thus the artificial tooth will look best if fitted directly against the mucosa without any labial flange. However, the lack of labial flange in 4.3b is quite inappropriate because there has been considerable resorption, making it impossible to create a good appearance without using a labial flange for 12, 11 and 21.



### Design of the polished surface

*Figure 4.4 — Design of the polished surface*

The polished surface of the denture saddle is that surface which lies between the denture border and the occlusal surface, indicated by the black dotted line. The muscles of the lips, cheeks and tongue press against this surface. If the saddle is shaped correctly, the muscular forces will enhance retention and stability. But if the shape is incorrect the activity of the musculature will tend to displace the denture.

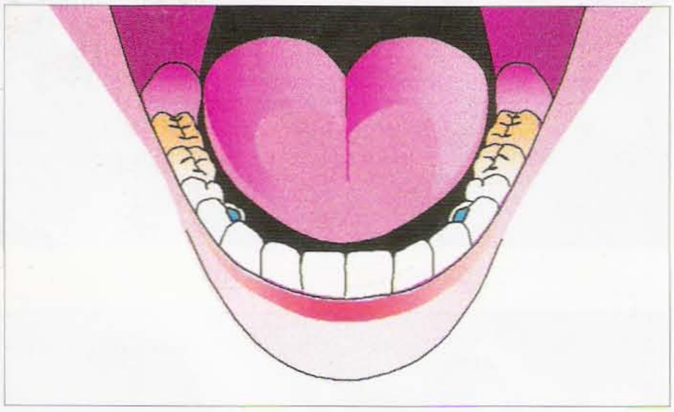


*Figure 4.5 — Design of the polished surface*

There is a space between tongue and cheeks where the opposing muscular forces are in balance. This space is known as the neutral zone or zone of minimal conflict. The concept of placing the denture within muscle balance is particularly important when designing distal extension saddles because less mechanical retention is possible and thus greater reliance must be placed on muscle control.

*Figure 4.6 — Design of the polished surface*

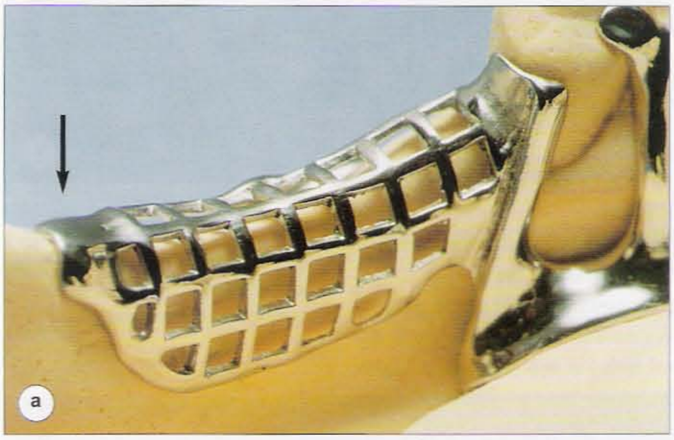
The distal extension saddle replacing 45, 46 and 47 has been incorrectly shaped. The molars are placed lingually and interfere with the tongue space. Every time the tongue moves it lifts the denture.

If the teeth are moved buccally as in the case of 35, 36 and 37, the tongue is provided with sufficient space and its muscular force will now play a positive role in stabilising the denture.

The mesial and distal margins of the base should be thinned so that any step between flanges and mucosa is minimised. This will reduce the tendency for food to lodge at this junction, will improve tolerance and, towards the front of the mouth, can make a major contribution to the appearance (see Figures 20.3, 20.4 in *A Clinical Guide to Removable Partial Dentures*).

### *Material for the impression surface*

The surface of the saddle in contact with the mucosa may be constructed in either metal or acrylic resin. An acrylic surface can be modified and added to with ease, a particular advantage where continuing bone resorption is expected as in the case of the distal extension saddle.



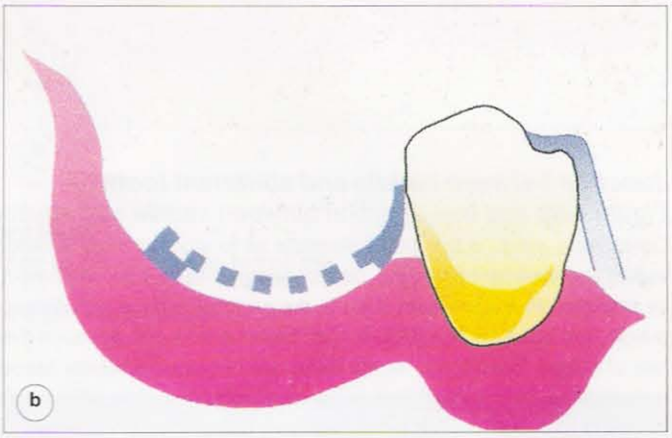




*Figure 4.7a and b — Material for the impression surface*

In cases where the clinician has decided on an acrylic impression surface, the material is attached to the metal framework via a spaced meshwork that has been constructed to lie above the mucosal surface. A small 'stop' of metal that contacts the surface of the cast in the distal extension edentulous areas may be included. This 'stop' is a valuable reference point when the fit of the framework is checked both on the cast and in the mouth. It will also support the framework on the cast during packing and processing of the denture. Lack of contact between the 'stop' and the mucosa should be corrected at the earliest possible stage using the altered cast technique (see *A Clinical Guide to Removable Partial Dentures*, chapter 19).

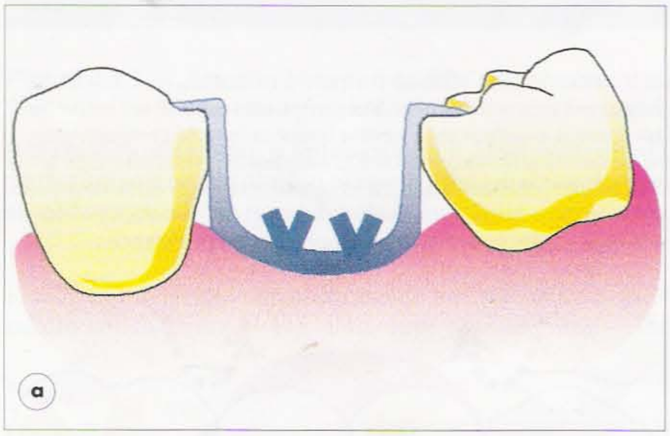
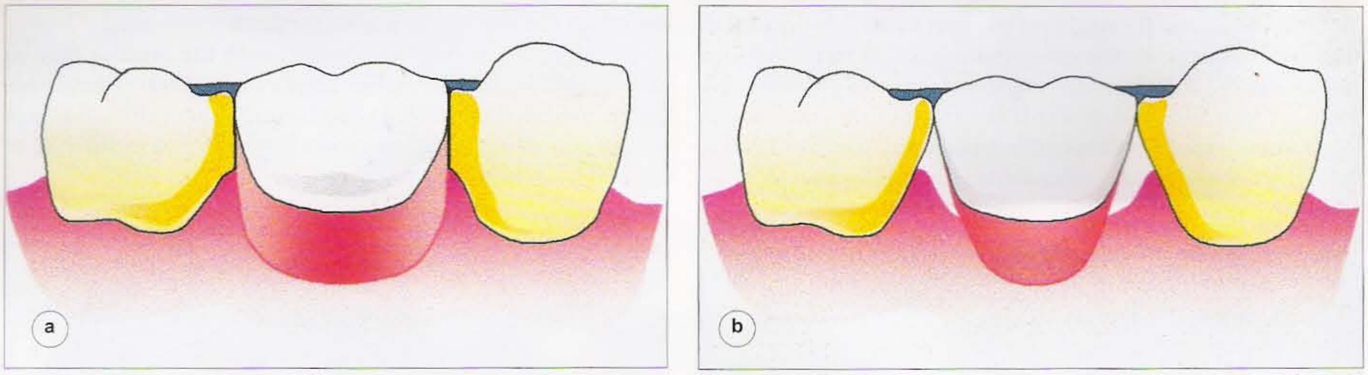




*Figure 4.8a and b — Material for the impression surface*

Where the impression surface is made in metal, more space is available for the artificial teeth. This method is therefore of particular value in tooth-borne saddles where vertical space has been restricted by overerupted opposing teeth. Retention of the acrylic resin to this 'on-ridge' metal base is usually mechanical via metal tags, posts, loops, beads or backings (see Figures 17.22, 17.23 in *A Clinical Guide to Removable Partial Dentures*)




***Junction between saddle and abutment tooth***

*Figure 4.9a and b — Junction between saddle and abutment tooth*

Controversy exists in the dental literature as to whether there should be widespread contact between the saddle and abutment tooth, the 'closed' design (Figure 4.9a, Statement 11.9), or whether the contact should be restricted to a small area close to the occlusal surface with generous clearance created at the gingival margin, the 'open' design (Figure 4.9b, Statement 11.10). Although there appears to be no difference in the rate of plaque formation or saliva clearance of plaque products associated with the two designs, a higher temperature of the gingival tissues has been recorded when a closed design has been used. This result may be due to a change in quality of the bacterial plaque causing increased irritation of the gingival tissues.

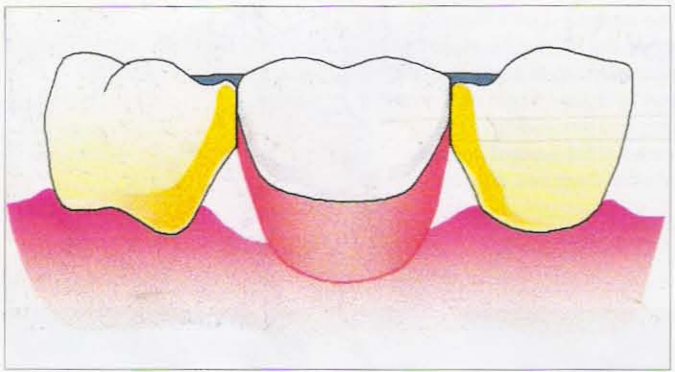


*Figure 4.10 — Junction between saddle and abutment tooth*

An advantage of the closed design is that the guide-surface philosophy can be adopted (Figures 3.9, 3.10), although it should be remembered that effective guide surfaces could be provided with an open design, as shown here if the clinical crowns are of sufficient length. Furthermore, it will be appreciated that guide surfaces can be created on the lingual or palatal surfaces of teeth and that reciprocating elements can be positioned to contact these surfaces (Figures 7.12–7.14).

As with so many judgements, the choice of design for a particular patient depends on a number of factors. For example, if the prospect for effective retention using conventional clasp arms is poor, it may be advisable to create guide surfaces and use a closed design. On the other hand, if plaque control is suspect, the decision may swing towards the open design in order to reduce gingival margin coverage to a minimum. A closed design may be required for an anterior saddle in order to produce a good appearance.

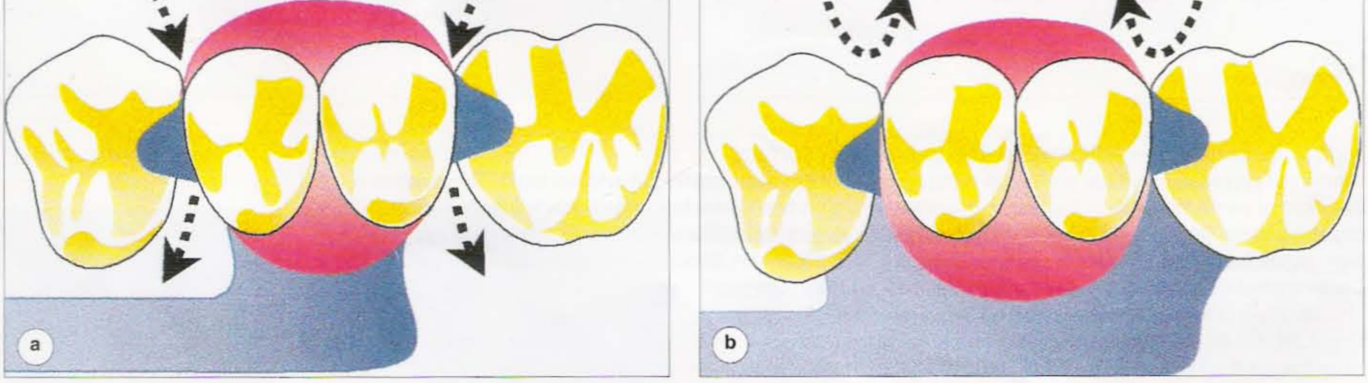



*Figure 4.11a and b — Junction between saddle and abutment tooth*

It should be appreciated that the full benefits of the open design will be realised only if care is taken with the shaping of the flanges and the underlying framework. In Figure 4.11a the denture has been so constructed that the advantages of the 'open' design are fully realised. In contrast, Figure 4.11b shows a connector that has closed off one side of the interdental spaces.

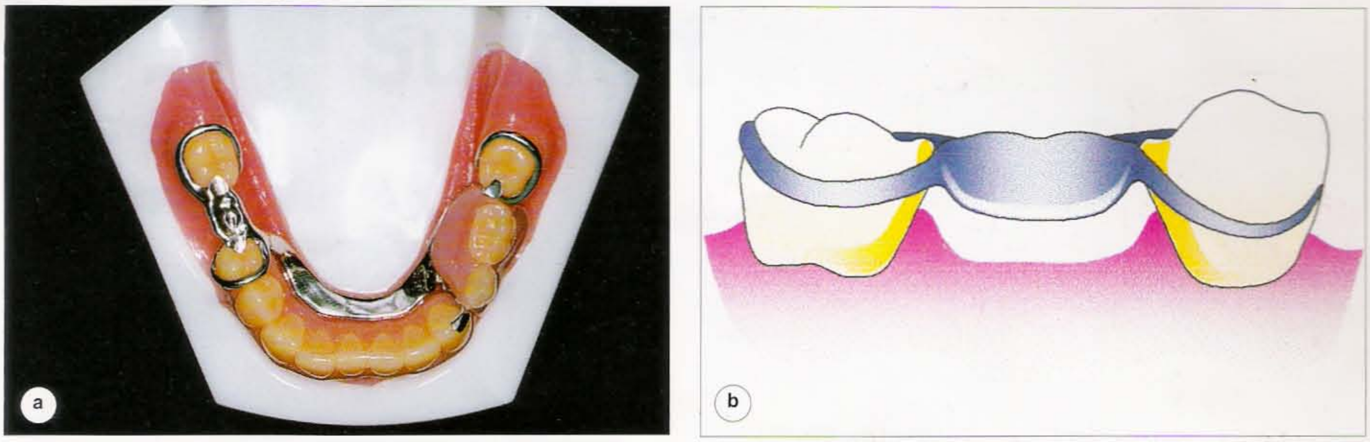


*Figure 4.12a and b — Junction between saddle and abutment tooth*

(a) If appearance is not a problem, the philosophy of an open design can be taken a stage further by constructing a hygienic pontic as at 46.

(b) The hygienic pontic design avoids all contact with the gingival margins and underlying mucosa.

*Figure 4.13 — Junction between saddle and abutment tooth*

Even where the junction between saddle and tooth is visible the spacing of the saddle and connector from the gingival margins can be maximised without compromising appearance by using an aesthetic pontic adjacent to the abutment tooth. An example of this arrangement is shown here where an aesthetic pontic replaces 45 allowing the connector and border of the distal extention saddle to be swept right away from the gingival margin around 44

Finally, in this chapter, mention should be made of a design of saddle which contacts the maximum possible area — the two-part or sectional denture. This appliance is described in Figure 6.36

# 5 Support

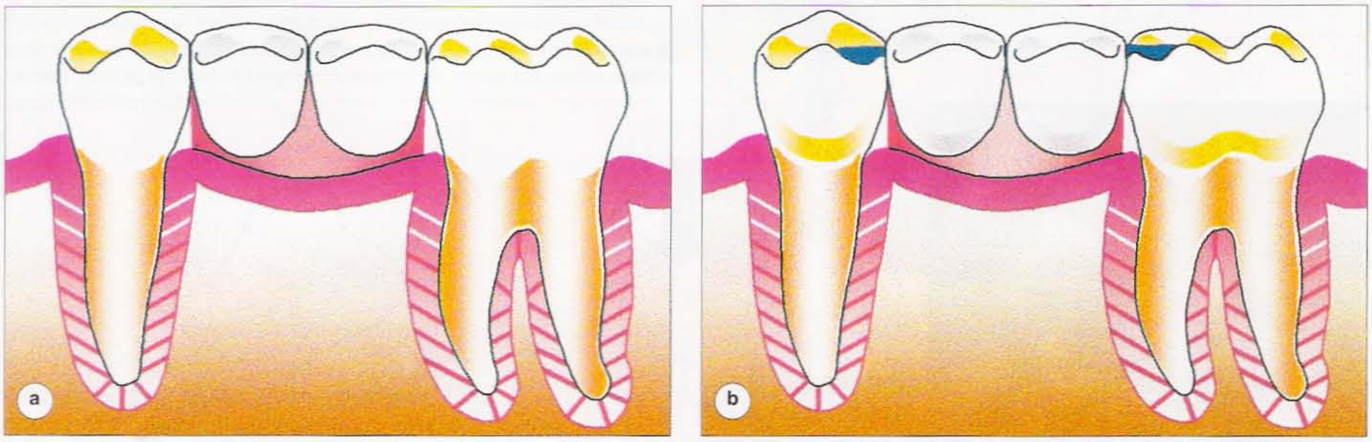
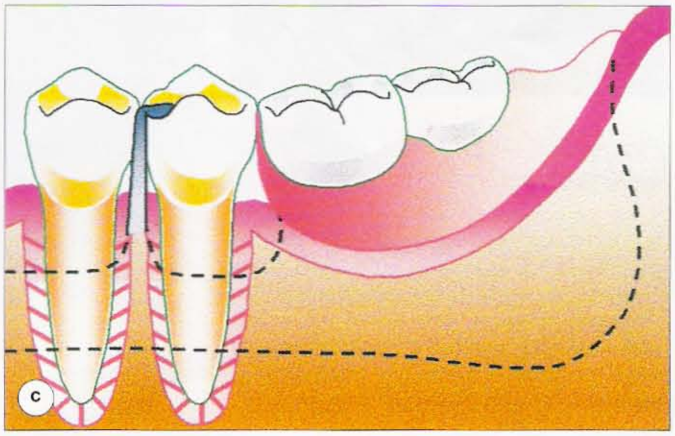



*Figure 5.1a–c — Support*

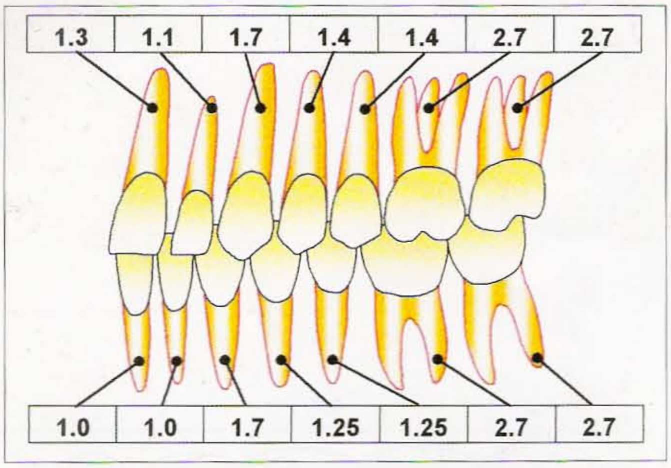
Support may be defined as resistance to vertical force directed towards the mucosa. During function, this force is transmitted through the saddles of the RPD and is ultimately resisted by the bone. If the denture rests solely on the mucoperiosteum, the force is transmitted through that tissue and the denture is termed 'mucosa-borne' (5.1a). If the denture is supported on adjacent teeth by components such as occlusal rests, the force is transmitted to the bone via teeth and periodontal ligaments, and the denture is described as 'tooth-borne' (5.1b). When a saddle has an abutment tooth at one end only (a distal extension saddle), the denture can at best be 'tooth/mucosa-borne' (5.1c). The benefits of tooth-borne and the potential dangers of mucosa-borne dentures have been indicated in Figures 2.21 and 2.22 in *A Clinical Guide to Removable Partial Dentures*.



## Planning support

When planning the denture design, a conscious decision must be made on the type of support most appropriate for the particular case. This decision is based on an assessment of:

- The root area of the abutment teeth.
- The extent of the saddles.
- The expected force on the saddles.




### *The root area of the abutment teeth*

*Figure 5.2 — The root area of the abutment teeth*

The area of root available to accept vertical force is governed by the type of tooth and its periodontal health. The tooth with the least root area is the mandibular incisor. If this tooth is given unit value, the ratios of the root areas of the other teeth are as shown in this figure.

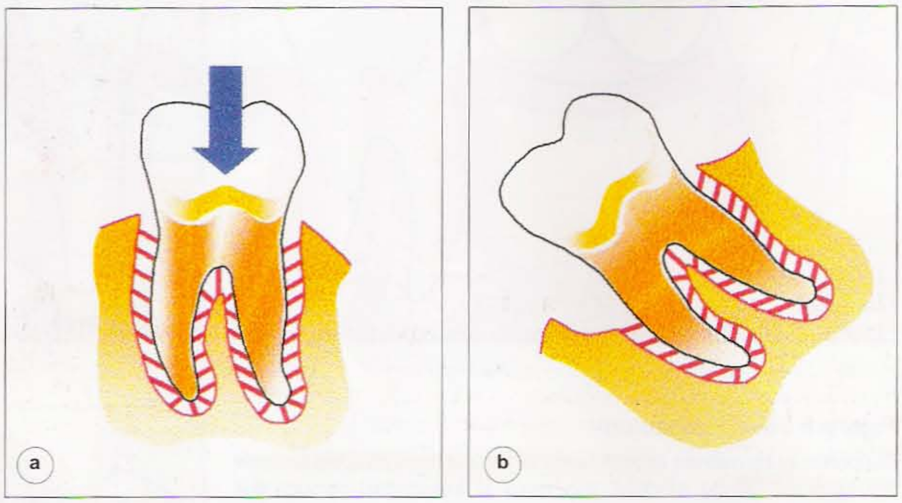



*Figure 5.3 — The root area of the abutment teeth*

If the periodontal ligament has been partly destroyed by periodontal disease the full support potential of that tooth cannot be realised. It will also be appreciated that periodontal disease first attacks the widest part of the root and thus its greatest area. In this example the available root area has been reduced by approximately two-thirds.

*Figure 5.4a and b — The root area of the abutment teeth*

(a) Most of the vertical force will be transmitted by the oblique fibres of the periodontal ligament. (b) This large group of fibres will not function as effectively if the tooth is tilted. Commonly, the mandibular molar teeth are tilted mesially. There is often more bone resorbed on the mesial side of the tooth — a factor that aggravates the situation.

### *Extent of saddles*

*Figure 5.5 — Extent of saddles*

The smaller the saddle, the lower the functional forces. In this example the forces transmitted through the saddles can be borne safely by the abutment teeth.

*Figure 5.6 — Extent of saddles*

In the restoration of these extensive saddles the tooth support offered by the remaining teeth must be augmented by mucosal support derived from extensive palatal coverage.

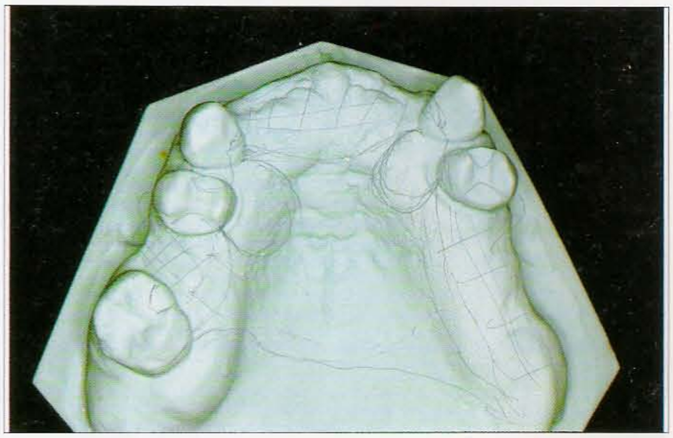
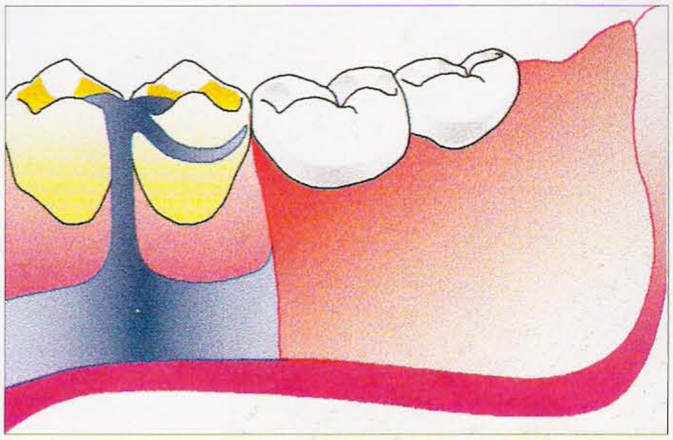


*Figure 5.7 — Extent of saddles*

It is of course possible to gain support from more than one tooth. In this instance, occlusal rests have been placed on both premolars so that the forces from the distal extension saddle are distributed widely. However, the occlusal rest on the first premolar will share the supportive function only if there is minimal downward movement of the saddle when a vertical load is applied. A larger movement will cause the rest to rotate away from the tooth.



### *The expected force on the saddles*

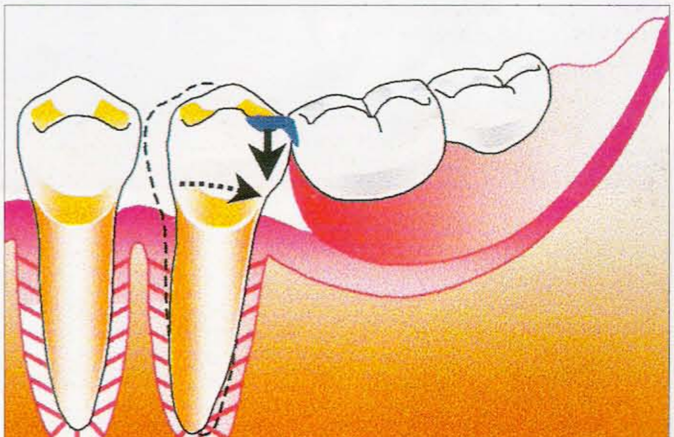
*Figure 5.8 — The expected force on the saddles*

We have already mentioned that the magnitude of force will increase as the artificial occlusal surface increases in area. The magnitude can also be expected to vary with the nature of the opposing dentition. Studies have shown that the functional force created by an opposing denture will be less than that arising from several natural teeth.

### *Tooth support for distal extension saddles*

*Figure 5.9 — Tooth support for distal extension saddles*

The support of distal extension saddles, especially in the mandibular jaw, is a particular problem and the optimum site for a rest is controversial. One view is that placing a distal rest on the abutment tooth encourages distal tipping of that tooth.



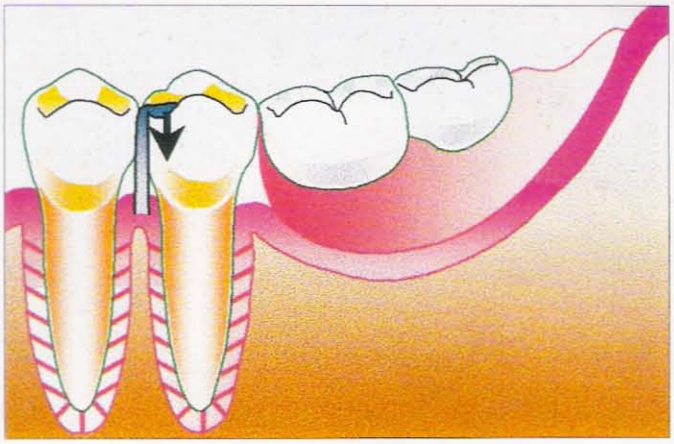


*Figure 5.10 — Tooth support for distal extension saddles*

On the other hand, the placement of a mesial rest would tend to tip the abutment tooth mesially. Such movement would be resisted by contact with the adjacent tooth.

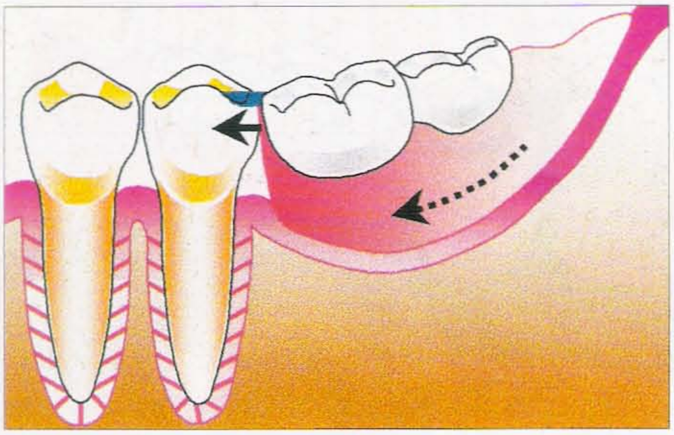


*Figure 5.11 — Tooth support for distal extension saddles*

However, *in vitro* and *in vivo* studies have shown that the movement of the abutment tooth is usually in a mesial direction even when a distal rest is used. This may be due in part to the influence of the slope of the ridge on denture movement when the saddle is loaded. For this reason the argument for a mesial rest for distal extension saddles is not as clear-cut as was once thought. However, the results of photoelastic studies, indicating more favourable stress distribution over the bone supporting the abutment tooth and the bone in the edentulous area, continue to justify the use of a mesial rest wherever possible.

In concluding this general discussion on principles of support, two final points should be made.

First, where the outlook of the patient and the state of the mouth indicate that an RPD is expected to have a long life, every effort should be made to secure tooth support. Second, a mucosa-borne denture is likely to be more successful in the maxillary jaw than in the mandibular jaw as palatal coverage ensures more effective support. More often than not, a mucosa-borne denture in the mandibular jaw causes tissue damage.

The remainder of this section will now be devoted to a more detailed consideration of components used to obtain tooth support.

***Components for tooth support***

*Figure 5.12 — Components for tooth support*

A denture may be supported on premolars or molars by occlusal rests and on maxillary canines by cingulum rests as on 23.

*Figure 5.13 — Components for tooth support*

Support may be gained from mandibular canines by incisal rests as a mandibular canine does not normally have a sufficiently well developed cingulum to accept a rest seat preparation without penetration of the enamel. However, an incisal rest is visible and so if the patient objects to this the alternative of developing a cingulum rest seat in a composite or in an adhesive metal veneer should be considered.

*Figure 5.14 — Components for tooth support*

A rather different approach to support is offered by overdenture abutment teeth. These anterior teeth, already severely worn, have been shaped to create dome-shaped preparations. When they are covered by an RPD the vertical force will be directed down the long axes of the teeth.

## Additional functions of rests

- Distribution of horizontal force.
- Maintaining components in their correct position.
- Protecting the denture/abutment tooth junction.
- Providing indirect retention.
- Reciprocation.
- Preventing overeruption.
- Improving occlusal contact.

### *Distribution of horizontal force*

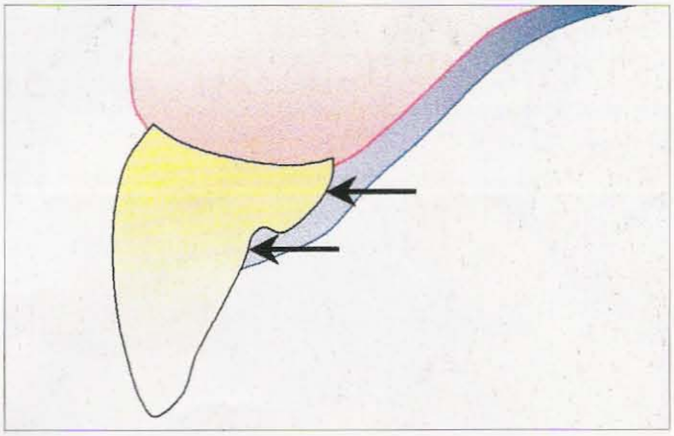


*Figure 5.15 — Distribution of horizontal force*

In addition to the vitally important function of transferring vertical forces through the root of the tooth and thence to the alveolar bone, certain shapes of rest will transfer some of the horizontal functional force; this is known as the bracing function (chapter 7).

For example, the portion of the cingulum rest on the canine, which lies against the side of the tooth, will transmit some horizontal force to the tooth. Whether or not this is appropriate for a particular tooth depends upon the periodontal support of that tooth.

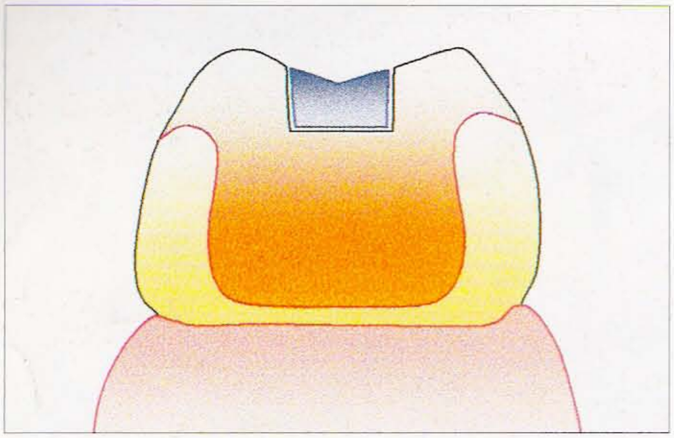


*Figure 5.16 — Distribution of horizontal force*

An occlusal rest that has been placed in a saucer-shaped rest seat will transmit less horizontal force to the tooth than will a rest placed in a box-shaped rest seat prepared in a cast gold restoration. This box-shaped preparation, if sufficiently deep, will also provide guide-surfaces to control the path of insertion of the denture. The amount of horizontal force that it is permissible to transmit to a tooth is dependent upon its periodontal health. Needless to say, this latter method can be used only on a tooth which has sufficient root area for support and whose periodontal condition is perfectly healthy. In reality the technique can be used on few occasions.

### *Maintaining components in their correct position*

If an RPD is fully supported on natural teeth it will not sink into the underlying tissues and therefore the various components will be held in the position they were originally designed to occupy.

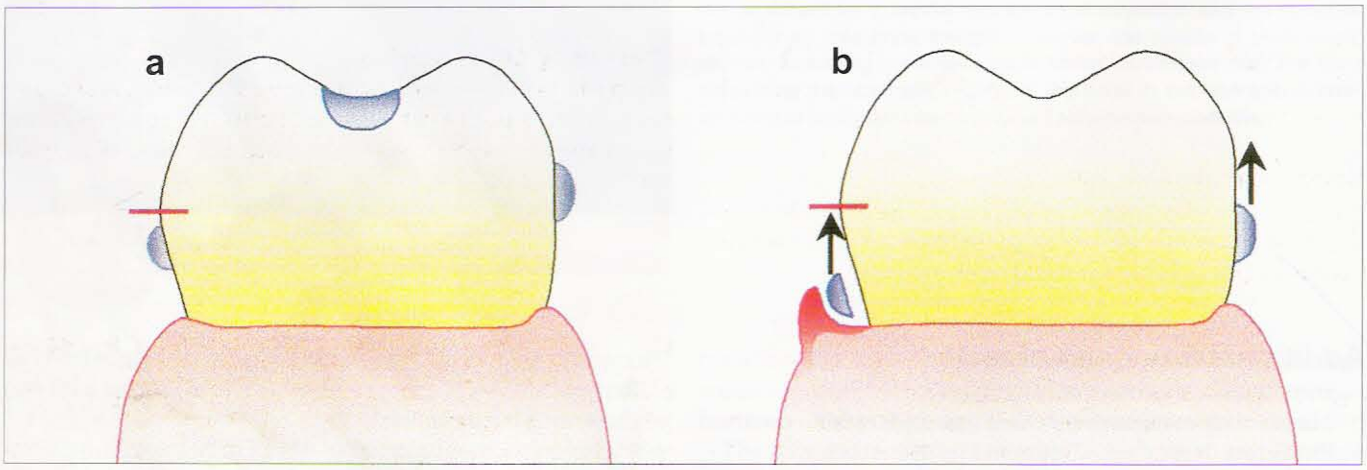



*Figure 5.17 — Maintaining components in their correct position*

(a) If the retentive clasp maintains its original position relative to the maximum bulbosity of the tooth, it will act immediately the denture is displaced occlusally. (b) If through lack of support, the denture sinks into the supporting tissues and the clasp retreats cervically, the denture will have to move some distance before the retentive tip commences to resist the displacement. Thus it can be seen that the rest improves the efficiency of a retentive clasp as well as keeping it well clear of the gingival margin, and avoiding trauma to the mucosa.

### *Protecting the denture/abutment tooth junction*

*Figure 5.18 — Protecting the denture/abutment tooth junction*

The occlusal rest may provide an effective roof to the space between saddle and abutment tooth as in this instance between 23 and 24. Although it will not prevent ingress of material from the buccal and lingual aspects, it will protect the gingival tissues from food being forcibly pushed down between denture and tooth by the power strokes of mastication.

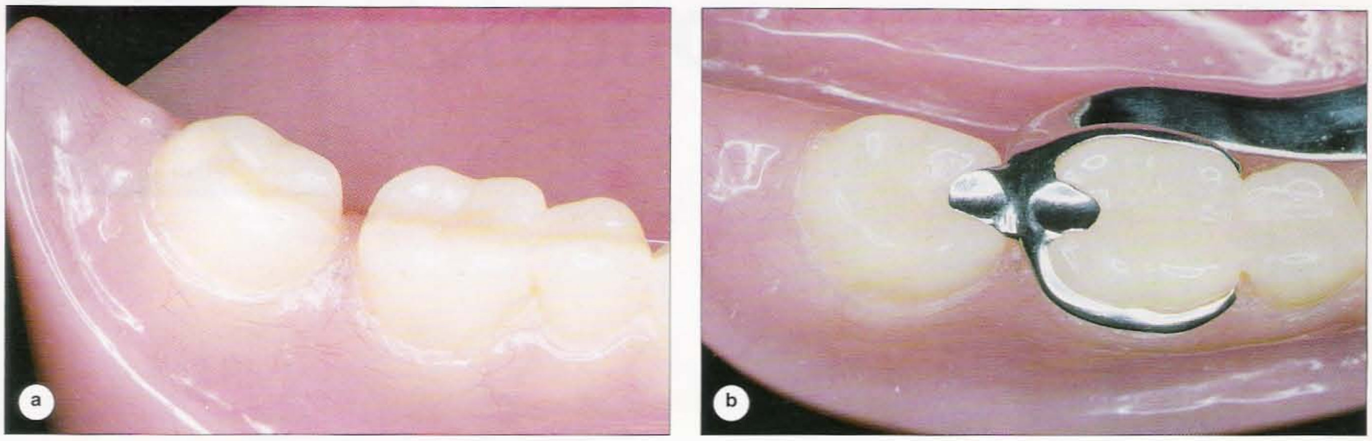


*Figure 5.19a and b — Protecting the denture/abutment tooth junction*

Occlusal rests can also be used to bridge a gap between teeth, thus again providing an effective roof over the vulnerable interdental area.

### *Providing indirect retention*

This concept is discussed fully in chapter 8. A rest is one of the components that can provide indirect retention.

### *Reciprocation*

This principle is described in chapter 7. A rest placed in a box-shaped preparation in a molar or premolar tooth can provide effective reciprocation for a retentive clasp.

### *Improving occlusal contact*

*Figure 5.20 — Improving occlusal contact*

On occasions, the support may be provided by the more widespread coverage of an onlay. This variation may be chosen when there is a need to improve the occlusal contact of the teeth.

### *Preventing Overeruption*

The position of a tooth is best maintained by intermittent contact with an opposing natural or artificial tooth. In the absence of an opposing tooth, a well-retained occlusal rest is able to prevent overeruption.

# 6 Retention

*Figure 6.1 — Retention*

Retention of an RPD can be achieved by:

- Using mechanical means such as clasps (1) which engage undercuts on the tooth surface.
- Harnessing the patient's muscular control (2) acting through the polished surface of the denture.
- Using the inherent physical forces (3) which arise from coverage of the mucosa by the denture.

Whether reliance is placed on all, or mainly on one of these methods, depends on clinical circumstances. Retention by mechanical means can also be obtained by selecting a path of insertion which permits rigid components to enter undercut areas on teeth or on ridges (Figures 3.23 and 3.26).

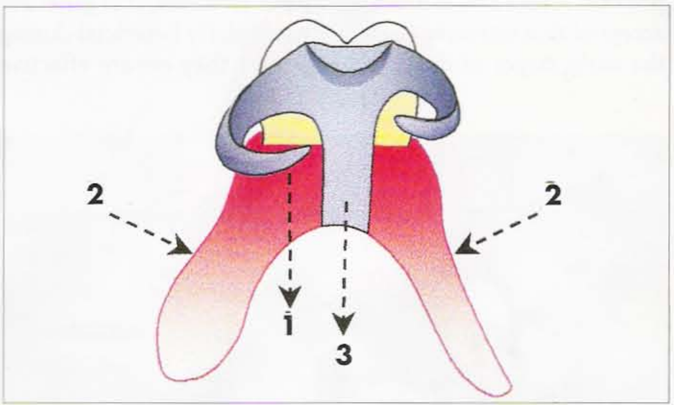



*Figure 6.2 — Retention*

In this particular case there are sufficient teeth with suitable undercut areas to allow the RPD to be retained by clasps. Successful clasp retention allows the palatal coverage to be reduced to a minimum. Not only does the patient appreciate this limited coverage but also it reduces the risk of damage to the oral tissues.

*Figure 6.3 — Retention*

In contrast to the previous case, this patient's remaining teeth offer less opportunity for clasp retention. It is necessary, therefore, to cover more of the palate in order to harness the physical forces of retention. The broad palatal plate connector also provides a surface that the patient's tongue can press against to achieve muscular control of the prosthesis.

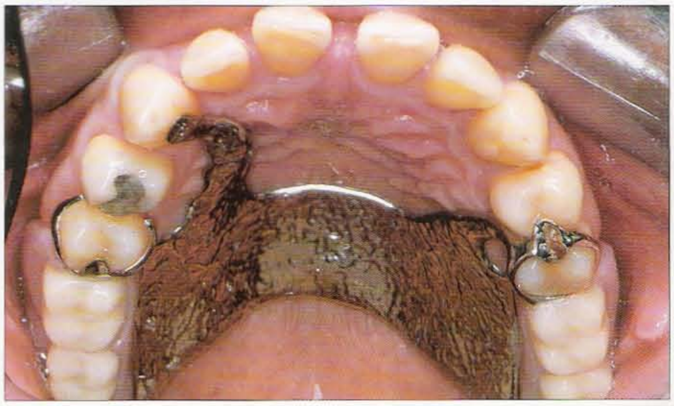
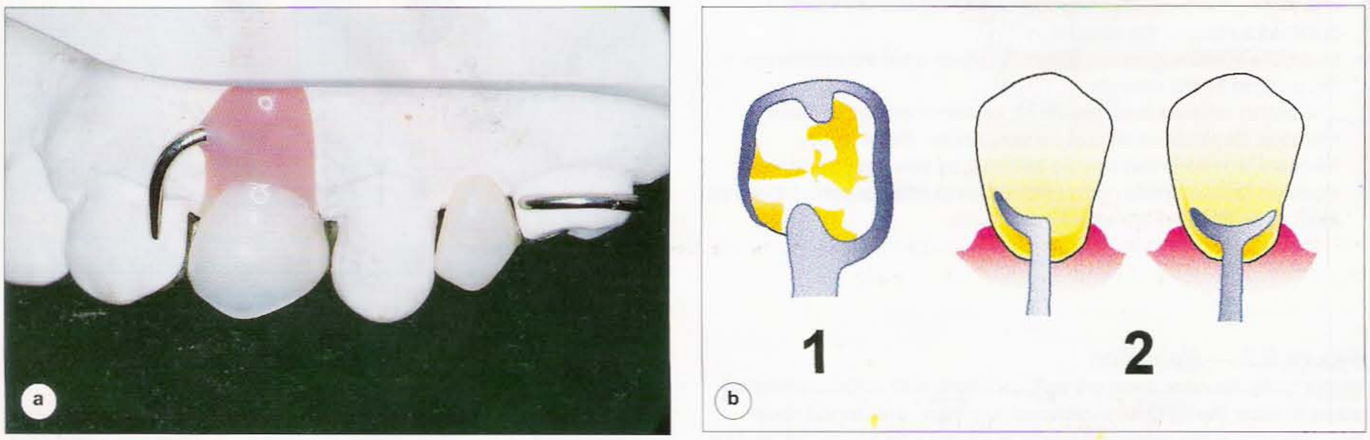


*Figure 6.4 — Retention*

Muscular control is of particular importance for the success of an extensive mandibular bilateral distal extension saddle denture. Although this denture achieves some retention from clasps its success will depend primarily on the muscles of the tongue and cheeks acting on the correctly designed polished surfaces of the saddles.

As will be seen later in this section, there are circumstances where there is a tendency for retentive clasps to lose some of their efficiency with the passage of time. Thus, in the long term, successful retention may become more dependent upon the physical forces and muscular control. However, it is generally accepted that retentive clasps are particularly beneficial during the early stages of denture wearing as they ensure effective mechanical retention while the patient learns the appropriate muscular skills that will either augment or replace the contribution of the clasps.

The remainder of this section is devoted to a consideration of components which provide mechanical retention, namely clasps, precision attachments and other devices.




## Clasps

*Figure 6.5a and b — Clasps*

Although many designs of retentive clasps have been described, they can be considered in one of two broad categories: the occlusally approaching clasp on 27 and the gingivally approaching I bar clasp on 23 (Figure 6.5a). Common variations in the design of clasps (Figure 6.5b) that may be selected primarily according to the distribution of tooth undercuts include:

1 the ring clasp (which is occlusally approaching).
2 the 'L'- or 'T'-shaped gingivally approaching clasp.

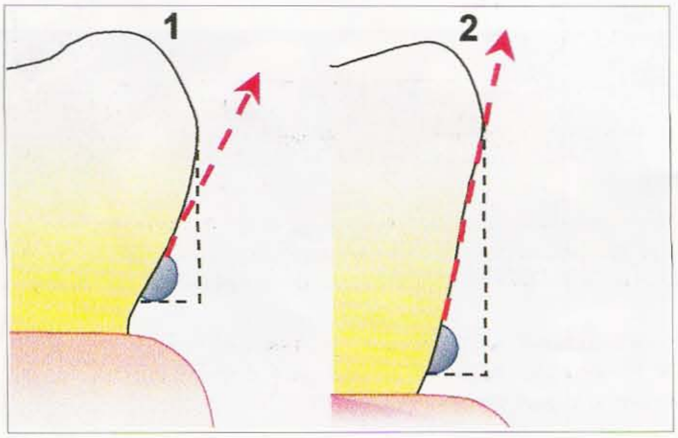



*Figure 6.6 — Clasps*

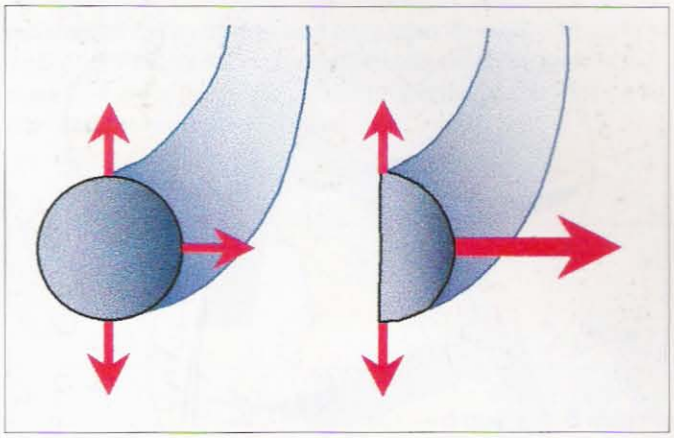
Whatever type of clasp is used a denture will be retained successfully only as long as the force required to flex the clasps over the maximum bulbosities of the teeth is greater than the force which is attempting to dislodge the denture. The retentive force is dictated by tooth shape and by clasp design.

Tooth shape influences retention by determining the depth and steepness of undercut available for clasping. Clasps 1 and 2 are positioned in the same amount of undercut and therefore provide the same overall retentive force. However, for the same small vertical displacement, clasp 1 is deflected more than clasp 2 and therefore offers greater initial resistance to the displacing forces.

*Figure 6.7 — Clasps*

The flexibility of a clasp is dependant on its design.

- ***Section***
  A round section clasp will flex equally in all directions, whereas a half round clasp will flex more readily in the horizontal than in the vertical plane.
- **Length**
  The longer the clasp arm the more flexible it is. Thus an occlusally approaching clasp on a molar tooth will be more flexible than one on a premolar.
- **Thickness**
  Thickness has a profound effect on flexibility. If the thickness is reduced by half the flexibility is increased by a factor of eight.
- **Curvature** (see Figure 6.8)
- **Alloy** (see Figure 6.9)



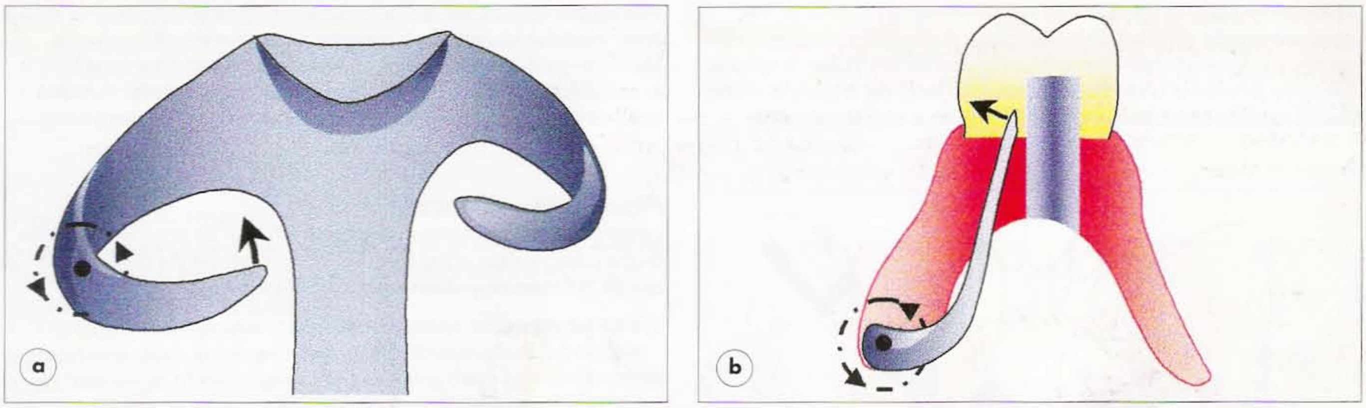


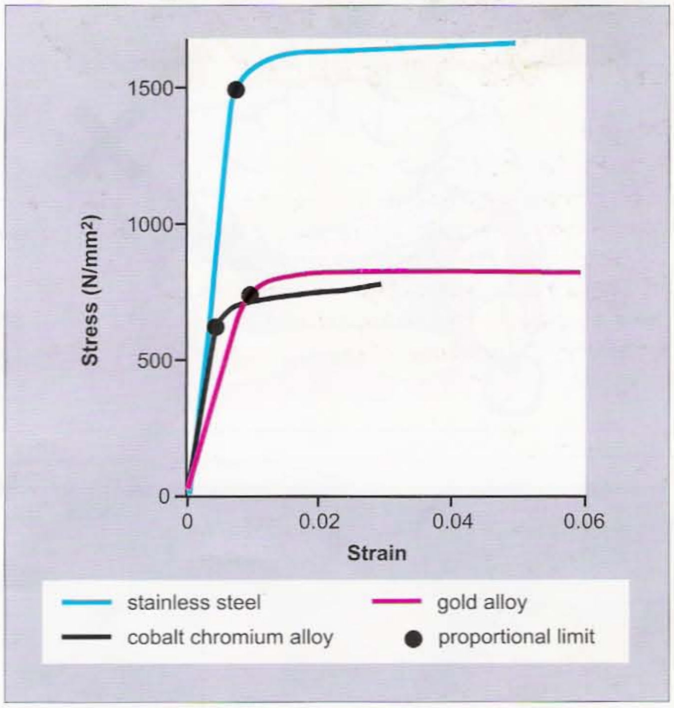

*Figure 6.8a and b — Clasps*

A clasp which is curved in two planes can exhibit the so-called 'bucket handle' effect in which torsional movement of the clasp increases flexibility of the clasp arm.

*Figure 6.9 — Clasps*

Flexibility is also dependent upon the alloy used to construct the clasp. The most commonly used alloy, cobalt chromium, has a value for modulus of elasticity (stiffness) indicated by the steepness of the first part of the black curve, which is twice that of gold alloy (the red curve). Thus, under identical conditions the force required to deflect the cobalt chromium clasp over the bulbosity of the tooth will be twice that of a gold clasp.

Of particular importance is the proportional limit of the alloy indicated by the solid circles on the curves. If a clasp is stressed beyond the proportional limit it will be distorted permanently. Hard gold and cobalt chromium have similar proportional limits. Hardened stainless steel wire (blue curve) has a much higher value.




It will be appreciated that the factors mentioned above interact with each other. Thus the choice of an appropriate clasp which will retain a denture satisfactorily and yet not stress the tooth unduly, or be distorted permanently during service, might appear to be somewhat bewildering. In this book we feel it is appropriate to offer the following clinical guidelines which have been shown to work in practice.

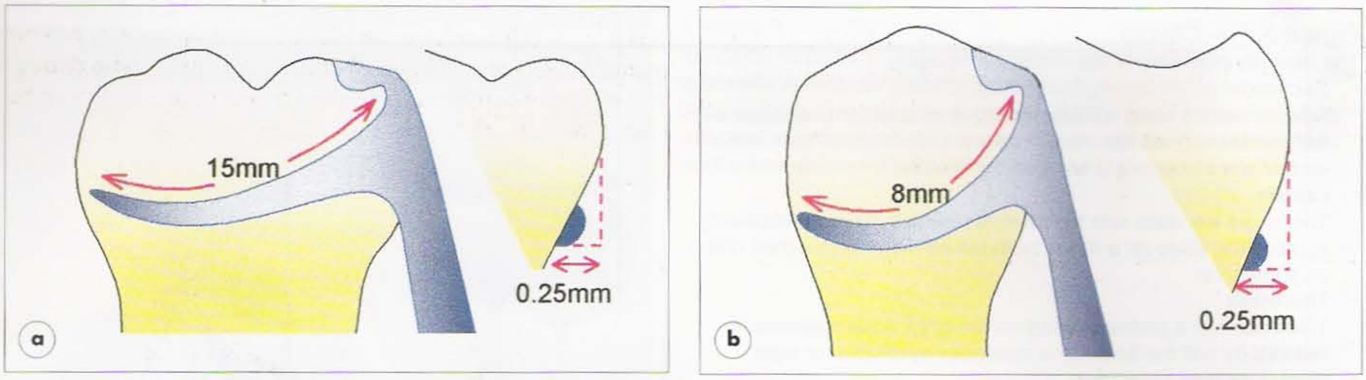



*Figure 6.10a and b — Clasps*

As shown in (a), a cobalt chromium clasp arm, approximately I5 mm long, should be placed in a horizontal undercut of 0.25 mm. If the undercut is less the retention will be inadequate. If it is greater, the clasp arm will be distorted because the proportional limit is likely to be exceeded. A cobalt chromium occlusally-approaching clasp engaging the same amount of undercut on a premolar tooth (b) is likely to distort during function because it is too short. In such a situation a longer clasp arm can be achieved by using a gingivally-approaching design. Whether this choice is appropriate depends on certain clinical factors that will be highlighted later in this chapter. Alternatively, an alloy with a lower modulus of elasticity but similar proportional limit, such as a platinum–gold–palladium wire, can be used. Yet another possibility is to use a material with a higher proportional limit but similar modulus such as wrought stainless steel or cobalt chromium (Wiptam) wires.

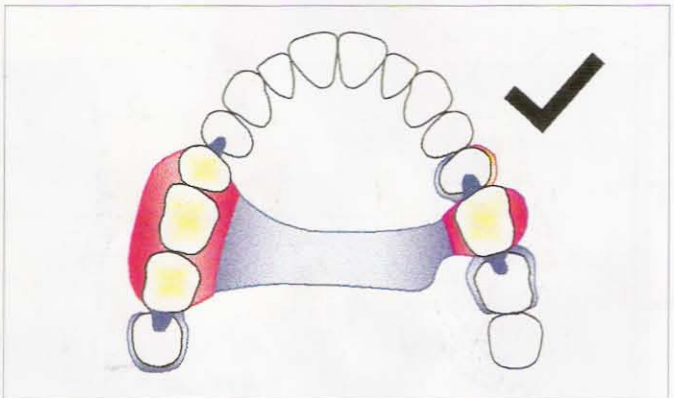


*Figure 6.11 — Clasps*

Whether a gold or stainless steel clasp arm can be provided depends on the configuration of the denture. In this example the gold clasp on 25 can be held securely within the acrylic of the saddle.

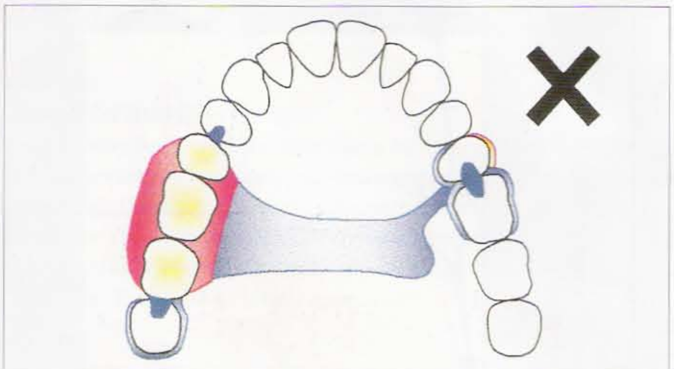


*Figure 6.12 — Clasps*

If a gold clasp were to be provided for 25 in this case, its only means of attachment to the remainder of the denture would be by soldering it to the cobalt chromium framework. Such a union is possible but relatively weak and thus is prone to fracture during use.The metal frame of an RPD ideally consists of a single alloy. However, if different metals or alloys are present in the same oral environment, as in the examples described above, interactions frequently occur between these materials that reduce their individual properties. Corrosion is the most common reaction and it begins as soon as different metals or alloys are in contact with each other.

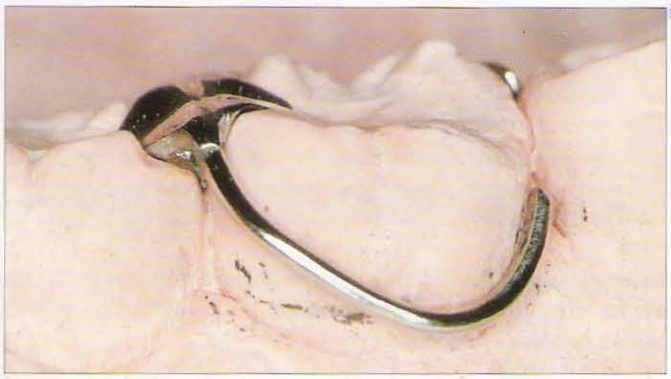


*Figure 6.13 — Clasps*

A cobalt chromium 'Wiptam' round wire clasp can be attached to the framework using a 'cast-on' technique.

Where it is necessary to add clasp retention to an acrylic transitional denture, stainless steel wire is a relatively inexpensive solution to the problem. Wire of 0.75mm diameter is appropriate for premolar teeth while 1 mm diameter wire is suitable for molar teeth.

Two final points are worth making before we leave the subject of clasp construction and progress to further consideration of design and clinical use. First, the efficiency of a retentive clasp is also influenced by the support of the denture (Figures 5.17) and by reciprocation (Figures 7.12 and 7.13). Second, the variables of clasp construction have been simplified by certain manufacturers producing preformed wax patterns with dimensions that are appropriate for the properties of the alloy to be used and the tooth to be clasped.

## Comparison of occlusally and gingivally approaching clasps

### *Retention*

*Figure 6.14 — Retention*

Only the terminal third of an occlusally-approaching clasp (stippled section) should cross the survey line and enter the undercut area. If, in error, too much of the clasp arm engages the undercut, the high force required to move it over the maximum bulbosity will put a considerable strain on the fibres of the periodontal ligament and is likely to exceed the proportional limit of the alloy, thus distorting the clasp.

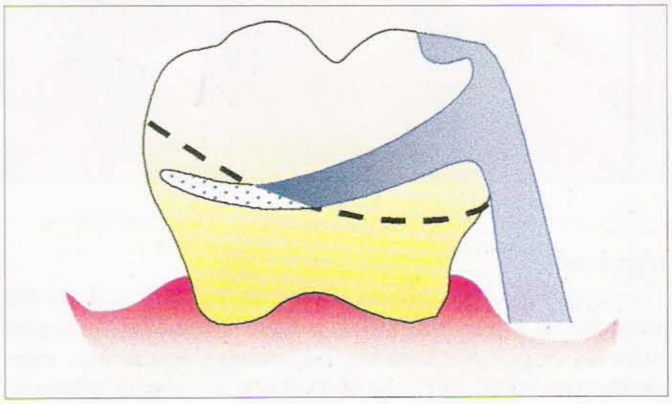
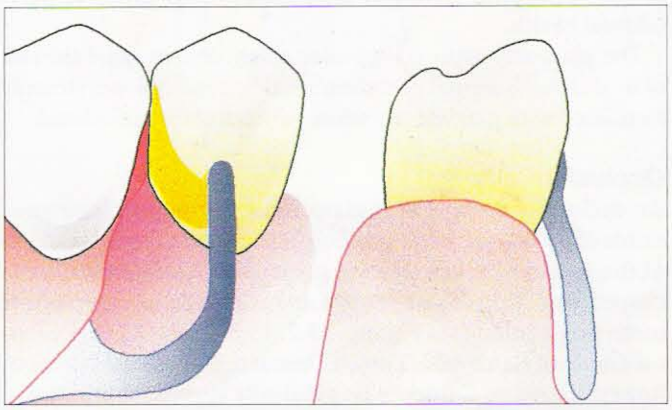


*Figure 6.15 — Retention*

A gingivally approaching clasp contacts the tooth surface only at its tip. The remainder of the clasp arm is free of contact with the mucosa of the sulcus and the gingival margin.

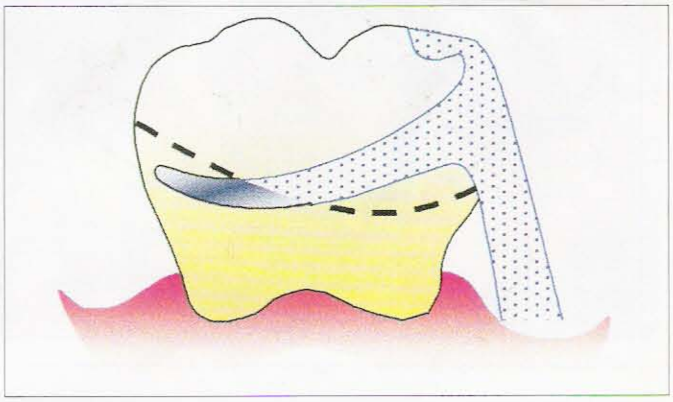
The length of the gingivally approaching clasp, unlike the occlusally approaching clasp, is not restricted by the dimensions of the clasped tooth. The length of the gingivally approaching clasp arm can therefore be increased to give greater flexibility which can be a positive advantage when it is necessary to clasp a premolar tooth or a tooth whose periodontal attachment has been reduced by periodontal disease.



### *Bracing*

*Figure 6.16 — Bracing*

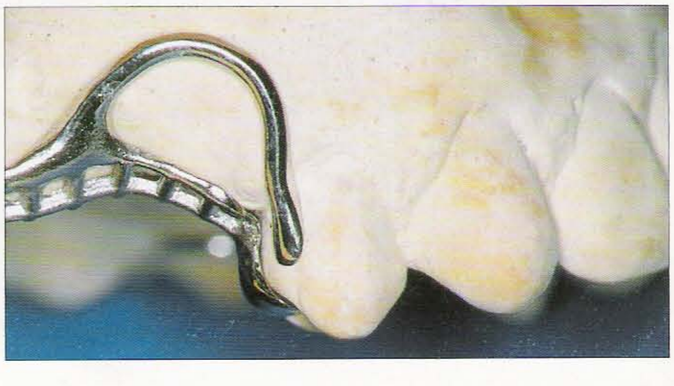
The occlusally approaching clasp is more rigid, and more of it (stippled section) is in contact with the tooth surface above the survey line. It is therefore capable of transmitting more horizontal force to the tooth and is a more efficient bracing component as a result (chapter 7). Whether such a measure is appropriate depends upon the health of the periodontal tissues and the functional requirements of the RPD.



### *Appearance*

*Figure 6.17 — Appearance*

Either type of clasp can detract from appearance when placed on a tooth that is toward the front of the mouth. However, the gingivally approaching clasp has more potential for being hidden in the distobuccal aspect of a tooth provided that there is a suitable undercut area for the clasp.



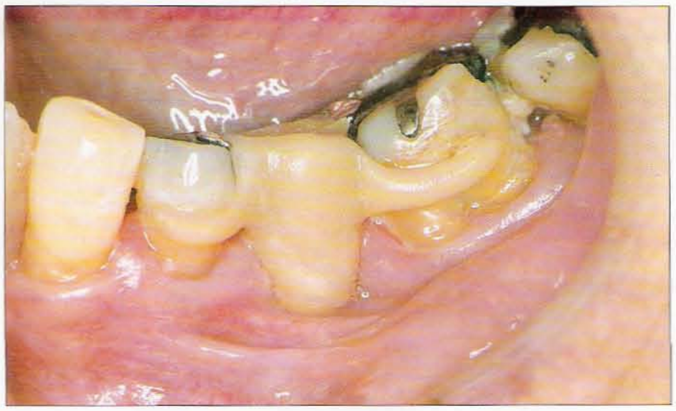


*Figure 6.18 — Appearance*
Tooth-coloured occlusally approaching polyoxymethylene clasps are an alternative to metal clasps where the colour of the clasp is a key factor. However, these clasps are bulkier than metal clasps and require a deeper undercut. Other disadvantages include lack of adjustability and increased cost.

### *Hygiene*

The gingivally approaching clasp can be criticized on the grounds that it crosses a gingival margin. There does not appear to be any evidence to indicate that one clasp encourages more plaque than the other. However, it is not unreasonable to assume that if the patient does not practise good oral hygiene the gingivally approaching clasp could pose a greater threat to periodontal health.

The gingivally approaching clasp might also increase the risk of root caries. It should be remembered that this lesion is strongly associated with gingival recession, which itself is age-related.

### *Occlusion*

An occlusally approaching clasp must begin, and have two-thirds of its length, in the area bounded by the occlusal contacts of the opposing teeth and the survey line on the tooth to be clasped. Provision of an adequate space for the clasp may require tooth preparation (see Figures, 15.7, 15.8, 15.21–22 in *A Clinical Guide to Removable Partial Dentures* ). Occlusal contacts, however, have no influence on gingivally approaching clasps.

## Factors governing the choice of retentive clasp

The choice of retentive clasp for an individual tooth depends upon the:

- Position of the undercut.
- Health of the periodontal ligament.
- Shape of the sulcus.
- Length of clasp.
- Appearance.
- Occlusion.

As we have already discussed the significance of the length of clasp, appearance and occlusion, particular attention will be focused on the first three factors.

### *The position of the undercut*

*Figure 6.19 — The position of the undercut*
The diagonal survey lines on the molar and premolar teeth shown here indicate that there is a larger undercut on that part of the tooth which is furthest away from the edentulous area. Typical designs of retentive clasp are the occlusally approaching clasp on the molar and the gingivally approaching 'I' bar on the premolar tooth.

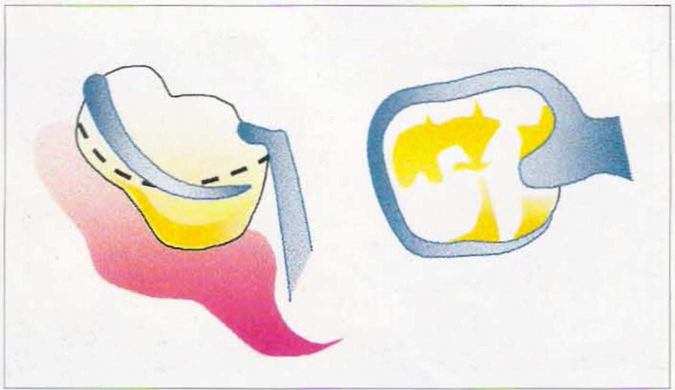


*Figure 6.20 — The position of the undercut*
The orientation of the diagonal survey line on this molar creates the larger undercut area nearer to the saddle. The design of occlusally approaching clasp used on the molar in Figure 6.19 would be quite inappropriate because it would prove difficult to keep the non-retentive two-thirds of the clasp out of the undercut whilst, at the same time, offering very little undercut for the retentive portion. An alternative design is the ring clasp that commences on the opposite side of the tooth and attacks the diagonal survey line from a more appropriate direction. An 'I' bar would be suitable for a premolar tooth with a survey line of similar orientation.

*Figure 6.21 — The position of the undercut*
A low survey line (on the buccal side of the tooth) is present because the tooth is tilted; thus there is a high survey line on the lingual side of the tooth. Again, a ring clasp is a solution to the problem: the bracing portion of the clasp is on the left side of the tooth and the retentive portion on the right side.

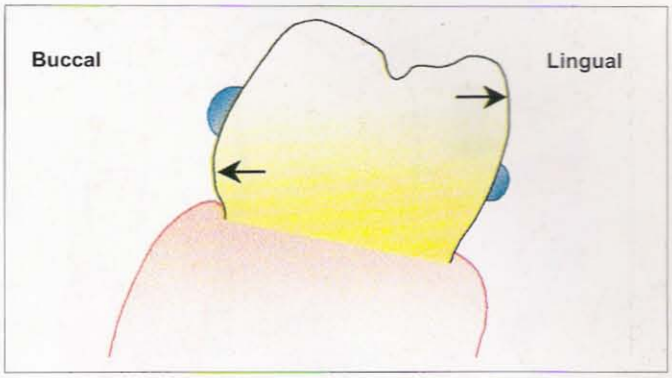
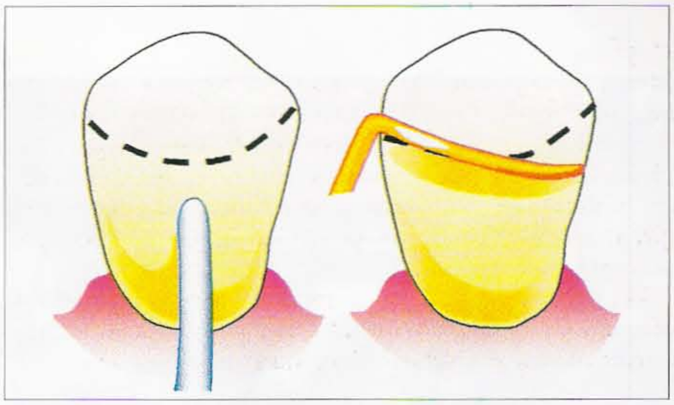



*Figure 6.22 — The position of the undercut*
A high survey line poses particular difficulties on a premolar tooth. If it is not appropriate or practical to lower the survey line by altering the crown shape, it may be possible to position a flexible gingivally approaching clasp higher up the crown or, if an occlusally approaching clasp is preferred, to use a more flexible platinum–gold–palladium wrought wire clasp.

Even if the survey line is not high enough to create difficulties in clasping there will be potential advantages in using one of these more flexible types of clasp on a premolar tooth (Figure 6.10).



### *The health of the periodontal ligament*

If a retentive clasp is placed on a tooth, it is inevitable that extra force will be transmitted to the supporting tissues of that tooth. Whether or not these tissues are able to absorb the extra force without suffering damage depends upon their health, the area of attachment and the magnitude of the force.

*Figure 6.23 — The health of the periodontal ligament*
This canine tooth has already lost approximately half its periodontal attachment as a result of previous periodontal disease. Although the disease process has been arrested, there is the possibility that further damage will occur if a relatively inflexible retentive clasp system, such as a cast cobalt chromium occlusally approaching clasp, is provided. If it is considered essential to rely on mechanical retention, a possible solution is to prescribe a more flexible gingivally approaching clasp. However, this option should be used with caution if the gingival recession is associated with root caries in which case a wrought wire occlusally approaching clasp might then be more suitable.

### *The shape of the sulcus*

*Figure 6.24 — The shape of the sulcus*
If a gingivally approaching clasp is envisaged, the shape of the sulcus must be checked carefully to ensure that there are no anatomical obstacles. In this example the prominent fraenal attachment would be traumatised by a gingivally approaching clasp of correct proportions and position. If there is no reasonable alternative to this clasp, and mechanical retention is thought to be essential, serious consideration must be given to surgical excision of the fraenal attachment.

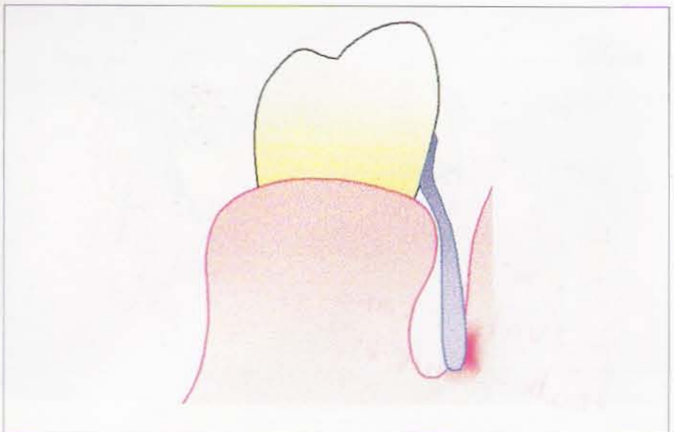


*Figure 6.25 — The shape of the sulcus*

If there is an undercut in the sulcus, the arm of a gingivally approaching clasp would have to be spaced from the mucosa of the ridge to allow the denture to be inserted and removed without the clasp traumatising the bulbous part of the ridge. If the undercut is deep, the resulting prominence of the clasp arm is likely to irritate the buccal mucosa and trap food debris, becoming an intolerable nuisance to the patient.

The German slang prosthodontic term for a gingivally approaching clasp, 'Sauerkrautfänger' ('cabbage catcher'), graphically describes the situation.

### ***The RPI system***

*Figure 6.26 — The RPI system*

The RPI system is a combination of occlusal rest (R) distal guide plate (P) and gingivally approaching I bar clasp (I) used primarily with mandibular distal extension saddles.

The minor connector carrying the mesial rest contacts the mesiolingual surface of the abutment tooth and, together with the distal plate, acts as a reciprocal for the tip of the retentive clasp which is positioned on or anterior to the midpoint of the buccal surface of the tooth.

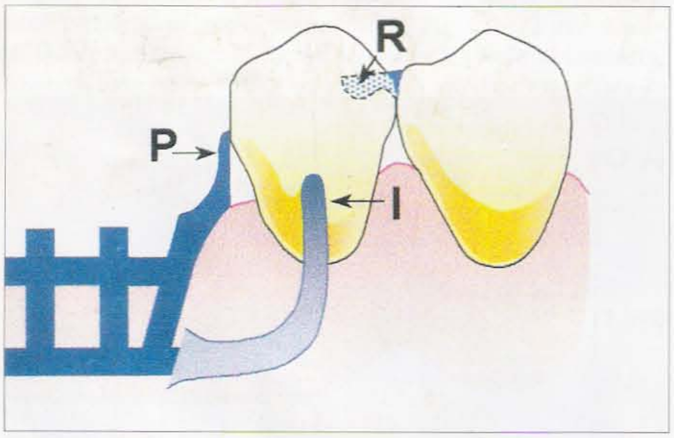



*Figure 6.27 — The RPI system*

The distal guide plate is positioned at the gingival end of a guide surface prepared on the distal aspect of the tooth.

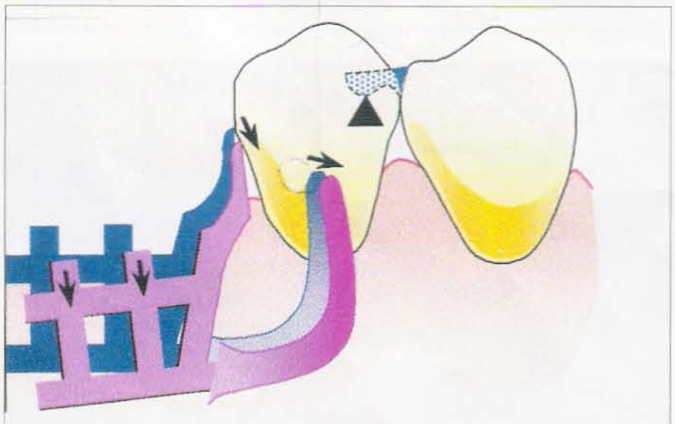
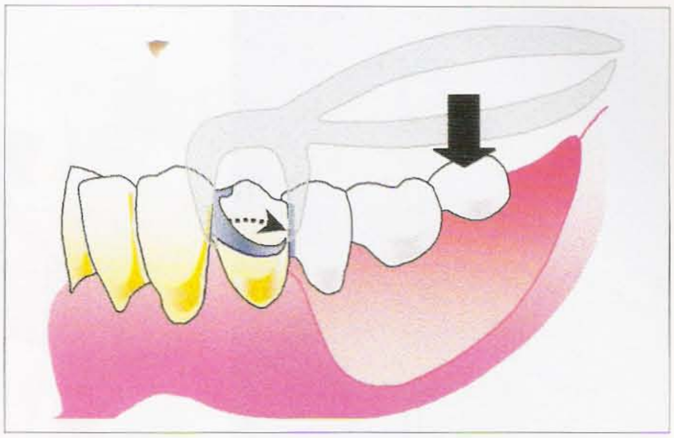


*Figure 6.28 — The RPI system*

The RPI system is designed to allow vertical rotation of a distal extension saddle into the denture-bearing mucosa under occlusal loading without damaging the supporting structures of the abutment tooth. As the saddle is pressed into the denture-bearing mucosa, the denture rotates about a point close to the mesial rest. Both the distal guide plate and the I bar move in the directions indicated and disengage from the tooth surface. Potentially harmful torque is thus avoided.

When trying in the metal framework, it is advisable to check that it is able to rotate about the abutment tooth in the intended fashion. If this is found not to be the case, the framework should be carefully adjusted to allow this rotation.

*Figure 6.29 — The RPI system*
A distal extension saddle should not be rigidly attached to the abutment tooth by a combination of stiff clasp and long guide plates. If these are incorporated the occlusal loads falling on the saddle, which is in effect a long cantilever arm, are likely to result in the RPD acting like extraction forceps, with consequent damage to the supporting structures of the tooth.

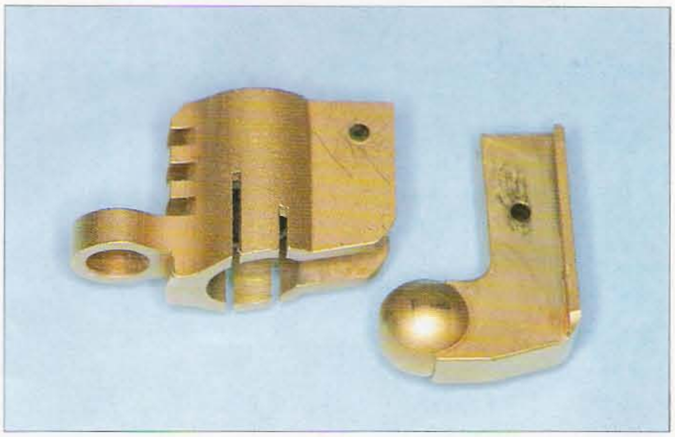


## Attachments

An attachment is made up of two components, one located in or on the abutment tooth and the other housed in the denture. When the two matched parts are linked together they produce very positive retention. Attachments are discussed further in *A Clinical Guide to Removable Partial Dentures*, Figures 3.6 – 3.12. However, it is not the purpose of this book to provide detailed information on precision attachments but rather to note their existence and refer the reader to texts that deal with this topic.

*Figure 6.30 — Attachments*
Tooth 46 has an example of an intracoronal micro-attachment. A slot is incorporated within the substance of a crown and is engaged by a matching component on the removable section.

*Figure 6.31 — Attachments*
The extracoronal micro-attachment, such as the Dalbo on the right of the figure, is attached to the outside of the crown. The matched component on the left is held in the denture and is designed to allow rotatory movement as the distal extension saddle sinks into the denture-bearing mucosa, thus taking some of the stress off the abutment tooth.



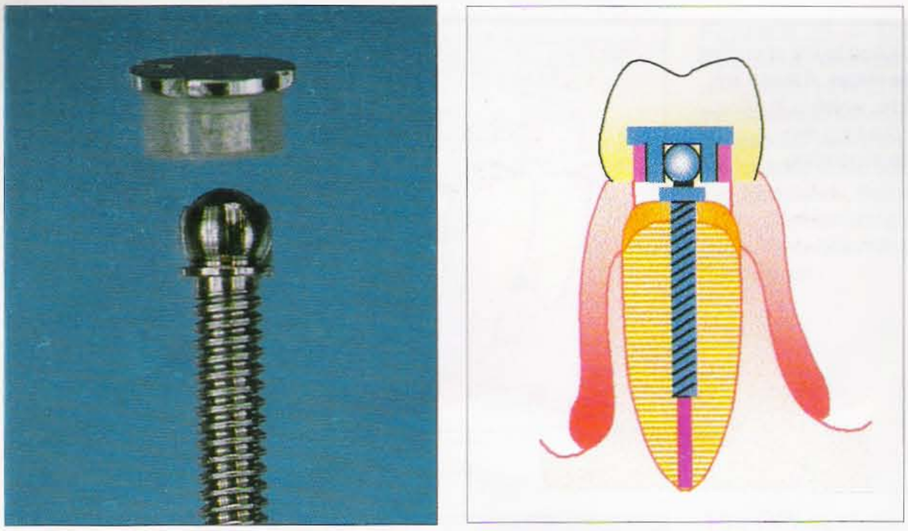


*Figure 6.32 — Attachments*
With attachments like the Kurer system, the stud is fixed to the root face of a root-filled tooth and a retainer held in the acrylic of the denture base snaps over the stud.

*Figure 6.33 — Attachments*
In this example the stud attachment affords positive retention in the anterior region for the extensive saddles.

The advantages of attachments include positive retention in the absence of clasp arms. Their use necessitates extensive preparation of the abutment teeth and an inevitable increase in cost of treatment. The more rigid attachments require the abutment teeth to have particularly healthy periodontal tissues. As the attachments tend to encourage the formation of plaque, the standard of oral hygiene must be immaculate. Maintenance of the denture may be complicated by wear of the attachments, which may necessitate replacement of the component parts.

## Other devices

*Figure 6.34 — Other devices*
The ZA anchor is an example of a spring-loaded attachment. The spring-loaded nipple engages an undercut on the surface of an abutment tooth adjacent to the saddle. It is used for retaining bounded saddles and is of particular value for maxillary canine or premolar teeth where a conventional clasp arm would detract from appearance.

*Figure 6.35 — Other devices*

In recent years there has been an increasing interest in the use of magnets. The modern alloys are powerful and retain their magnetism for a long time. Each magnetic unit has a force of attraction in the region of 200–300g, which is maximal as soon as the denture starts to move. This force of attraction imparts a degree of security to the denture, without putting great demands on the periodontal tissues of the abutment teeth. In this example the bipolar magnet will be incorporated in the denture. The keeper is housed in a gold coping fitted to a root-filled tooth.

*Figure 6.36 — Other devices*

The two-part denture makes use of opposing undercuts. Both parts are inserted separately using different paths of insertion. In this figure the portion coloured blue is inserted first from a mesial direction (1) to engage the mesial undercut on the molar. Then the yellow portion is inserted from a distal direction (2) to engage the distal undercut on the premolar. Once the components are fully seated they are locked together — in this instance with a bolt. This type of RPD is discussed further in Statement 11.2.

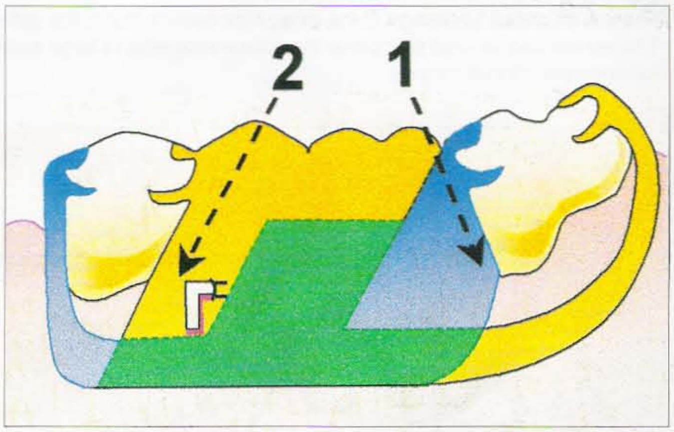



*Figure 6.37 — Other devices*

A bolt retained sectional denture is shown *in situ*. The patient needs to be reasonably dextrous to successfully manage a denture of this type.

*Figure 6.38 — Other devices*

The swing-lock denture has a hinged labial bar which has extensions into undercuts on the labial surfaces of the teeth. When the 'gate' is closed and locked into position, the denture is held securely by the 'gate' on the labial aspect and by the reciprocating components on the lingual aspects of the teeth. The denture can be particularly helpful where the remaining natural teeth offer very little undercut for conventional clasp retention. This patient, a trombone player, required a positively retained RPD. The swing-lock design allowed optimum use to be made of the incisors. As this type of denture covers a considerable amount of gingival margin, the standard of plaque control must be high.

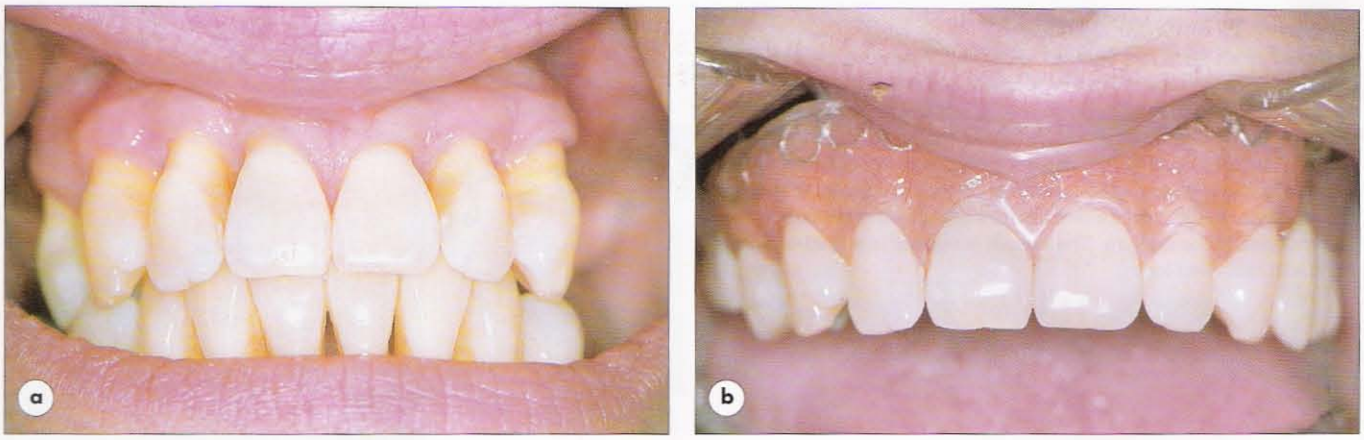
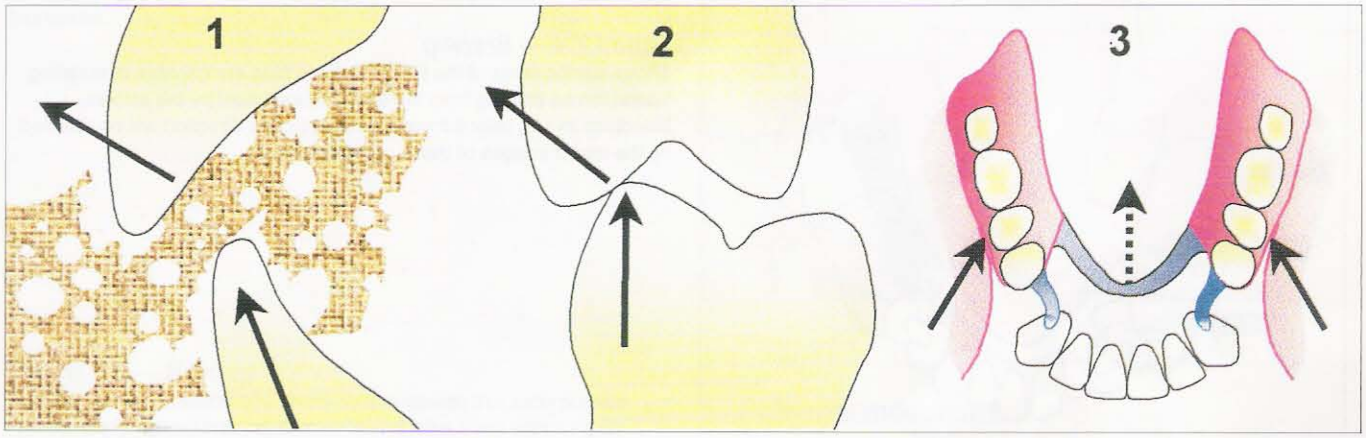


*Figure 6.39a and b — Other devices*

There is an added advantage of the swing-lock denture in that the 'gate' can carry a labial acrylic veneer. This veneer can be used to improve the appearance when a large amount of root surface has been exposed following periodontal surgery.

# 7 Bracing and reciprocation




## Bracing

*Figure 7.1 — Bracing*

Horizontal forces are generated during function by occlusal contact (1 and 2) and by the oral musculature surrounding the denture (3). These forces tend to displace the denture in both antero-posterior and lateral directions.

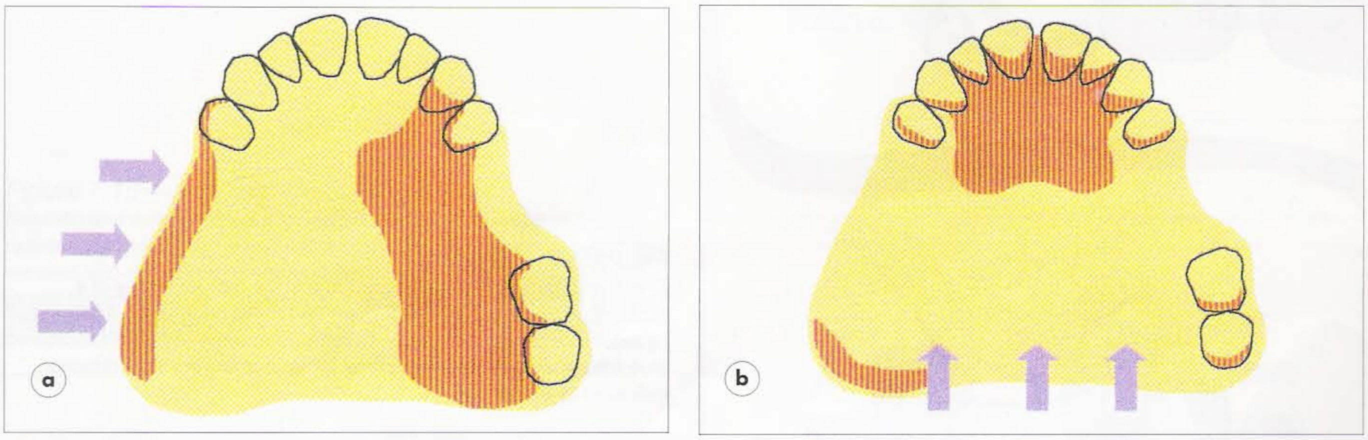



*Figure 7.2a and b — Bracing*

The horizontal forces are resisted by placing rigid components of the denture (bracing components) against suitable vertical surfaces on the teeth and residual ridges. Parts of a denture resting against the shaded areas will resist the forces whose directions are shown by the arrows. It is important to appreciate that bracing occurs only when the denture is fully seated.

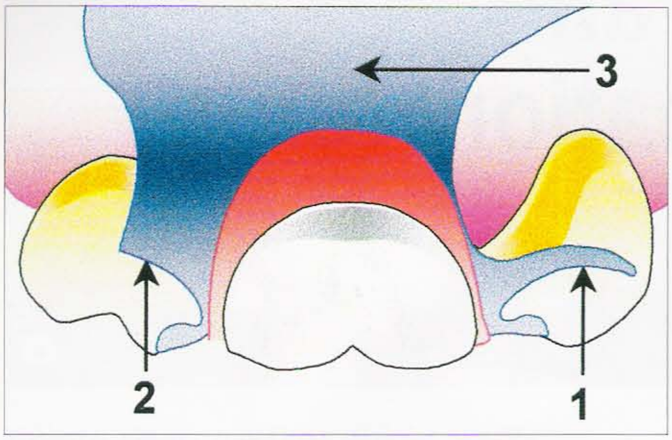



*Figure 7.3 — Bracing*
The lateral forces in particular are capable of inflicting considerable damage on the periodontal tissues and alveolar bone in the edentulous areas. Thus they have to be carefully controlled. Bracing on teeth may be achieved by means of rigid portions of clasp arms (1) or plates (2). Bracing on the ridges and in the palate is obtained by means of major connectors and flanges (3).

A distal extension saddle creates particular problems, as it is capable of being displaced posteriorly and of rotating in the horizontal plane. Furthermore, the lateral force must be distributed widely so that tissue damage is avoided. The problems are more acute in the mandibular arch.

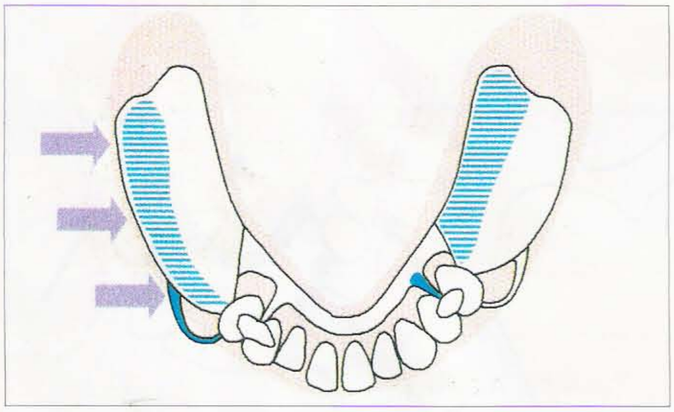


*Figure 7.4 — Bracing*
Those components of the RPD coloured blue are capable of resisting lateral forces coming from the direction indicated by the arrows. Needless to say, lateral forces in the opposite direction will be resisted by the mirror images of these components.

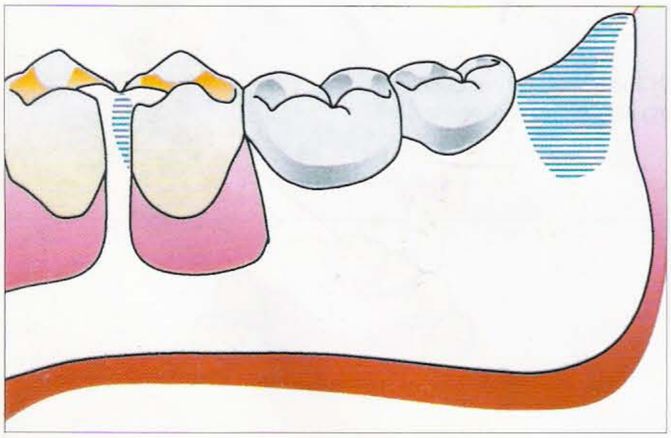


*Figure 7.5 — Bracing*
Posterior movement of the distal extension saddle is prevented by coverage of the pear-shaped pad and by the minor connector which contacts the mesiolingual surface of the premolar tooth.

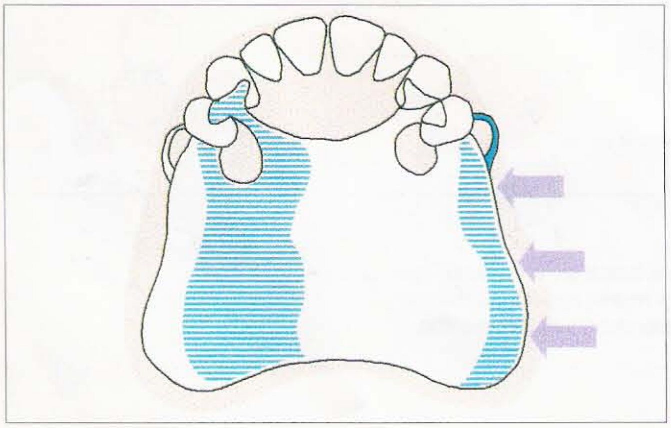


*Figure 7.6 — Bracing*
Effective distribution of the lateral force in the maxilla is less of a problem as much of it can be transmitted to the bone of the palatal vault by extensive palatal coverage. Those components of the RPD coloured blue are capable of resisting lateral forces coming from the direction indicated by the arrows.

*Figure 7.7 — Bracing*

The posterior part of the distal extension saddle is capable of rotating in the horizontal plane. If a long saddle is clasped rigidly to a single abutment tooth the rotatory movement can transmit considerable force to that tooth.

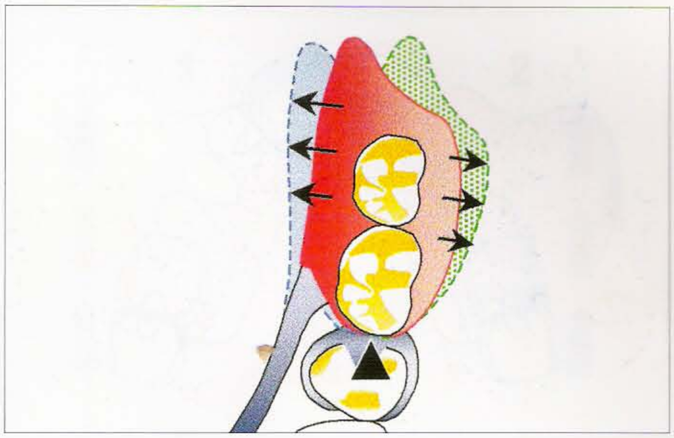


*Figure 7.8 — Bracing*

The flatter the ridge (1) or the more compressible the mucosa (2), the greater is the potential for movement. It should also be remembered that the close fit of a denture will deteriorate following resorption of the residual ridge. Once more the potential for rotatory movement is increased.

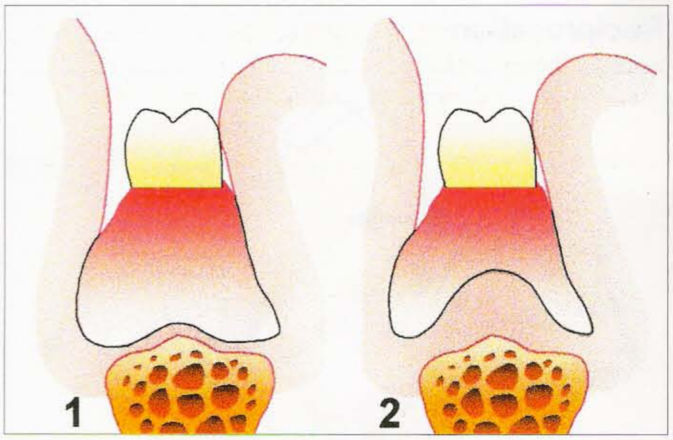



*Figure 7.9 — Bracing*

Rotation can be resisted effectively by this design that incorporates appropriately placed bracing elements and joins them with a rigid connector. Rotation of the right saddle in the direction of the blue arrow is resisted by the minor connector contacting the mesial surface of 35. Movement of the saddle in the direction of the red arrow will be resisted by the minor connector contacting the distal surface of the same tooth.

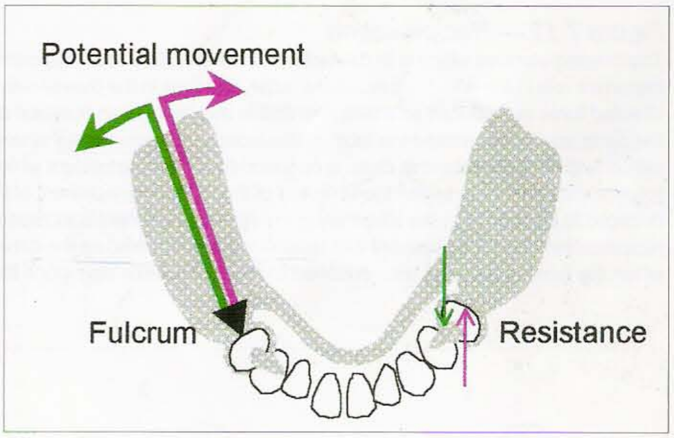
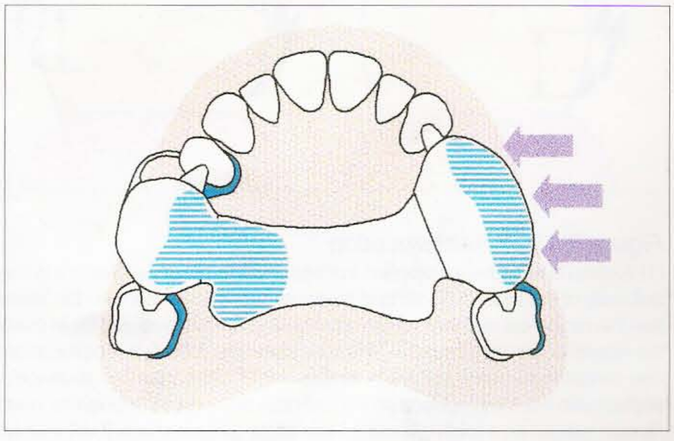



*Figure 7.10 — Bracing*

Rotation and anteroposterior movement of bounded saddles are resisted by contact of the saddles with the abutment teeth. It therefore remains to design bracing elements which will safely distribute the lateral forces acting on the denture. The bracing elements that oppose a lateral force indicated by the arrows are shown in this illustration.



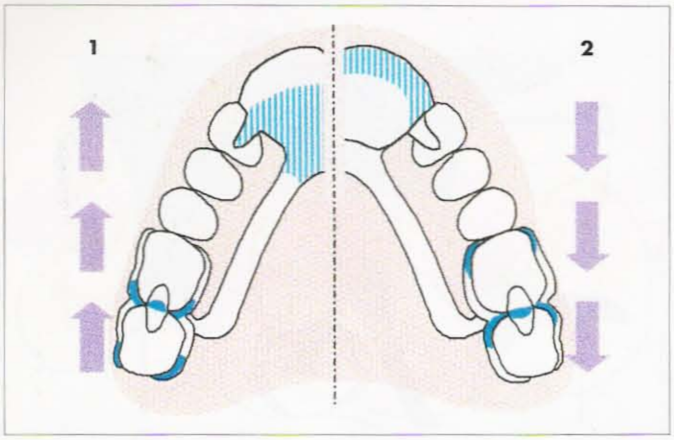



*Figure 7.11 — Bracing*

(1) Anterior displacement of a maxillary Kennedy Class IV denture can be resisted by elements of the framework contacting the disto-palatal and disto-buccal surfaces of the teeth and, in some cases, by the connector covering the anterior slope of the palate.
(2) Posterior displacement is resisted by the labial flange, by contact between the saddle and the mesial surfaces of 12 and 23, by contact of the minor connectors against the mesiopalatal surfaces of 17 and 27, and by the mesio-palatal and mesio-buccal portions of the clasp arms on 16,17, 26 and 27.

## Reciprocation

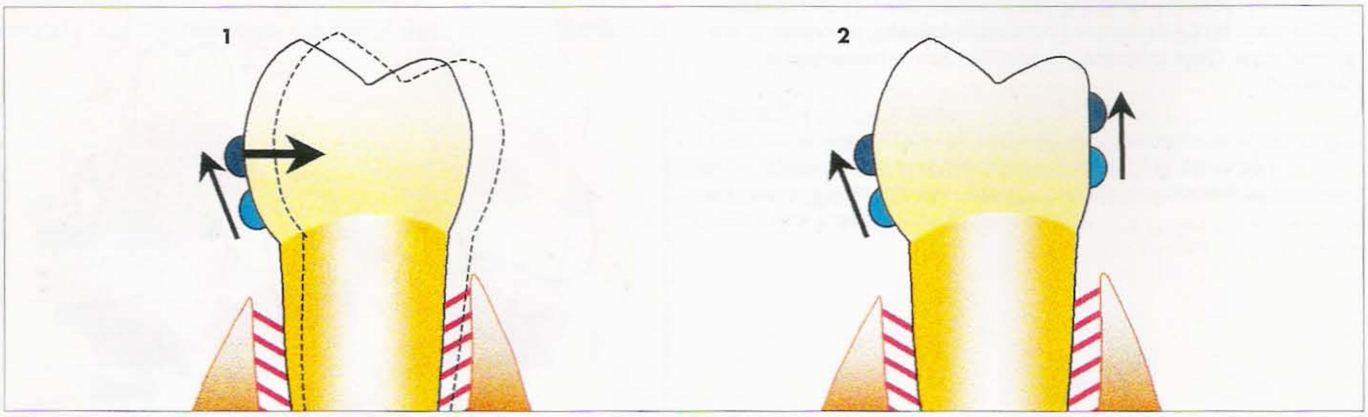



*Figure 7.12 — Reciprocation*

The bracing element which is in contact with the side of the tooth opposite the retentive clasp can also play an important role in the effectiveness of the latter, and thus in the overall retention of the denture. (1) A horizontally directed force is produced as a retentive arm is displaced in an occlusal direction over the bulbosity of a tooth. If the clasp arm is unopposed the tooth is displaced in the periodontal space and much of the retentive capability will be lost. (2) If the retentive clasp is opposed by a rigid component which maintains contact with the tooth as the retentive arm moves over the bulbosity of the tooth, displacement of the tooth is resisted, the retentive arm is forced to flex and thus the efficiency of the retentive element is increased. This principle is known as reciprocation. It is thus apparent that reciprocation is required as the denture is being displaced occlusally whilst the bracing function, as mentioned earlier, comes into play when the denture is fully seated.

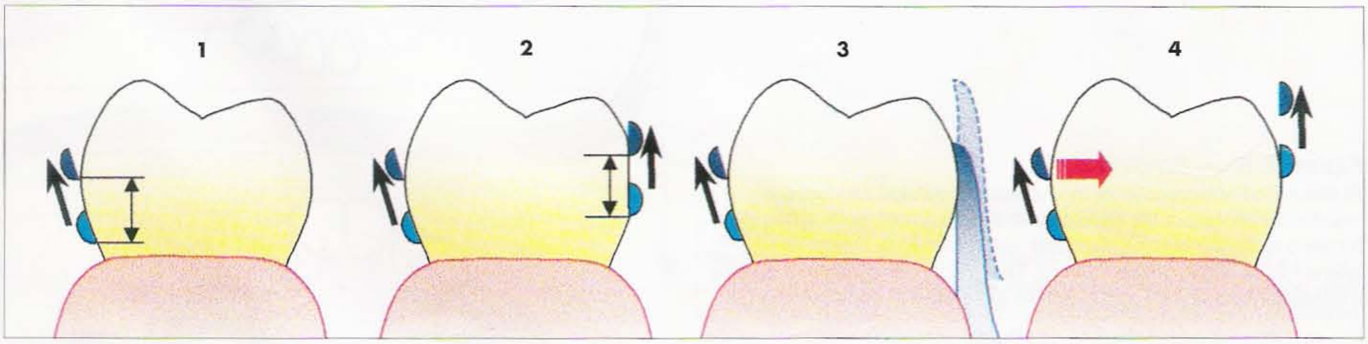



*Figure 7.13 — Reciprocation*

(1) A clasp is effective in retention from its position when the denture is fully seated to where it escapes over the bulbosity of the tooth. This vertical measurement may be termed the 'retention distance'. It will be appreciated that the reciprocal element on the other side of the tooth should be in continuous contact with the tooth surface as the retentive arm traverses the 'retention distance'. Effective reciprocation can be achieved either (2) by a clasp arm contacting a guide surface of similar height to the 'retention distance', or (3) by a plate making continuous contact with the tooth surface as the retentive arm moves through its 'retention distance'. (4) If the reciprocating clasp is placed on a tooth without an adequate guide surface, it will lose contact with the tooth before the retentive arm has passed over the maximum bulbosity of the tooth and fail to provide effective reciprocation.

*Figure 7.14 — Reciprocation*

On rare occasions it may be possible to find a guide surface which occurs naturally on a tooth. More often it will be necessary to create a suitable surface by (1) minimal shaping of the enamel or (2) building the appropriate surface into a cast metal restoration, always supposing that such an extensive restoration is justified on that particular tooth.

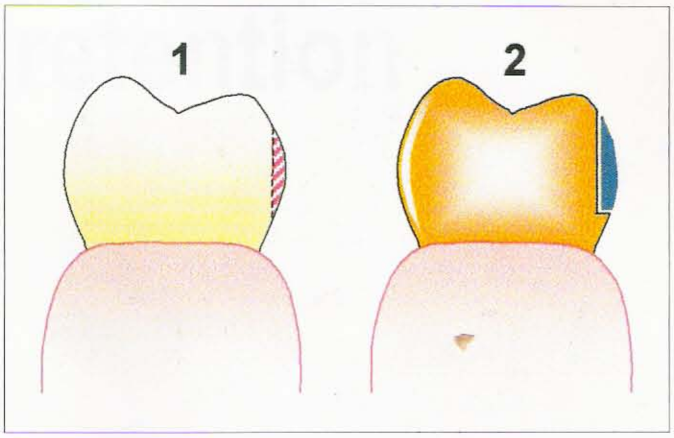
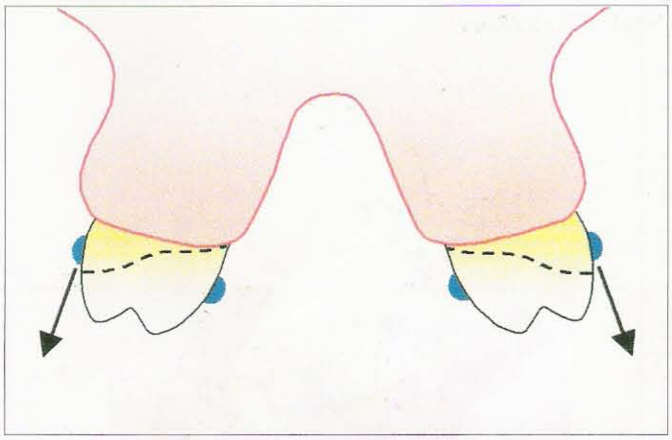



*Figure 7.15 — Reciprocation*

If the tooth surface on which the bracing arm is to be placed has a survey line at the level of the gingival margin, it will not be possible to achieve effective reciprocation on the same tooth. In such circumstances one may use the principle of cross-arch reciprocation, where a retentive clasp on one side of the arch opposes a similar component on the other side. The retentive clasps can be placed either buccal/buccal (as in the illustration) or lingual/lingual. The disadvantage of this approach is that, as the bracing arms leave the tooth surfaces, the teeth will move in their sockets. This 'jiggling' action is potentially damaging to the supporting tissues and will reduce the effectiveness of the retention.



# 8 Indirect retention

The principle of indirect retention may be explained by reference to the behaviour of a mandibular distal extension saddle in function.

*Figure 8.1 — Indirect retention*

This saddle has an occlusal rest and a clasp on the abutment tooth, and the connector is a sublingual bar. Although normally a mesial rest might well be preferred, a distal rest has been used in this example to simplify the explanation which follows. When sticky foods displace the saddle in an occlusal direction the tips of the retentive clasps engaging the undercuts on the abutment teeth provide the only mechanical resistance to the movement. The saddle thus pivots about the clasp tips.

In the maxilla this movement of the saddle away from the ridge may also be caused by gravity.

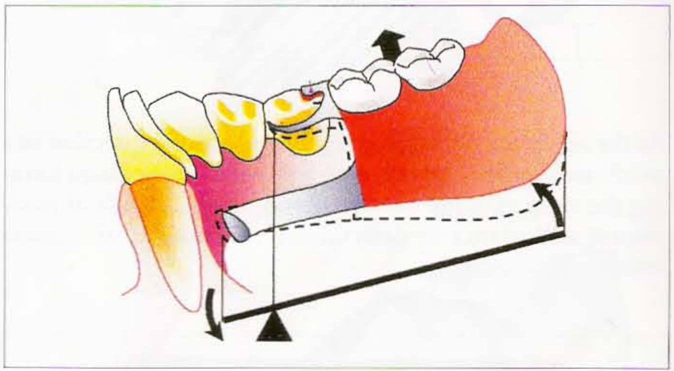


*Figure 8.2 — Indirect retention*

If the design is modified by placing a rest on an anterior tooth, this rest (indirect retainer) becomes the fulcrum of movement of the saddle in an occlusal direction causing the clasp to move up the tooth, engage the undercut and thus resist the tendency for the denture to pivot.

F = FULCRUM — indirect retainer, a component which obtains support.
R = RESISTANCE — retention generated by the clasp.
E = EFFORT — displacing force, e.g. a bolus of sticky food.

It can thus be seen that to obtain indirect retention the clasp must always be placed between the saddle and the indirect retainer.

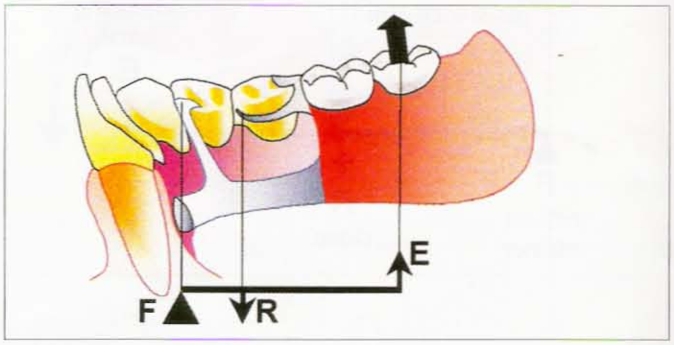
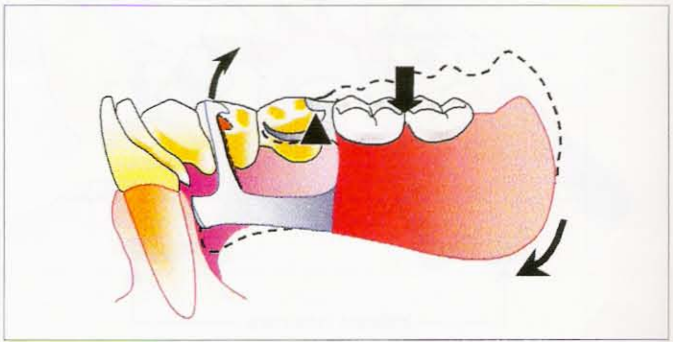



*Figure 8.3 — Indirect retention*

Indirect retainers do not prevent displacement towards the ridge. This movement is resisted by the occlusal rest on the abutment tooth and by full extension of the saddle to gain maximum support from the residual ridge. In addition, it may be necessary to compensate for the compressibility of the denture-bearing mucosa by using the altered cast impression technique (*A Clinical Guide to Removable Partial Dentures*, chapter 19).



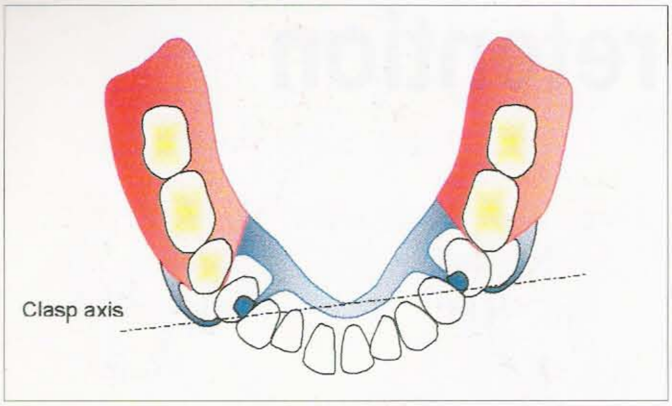



*Figure 8.4 — Indirect retention*

In order to understand the way in which indirect retainers are located it is necessary to consider the possible movement of the denture around an axis formed by the clasps. This clasp axis is defined as the line drawn between the retentive tips of a pair of clasps on opposite sides of the arch.

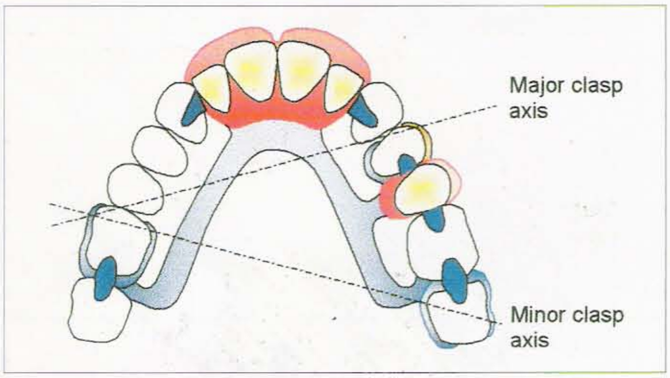


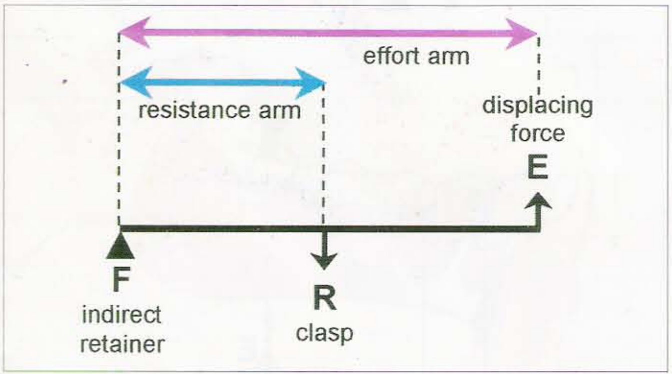

*Figure 8.5 — Indirect retention*

Where there is more than one clasp axis, as in this Kennedy Class III denture, it is the clasps on the axis closer to the saddle in question which make the major contribution to indirect retention.

As the resistance to displacement in an occlusal direction of a saddle utilizing indirect retention is provided by the clasps forming the clasp axis, the effectiveness of these clasps is of paramount importance in determining the amount of indirect retention obtained.

Other factors which influence the effectiveness of indirect retention are:

- the mechanical disadvantage of the denture design,
- the support of the indirect retainers.




## Mechanical disadvantage of the denture design

*Figure 8.6 — Mechanical disadvantage of the denture design*

The clasp is always nearer to the indirect retainer (fulcrum) than is the displacing force. The clasp is therefore working at a mechanical disadvantage relative to the displacing force.

The RPD design should strive to reduce the mechanical advantage of the displacing force by placing the clasp axis as close as possible to the saddle and by placing the indirect retainers as far as possible from the saddle.

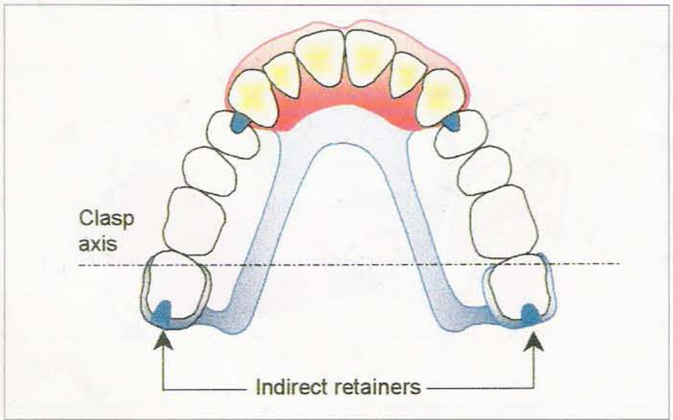
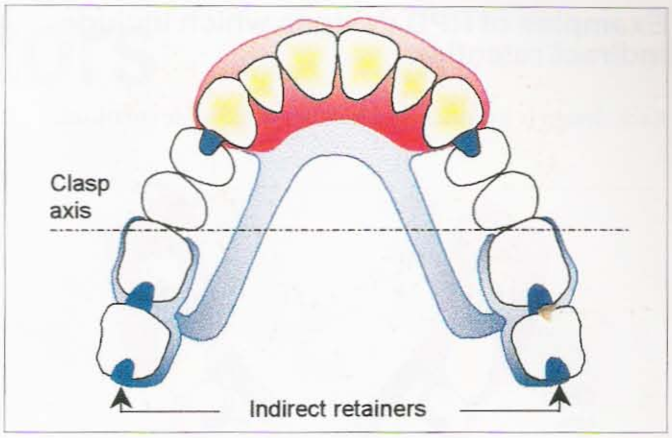



*Figure 8.7 — Mechanical disadvantage of the denture design*

In this RPD design the indirect retainers (the rests on the molar teeth) are inefficient because they are placed too close to the clasp axis.

*Figure 8.8 — Mechanical disadvantage of the denture design*

If the clasp axis is moved closer to the saddle the effectiveness of the indirect retention is improved.




## Support for the indirect retainer

*Figure 8.9 — Support for the indirect retainer*

Tooth support is preferable to mucosal support because the compressibility of mucosa allows movement of the denture to occur.

If there is no alternative to mucosal support the indirect retainer should cover a sufficiently wide area to spread the load and avoid mucosal injury. This consideration effectively limits mucosally supported indirect retainers to the maxilla where the load can be distributed over the hard palate (shaded area of the connector). However, this plan view is somewhat misleading as it suggests that the indirect retention achieved is more effective than it really is.

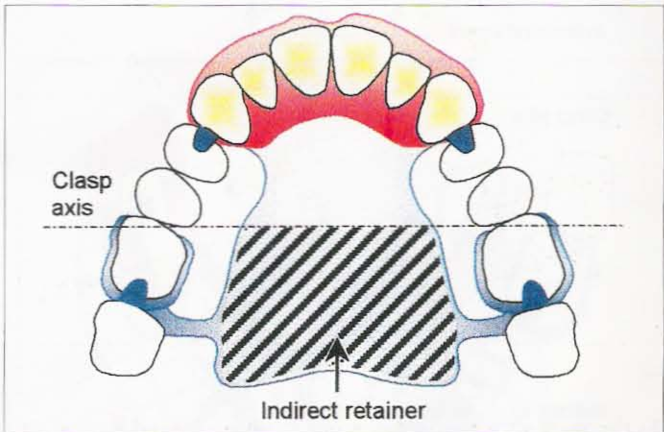



*Figure 8.10 — Support for the indirect retainer*

The side view (simplified) of a similar design shows that, when the saddle is first displaced, mucosal compression beneath the indirect retainer allows the denture to rotate around the clasp axis (fulcrum). The path of movement of the indirect retainer is thus directed obliquely, rather than at right angles, to the mucosal surface. This combination of oblique approach and mucosal compression may allow a significant degree of movement of the denture in function.

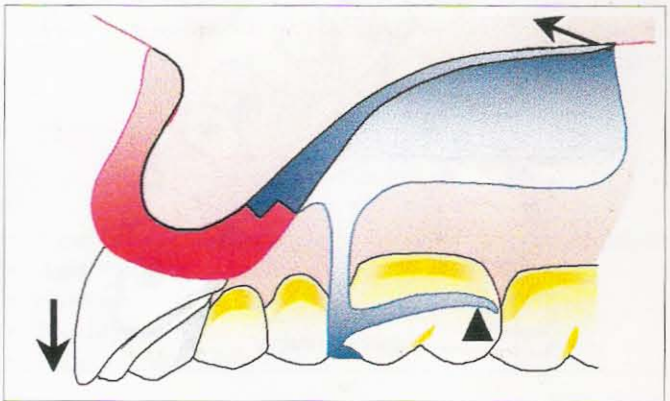
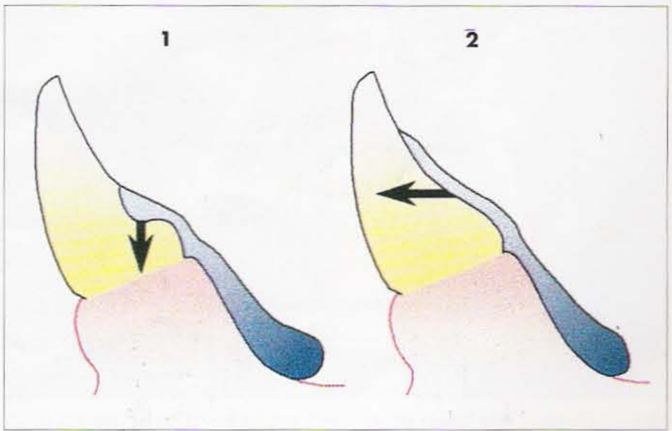


*Figure 8.11 — Support for the indirect retainer*

(1) When possible, the indirect retainer should rest on a surface at right angles to its potential path of movement. (2) If it rests on an inclined tooth surface, movement of the tooth might occur with resulting loss of support for the indirect retainer.



## Examples of RPD designs which include indirect retention

Each design is only one of a number of possible solutions.

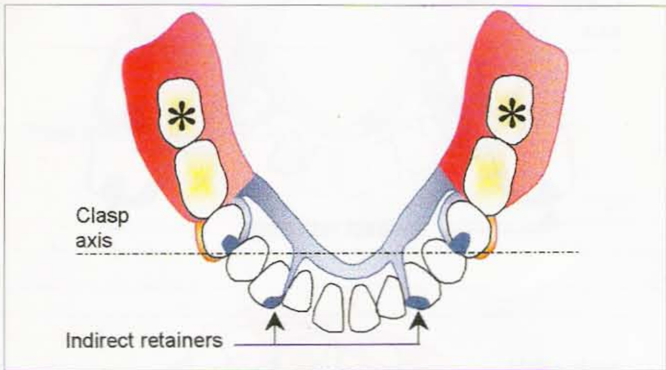



*Figure 8.12 — RPD Designs which include indirect retention*

Kennedy I Indirect retention in this design is provided by incisal rests on 43 and 33.

In this example and in 8.13 to 8.15 the part of the saddle susceptible to displacement in an occlusal direction is indicated by an asterisk.

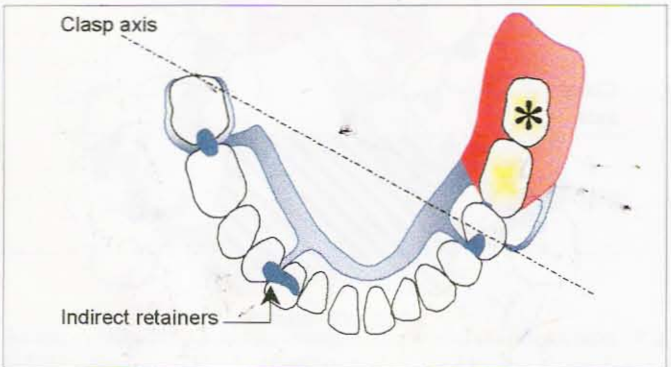



*Figure 8.13 — RPD designs which include indirect retention*

Kennedy II Indirect retention in this instance is provided primarily by rests on 44 and 43 as they are furthest from the clasp axis. The rests on 35, 46 and 47 are close to the clasp axis and therefore contribute little to the indirect retention.

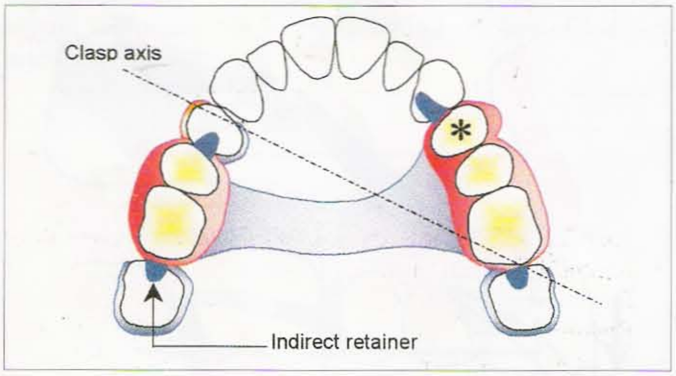



*Figure 8.14 — RPD designs which include indirect retention*

Kennedy III In the case of a bounded saddle there is the potential for direct retention from both abutments. When this can be achieved, as for the saddle replacing 16 and 15, indirect retention is not required. However, it is not uncommon for only one of the abutments to be suitable for clasping. In this design a clasp on 23 has been omitted for aesthetic reasons. Under such circumstances indirect retention can be employed, the major contribution being made by the rest on 17.

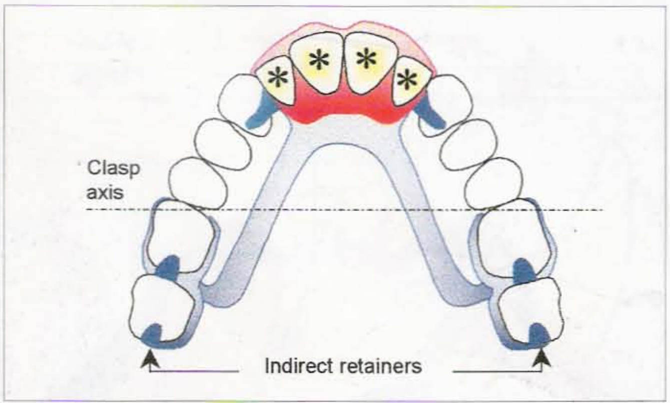



*Figure 8.15 — RPD designs which include indirect retention*

Kennedy IV In a maxillary denture it is sometimes difficult to achieve much separation of the clasp axis and indirect retainers. In this example, clasps engage the mesiobuccal undercuts on 16 and 26 and indirect retention has been achieved by placing the rests on 17 and 27 as far posteriorly as possible.

An additional function of indirect retainers is to allow accurate location of the RPD framework against the teeth when undertaking the altered cast procedure (*A Clinical Guide to Removable Partial Dentures*, chapter 19), or when obtaining a wash impression to rebase a distal extension saddle.

# 9 Connectors

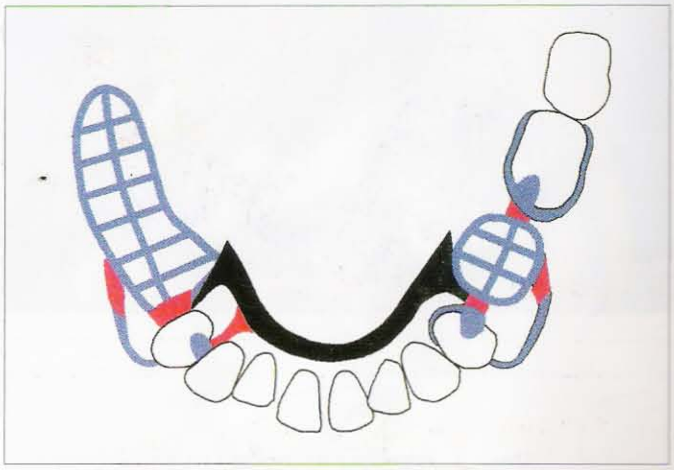


*Figure 9.1 — Connectors*

Connectors can be classified as either minor or major. The minor connectors (coloured red) join the small components, such as rests and clasps, to the saddles or to the major connector. In addition, they may contribute to the functions of bracing and reciprocation as in the RPI system (Figure 6.26). The positioning of the minor connectors joining rests to a saddle will vary according to whether an 'open' or 'closed' design is to be used (Figure 4.9). The number of minor connectors should be kept to a minimum to conform to the key design principle of simplicity.

The major connector (coloured black) links the saddles and thus unifies the structure of the denture. The remainder of this chapter is devoted to the major connector. The major connector may fulfil a variety of functions. In addition to its basic connecting role it contributes to the support and bracing of a denture by distributing functional loads widely to the teeth and, in appropriate maxillary cases, to the mucosa. It can help to retain the denture by providing indirect retention, by contacting guide surfaces and, in the upper jaw, by coverage of palatal mucosa.

## Designs of connector for the upper jaw

The choice of the shape and location of connectors is greater in the upper jaw because of the area available for coverage offered by the hard palate.

A decision on choice of connector type is based upon the requirements of:

- Function (e.g. connection of components, support, retention).
- Anatomical constraints.
- Hygiene.
- Rigidity.
- Patient acceptability.

### *Palatal Plate*

*Figure 9.2 — Palatal plate*

The basic functional requirement of a major connector is to link the various saddles and other RPD components. In this tooth-supported RPD a simple mid-palatal plate has been used. This is a very satisfactory connector for such situations as it:

- Leaves all gingival margins uncovered.
- Can be made rigid.
- Has a simple outline.
- Is well tolerated as it does not encroach unduly on the highly innervated mucosa of the anterior palate.

*Figure 9.3 — Palatal plate*

In contrast, the greater extent of the saddles in this tooth–mucosa supported RPD presents more of a support problem. The functional forces can be shared between teeth and mucosa by utilizing a larger connector that extends posteriorly to the junction of hard and soft palates. It is still possible to leave the gingival margins of the majority of teeth uncovered.

*Figure 9.4 — Palatal plate*

Where two or more teeth separate adjacent saddles it is possible to keep the border of the connector well away from the vulnerable gingival margins. Where only a single tooth intervenes between two saddles (e.g. 14) it may not be possible to uncover the gingival margin widely enough to avoid problems of gingival irritation and patient tolerance. However, any opportunity to uncover the gingival margin around even a single tooth should normally be grasped (Statement 15.10)

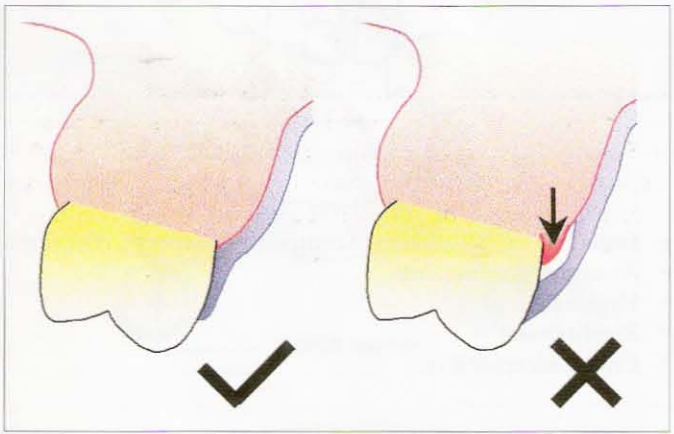


*Figure 9.5 — Palatal plate*

If coverage of the gingival margin by the connector is unavoidable, close contact between the connector and gingival margin should be achieved whenever possible. If 'gingival relief' is created, the space is soon obliterated by proliferation of the gingival tissue; this change in shape increases the depth of the periodontal pocket and thus makes plaque control more difficult.

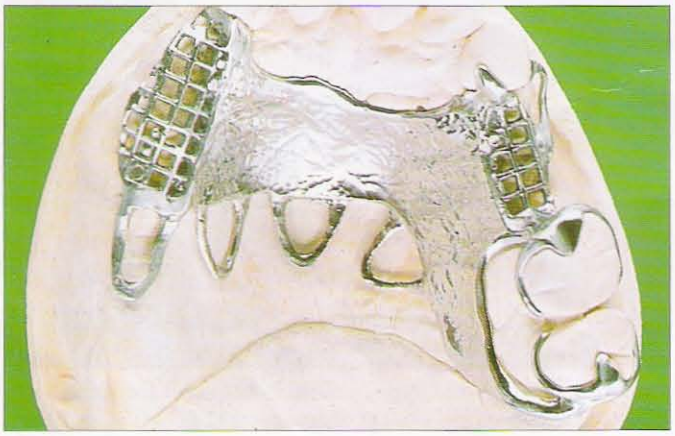


*Figure 9.6 — Palatal plate*

Full palatal coverage with cobalt chromium has two disadvantages. First, the weight of a large metal connector can contribute to displacement of the prosthesis. Second, the position of the post-dam cannot be altered should it prove to be poorly tolerated by the patient. An alternative approach which may possibly be used to overcome these problems is illustrated. The posterior part of the casting has a retaining mesh to which an acrylic extension will be attached.

### *Ring connector*

*Figure 9.7 — Ring connector*

A ring connector, outlined here on a cast, may be used in cases where there are multiple saddles widely distributed around the arch, and where tooth support can be obtained. This connector may also be indicated where a prominent palatal torus would contraindicate a mid-palatal plate.

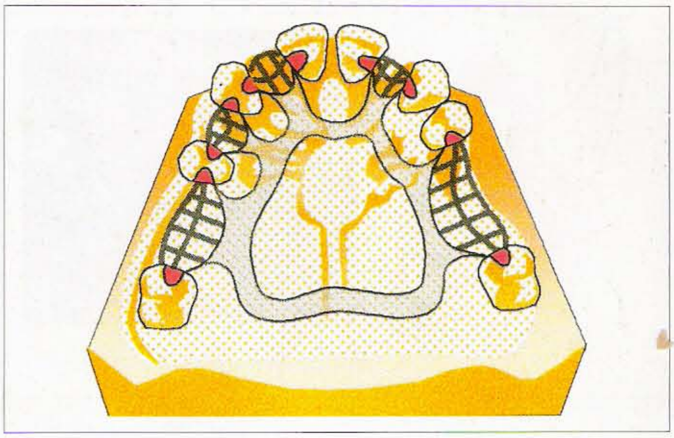
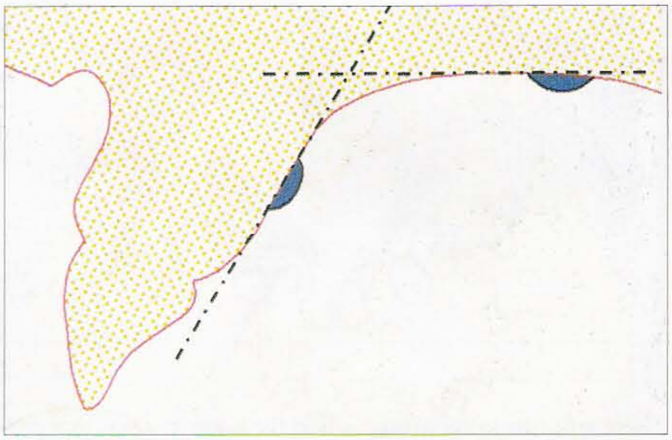


*Figure 9.8 — Ring connector*

The ring connector exhibits good rigidity for a relatively low bulk of metal. This is because the anterior and posterior bars can be positioned in different planes so that an 'L'-shaped girder effect is created.

Although this connector leaves a large area of the palate uncovered, it does have the potential disadvantage that the anterior bar crosses mucosa that is richly innervated and is contacted frequently by the tongue during swallowing and speech. The anterior bar may interfere with these functions and be poorly tolerated as a result. If this design is selected the anterior bar must be carefully positioned and shaped to blend with the contours of the palatal rugae.



## Designs of connector for the lower jaw

The main anatomical constraint for connector design in the lower jaw is the relatively small distance between the lingual gingival margin and the functional depth of the floor of the mouth. In terms of functional requirements the mandibular connector does not contribute to support by distributing loads directly to the mucosa. It connects the RPD components and can provide indirect retention and guide surfaces.

With gingival recession there is even less room to manoeuvre and it may be difficult to design a connector that satisfies two of the main requirements: maintenance of oral hygiene and rigidity.

Five of the common connectors are illustrated diagrammatically and clinically.

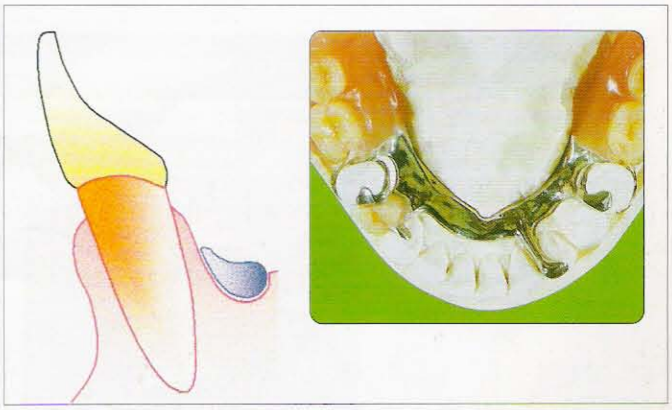
### *Sublingual bar*

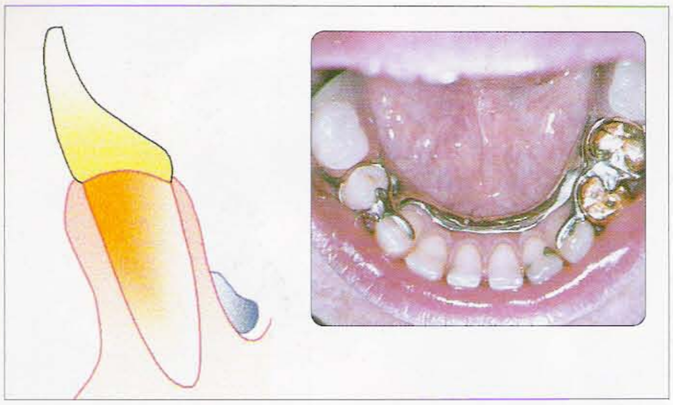
*Figure 9.9 — Sublingual bar*

The sublingual bar differs from the lingual bar (see below) in that its dimensions are determined by a specialized master impression technique that accurately records the functional depth and width of the lingual sulcus (*A Clinical Guide to Removable Partial Dentures*, Figures 16.23–16.25). These sulcus dimensions are retained on the master cast so that the technician waxes up the connector to fill the available sulcus width at its maximum functional depth. This results in a bar whose maximum cross-sectional dimension is oriented horizontally.

The rigidity of a lingual bar increases by a square factor when its height is increased and by a cube factor when its width is increased. The increased width of the sublingual bar connector therefore ensures that the important requirement of rigidity is satisfied. This is not invariably the case with a conventional lingual bar.

As the vertical height of a sublingual bar is less than a lingual bar it can be used in shallower lingual sulci and be kept further away from the gingival margins.





### *Lingual bar*

*Figure 9.10 — Lingual bar*

The lingual bar, like the sublingual bar, should be placed as low as the functional depth of the lingual sulcus will allow. The cross-section of the lingual bar is determined by the shape of a prefabricated wax pattern, either prescribed by the dentist or selected by the dental technician. The maximum cross-sectional dimension of this connector is oriented vertically.

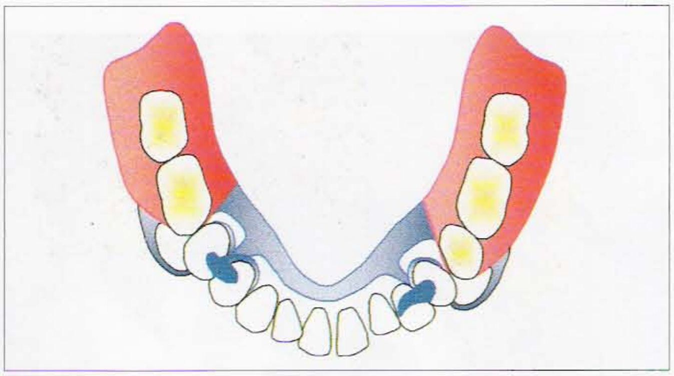
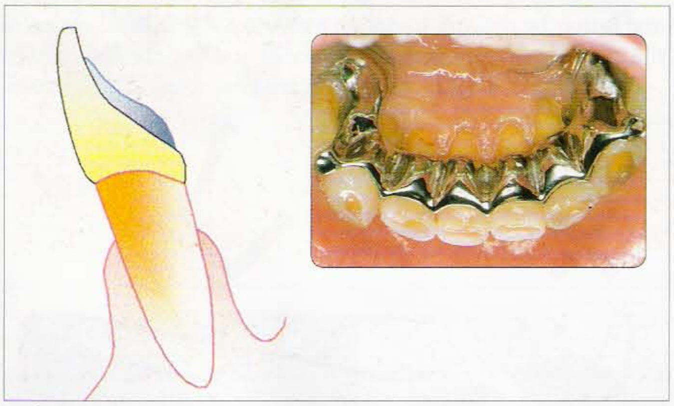


*Figure 9.11 — Lingual bar*

If either a lingual or sublingual bar is to be used and additional bracing and indirect retention are required, bracing arms and rests can be incorporated in the design.

There are anatomical constraints in the lower jaw that may prevent the use of sublingual or lingual bars. Mention has already been made of lack of space between the gingival margin and the floor of the mouth. A prominent lingual fraenum may compound the problem and make it impossible to use either of these connectors. A mandibular torus may be of such a size that a sublingual or lingual bar, sitting on top of the bony protuberance, would be excessively prominent, creating major difficulties for the patient in tolerating the prosthesis.



### *Dental bar*

*Figure 9.12 — Dental bar*

On occasions, there is insufficient room between gingival margin and floor of the mouth for either a sublingual or lingual bar. A lingual plate should be avoided wherever possible because it might well tip the delicate balance between health and disease in favour of the latter. An alternative connector, where the clinical crowns are long enough, is the dental bar. Patient tolerance inevitably places some restriction on the cross-sectional area of this connector and thus some reduction in rigidity may have to be accepted.

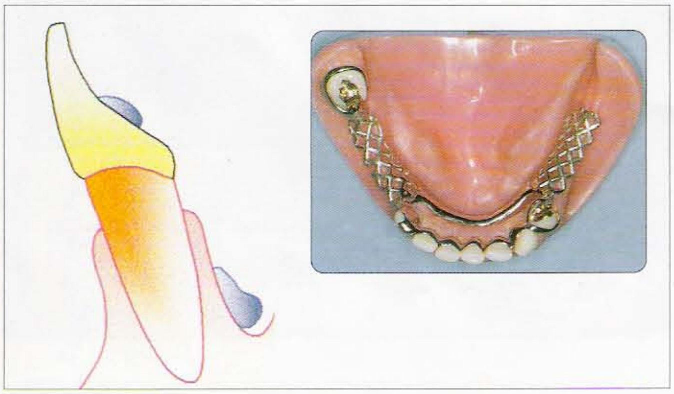
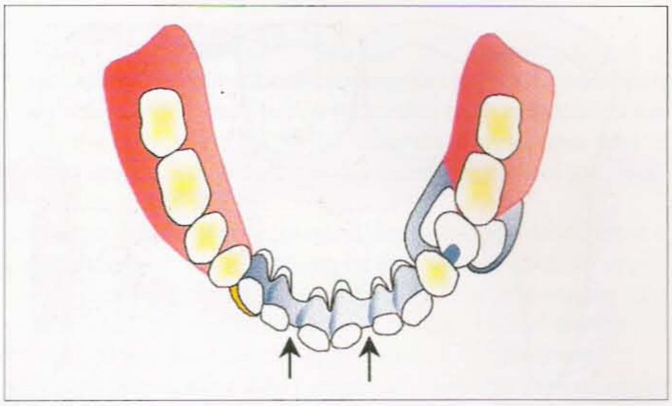


*Figure 9.13 — Dental bar*

Another connector (sometimes referred to as a 'Kennedy Bar' or continuous clasp) consists of a dental bar, combined with a lingual bar. This combination allows the dimensions of each component to be reduced to a limited extent without compromising the overall rigidity of the connector. However, this is a relatively complex design and is best avoided if any of the simpler alternatives are feasible. Tolerance of the patient must be assessed carefully before prescribing either a dental bar or a lingual bar and continuous clasp.

*Figure 9.14 — Dental bar*

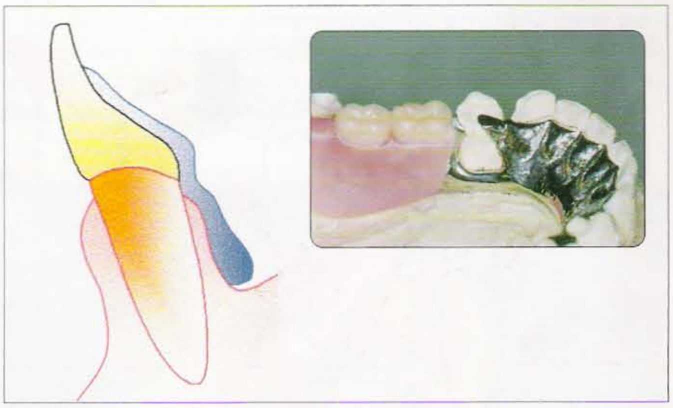
Spaces between the incisors are likely to preclude the use of the dental bar or continuous clasp on aesthetic grounds as the metal will show through the gaps (arrows). A sublingual or lingual bar would avoid this problem, although a lingual plate with its superior border notched where it passes behind the spaces is an alternative solution. If the space is small, composite may be added to the adjacent teeth to close it and allow a dental bar to be used.



### *Lingual plate*

*Figure 9.15 — Lingual plate*

The lingual plate covers most of the lingual aspects of the teeth, the gingival margins and the lingual aspect of the ridge. The plate terminates inferiorly at the functional depth of the sulcus. Rigidity is achieved by thickening the lower border to a bar-like section. One of the major drawbacks of the lingual plate is its tendency to encourage plaque formation. Plaque control should therefore be impeccable before a lingual plate can be prescribed with any confidence.



### *Labial (or buccal) bar*

*Figure 9.16 — Labial (or buccal) bar*

Mention has already been made of lingually inclined teeth creating an obstruction to the insertion of an RPD, and how a change in path of insertion can sometimes avoid this obstruction (Figures 3.23 and 3.24). However, on rare occasions the lingual tilt is so severe that it is impossible to use any of the lingual connectors. Under such circumstances a labial (or buccal) bar can be used. The cross-sectional area of the bar is severely restricted by the limited space available and also by patient tolerance.

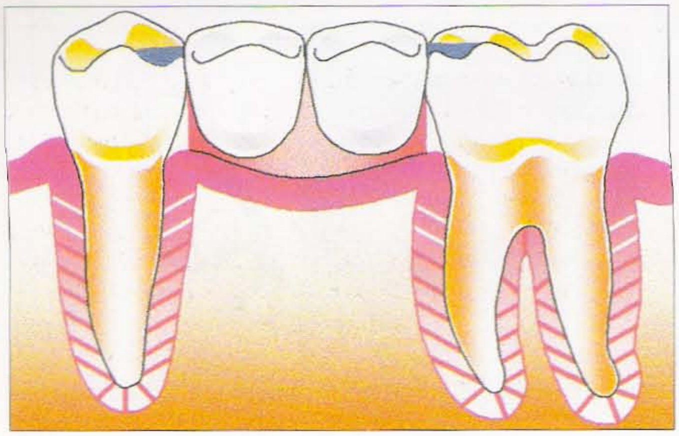
The combination of limited space for the bar and its increased length as it travels around the outer circumference of the dental arch makes it difficult to achieve rigidity although, in this example, the short spans minimize this problem.

A summary of the functions and essential qualities of the mandibular connectors is presented in Table 9.1;

√ present.
? uncertain.
× absent.

**Table 9.1 Summary of functions and essential qualities of connectors**

| Connector | Connect | Bracing | Indirect retention | Rigidity | Hygiene | Tolerance |
|---|---|---|---|---|---|---|
| Sublingual bar | ✓ | ✗ | ✗ | ✓✓ | ✓ | ✓ |
| Lingual bar | ✓ | ✗ | ✗ | ? | ✓ | ✓ |
| Dental bar | ✓ | ✓ | ✓ | ? | ✓ | ? |
| Lingual plate | ✓ | ✓ | ✓ | ✓ | ✗ | ✓ |
| Labial bar | ✓ | ✗ | ✗ | ? | ✓ | ? |



## *Non-rigid (stress breaking) connectors*

*Figure 9.17 — Non-rigid (stress-breaking) connectors*

During loading, a component resting on a tooth will be displaced very much less than one which rests on mucosa. If a denture is entirely tooth-supported, the displacement differential between teeth and mucosa is immaterial. The connector should be designed so that it is rigid and thus distributes the functional forces throughout the structure of the denture and thence to the supporting tissues.

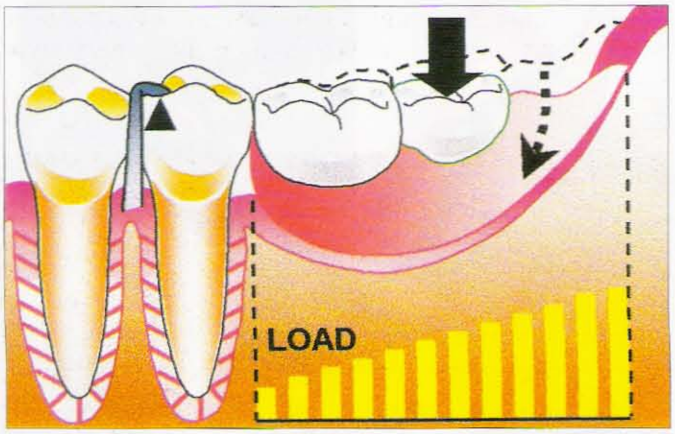



*Figure 9.18 — Non-rigid (stress-breaking) connectors*

A distal extension saddle gains some of its support from teeth and some from the tissues of the edentulous area. This support differential can result in tipping of the denture when it is loaded during function, causing an uneven distribution of load over the edentulous area. It will also result in a relatively greater share of the load being taken by the tooth. One way of minimising the problem is to refine the impression surface of the saddle by using the altered cast impression technique (*A Clinical Guide to Removable Partial Dentures*, chapter 19).

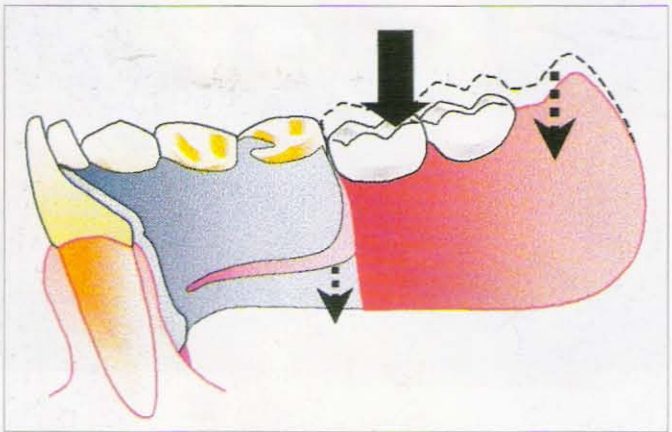


*Figure 9.19 — Non-rigid (stress-breaking) connectors.*

An alternative approach is to create a design with 'independent rear suspension' by using a flexible connector such as this split lingual plate. If the saddle component is able to move more than the tooth-supported component, a greater proportion of the load will be transmitted to the tissues of the edentulous area and will be more evenly distributed. This is the principle on which the stress-broken denture is based and it has been suggested that perhaps it has its greatest application in the lower jaw. However, research evidence suggests that this desired result is not reliably achieved in practice.

Inevitably, the stress-broken design is a more complex construction and thus more costly. It may also pose greater demands on plaque control and be less well tolerated by the patient. The use of a rigid connector may make it easier to design a simple shape. For these reasons it is our preference to design distal extension saddle RPDs that incorporate the following:

- A rigid connector.
- Control of the load distribution to the various tissues by:
  - reducing the area of the artificial occlusal table,
  - maximising coverage of the edentulous area,
  - employing the altered cast technique,
  - utilising one of the more flexible clasp systems,
  - instituting a regular maintenance programme.

## Acrylic dentures

Although this book is primarily concerned with the design and construction of dentures with cast metal frameworks, there are occasions when it is appropriate to provide dentures made entirely in acrylic resin.

The main advantages of acrylic dentures are their relatively low cost and the ease with which they can be modified. They are therefore most commonly indicated where the life of the denture is expected to be short or where alterations such as additions or relines will be needed. Both these reasons may make the expense of a metal denture difficult to justify.

Indications for such treatment include the following:

1. When a denture is required during the phase of rapid bone resorption following tooth loss, for example an immediate denture replacing anterior teeth. In this case a reline followed by early replacement of the denture is to be expected.
2. When the remaining teeth have a poor prognosis and their extraction and subsequent addition to the denture is anticipated. A transitional denture may be fitted under such circumstances so that the few remaining teeth can stabilize the prosthesis for a limited period while the patient develops the neuromuscular skills necessary to sucessfully control a replacement complete denture.
3. When a diagnostic (or interim) denture is required before a definitive treatment plan can be formulated. Such an appliance may be required, for example, to determine whether the patient can tolerate an increase in occlusal vertical dimension required to allow effective restoration of the dentition.
4. When a denture must be provided for a young patient where growth of the jaws and development of the dentition are still proceeding.

In addition, acrylic dentures may also provide a more permanent solution; for example, where only a few isolated teeth remain an acrylic connector may function just as effectively as one in metal.

*Figure 9.20 — Acrylic dentures*

Where an acrylic denture is provided as a long-term prosthesis it is particularly important that its potential for tissue damage is minimized by careful design. This is easier to achieve in the upper jaw where the palate allows extensive mucosal coverage for support and retention without the denture necessarily having to cover the gingival margins. A popular form of design for the replacement of one or two anterior teeth in young people is the 'spoon' denture. It reduces gingival margin coverage to a minimum, but a potential hazard is the risk of inhalation or ingestion.

*Figure 9.21 — Acrylic dentures*

A more stable and therefore more widely applicable design is the modified spoon denture. Here one has the choice of relying on frictional contact between the connector and the palatal surfaces of some of the posterior teeth, or of adding wrought wire clasps.

*Figure 9.22 — Acrylic dentures.*

Another acceptable design is the 'Every' denture which can be used for restoring multiple bounded edentulous areas in the maxillary jaw. Its characteristics are as follows:

- All connector borders are at least 3 mm from the gingival margins.
- The 'open' design of saddle/tooth junction is employed.
- Point contacts between the artificial teeth and abutment teeth are established to reduce lateral stress to a minimum.
- Posterior wire 'stops' are included to prevent distal drift of the posterior teeth with consequent opening of the contact points. These 'stops' can also contribute to the retention of the RPD posteriorly.
- Flanges are included to assist the bracing of the denture.
- Lateral stresses are reduced by achieving as much balanced occlusion and articulation as possible, or by relying on guidance from the remaining natural teeth to disclude the denture teeth on excursion.

When considering whether or not to provide an RPD in acrylic resin, the limitations of the material should be borne in mind. This material is weaker and less rigid than the metal alloys and therefore the denture is more likely to flex or fracture during function. To minimize these problems the acrylic connector has to be relatively bulky. This, in turn, can cause problems with tolerance and offers less scope for a design that allows the gingival margins to be left uncovered.

Another significant disadvantage of acrylic resin is that it is radiolucent so that location of the prosthesis can prove difficult if the denture is swallowed or inhaled.

Acrylic RPDs in the mandible often lack tooth-support making tissue damage highly probable. Such RPDs should therefore be avoided whenever possible.

# 10 A system of design

It will already be appreciated that an RPD is the sum of a number of components. In this final chapter of Part 1 we describe a method of building these components into a design and emphasize the importance of clearly detailing the design to the dental technician.

It must of course be remembered that the design sequence is but one stage of the overall treatment plan for a partially edentulous patient and is undertaken after completing the all-important stages of surveying the cast and selecting a path of insertion.

The following two examples illustrate how to apply the basic principles of design using the following sequence:

1. Saddles.
2. Support.
3. Retention.
4. Bracing and reciprocation.
5. Connector.
6. Indirect retention.
7. Review of completed design.

To help with identification, the various RPD components are illustrated in different colours.

## Example 1

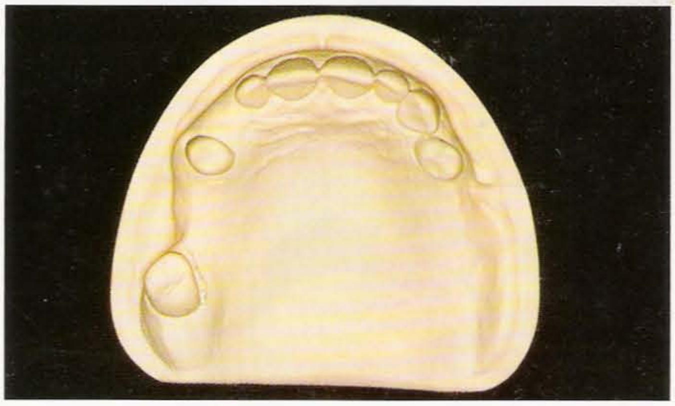


*Figure 10.1 — Example 1*

This maxillary arch has two bounded edentulous areas on the right side and a distal extension edentulous area on the left. The teeth have small crowns. Tooth 24 is rotated disto-buccally.

### *Saddles (yellow) and support (red)*

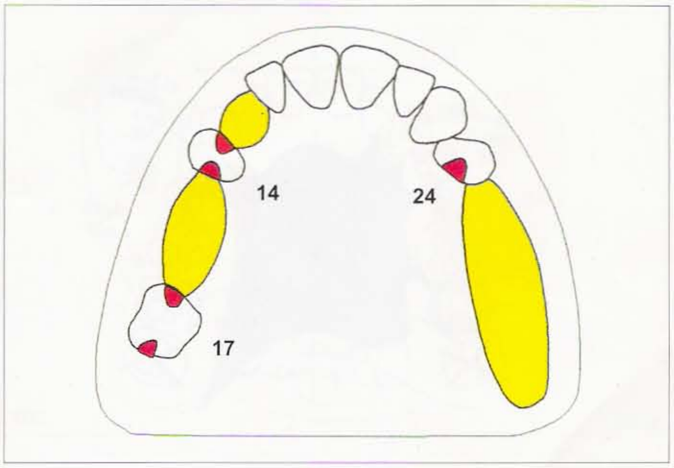
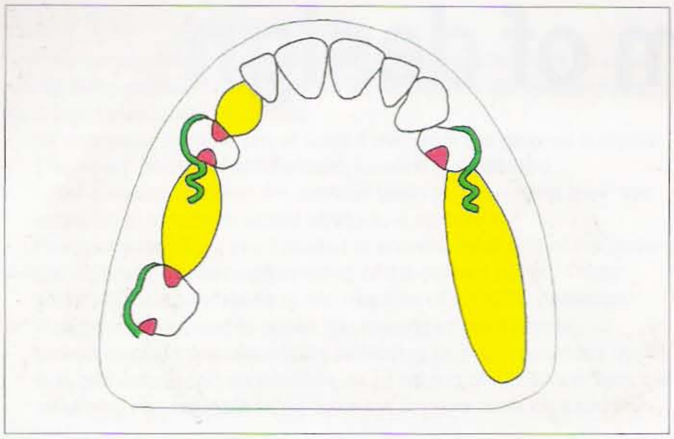



*Figure 10.2 — Saddles and support*

There is no requirement for a labial flange at 13. It has been decided to use a 'closed' design for all three saddles as the short clinical crowns offer limited prospects for clasp retention. The saddle must be fully extended in the distal extension edentulous area. Spaced meshwork will be requested for the two posterior saddles to enable them to be relined when required.

Tooth support is to be gained on 17, 14 and 24. Because 24 is rotated, a mesial rest would be very visible and unsightly. The occlusal rest is therefore placed on the distal aspect of the tooth. This conflicts with advice given elsewhere in this book to support a distal extension saddle with a mesial rest. However, as the load from a maxillary RPD can be distributed widely over the hard palate the problems associated with differential support are not so marked here as they are in the mandible. Rest seat preparation is planned for the three teeth. As it is not possible to make this denture totally tooth-supported, additional support must be gained from palatal coverage.

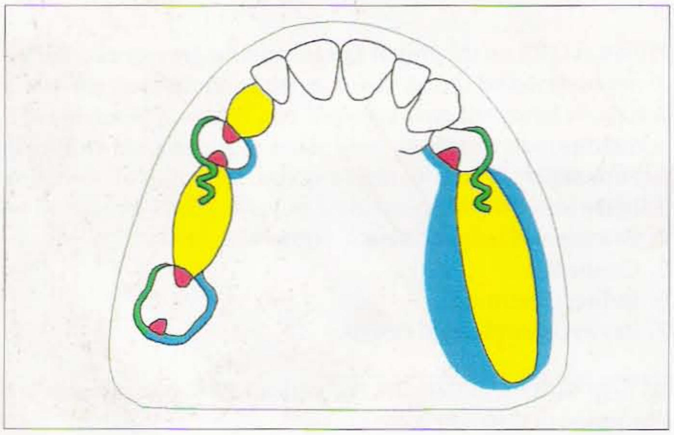


### *Retention (green)*

*Figure 10.3 — Retention*

It is practicable to obtain clasp retention from only three teeth (17, 14 and 24). Thus supplementary retention must be obtained by wide palatal coverage, full extension of the denture base into the left buccal sulcus and around the left tuberosity, and by contact with the guide surfaces which will be prepared on the abutment teeth.

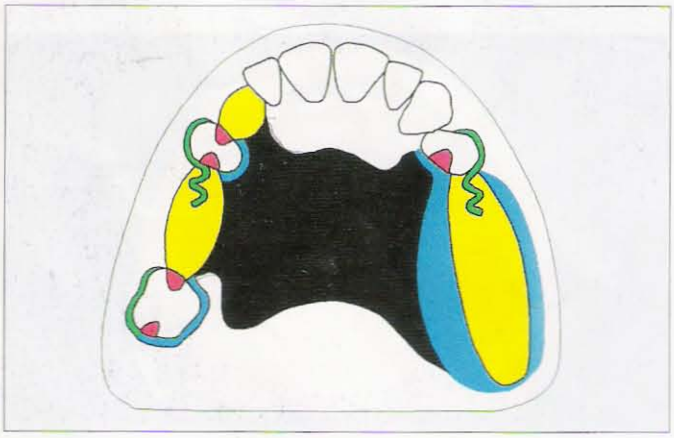
As most of the undercut on 17 is situated on its mesiobuccal aspect, a 'ring' clasp is a suitable design. It is not possible to use a gingivally approaching clasp on 14 because of a bony undercut in the buccal sulcus. As an occlusally approaching clasp is the only reasonable alternative, wrought gold wire has been chosen because it possesses sufficient flexibility for the short clasp arm to function efficiently. As a prominent fraenum precludes a gingivally approaching clasp on 24, a wrought gold occlusally approaching clasp is to be used here also.



### *Bracing and reciprocation (blue)*

*Figure 10.4 — Bracing and reciprocation*

It has been decided to obtain bracing from the rigid palatal arm of the 'ring' clasp on 17, by contacting the palatal aspects of 14 and 24 with the connector and by full extension of the distal extension saddle. In this instance the bracing components on the teeth will also provide reciprocation to the retentive arms on the premolars. Retention will also be assisted by the buccal placement of all retentive arms, thus providing cross-arch reciprocation.

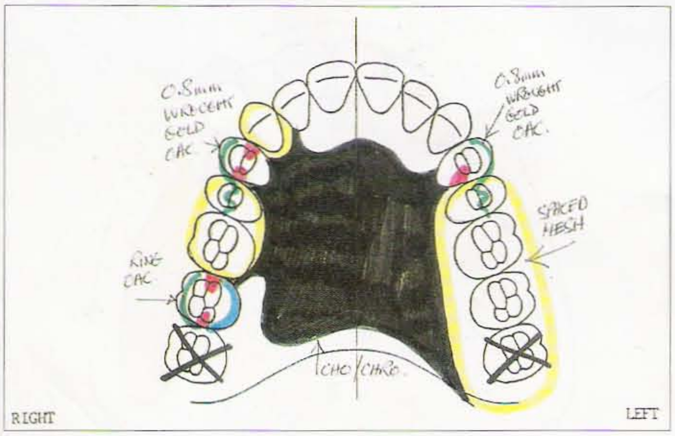


### *Connector (black) and indirect retention*

*Figure10.5 — Connector and indirect retention*

For the reasons given already, wide palatal coverage by the connector is needed. However, it is possible to keep the anterior border of the palatal plate away from the anterior teeth and from the sensitive area around the incisive papilla to promote hygiene and tolerance to the framework.

It is necessary to plan for indirect retention to prevent the distal extension saddle from moving occlusally. The major clasp axis is sited through 17 and 24. The mesial occlusal rest on 14 will be the indirect retainer to resist the displacing force.




### *Design prescription*

*Figure10.6 — Design prescription*

A provisional RPD design, produced at the initial treatment planning stage, should be drawn on a proforma to provide easy reference while any other restorative treatment is being carried out. Once this treatment has been completed the provisional design should be reviewed and updated in the light of any changes in the treatment plan that proved to be necessary.

Having completed the design it is important to review the result and to check that the design satisfies the four principles that have been shown to promote continued oral health (*A Clinical Guide to Removable Partial Dentures*, chapter 2):

- Effective support.
- Clearance of gingival margins.
- Simplicity.
- Rigid connector.

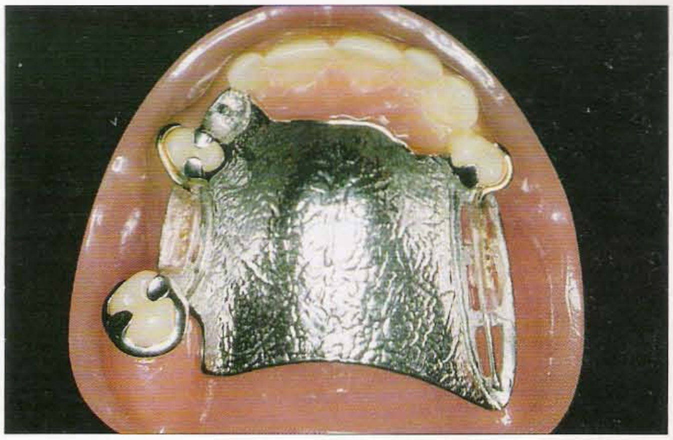
*Figure 10.7 — Design prescription*

The confirmed design should also be drawn on the surveyed master cast. The use of a different coloured lead to that used in the survey will improve clarity.

The resulting definitive RPD design prescription is given to the dental technician with the final impression. The prescription must include details of the materials to be used. In this case the dental technician will be asked to construct a cobalt chromium casting with the retentive clasps on 14 and 24 being made from 0.8 mm wrought gold wire.

*Figure 10.8 — The completed framework*

Careful planning and clear prescription result in the required metal framework.



## Example 2

*Figure 10.9 — Example 2*

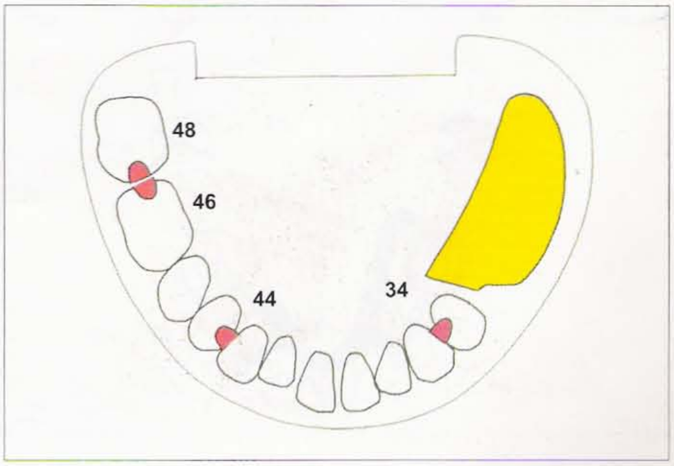
This mandibular arch has a unilateral distal extension edentulous area. A gap exists between 46 and the mesially tilted 48.

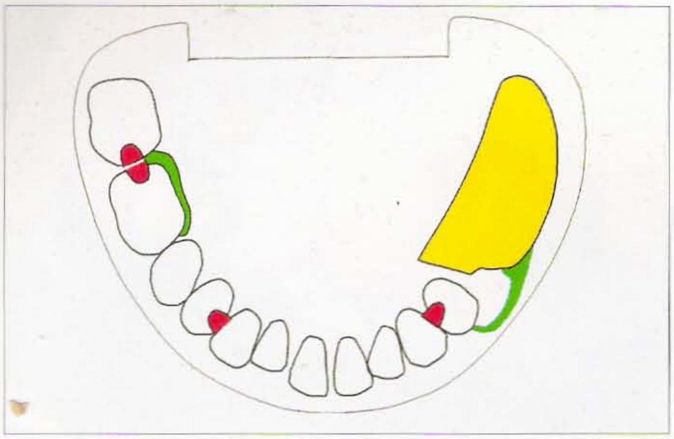
***Saddles (yellow) and support (red)***

*Figure 10.10 — Saddles and support*

A spaced retaining meshwork will be required to enable the saddle to be relined following alveolar resorption. A narrow occlusal table will be used to reduce the load falling on the tissues of the edentulous area. A closed design will be used to provide reciprocation on the distal surface of 34.

Tooth support for the saddle will be gained from a mesial occlusal rest on 34. The greatest possible mucosa support for the saddle is achieved by extending the denture base onto the pear-shaped pad and to the full functional depth of the lingual and buccal sulci. On the right side of the arch it is important to spread the support so that a stable prosthesis can be produced, thus rests have been placed on 44, 46 and 48. The occlusal rests on the molars bridge the gap between the two teeth. Rest seat preparations will be carried out.

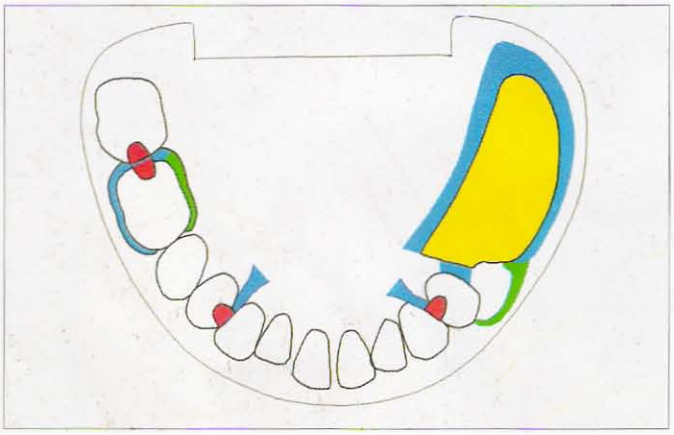




### *Retention (green)*

*Figure 10.11 — Retention*

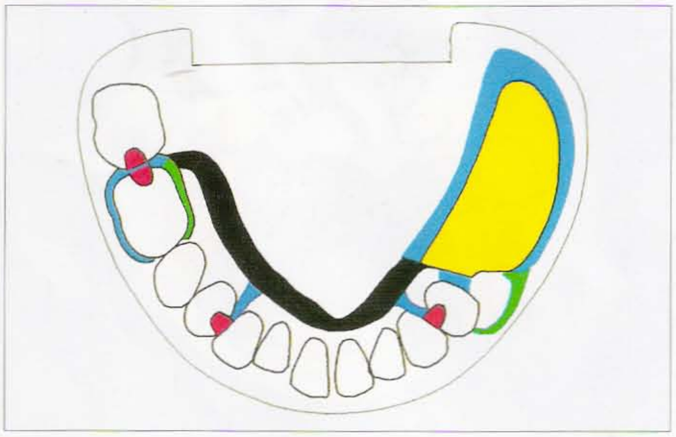
The distal extension saddle will be carefully shaped to enable the oral musculature to act against the polished surface to control the denture. Suitable undercut and sulcus shapes allow a gingivally approaching clasp to be used on 34. This clasp will be one of the components for the RPI system and the tooth will be prepared accordingly. On 46 the usable undercut is on the mesiolingual aspect of the tooth and will be engaged by an occlusally approaching clasp.



### *Bracing and reciprocation (blue)*

*Figure 10.12 — Bracing and reciprocation*

Lateral forces will be transmitted through the minor connectors, through the buccal bracing arm on 46 and to the tissues of the edentulous area through the fully extended flanges. Guide surfaces will be prepared on 34 and 46 to provide reciprocation for the retentive clasps.

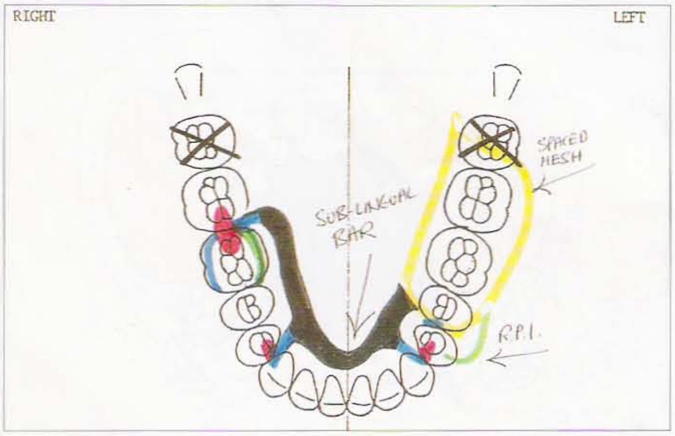


### *Connector (black) and indirect retention*

*Figure10.13 — Connector and indirect retention*

There is sufficient depth in the lingual sulcus for a sublingual bar. This connector will be rigid and will avoid coverage of the gingival margins. The three minor connectors will be placed as unobtrusively as possible in the embrasures between the teeth so that the framework is well tolerated by the patient.

The occlusal rest on 44 will provide effective indirect retention for the distal extension saddle because it is positioned well in front of the clasp axis passing through 34 and 46.




### *Design prescription*

*Figure10.14 — Design prescription*

The design is reviewed as described in Figure 10.6 and then given to the dental technician on a clearly labelled proforma as described for Example 1.

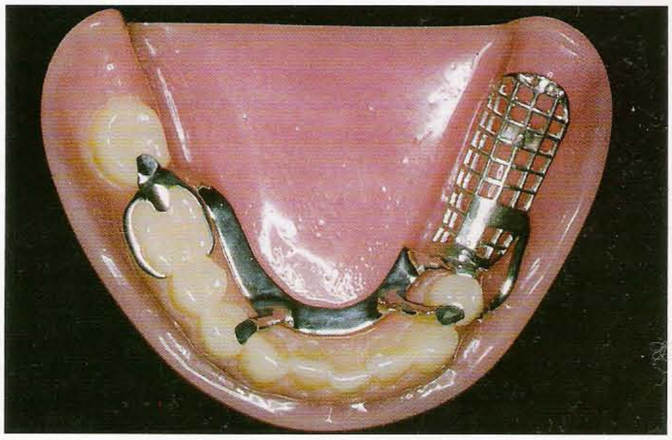
In this instance the whole casting will be constructed in cobalt chromium alloy.

*Figure 10.15 — Design prescription*

The shape of the lingual sulcus, faithfully recorded on the cast, dictates the shape and location of the sublingual bar. Nevertheless, it is wise to draw the outline of the connector on the cast to avoid any misunderstanding about its required position.

*Figure 10.16 — The completed framework*

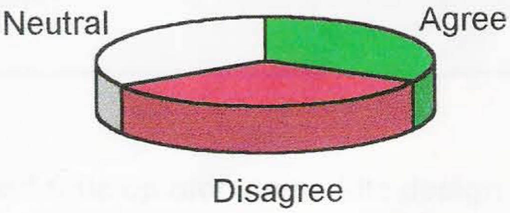
Careful planning and clear prescription again result in the required metal framework.



# Part 2 - Principles of design

Many RPD design principles are based more on clinical experience than scientific evidence. Under these circumstances it is advisable for a dentist, when making RPD design decisions, to draw on the widest possible range of specialist opinion rather than to rely on the views of just one, or a few, prosthodontists.

To this end, chapters 11–15 present statements that have been proposed as principles governing metal RPD design. Numerous experts have expressed their opinion on these principles as part of a survey of the departments of removable prosthodontics in all dental schools in the UK and the Republic of Ireland. All 17 of the departments responded and the results of the survey are given as pie charts indicating the experts' level of agreement or disagreement with each design principle:




Chapters 11–15 have been broadened and strengthened by comments from the international prosthodontic experts listed in the Acknowledgements. These comments have been incorporated into the discussions that follow each design principle.

Readers are invited to use this part of the book in an interactive way by first forming their own opinion on the design principles listed at the beginning of each chapter. When doing this it should be assumed that, to be acceptable, a design statement is likely to apply to the majority of, though not necessarily all, cases. Readers can then compare their opinions with those of the experts and consider the points raised in the discussions.

# 11 Saddles

## Design Statements

**11.1** Bounded edentulous areas should always be restored.

**11.2** Bounded edentulous areas should not be restored with a unilateral denture.

**11.3** Spaced mesh retention for the acrylic base should be used for tooth-supported bounded saddles.

**11.4** On-ridge (solid metal) retention for the acrylic base should be used for tooth-supported bounded saddles.

**11.5** Spaced mesh retention for the acrylic base should be used for distal extension saddles.

**11.6** A tissue stop, which contacts the crest of the posterior portion of the residual ridge on the cast, should be included beneath the metal retention latticework in distal extension saddles.

**11.7** A posterior bounded saddle should be restored with a metal pontic rather than with an artificial tooth if it is replacing a molar and if the saddle is less than 8mm in length mesio-distally.

**11.8** A posterior bounded saddle should be restored with an artificial tooth rather than with a metal pontic if it is replacing a molar and if the saddle is more than 8mm in length.

**11.9** A posterior bounded saddle should be of 'closed' design (with guide surface contact) if the plaque control is good.

**11.10** A posterior bounded saddle should be of 'open' design (3mm rule) if the plaque control is suspect.

**11.11** Anterior bounded saddles should be closely adapted to the guide surfaces on the abutment teeth ('closed design') to obtain good appearance and retention.

**11.12** Anterior bounded saddles in the maxillary arch should have backings if the opposing incisal edges are 2 mm or less from the mucosa of the edentulous area.

**11.13** Anterior bounded saddles should have a labial flange if significant labial resorption of the ridge is apparent.

**11.14** Anterior bounded saddles should have a partial labial flange extended to 1mm beyond the survey line on the ridge if there is minimal labial resorption and the smile line is low enough to conceal the junction between flange and mucosa.

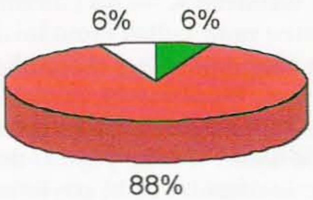
**11.15** Anterior bounded saddles should have an open-face, gum-fitted design if there is no labial resorption of the ridge.

**11.16** Mandibular distal-extension saddles should carry artificial teeth which are reduced in width occlusally.

**11.17** Distal-extension saddles in the mandibular arch should have a base extended posteriorly to cover the pear-shaped pad.

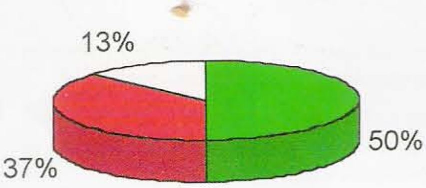
**11.18** Distal-extension saddles in the maxillary arch should have a base extended posteriorly to the hamular notch.

## Prosthodontic opinion on saddle design




***Statement 11.1 — Bounded edentulous areas should always be restored***

A bounded edentulous area should not automatically be restored. The decision of whether or not to restore an edentulous area should be based on clear functional indications, the absence of overwhelming contraindications, and on patient preference.




***Statement 11.2 — Bounded edentulous areas should not be restored with a unilateral denture***

Unilateral dentures are potentially dangerous because they are small and may be swallowed or inhaled if dislodged. Such a denture should only be considered if it can be positively and reliably retained by abutment teeth with good periodontal support, sufficient clinical crown length and adequate undercut.

The decision of whether or not to provide such a denture will be influenced by the length of the saddle to be restored. A shorter edentulous area is more likely to be suitable for a unilateral RPD, while a longer edentulous area would benefit from a conventional RPD that incorporates cross-arch bracing, support and retention.

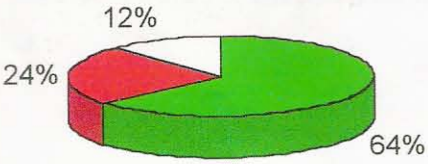
Unilateral dentures do not distribute functional loads as widely as do conventional dentures. However, as the retention of a removable prosthesis is not as positive as a fixed prosthesis, some stress-breaking may occur between the prosthesis and the abutment teeth reducing the load applied to the latter. Also, the sensation of the relatively insecure denture compared with a fixed prosthesis may cause the patient to limit the load applied to the denture in function.

If a unilateral denture is provided the retainers must be secure and reliable, eg:

1. **Bolt-retained sectional dentures** (Figures 6.36, 6.37) In these RPDs a bolt locks the two parts of the sectional denture together. Each part carries a guide plate engaging a proximal undercut on the abutment tooth, and bracing components which prevent movement of the abutment teeth. Thus the sectional denture is prevented from escaping from the undercuts once the bolt has locked the denture. However, in spite of the apparent reliability of this system, such dentures do occasionally become loose, possibly as the result of the wear of components or the movement of teeth. These dentures often require good manual dexterity on behalf of the patient to insert and lock them.
2. **Swing lock dentures** (Figures 6.38, 6.39) — The two parts of these dentures have rigid retaining components that engage buccal and lingual undercuts on the abutment teeth. They are maintained in this position by a catch. This design requires multiple components or plates which cross the gingival margins.
3. **Attachment retained dentures with locking device** (Figure 6.30) — For example, a dovetail attachment with a spring-loaded plunger in the patrix component to lock the two parts together by engaging a dimple in the matrix component.

The following retainers may be insufficiently reliable for a unilateral denture:

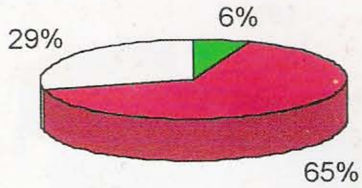
1. **Conventional clasps** - may permanently deform in function and become inactive.
2. **Magnets** — The available magnetic retentive force may be exceeded by the displacing forces. Also magnets do not resist shear forces efficiently.
3. **Attachments that rely on frictional retention — (eg split pins and tubes)** — These may be used to guide the insertion of the second part of a sectional denture. However, they should not be relied on to provide the retention between the two parts as the pins and tubes wear until the friction between them is insufficient to prevent separation of the two parts of the denture which can then escape from the abutment tooth undercuts.




***Statement 11.3 — Spaced mesh retention for the acrylic base should be used for tooth-supported bounded saddles***

Both spaced mesh retention and on-ridge retention (statement 11.4) may be suitable for tooth supported and bounded saddles, but the former is more popular than the latter. This popularity is possibly due to the greater adjustability of the acrylic impression surface of the saddle associated with the spaced mesh design — an advantage likely to become more significant as the length of the saddle increases (Figures 4.7a and b).

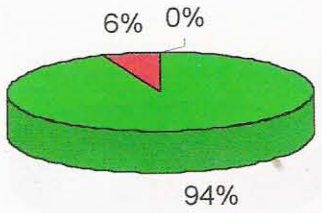
***Statement 11.4 — On-ridge (solid metal) retention for the acrylic base should be used for tooth-supported bounded saddles***




Although statement 11.4 received little support, on-ridge retention may function adequately for tooth-supported saddles since there may be little need to reline such saddles particularly if they are short, and therefore the metal fitting surface is not a disadvantage.

The indications for on-ridge retention are increased when there is insufficient room between the ridge and opposing teeth to accommodate spaced mesh retention (Figures 4.8a and b).

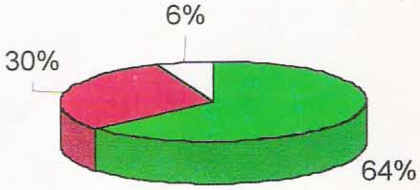
***Statement 11.5 — Spaced mesh retention for the acrylic base should be used for distal extension saddles***




When spaced mesh retention is used the resulting saddle has an acrylic resin impression surface. This facilitates relining of the saddle when alveolar resorption occurs. Relining to restore the fit will assist load distribution by any saddle which is supported, at least in part, by the mucosa. This is particularly important in the case of distal extension saddles.

Care must be taken when using mesh retention to ensure that it is substantial enough to be rigid under the stresses of processing and in function.

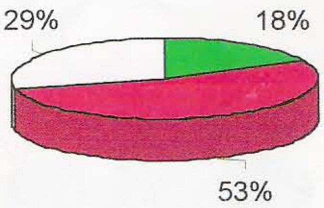
***Statement 11.6 — A tissue stop, which contacts the crest of the posterior portion of the residual ridge on the cast, should be included beneath the metal retention latticework in distal extension saddles***




The tissue stop (Figures 4.7a and b) stabilizes the mesh during processing of the acrylic resin in the flask. Without this support movement of the framework, or flexing of the mesh, may occur resulting in loss of fit of the distal extension saddle in the mouth.

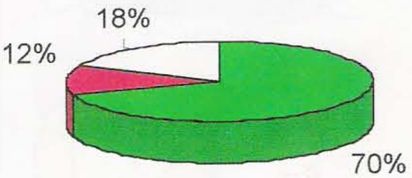
If the altered cast technique is used (*A Clinical Guide to Removable Partial Dentures*, chapter 19), the tissue stop may no longer touch the crest of the ridge on the new cast. This contact and support can be re-established before processing the acrylic base by placing a small amount of cold-cure resin between the stop and the cast.

***Statement 11.7 — A posterior bounded saddle should be restored with a metal pontic (Figure 4.12) rather than with an artificial tooth if it is replacing a molar and if the saddle is less than 8mm in length mesiodistally***



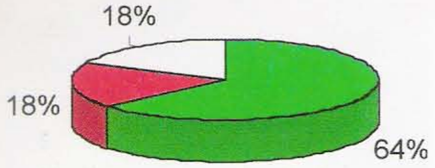

The discussion of this design statement follows statement 11.8.

***Statement 11.8 — A posterior bounded saddle should be restored with an artificial tooth rather than with a metal pontic if it is replacing a molar and if the saddle is more than 8mm in length***




A single molar space will not always have a significant impact on appearance. Therefore if the functional requirements justify filling the space at all, there may be the option of using a metal 'hygienic' ('wash-through') pontic (Figure 4.12). This will contribute to masticatory function and occlusal stability without covering as much tooth and mucosal surface as would a conventional saddle carrying an artificial tooth.

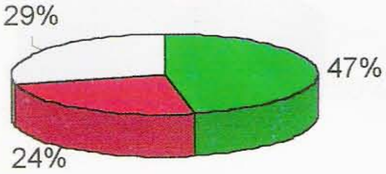
However, occasionally a molar can be highly visible, particularly in the maxilla, so that aesthetic considerations take precedence, requiring an artificial tooth to be used for the restoration.




***Statement 11.9 — A posterior bounded saddle should be of 'closed' design (with guide surface contact) if the plaque control is good***

The closed design of saddle maintains close contact between the saddle and the proximal surfaces of the abutment teeth (Figures 4.9, 4.10). This:

- Produces a defined path of insertion.
- Increases frictional retention.
- Produces reciprocation over a long 'retention distance' (Figure 7.13) which can help with clasp retention.
- Eliminates spaces between the saddle and the abutment teeth in which food particles may collect. This can be a source of irritation for the patient and reduce the acceptability of the RPD.




***Statement 11.10 — A posterior bounded saddle should be of 'open' design (3 mm rule) if the plaque control is suspect***

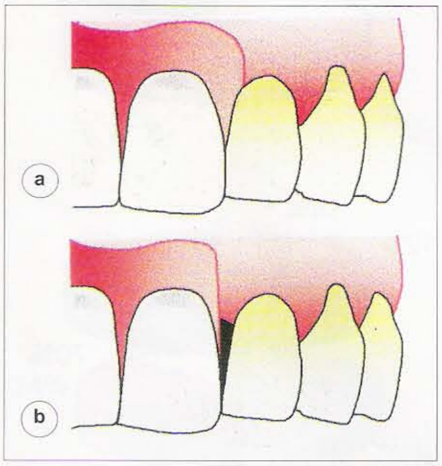
The 'open' design of saddle has subcontact point spaces between the saddle and abutment teeth (Figures 4.9–4.13). It has been suggested that this design might have certain health advantages, although there is little evidence for this in the literature. Indeed, recent work has suggested that the design has no effect on the rate of saliva clearance of plaque products. The benefits claimed for the open design are as follows:

- Saliva access may dilute plaque products and substrate.
- Salivary antibodies may qualitatively modify plaque composition.
- Saliva might physically dislodge solid matter from between saddle and tooth.
- Denture plaque is distanced from gingival margin and tooth.
- The denture cannot directly impinge on the gingival margin in this area and damage it — an aspect of particular importance for mucosally supported dentures.

In spite of these potential beneficial effects related to the open saddle design they are likely to be of marginal importance. The dominant factors will be the level of plaque control that the patient can maintain, and the patient's resistance to that plaque.

Potential disadvantages of the 'open' design of saddle are as follows:

- The spaces may allow the collection of food particles.
- The shortening of the guide surfaces might:
  - reduce frictional retention,
  - allow multiple paths of displacement,
  - reduce reciprocation.

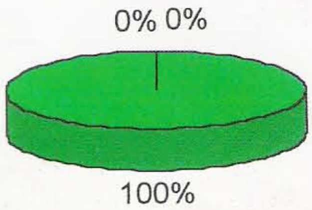



***Statement 11.11 — Anterior bounded saddles should be closely adapted to the guide surfaces on the abutment teeth ('closed' design) to obtain good appearance and retention***

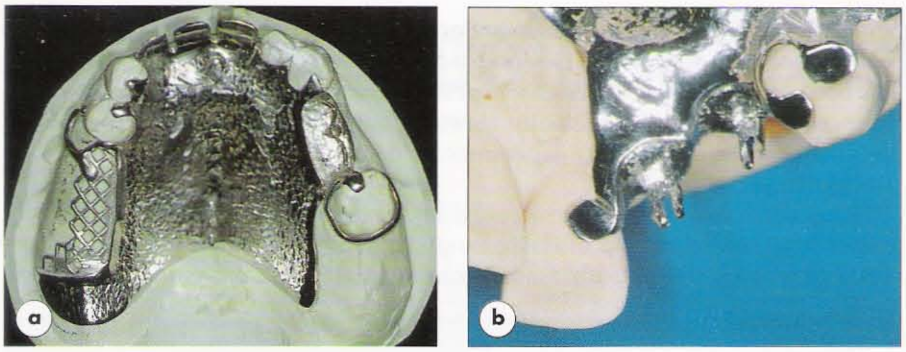
A 'closed' design is important for anterior saddles in order to obtain the best possible appearance and retention. The close contact between the saddle (acrylic base or artificial teeth) and the abutment teeth allows the former to blend with the latter so that the two cannot be easily distinguished and a more natural appearance is obtained (Figure 11.11a). Failure to achieve this close contact, perhaps by selecting an inappropriate path of insertion at right angles to the occlusal plane, will result in unsightly black triangles appearing gingivally to the contact points between saddle and teeth (Figure 11.11b).

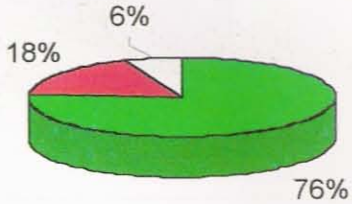
There are often undercuts on the mesial surfaces of the abutment teeth of anterior saddles relative to the path of displacement of the denture. Selecting a path of insertion parallel to these surfaces allows the saddle to maintain close contact with the teeth resulting in very positive retention without resorting to unsightly anterior clasps.

Because the abutment teeth are commonly proclined, the required path of insertion can often be found by surveying the cast with a heels-down tilt (Figures 3.19–3.21). While this path of insertion may solve the problems of the anterior saddle, vigilance needs to be maintained for the possible creation of difficulties posteriorly. For example, careful blocking out of undercuts distal to posterior teeth will be required.




Also, attention must be paid to the effect of the path of insertion on the survey lines related to posterior clasps. This analysis is further complicated by the fact that varying degrees of rotation of the denture might be possible on insertion. As a result the path of final seating of the posterior clasp may differ from the anterior part of the denture.



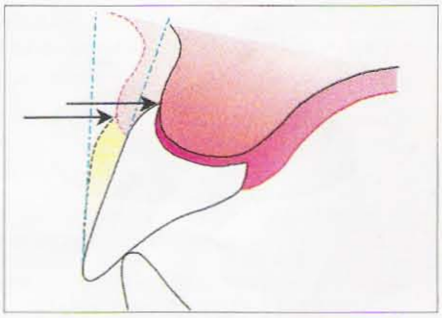


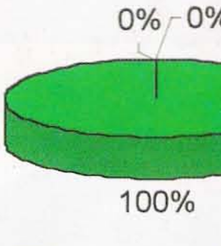

***Statement 11.12 — Anterior bounded saddles in the maxillary arch should have backings if the opposing incisal edges are 2 mm or less from the mucosa of the edentulous area.***

Where there is such close proximity of ridge and teeth in relation to an anterior maxillary saddle there will be insufficient room for spaced mesh retention. Attempting to use this design of saddle rather than backings (Figure 11.12a) will either result in a premature anterior occlusal contact or a saddle so weak that the acrylic base is likely to fracture in function.

Where space between lower incisors and ridge is at a premium reduction of the lower incisal edges may be required to provide the necessary room for the saddle.

For single or two-tooth saddles, backings rather than spaced mesh may be preferred, even when there is not a close occlusion, because mesh does not always provide sufficiently reliable retention for small saddles. Post retention, shown in Figure 11.12b, is another option that provides a stronger attachment for the denture teeth than mesh.

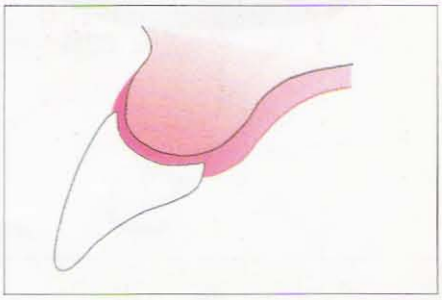


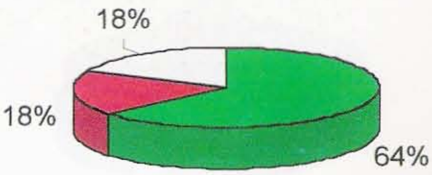



***Statement 11.13 — Anterior bounded saddles should have a labial flange if significant labial resorption of the ridge is apparent***

The labial flange will replace the resorbed alveolar bone resulting in the following:

- Optimum vertical positioning of the necks of the artificial teeth and optimum antero-posterior angulation of the artificial teeth. As indicated in the diagram, the appearance of the RPD is likely to suffer in the absence of a labial flange as the artificial teeth have to be too proclined and have their necks at too high a level. This is because the denture teeth have to be 'stretched' as their incisal edges often need to be placed in a similar position to that of their natural predecessors, but their necks placed further palatally and higher to contact the retreating, resorbed ridge.
- Improved lip support.
- Retention and stability from the flange contacting the labial surface of the ridge — an effect which will be of greater significance for large rather than small saddles. Small, single tooth saddles rarely require a flange that is fully extended into the sulcus. A part flange shaped to blend with the surrounding mucosa is usually more satisfactory.

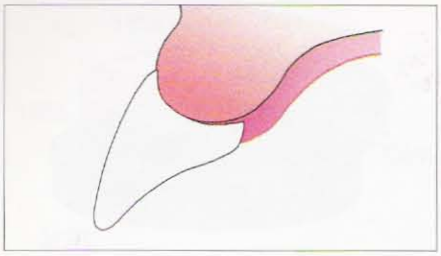


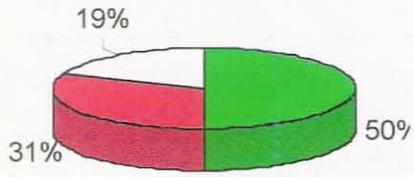



***Statement 11.14 — Anterior bounded saddles should have a partial labial flange extended to 1mm beyond the survey line on the ridge if there is minimal labial resorption and the smile line is low enough to conceal the junction between flange and mucosa***

The partial labial flange, like the full flange, assists the optimum positioning of the artificial teeth. But if the smile line is high, revealing the junction of the flange and mucosa, the appearance of the saddle may be poor as it is difficult to disguise this junction completely. For optimum appearance and tolerance, the border of the partial flange should be finished as a knife-edge.

Efforts should be made to avoid or minimise the limitations of a partial flange by carefully selecting a path of insertion that allows the flange to be extended as far as possible.



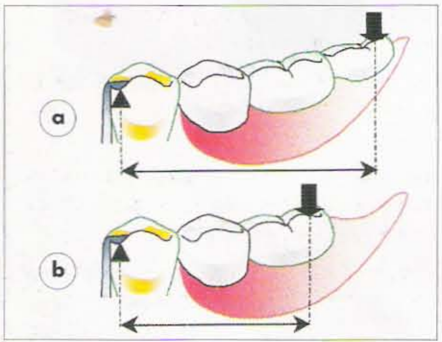


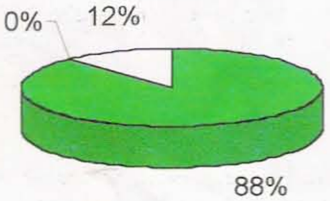

### *Statement 11.15 — Anterior bounded saddles should have an open-face, 'gum-fitted' design if there is no labial resorption of the ridge*

The open-face, 'gum-fitted' design will probably produce the best appearance under these circumstances, at least initially. However, as resorption of the ridge occurs the appearance will deteriorate as a gap commonly develops between the neck of the denture teeth and the ridge.

This design is likely to be most successful for smaller rather than larger saddles.

With larger saddles, the lack of a labial flange can result in loss of retention and support anteriorly with a greater potential for the denture to cause significant damage to the ridge.




### *Statement 11.16 — Mandibular distal extension saddles should carry artificial teeth that are reduced in width occlusally*

Distal extension saddles are tooth- and mucosally supported. There is invariably a support deficit that is particularly marked in the mandible where there is no hard palate to contribute to the support of the saddle. It is therefore important to design the denture so that the occlusal loads are reduced as much as possible. This will reduce trauma to the mucosa (and possibly pain) and encourage a slower rate of alveolar bone resorption.

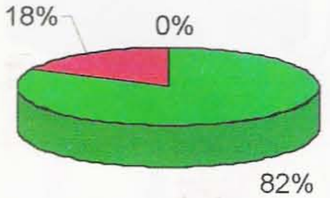
Shortening and narrowing the occlusal table of the artificial posterior teeth (Figure 4.1) will reduce the loads generated during mastication. Shortening the occlusal table is achieved by leaving one or more posterior teeth off the saddle and this will reduce the leverage effect of occlusal loads falling distally. As a general rule it is advisable to avoid tooth contact on the posterior third of a distal extension saddle (Figure 11.16b).

Less force is required for a small occlusal table to penetrate a bolus of food than for a large one. An analogy is the force required to cut food with a sharp knife (narrow teeth) compared with a blunt knife (wide teeth).

Reducing the width of the occlusal table does nothing to reduce the load created by empty mouth tooth contact, for example during bruxism. However, shortening the occlusal table will have a beneficial effect.

If there is a distal maxillary molar tooth which requires occlusal contact to prevent overeruption, this might be achieved, if there is a maxillary RPD, by placing an occlusal rest on this tooth rather than by providing occlusion with the mandibular distal extension saddle.

Another possible advantage of using narrow teeth on mandibular distal extension saddles is to increase space for the tongue. This can improve the tolerance to and, stability of, the prosthesis.

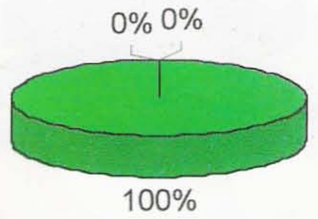



### *Statement 11.17 — Distal extension saddles in the mandibular arch should have a base extended posteriorly to cover the pear-shaped pad*

Extension of a distal extension saddle onto the pear-shaped pad (Figure 4.2; *A Clinical Guide to Removable Partial Dentures*, figures 5.9, 5.10 and 5.12) is important in resisting posterior displacement. This pad is the most distal extension of the attached keratinised mucosa overlying the mandibular ridge crest and is formed by the scarring pattern after extraction of the most posterior molar.

This extension also contributes to optimum load distribution. Posterior to the pear-shaped pad the retromolar pad is soft and mobile and will contribute little to the support of the prosthesis even if it is covered. Such overextension of the saddle posteriorly is also likely to create problems with tolerance.

There are other anatomical landmarks for the full extension of a distal extension saddle necessary for optimum load distribution, for example the saddle must be fully extended into the buccal and lingual sulci. In the mandible this requires the saddle to extend over the buccal shelf and onto the external oblique ridge.




### *Statement 11.18 — Distal extension saddles in the maxillary arch should have a base extended posteriorly to the hamular notch*

Extension of the saddle into the hamular notch (*A Clinical Guide to Removable Partial Dentures*, figure 5.7) in the maxilla allows:

- The production of an effective postdam because the tissues here are displaceable.
- Maximum tissue coverage for support, bracing and retention.

# 12 Occlusal rests

## Design Statements

**12.1** The support axis for a saddle should be placed as close to the line of the dental arch as possible.

**12.2** Where there is a unilateral saddle at least one additional rest should be placed on the opposite side of the arch.

**12.3** Rests should not be placed on the maxillary lateral incisors or on the mandibular incisors.

**12.4** A rest on a mandibular canine should be placed on the incisal edge.

**12.5** A rest on a mandibular canine should be placed on a cingulum rest seat produced in composite.

**12.6** A rest should be placed on an essentially horizontal tooth surface that will result in occlusal loads being transmitted axially down the root, reducing the generation of horizontal components of force.

**12.7** Rests should be placed in prepared rest seats.

**12.8** Rest seats should be prepared only where there is lack of occlusal space or if the tooth surface is sloping.

**12.9** If the abutment teeth are periodontally sound, rests supporting a bounded saddle should be placed immediately adjacent to the saddle.

**12.10** If an abutment tooth has lost a moderate amount of periodontal support, rests supporting a bounded saddle should be placed non-adjacently on the abutment tooth and on the next tooth.

**12.11** If an abutment tooth has lost a considerable amount of periodontal support, a rest supporting a bounded saddle should be placed on the nearest suitable site on the next tooth.

**12.12** When an anterior saddle replaces a single tooth, it can, if necessary, be supported by a rest at one end only.

**12.13** If the distal abutment tooth of a posterior bounded saddle is an isolated molar, rests should be placed both mesially and distally on this tooth.

**12.14** If an isolated distal molar abutment of a posterior bounded saddle has a poor prognosis, rests should be placed both mesially and distally on the mesial abutment.

**12.15** A rest for a distal-extension saddle should be placed mesially on the abutment tooth if this tooth is periodontally and coronally sound.

**12.16** A rest for a distal-extension saddle should be placed mesially on the tooth anterior to the abutment tooth if the latter has a poor prognosis.

**12.17** A rest providing indirect retention should be placed on the opposite side of a clasp axis from the potentially displaceable saddle

**12.18** A rest providing indirect retention should be placed as far from the clasp axis as possible.

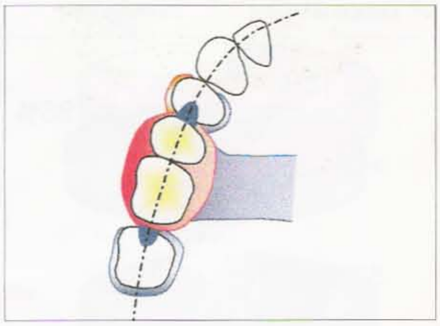
**12.19** A plate connector covering gingival margins should be supported by rests at both ends.

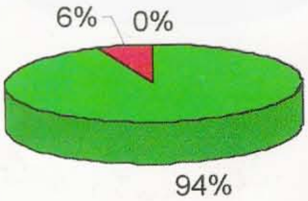
## Prosthodontic opinion on occlusal rest design

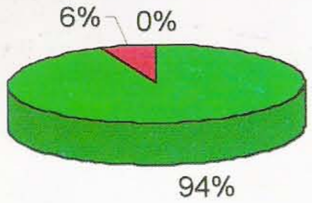
***Statement 12.1 — The support axis for a saddle should be placed as close to the line of the dental arch as possible.***

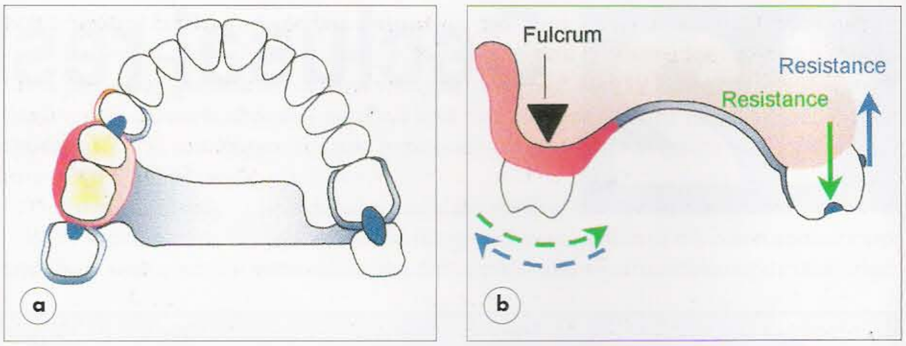
The support axis in this instance is an imaginary line passing through the rests supporting a saddle. Placing this axis close to the line of the dental arch contributes to axial loading of the abutment teeth and stability of the saddle.

Placing the rests to one side of the line of the dental arch is sometimes clinically necessary, eg to avoid creating an occlusal interference, but occlusal loading of the saddle will then result in tilting forces being applied to the teeth. If the denture is of unilateral design there will also be a tendency for the saddle to rotate around an axis passing through the rests.



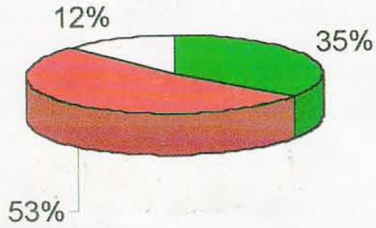





***Statement 12.2 — Where there is a unilateral saddle at least one additional rest should be placed on the opposite side of the arch.***

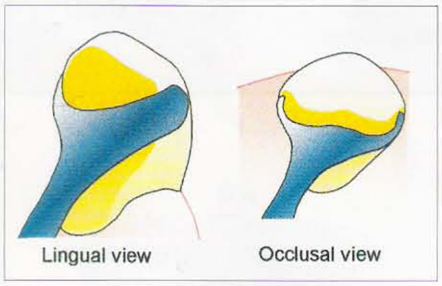
Cross-arch support provided by an occlusal rest is an effective way of stabilizing a saddle by preventing rotation around its long axis in the direction of the rest. The addition of a clasp to the rest will resist rotation of the saddle in the opposite direction .

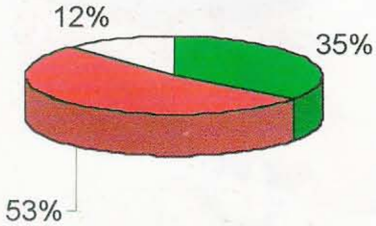



***Statement 12.3 — Rests should not be placed on the maxillary lateral incisors or on the mandibular incisors***

These teeth have relatively small periodontal ligament areas and it has therefore been suggested that they are not well suited to accepting additional loads from RPDs. However, the majority of prosthodontists in the survey did not feel that the statement could be supported. It is believed that if these teeth are periodontally sound they can be used to support prostheses.

This is particularly so if it can be arranged that the rests load the teeth axially. To achieve axial loading, cingulum rest seats will normally be required (*A Clinical Guide to Removable Partial Dentures*, Figure 15.9), yet because of the morphology of these teeth adequate rest seat preparation is unlikely to be achieved without penetrating enamel. One way in which this dilemma can be resolved is by creating cingulum rest seats in composite (see statements 12.4 and 12.5).



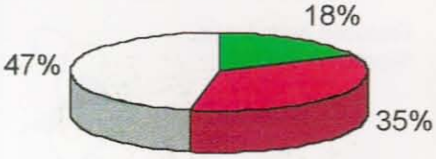

***Statement 12.4 — A rest on a mandibular canine should be placed on the incisal edge***

Placing the rest on the incisal edge of the mandibular canine achieves very positive tooth support (*A Clinical Guide to Removable Partial Dentures*, Figure 15.11). However, the rest is visible and might be rejected by the patient as a result. Therefore if an incisal rest is being considered, its likely aesthetic effect should be explained to the patient at the treatment planning stage and consent for it obtained.

The alternative of placing the rest on the cingulum may not be straightforward because the cingulum on mandibular canines is not usually sufficiently well developed to support a rest. The preparation of a rest seat might be attempted to overcome this problem, but the enamel in this area is so thin that the amount of preparation possible is very limited if perforation of the enamel is to be avoided. This dilemma can be resolved by creating a cingulum rest seat in composite (statement 12.5). There is a view that the success of this simple procedure has made the incisal rest obsolete.

Another option, if the morphology of the canine is suitable, is to use a mesio-distal rest as shown in the diagram. This component has rigid arms that gain support by contacting the mesial and distal surfaces of the tooth above the survey line.

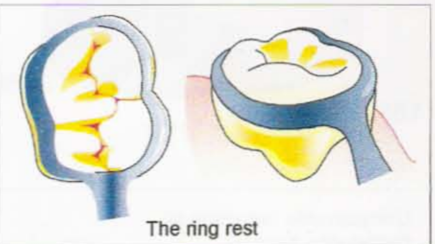
***Statement 12.5 — A rest on a mandibular canine should be placed on a cingulum rest seat produced in composite***

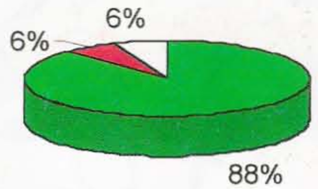



Possible difficulties in achieving support from the cingulum of a mandibular canine are mentioned in the comments on statement 12.4 above. If a cingulum rest is required the possibility of creating a rest seat by adding composite to the cingulum area of the tooth can be considered. Composite provides a conservative means of modifying tooth form to assist with RPD support, but there is little published information on the long-term success rates of this approach.

An alternative to the cingulum rest seat is the acid-etch metal veneer, which is bonded to the lingual aspect of the tooth to create a seat. These metal components bonded to the teeth can assist RPDs in other ways, eg by incorporating precision attachments or undercuts for clasps.

***Statement 12.6 — A rest should be placed on an essentially horizontal tooth surface that will result in occlusal loads being transmitted axially down the root, reducing the generation of horizontal components of force***

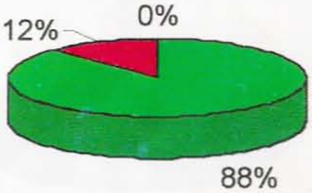

The ring rest




If a rest is placed on an inclined tooth surface a horizontal force will be transmitted to the tooth whenever the denture is loaded. Over a period of time this is likely to cause the tooth to move away from the rest thus reducing the support for the denture (*A Clinical Guide to Removable Partial Dentures*, Figure 15.1).

Exceptions to this statement, for bounded saddles, are the mesio distal rest described in statement 12.4 and the ring rest shown in the diagram. Although these components rest on inclined planes, one horizontal vector of force opposes another so that the result is axial loading of the tooth. However, if the denture tilts, as is likely to be the case for a distal extension saddle, the part of the component on the opposite side of the abutment tooth from the saddle will lift resulting in non-axial loading of the tooth.

***Statement 12.7 — Rests should be placed in prepared rest seats***

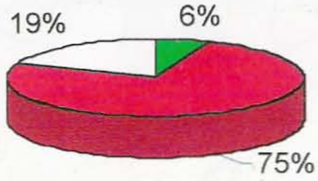



Prepared rest seats (*A Clinical Guide to Removable Partial Dentures*, Figures 15.1–15.12) have a number of potential advantages:

- Creating space for the rest to avoid occlusal interference
- Producing a favourable inclination of tooth surface for support.
- Reducing the prominence of the rest.

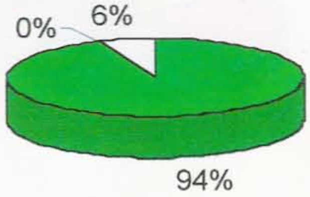
If rest seats are prepared, these can indicate precisely to the technician where the rests are to be placed. However, this is not always the case, for example, in a worn dentition. Here a rest seat can be 'camouflaged' by numerous other occlusal irregularities. It is therefore very important to make the location of rest seats quite clear to the technician by marking the cast, or by clear labeling of the design diagram.

***Statement 12.8 — Rest seats should be prepared only where there is lack of occlusal space or if the tooth surface is sloping***



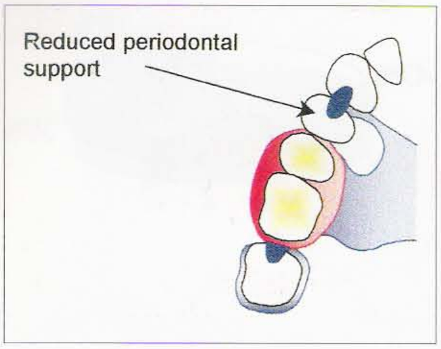

This implies that rest seats should not be prepared in enamel solely to reduce the prominence of a rest. However, the majority of prosthodontists do not agree with the statement.

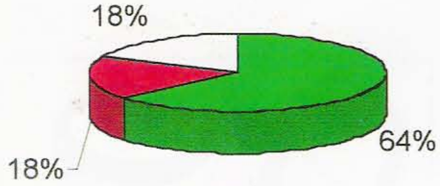
***Statement 12.9 — If the abutment teeth are periodontally sound, rests supporting a bounded saddle should be placed immediately adjacent to the saddle.***




Placing rests adjacent to both ends of bounded saddles has a number of potential benefits:

- Efficient support.
- A simple, clean design avoiding the need for minor connectors to carry rests to more distant sites.
- Deflection of food from the denture–abutment tooth contact points. A rest, however, is not essential for this purpose, as a saddle with well-shaped good contacts with the abutment tooth will not usually be associated with food packing between tooth and denture.

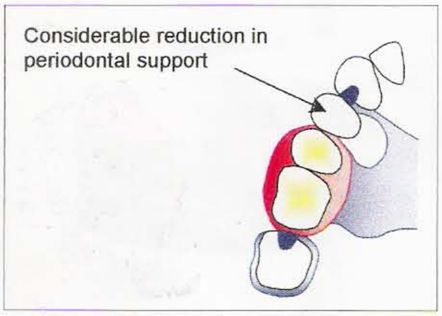


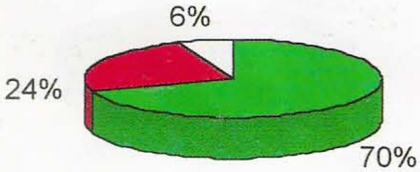




***Statement 12.10 — If an abutment tooth has lost a moderate amount of periodontal support, rests supporting a bounded saddle should be placed non-adjacently on the abutment tooth and on the next tooth***

This shares the occlusal loads between two teeth, thus sparing the tooth, which has diminished periodontal support.

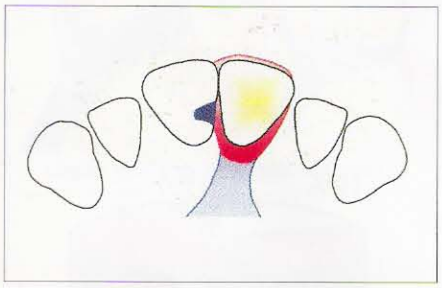
This approach, however, does not have universal support. There is a view that this distribution of rests complicates the design unnecessarily, which could in itself have adverse periodontal consequences. It is also suggested that a tooth with moderate loss of support, but without active periodontal disease should be treated as any other sound tooth for the purpose of RPD support.

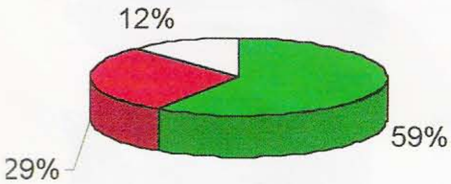



***Statement 12.11 — If an abutment tooth has lost a considerable amount of periodontal support, a rest supporting a bounded saddle should be placed on the nearest suitable site on the next tooth***

Here it is assumed that the abutment tooth is unable to contribute to the support of the denture. If the tooth is subsequently lost it can be added to the saddle which is still fully tooth-supported by occlusal rests mesially and distally. This illustrates the principle of contingency planning in the design of RPDs. It could of course be argued that in most cases where such a compromised tooth exists, it should be extracted before constructing the RPD. However, appropriately designed metal RPDs can be highly adaptable when the need arises.



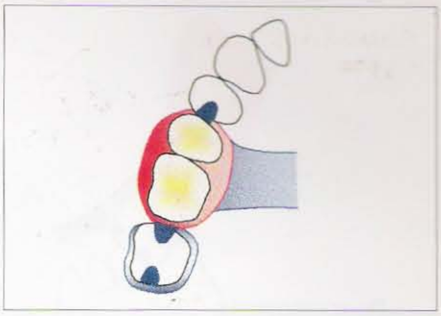


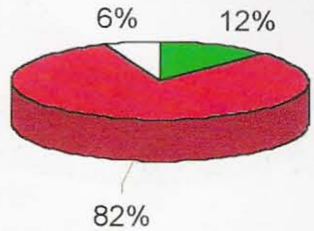

***Statement 12.12 — When an anterior saddle replaces a single tooth, it can if necessary be supported by a rest at one end only***

Where it is practicable such an anterior saddle would normally be supported by rests at either end. However, occasionally one of the abutment teeth might be unsuitable for accommodating a rest, eg reduced periodontal support, unfavourable shape or occlusion or the need for a space between artificial tooth and abutment tooth that would mean that the rest would be visible. Under such circumstances support from a single abutment is acceptable providing that abutment is periodontally sound and that the rest can be placed in a prepared rest seat to achieve axial loading of the tooth. In addition, other features of the design should adequately resist the tilting forces developed during occlusal loading of the saddle.

***Statement 12.13 — If the distal abutment tooth of a posterior bounded saddle is an isolated molar, rests should be placed both mesially and distally on this tooth***

The isolated distal abutment of a bounded saddle is often tilted mesially. If this is the case the placement of rests both mesially and distally on the tooth may help to achieve more axially directed loading. If mesial tilting is not present there is little advantage in using this distribution of rests for this purpose, and in fact the majority view in the survey does not support this statement. However, if a ring clasp were placed on this tooth the distal rest would help to stabilize and support the long, flexible and vulnerable clasp arm.

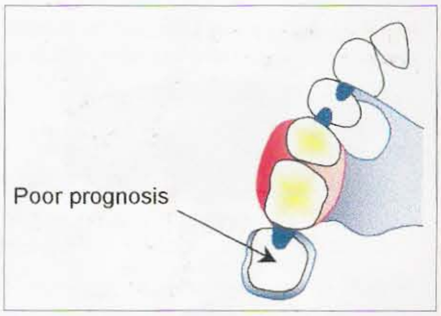


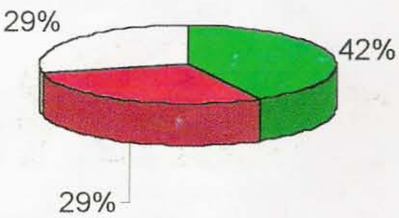



***Statement 12.14 — If an isolated distal molar abutment of a posterior bounded saddle has a poor prognosis, rests should be placed both mesially and distally on the mesial abutment***

Placing rests in this configuration allows conversion to a distal extension saddle supported by a mesial rest if the distal abutment is lost. The distal rest on the mesial abutment would be removed and the denture base extended posteriorly. This is another example of contingency planning when designing an RPD.

It can of course be argued, as for statement 12.11, that in most cases where such a compromised tooth is present, it should be extracted before constructing the RPD.



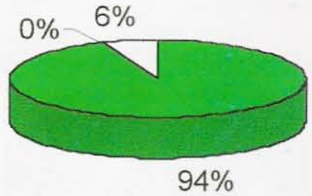



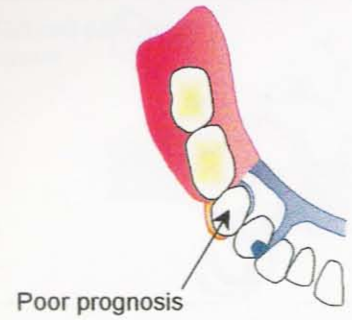

***Statement 12.15 — A rest for a distal-extension saddle should be placed mesially on the abutment tooth if this tooth is periodontally and coronally sound***

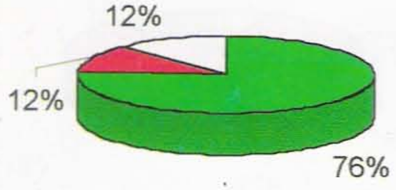
The use of a mesial rest results in a more even distribution of load to the edentulous area than is achieved with a distal rest (Figures 5.9–5.11).

It has been suggested that the use of a mesial rest avoids the distal tilting of the abutment tooth said to be caused by a distal rest. However, the weight of the evidence from both *in vitro* and *in vivo* research does not support the suggestion that a distal rest causes distal tilting.

Concern over optimal distribution of load is greatest for the mandible as the support deficit tends to be greater than in the maxilla where the hard palate can contribute to support. Mesial rests may therefore be less routinely employed in the maxilla than in the mandible.

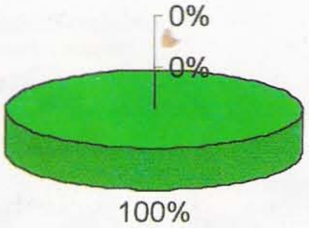




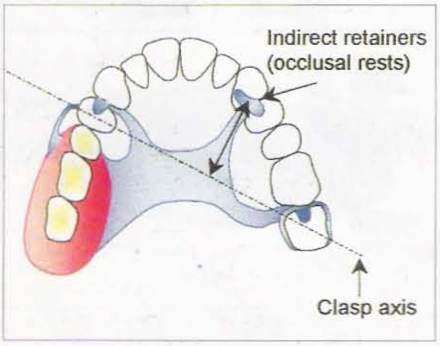

***Statement 12.16 — A rest for a distal extension saddle should be placed mesially on the tooth anterior to the abutment tooth if the latter has a poor prognosis***

This allows the saddle to be extended mesially if the periodontally affected tooth is lost, while still retaining tooth support from a rest placed mesially on the abutment tooth. However, as mentioned in statement 12.11, a metal RPD might not be provided in the presence of a tooth of such poor prognosis. The tooth is likely to be extracted before prosthetic treatment is started.



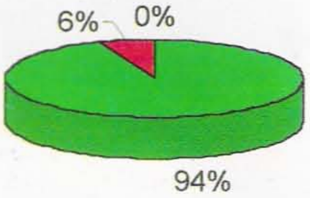

***Statement 12.17 — A rest providing indirect retention should be placed on the opposite side of a clasp axis from the potentially displaceable saddle***

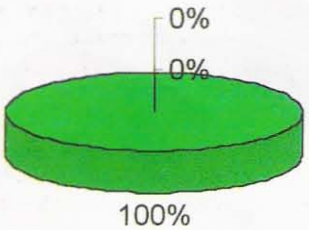
Rests can be effective indirect retainers (chapter 8). For indirect retention to be obtained the rests must always be separated from the saddle by a clasp axis (an imaginary line joining the retentive tips of a pair of clasps on opposite sides of the arch). The effectiveness of the indirect retention depends to a large extent on the retentiveness of the clasps creating the clasp axis.




***Statement 12.18 — A rest providing indirect retention should be placed as far from the clasp axis as possible***

When clasps contribute to indirect retention they are always working at a mechanical disadvantage to the forces tending to displace the saddle (Figures 8.6, 8.7 and 8.8). This mechanical disadvantage should be minimised by placing the rests acting as indirect retainers as far from the clasp axis as possible




***Statement 12.19 — A plate connector covering gingival margins should be supported by rests at both ends***

This ensures that occlusal forces do not make the plate slip down the teeth and traumatize the gingivae.

Uncovering gingival margins is a widely accepted key principle of RPD design, but a lingual plate does not achieve this. Alternative connectors that do uncover gingival margins (lingual bar, sublingual bar, dental bar) should be chosen in preference wherever possible.

# 13 Clasp design

## Design Statements

13.1 A clasp should always be supported by a rest.

13.2 A molar ring clasp should have occlusal rests mesially and distally.

13.3 A molar ring clasp, which engages lingual undercut, should have a buccal strengthening arm.

13.4 Retentive clasps can be used to provide indirect support for a distal extension saddle by being placed on the opposite side of the support axis from the saddle.

13.5 A wrought wire clasp should be attached to a saddle, not to exposed parts of the metal framework.

13.6 An occlusally-approaching clasp should not approach closer than 1mm to the gingival margin.

13.7 A retentive occlusally-approaching clasp should run from the side of the tooth with the least undercut to the side with the greatest undercut.

13.8 Occlusally-approaching retentive clasps should have the terminal third of the retentive arm entering the undercut.

13.9 A retentive clasp should engage 0.25mm of undercut if it is constructed in cast cobalt-chromium alloy.

13.10 If an undercut on a tooth that needs to be clasped for retention is less than 0.25mm, then composite resin should be added to the tooth to create at least this amount of undercut.

13.11 A retentive clasp should be at least 15mm in length if it is constructed in cast cobalt-chromium alloy.

13.12 Occlusally-approaching retentive clasps should be restricted to molar teeth if constructed in cast cobalt chromium alloy

13.13 A retentive clasp should engage 0.5mm of undercut if it is constructed in wrought wire.

13.14 A retentive clasp should be at least 7mm in length if it is constructed in wrought wire.

13.15 If an occlusally-approaching retentive clasp is used on a premolar or canine it should be constructed in wrought wire.

13.16 Retentive clasps should usually be placed buccally on upper teeth.

13.17 Retentive clasps should usually be placed lingually on lower molars.

13.18 Retentive clasps should usually be placed buccally on lower premolar or canine teeth.

13.19 Where there are clasps on opposite sides of the arch, the retentive arms are best placed on opposing tooth surfaces i.e. buccal/buccal or lingual/lingual.

13.20 Retentive and bracing/reciprocating elements of a clasp should encircle the tooth by more than 180 degrees.

13.21 Reciprocation should be provided on a clasped tooth diametrically opposite the retentive clasp tip.

13.22 If a reciprocating clasp, rather than a plate, is used it should be placed at the gingival end of a guide surface on the clasped tooth.

13.23 Where a plate connector is used, reciprocation can be obtained by a guide plate on the connector.

13.24 Gingivally-approaching clasps are contra-indicated if the buccal sulcus is less than 4mm in depth.

13.25 Gingivally-approaching clasps are contra-indicated if there is a tissue undercut buccally on the alveolus more than 1mm in depth and within 3mm of the gingival margin.

13.26 A gingivally-approaching clasp should be used if a retentive cast cobalt chromium clasp is required on a premolar or canine tooth, assuming that sulcus anatomy is favourable.

13.27 The RPI system (rest, plate, I-bar clasp) should be used on premolar abutment teeth for mandibular distal extension saddles if the tooth and buccal sulcus anatomy is favourable.

13.28 The RPI system (rest, plate, I-bar clasp) should be used on premolar abutment teeth for maxillary distal extension saddles if the tooth and buccal sulcus anatomy is favourable.

13.29 A distal extension saddle should have a retentive I-bar clasp whose tip contacts the most prominent part of the buccal surface of the abutment tooth mesio-distally.

13.30 If the retentive clasp for a distal extension saddle is on a premolar or canine abutment, it should be either a cast gingivally-approaching I-bar or a wrought wire occlusally-approaching clasp.

13.31 A distal extension saddle should have a retentive clasp on the abutment tooth.

13.32 A unilateral distal extension saddle denture (Kennedy II) should have one clasp as close to the saddle as possible and the other as far posteriorly as possible on the other side of the arch.

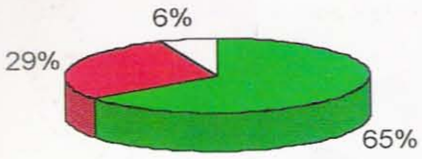
13.33 Rather than making a design statement this section poses a question: 'What is the preferred number of clasps for RPDs restoring each of the Kennedy classes of partially dentate arch?'

13.34 Bounded saddles should have a clasp at least at one end.

13.35 A Kennedy III modification 1 denture should have 2 retentive clasps forming a diagonal clasp axis which bisects the denture.

13.36 A Kennedy IV denture should have retentive clasps on the first molars if there is suitable undercut present.

## Prosthodontic opinion on clasp design

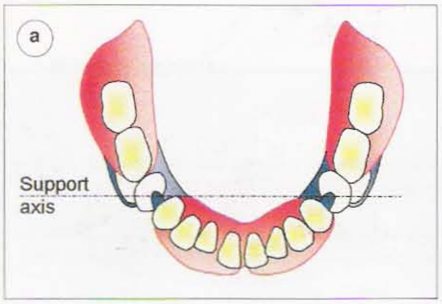



### *Statement 13.1 — A clasp should always be supported by a rest*

A clasp should be supported to maintain its vertical relationship to the tooth. Without such support the clasp will tend to move gingivally with the following detrimental effects:

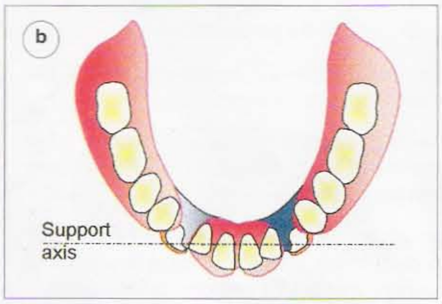
- The retentive tip of the clasp will lose contact with the tooth. It will not therefore provide retention for the denture until there has been sufficient movement of the denture in an occlusal direction to re-establish contact of the clasp with the tooth. The denture may therefore seem loose to the patient.
- The tip of the clasp may sink into and damage the gingivae.

This statement is not universally applicable. For example, acrylic mucosally supported RPDs often employ wrought wire clasps without tooth support. However, even in this situation tooth support for clasps can sometimes usefully be obtained by wrought wire rests or clasp arms extending onto the occlusal surfaces.

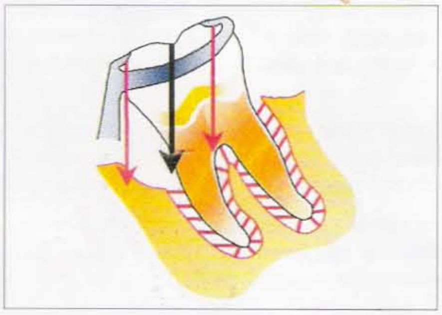



It might be preferable to omit tooth support when, as shown in Figure 13.1a, there are very few teeth remaining and rests on them would produce a support axis that approximately bisects the denture. In this situation tooth support can contribute to instability of an RPD because the denture tends to rock about the support axis.

If however, there are very few teeth remaining, but rests on them would produce a support axis which forms a tangent to the residual ridge, tooth support can usually be employed to advantage and the denture remain acceptably stable (Figure 13.1b).



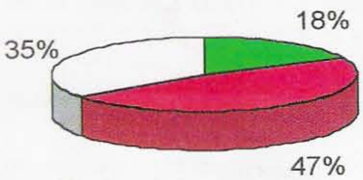

### *Statement 13.2 — A molar ring clasp should have occlusal rests mesially and distally*



Such an arrangement may:

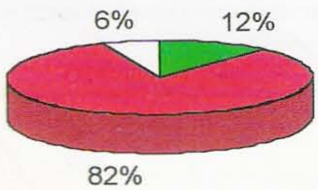
- Contribute to more axial loading of a tilted abutment tooth as indicated by the black arrow in the figure. This will reduce the leverage on the tooth compared with a mesial rest used alone.
- Support the clasp arm on the tooth distally so that if the clasp arm is inadvertently bent it is unlikely that the arm can move far enough gingivally to traumatise the periodontal tissues.

However, the prosthodontic specialists do not favour this arrangement. The commonest method of supporting a ring clasp is with an occlusal rest adjacent to the saddle. Occasionally clinical circumstances may dictate that a non-adjacent rest be used. This results in the entire load from the saddle to the rest being transmitted along the proximal section of the clasp. It is necessary therefore to strengthen this section, for example by thickening it.

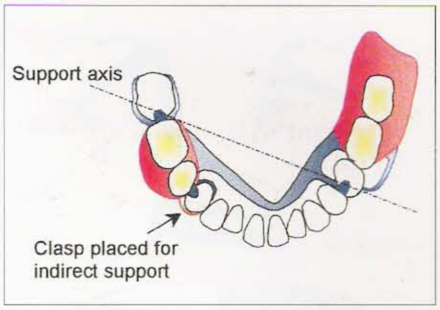


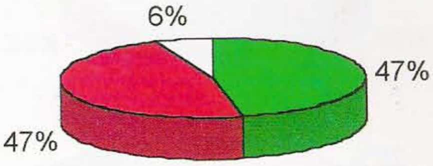

### *Statement 13.3 — A molar ring clasp, which engages lingual undercut, should have a buccal strengthening arm.*

A molar ring clasp has a long arm, which is vulnerable to accidental deformation through mishandling. The addition of a buccal reinforcing arm is intended to prevent this happening. This variant is not popular with the prosthodontic specialists possibly because it complicates the design, thereby tending to retain plaque and reduce patient tolerance.



### *Statement 13.4 — Retentive clasps can be used to provide indirect support for a distal extension saddle by being placed on the opposite side of the support axis from the saddle*




When an occlusal load is applied to a distal-extension saddle the displaceability of the supporting mucosa allows the saddle to sink. The denture rotates about the 'support axis' (an imaginary line passing through the occlusal rest adjacent to the saddle and the most distal rest on the other side of the arch) so that denture components anterior to the support axis move in an occlusal direction.

A clasp placed on the other side of the support axis from the distal extension saddle will tend to resist this movement to a limited extent. This resistance is known as indirect support. However, the occlusal loads tend to be high and the retentive force generated by the clasp relatively low; also the occlusal loads are usually working at a mechanical advantage to the clasp. This arrangement is therefore ineffective.

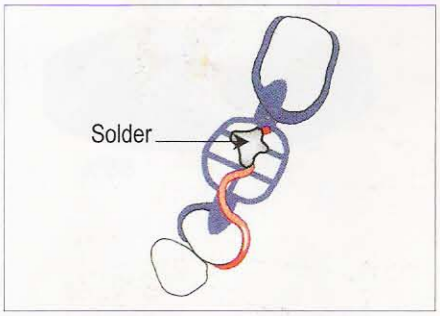
If the clinician does judge that indirect support is justified for a particular case the use of multiple clasps should be considered.

Rather than trying to obtain indirect support for a distal extension saddle it is normally advisable to focus on:

- Optimising direct support of the saddle through:
  - full extension of the base (Figure 4.2, statement 11.17);
  - the altered cast technique (*A Clinical Guide to Removable Partial Dentures*, chapter 9);
  - the use of mesial occlusal rests (Figures 5.9–5.11, statement 12.15);
  - regular maintenance, including relining when necessary (*A Clinical Guide to Removable Partial Dentures*, Figures 10.9–10.17).
- Minimizing occlusal loads generated during mastication by reducing the area of the occlusal table (Figure 4.1, statement 11.16). It is particularly important to shorten the occlusal table as this reduces the length of the cantilever arm created by the distal extension saddle. However, reducing the width of the occlusal table also helps, in this case by allowing the denture teeth to be pushed through the bolus more easily and therefore with less load being transmitted to the supporting tissues.

Indirect support can be of value for the Kennedy Class IV denture (statement 13.36).

### *Statement 13.5 — A wrought wire clasp should be attached to a saddle, not to exposed parts of the metal framework*

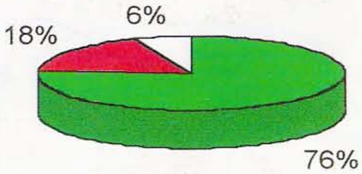



An effective method of attaching a wrought clasp (stainless steel or gold) to a denture is to solder the origin of the clasp to the metal base of the saddle and then cover the solder joint with the acrylic resin of the saddle. The advantages of this are:

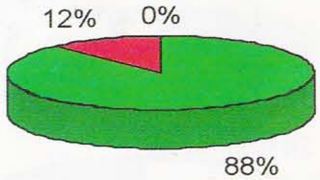
- The heat created by soldering is far enough away from the active part of the clasp arm not to change the properties of the wrought alloy.
- Subsequent corrosion of the solder joint by exposure to oral fluids is prevented by the investing acrylic resin.

These benefits are not obtained if an attempt is made to solder a wrought clasp directly to an exposed part of the cobalt chromium framework.

The soldering of the wrought wire clasp to the metal base of the saddle is best completed before the trial insertion of the metal framework into the mouth as this allows the adequacy of the clasp to be checked along with the other metal components.

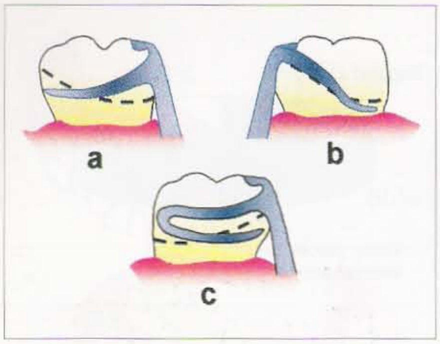



### *Statement 13.6 — An occlusally-approaching clasp, which is supported by a rest, should not approach closer than 1mm to the gingival margin*




If a clasp is closer than 1mm to the gingival margin there is the likelihood of gingival irritation.

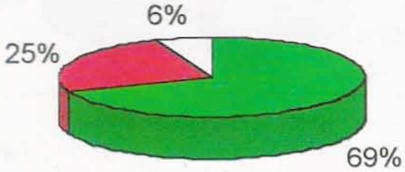
If the clasp is not supported by a rest the separation of clasp tip and gingival margin should be greater than 1mm so that when the saddle sinks the clasp does not traumatize the gingivae.




### *Statement 13.7 — A retentive occlusally-approaching clasp should run from the side of the tooth with the least undercut to the side with the greatest undercut (Figure 13.7a)*

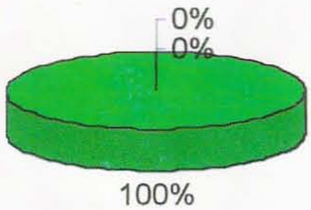
This usually results in:

- Most effective utilization of available undercut.
  If a clasp arm runs from maximum to least undercut, the undercut might be too little to provide effective retention in the region of the tip of the clasp.
- Optimum positioning of the clasp arm on the tooth.
  Only the terminal third of the clasp arm can cross the survey line and enter the undercut. The remaining, more rigid proximal part of the clasp arm has to be above the survey line. Therefore if the clasp is going the 'wrong' way the tip of the clasp may have to be placed unnecessarily close to the gingival margin, and the origin of the clasp located so high on the tooth that it might create an occlusal interference (Figure 13.7b).



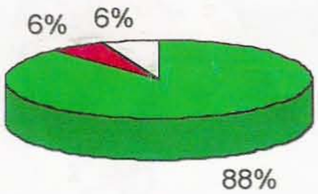

There are exceptions to this statement particularly if the tooth has a long clinical crown. In this situation the survey line may allow the clasp to run from the greater to the lesser undercut without compromising the positioning of the proximal or distal portions of the clasp arm or the depth of undercut engaged..

A clasp type, which does not strictly comply with the statement, is the recurved occlusally-approaching clasp (Figure 13.7c).




### *Statement 13.8 — Occlusally-approaching retentive clasps should have the terminal third of the retentive arm entering the undercut*

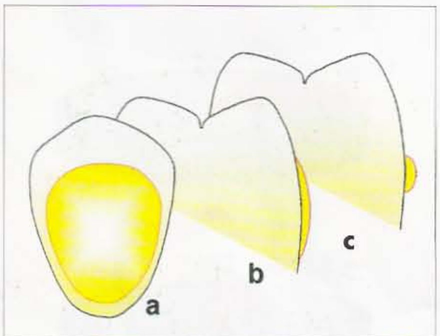
The flexibility of a clasp arm made of a particular alloy is related to length and thickness. The clasp arm is normally manufactured with a length and taper designed to provide sufficient flexibility for the terminal third to safely enter the undercut. If the clasp arm crosses the survey line prematurely, the arm is likely to permanently deform in function and to apply excessive force to the tooth. It is also likely to make insertion and removal of the denture difficult or impossible.




### *Statement 13.9 — A retentive occlusally-approaching clasp should engage 0.25mm of undercut if it is constructed in cast cobalt chromium alloy*

If a cast cobalt chromium occlusally-approaching clasp engages less than 0.25mm, the inaccuracies in its production will represent a significant proportion of this value and thus the resulting retention is unpredictable.

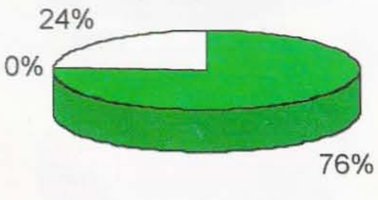
If the clasp engages more than 0.25mm it is likely that its proportional limit will be exceeded when the denture is seated or removed. The clasp thus becomes permanently deformed and therefore non-retentive.The length of a clasp is a critical factor in determining how much undercut it can safely engage (statements 13.11-13.15)




### *Statement 13.10 — If an undercut on a tooth, which needs to be clasped for retention, is less than 0.25 mm, then composite resin should be added to the tooth to create at least this amount of undercut*

The modification of tooth contour with composite resin is a conservative, simple, durable and effective way of creating undercut for clasping where no, or inadequate, undercut exists (*A Clinical Guide to Removable Partial Dentures*, Figure 15.25). The technique consists of creating a supragingival composite resin veneer that produces an undercut just detectable to the eye. A more precise check can be made by obtaining a study cast and measuring the amount of composite resin undercut with a surveyor, but in practice this is often not necessary. The composite resin should cover a broad area of the tooth surface so that it can be shaped to blend smoothly with the tooth contour (Figure 13.10a, b). A small 'button' of composite resin is less satisfactory (Figure 13.10c).

With early composite resins, the large, irregular filler particles caused significant abrasion of the clasps resulting in loss of retention and even fracture of the clasp. This does not occur with modern composite resins. Also abrasion of the composite resin by the clasp is not generally a problem particularly if a round section wrought wire clasp is employed. Abrasion of composite resin sometimes occurs when a cast gingivally-approaching clasp is used since the tip of the clasp can act like a chisel.

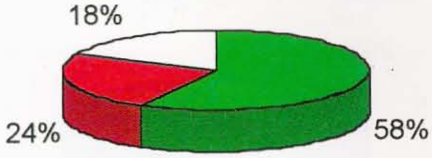


Other ways of creating undercuts for clasp retention are:

- Enameloplasty, by using a bur to create a small dimple in the enamel which can be engaged by the tip of a clasp (*A Clinical Guide to Removable Partial Dentures*, Figure 15.24).
- Metal or porcelain veneers bonded to the enamel surface.
- The fitting of suitably contoured crowns.

***Statement 13.11 — A retentive clasp should be at least 15mm in length if it is constructed in cast cobalt chromium alloy***

For the retentive tip of a cobalt chromium clasp to flex 0.25mm without deforming permanently, it needs to be about 15mm in length (Figure 6.10). This length can usually be achieved with an occlusally-approaching clasp on a molar tooth, and a gingivally-approaching clasp on any tooth.

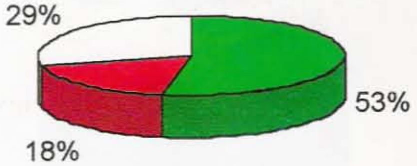



***Statement 13.12 — Occlusally-approaching retentive clasps should be restricted to molar teeth if constructed in cast cobalt chromium alloy***

An occlusally-approaching clasp on a molar tooth will be about 15mm in length, but on a premolar or canine tooth will be considerably less than this. A ring clasp on a molar tooth may be longer than 15mm, but the increased curvature results in a corresponding increase in stiffness so that an undercut of 0.25mm remains the maximum that can be engaged safely.

A gingivally-approaching clasp can be made longer than 15mm and in such cases the clasp can engage a depth of undercut greater than 0.25mm.

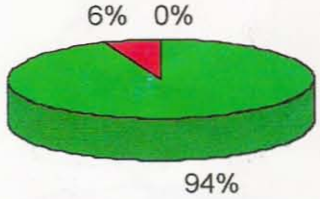
It should be remembered that a clasp may be used for stability rather than retention and in this case the above statement does not apply. A short cobalt chromium occlusally-approaching clasp placed on a non-undercut area of a tooth is ideal for this purpose. Even though such a clasp is for bracing and does not engage undercut, it may make a contribution to retention through frictional contact with the tooth.




***Statement 13.13 — A retentive clasp should engage 0.5mm of undercut if it is constructed in wrought wire***

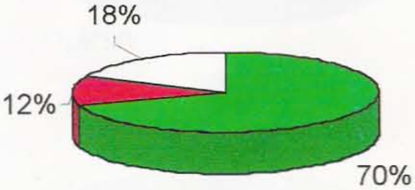
A wrought stainless steel or gold wire clasp is more flexible than a comparable design of cast clasp in cobalt chromium alloy and therefore needs to engage a greater depth of undercut to generate equivalent retention. As a wrought wire clasp has a higher proportional limit than a cast clasp (Figure 6.9) it can engage this increased undercut without deforming permanently.

There can be technical difficulties in the production of accurately fitting wrought wire clasps as the required skill is not universally available.



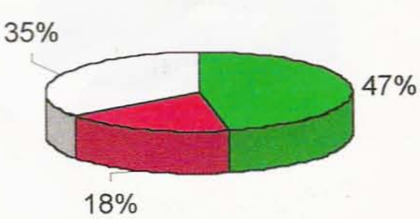

***Statement 13.14 — A retentive clasp should be at least 7 mm in length if it is constructed in wrought wire***

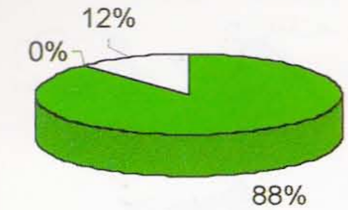
A wrought clasp of about 7mm in length can engage 0.5mm of undercut without deforming permanently. However, if the wrought clasp is shorter that 7mm, flexing into this undercut is likely to result in permanent deformation.




***Statement 13.15 — If an occlusally-approaching retentive clasp is used on a premolar or canine it should be constructed in wrought wire***

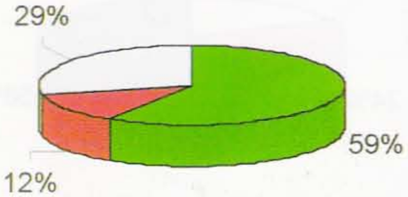
A premolar or canine tooth is usually wide enough mesiodistally to accept an occlusally-approaching clasp of about 7mm in length but not much longer. A wrought clasp can therefore provide reliable retention in this situation whereas a cast clasp would be too rigid.





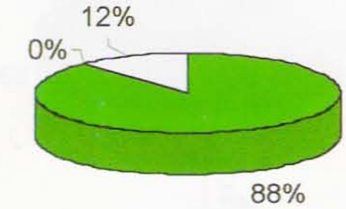

***Statement 13.16 — Retentive clasps should usually be placed buccally on upper teeth***

Retentive clasps should obviously only be placed where suitable undercuts exist or can be created. The statements 13.16–13.18 are commonly true because they reflect the usual distribution of tooth undercuts that are available for clasp retention. In the molar region this distribution of undercuts is associated with the tilt of the teeth creating the Curve of Monson.



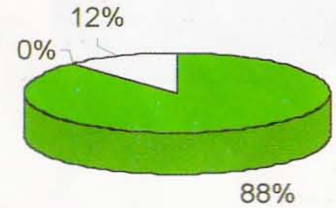

***Statement 13.17 — Retentive clasps should usually be placed lingually on lower molar teeth.***

Undercuts suitable for retentive clasping of lower molar teeth are most frequently located lingually.



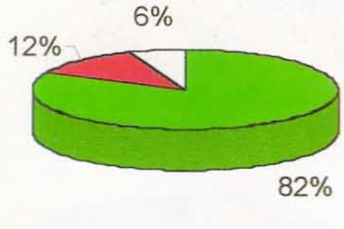

***Statement 13.18 — Retentive clasps should usually be placed buccally on lower premolar or canine teeth***

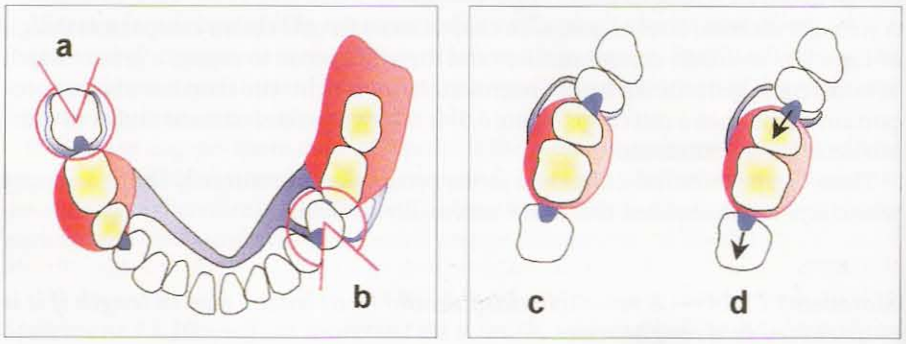
Undercuts suitable for retentive clasping of lower premolar or canine teeth are most frequently located buccally.




***Statement 13.19 — Where there are clasps on opposite sides of the arch, the retentive arms are best placed on opposing tooth surfaces, ie buccal/buccal or lingual/lingual***

This is because the retentive clasps then move along divergent paths of displacement. This is sometimes referred to as 'cross-arch reciprocation' (Figure 7.15). It is not as effective as reciprocation via guide surfaces on the clasped teeth as relative movement of the teeth within the periodontal ligaments is not prevented.




***Statement 13.20 — Retentive and bracing/reciprocating elements of a clasp should encircle the tooth by more than 180 degrees***

This is the principle of 'encirclement'. Unless encirclement is achieved the clasp can move away from the tooth (or vice versa) and thus lose its retentive and bracing functions.

Encirclement can be by a combination of retentive and bracing clasp arms (Figure 13.20a), or by clasps and guide plates as in the RPI system (Figure 13.20b).

Any attempt at utilising teeth other than the clasped tooth to provide bracing to prevent the clasp 'escaping' is not an effective substitute for encirclement. This is because loss of contact of the clasp with the tooth can still occur as a result of the movement of one tooth in relation to the other (Figures 13.20c and d).

*Statement 13.21 — Reciprocation should be provided on a clasped tooth diametrically opposite the retentive clasp tip*

Reciprocation (Figures 7.12–7.15) is resistance to:

a) Displacement of a tooth by a direct retainer.

If a retentive clasp is not reciprocated, the clasp will apply a horizontal force to a tooth as it moves towards the height of contour of the tooth and this will displace the tooth within the periodontal ligament. This movement of the tooth will reduce the retentiveness of the clasp.

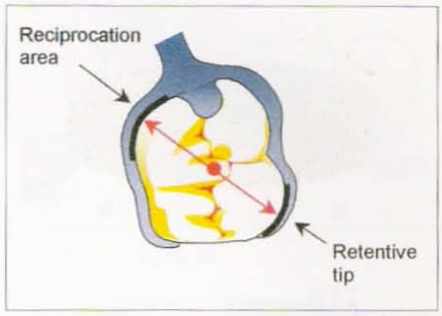
b) Escape of a direct retainer from an undercut.

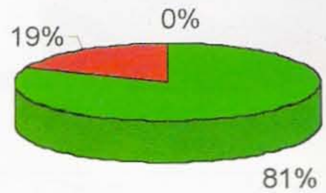
If there is no reciprocation, the clasp will be able to escape from the undercut without flexing and creating a retentive force.

The most effective location for a reciprocating component is:

a) On the clasped tooth

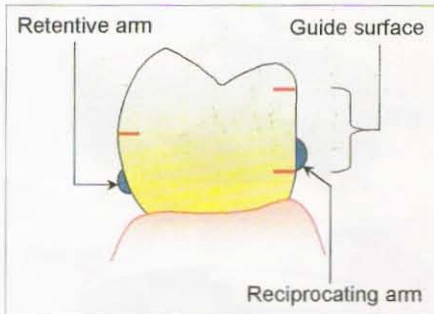
b) Diametrically opposite the retentive tip of the clasp.However, (a) is more important than (b) although the further that the reciprocation is from the ideal position the greater is the potential for tooth or denture movement resulting in reduced retention.It should be remembered that the RPI system does not conform to (b) as effective reciprocation is provided by the combination of mesial and distal guide plates that are not diametrically opposite the I-bar (Figure 6.26).

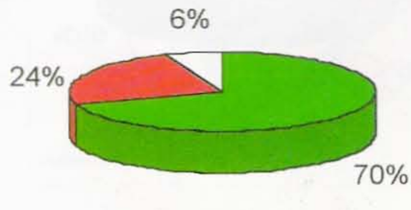


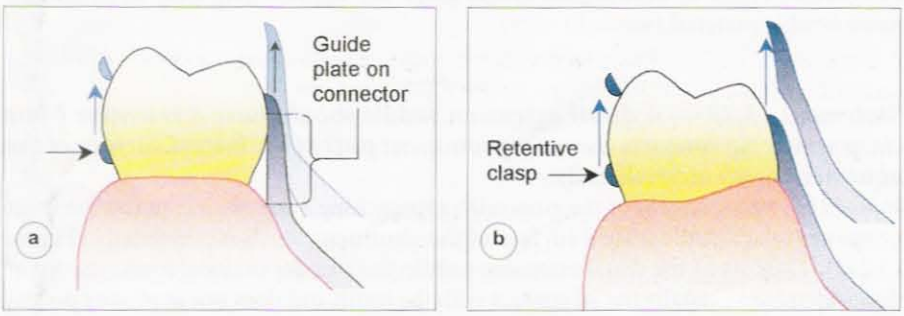

*Statement 13.22 — If a reciprocating clasp, rather than a plate, is used it should be placed at the gingival end of a guide surface on the clasped tooth*

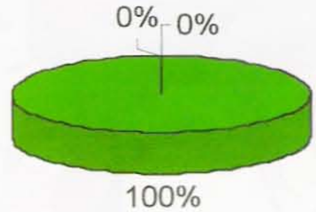
If the reciprocating clasp is placed at the gingival end of a guide surface (which is usually 2–3mm in length), it will maintain contact with that surface as the retentive clasp moves through the retentive distance. Reciprocation will therefore be maintained for as long as the retentive clasp is active.



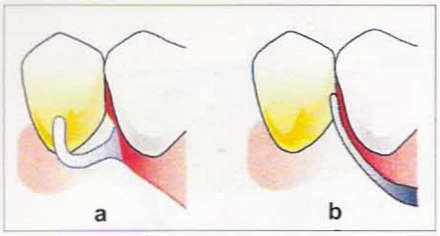



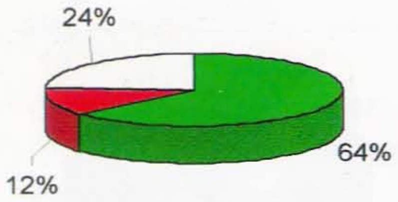

*Statement 13.23 — Where a plate connector is used, reciprocation can be obtained by a guide plate on the connector*




Where a plate major connector contacts a clasped tooth, a guide surface can be incorporated into it by using a surveyor to block out undercuts on the master cast prior to fabricating the refractory cast. The guide surface is therefore made parallel to the planned path of insertion and removal of the denture (Figure 13.23a). However, reciprocation will not be provided by a plate if the tooth surface contacted has no undercut (Figure 13.23b).

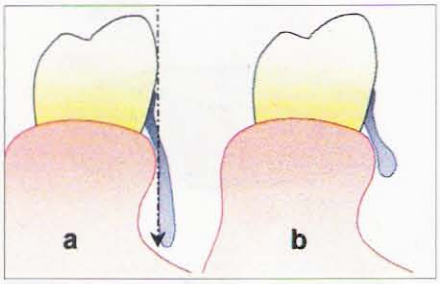


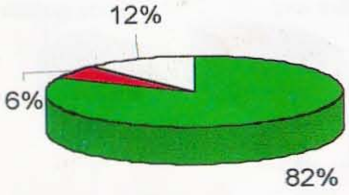




***Statement 13.24 — A gingivally-approaching clasp is contraindicated if the buccal sulcus is less than 4mm in depth***

A sulcus of less than 4mm does not have sufficient depth to accommodate a gingivally-approaching clasp without much of the length of the clasp arm being placed too close to the gingival margin (Figure 13.24a).

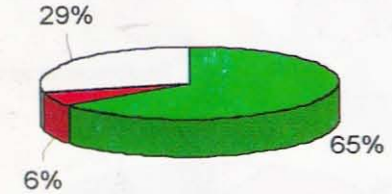
An exception to this statement is the 'De Van' clasp which is a gingivally-approaching clasp running along the border of the saddle to engage the disto buccal undercut of the abutment tooth. It does not enter the sulcus area buccal to the clasped tooth (Figure 13.24b).




***Statement 13.25 — Gingivally-approaching clasps are contra indicated if there is a tissue undercut buccally on the alveolus more than 1mm in depth within 3mm of the gingival margin***

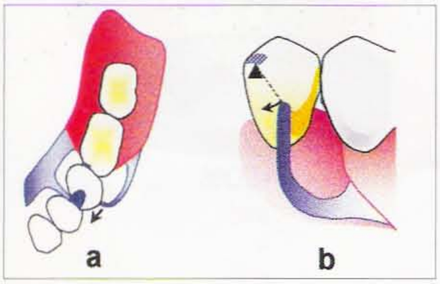
An undercut of these dimensions results in the gingivally-approaching clasp being relieved extensively from the attached mucosa so that the denture can be inserted without traumatizing the tissues. Such relief causes the arm of the clasp to be excessively prominent, resulting in possible irritation of the buccal mucosa, and the trapping of food debris (Figure 13.25a). Alternatively, if the clasp arm is placed on the mucosa survey line it is likely to be too prominent and too close to the gingival margin (Figure 13.25b).

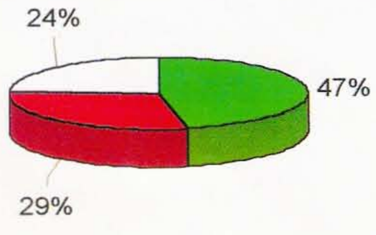



***Statement 13.26 — A gingivally-approaching clasp should be used if a retentive cast cobalt chromium clasp is required on a premolar or canine tooth, assuming that sulcus anatomy is favourable***

A gingivally-approaching clasp is an appropriate choice under such circumstances as it can be made long enough to achieve adequate flexibility.

Canine and premolar teeth obviously vary in their mesiodistal dimension but are generally of the order of 7mm. A cast cobalt chromium occlusally-approaching clasp may be a little longer than this (allowing for the curvature of the tooth surface and the fact that the clasp passes diagonally across the tooth). However, this may not be long enough to ensure that such a clasp has adequate flexibility and is working within its proportional limit. Therefore, on such teeth, more effective and reliable clasping can be obtained either by utilizing the longer gingivally-approaching clasp or by using a more flexible material (wrought wire).



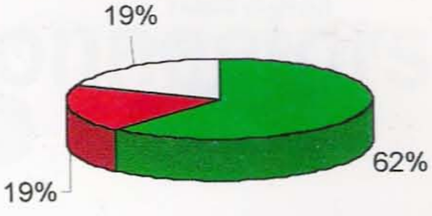




***Statement 13.27 — A distal extension saddle should have a retentive I-bar clasp whose tip contacts the most prominent part of the buccal surface of the abutment tooth mesiodistally.***

In the RPI system, the tip of the gingivally-approaching I-bar clasp contacts the most prominent part of the buccal surface of the abutment tooth mesiodistally (Figure 13.27a). Thus when the distal extension saddle sinks under occlusal loads, the tip of the clasp moves mesially out of contact with the tooth and does not apply any potentially damaging torque to it (Figure 13.27b).

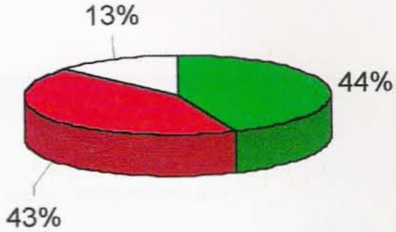
***Statement 13.28 — The RPI system (Rest, Plate, I-bar clasp) should be used on premolar abutment teeth for mandibular distal extension saddles if the tooth and buccal sulcus anatomy is favourable***

The RPI system is described in Figures 6.26–6.28.




***Statement 13.29 — The RPI system (Rest, Plate, I-bar clasp) should be used on premolar abutment teeth for maxillary distal extension saddles if the tooth and buccal sulcus anatomy is favourable***

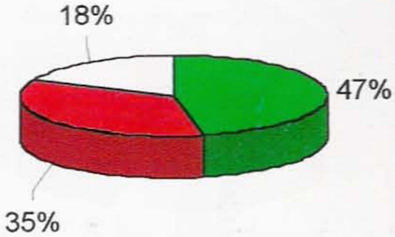
The RPI system is not such a popular choice for the maxilla as in the mandible, possibly because the potential for support from the denture-bearing area is greater in the maxilla than in the mandible, ie the 'support deficit' is less. The potential for harmful torque forces being applied to the abutment tooth is therefore reduced.




***Statement 13.30 — If the retentive clasp for a distal extension saddle is on a premolar or canine abutment, it should be either a cast gingivally-approaching I-bar or a wrought wire occlusally-approaching clasp.***

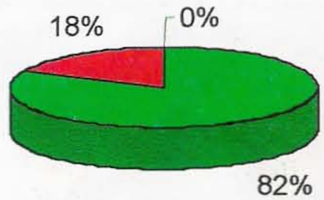
These are two types of clasp that minimize the chance of applying damaging torque to the abutment teeth of distal extension saddles.

In the case of a wrought wire occlusally-approaching clasp, the ability of the round section wire to flex in any direction also assists in avoiding potentially damaging torque.




***Statement 13.31 — A distal extension saddle should have a retentive clasp on the abutment tooth***

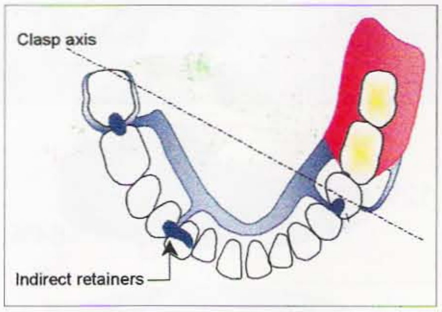
When practicable it is desirable to place a retentive clasp on the abutment tooth adjacent to a distal extention saddle so that one end of the clasp axis is located as close to the saddle as possible (see statement 13.32)

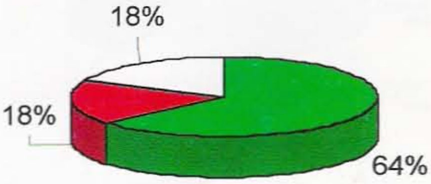


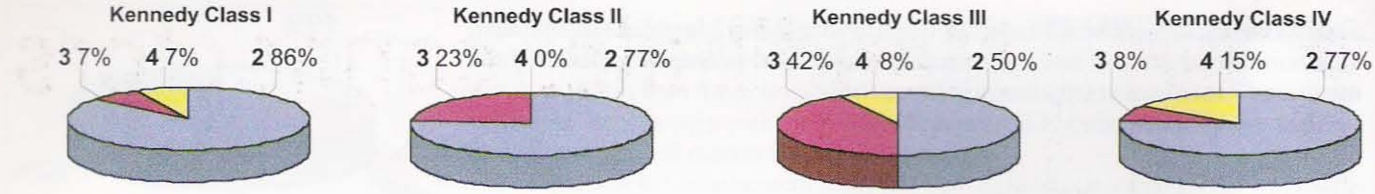

***Statement 13.32 — A unilateral distal extension saddle denture (Kennedy II) should have one clasp as close to the saddle as possible and the other as far posteriorly as possible on the other side of the arch***

These principles:

- Provide the most efficient direct retention for the mesial end of the saddle.
- Locate the clasp axis as far posteriorly as possible so that the most effective indirect retention can be provided for the distal extension saddle.



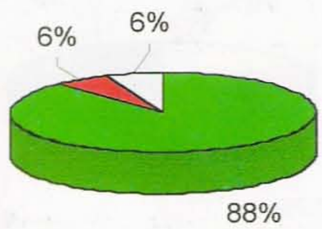



***Statement 13.33 — Rather than making a design statement this section poses a question: 'What is the preferred number of clasps for RPDs restoring each of the Kennedy classes of partially dentate arch?'***

The pie charts indicate the percentage of prosthodontists preferring 2, 3 or 4 clasps for each of the Kennedy classes.

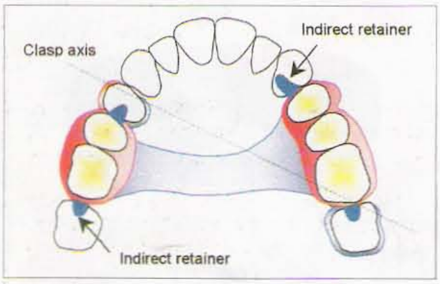
For all of the Kennedy classes the use of two clasps is the most popular choice for RPD retention. Two clasps are advantageous because:

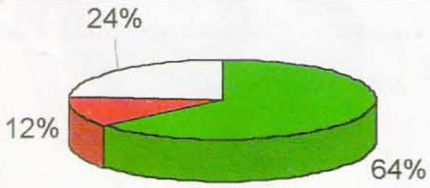
- Simple denture designs are often better tolerated and minimize tissue coverage.
- Two clasps usually generate sufficient retention.
- A pair of clasps creates a clasp axis that can be positioned to bisect the denture and allow indirect retention to be obtained.




***Statement 13.34 — Bounded saddles should have a clasp at least at one end***

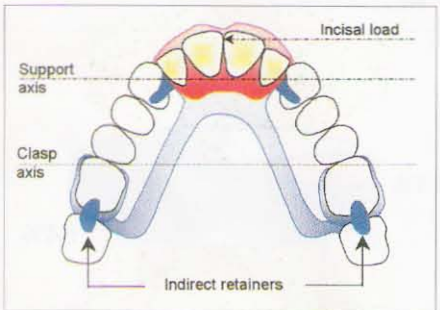
This allows for the utilization of indirect retention if required (see statement 13.35).

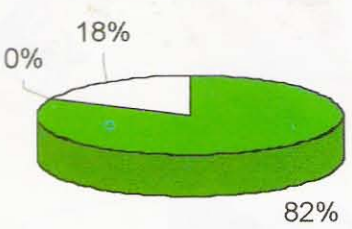



***Statement 13.35 — A Kennedy III Modification 1 denture should have two retentive clasps forming a diagonal clasp axis which bisects the denture***

If one end of a bounded saddle has a retentive clasp the other end will tend to be lifted by displacing forces. This tilting effect can be resisted by using an indirect retainer. If a bounded saddle has no direct retainer at either end indirect retention cannot be used to assist in the stabilization of the saddle.




***Statement 13.36 — A Kennedy IV denture should have retentive clasps on the first molars if there is suitable undercut present***

This is usually a good site for a pair of clasps retaining a Kennedy IV denture because:

- Normally the clasps are far enough posteriorly to be aesthetically acceptable. In those cases, usually maxillary RPDs, where clasps on the first molars would be too visible, it might be better to place the clasps even further back on the second molars if suitable sites exist.
- The molar is a sufficiently large tooth for cast occlusally-approaching clasps to be long enough to achieve adequate flexibility and resistance to permanent deformation.
- The clasps are sufficiently posterior to the support axis of the saddle to efficiently resist tipping of the denture as the result of incising forces, ie to provide indirect support for the saddle.
- If the retentive tips of the clasps can be placed mesially on the molars, the occlusal rests on the molar teeth will provide some indirect retention for the anterior saddle. In this instance the indirect retainers will be relatively close to the clasp axis and therefore their effectiveness will be limited. However, some direct retention is already likely to have been obtained for the anterior saddle by the saddle contacting guide surfaces on the abutment teeth and by the labial flange engaging undercut on the ridge. Therefore the modest indirect retention provided by the molar rests may be sufficient to stabilize the RPD.

# 14 Mandibular connectors

## Design Statements

**14.1** A mandibular major connector should be rigid.

**14.2** A bar connector is preferred to a plate connector.

**14.3** A sub-lingual bar is preferred to a lingual bar.

**14.4** The upper border of a lingual or sub-lingual bar connector should not be placed closer than 3mm to the gingival margins.

**14.5** The minimum cross-sectional dimensions of a lingual bar should be 4mm occluso-gingivally and 2mm in width.

**14.6** A lingual bar connector requires a minimum depth of lingual sulcus of 7mm.

**14.7** The minimum cross-sectional dimensions of a sub-lingual bar are 2mm in height and 4mm in width.

**14.8** A sub-lingual bar requires a minimum sulcus depth of 5mm.

**14.9** A lingual plate is indicated if the sulcus depth is less than 5mm.

**14.10** A lingual plate requires support at either end from occlusal rests in positive rest seats.

**14.11** If the lower natural anterior teeth have a questionable prognosis, a lingual plate is indicated to facilitate additions to the denture if they should prove necessary in the future.

**14.12** A lingual plate is indicated if mandibular tori are present whose surgical removal is contra-indicated.

**14.13** A dental bar (modified continuous clasp) should be 4mm in depth and 2mm in thickness.

**14.14** A dental bar requires a clinical crown height of 8mm.

**14.15** A dental bar requires positive rest seats.

**14.16** A dental bar should not be used if there are diastemas between the anterior teeth.

**14.17** A dental bar should not be used if the anterior teeth show marked crowding.

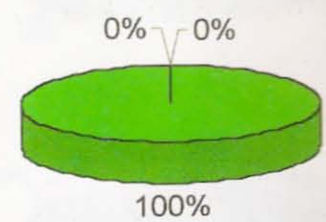
**14.18** If the mandibular anterior teeth show marked lingual tilting, a labial bar is likely to be indicated.

**14.19** The combination of Kennedy bar (continuous clasp) with lingual bar is obsolete.

**14.20** Stress breaking (stress directing, flexible major connector, movable attachment) is indicated for mandibular Kennedy Class I cases in which 47,46,45,35,36,37 are being replaced.

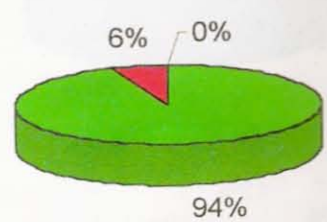
**14.21** Stress breaking (stress directing, flexible major connector, movable attachment) is indicated for mandibular Kennedy Class II cases in which 47, 46, 45, or 35, 36, 37 are being replaced.

## Prosthodontic opinion on mandibular connector design



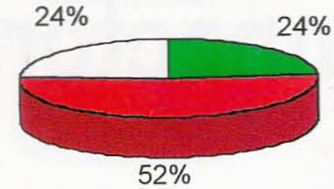

*Statement 14.1 — A mandibular major connector should be rigid*

A rigid connector is able to efficiently distribute forces that are applied to one part of the denture around other supporting structures in the dental arch. This distribution lessens the risk of individual teeth, or the residual ridges, being overloaded and also increases the stability of the prosthesis.




*Statement 14.2 — A bar connector is preferred to a plate connector.*

A bar connector (lingual, sublingual, dental or labial bars) leaves the gingival margins uncovered and will not therefore contribute directly to deterioration in gingival health. Lingual plates, on the other hand, have been shown to stimulate plaque growth more than bars, and may directly traumatize the gingivae if inadequately supported.

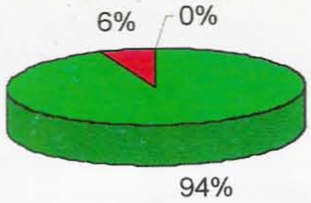



***Statement 14.3 — A sub-lingual bar is preferred to a lingual bar***

This is not supported by the results of the survey. However, it has been suggested that the sublingual bar (Figure 9.9) has the following advantages over the conventional lingual bar (Figure 9.10):

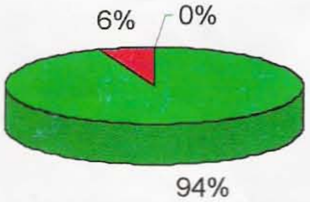
- As its greatest cross-sectional dimension is horizontally oriented, it is more rigid in this plane than a conventional lingual bar for the same cross-sectional area. It therefore distributes horizontal forces around the arch more efficiently.
- It can be used in a shallower lingual sulcus than a conventional lingual bar and therefore has a wider application.
- Its shape is determined by the anatomical form (depth and width) of the lingual sulcus. This, together with the smaller height of the sublingual bar, means that it can be placed lower in the sulcus than a conventional lingual bar and be less obtrusive to the tongue.

To be successful the sublingual bar has to conform accurately to the functional height and width of the lingual sulcus. A very precise, correctly border-moulded impression of the lingual sulcus is therefore essential (*A Clinical Guide to Removable Partial Dentures*, Figure 16.23–16.25).



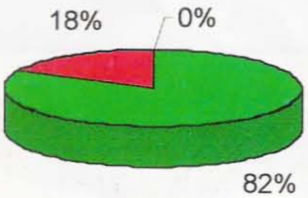

***Statement 14.4 — The upper border of a bar connector should not be placed closer than 3mm to the gingival margins***

This is widely accepted as the closest that the connector can approach the gingival margin without begining to sacrifice the benefits of uncovering the gingivae.




***Statement 14.5 — The minimum cross-sectional dimensions of a lingual bar should be 4 mm occluso-gingivally and 2 mm in width***

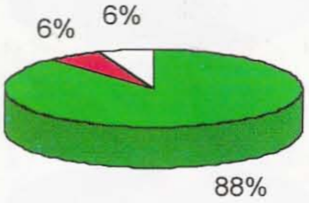
These dimensions result in a bar that has acceptable rigidity to distribute forces efficiently around the dental arch.




***Statement 14.6 — A lingual bar connector requires a minimum depth of lingual sulcus of 7 mm***

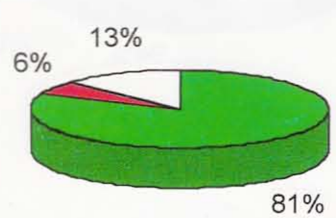
The total of the dimensions given in design statements 14.4 and 14.5 for gingival clearance and the height of a lingual bar is 7mm. In order for a lingual bar to be placed in a sulcus of this minimum depth a meticulous impression technique with precise lingual border moulding is required.

If the sulcus is shallower than this, alternative connectors (sublingual bar, dental bar or, if there is no other possibility, lingual plate) should be considered.




***Statement 14.7 — The minimum cross-sectional dimensions of a sub-lingual bar are 2 mm in height and 4 mm in width***

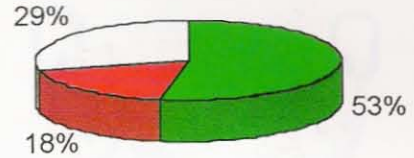
These dimensions result in a bar that has sufficient rigidity to distribute forces efficiently around the dental arch. However, the width of the sublingual bar is limited by the functional width of the lingual sulcus. Therefore if part of the sulcus is narrower than 4 mm a compromise will be necessary with the sublingual bar in the affected area approaching the cross-section and rigidity of the lingual bar.




***Statement 14.8 — A sublingual bar requires a minimum sulcus depth of 5mm***

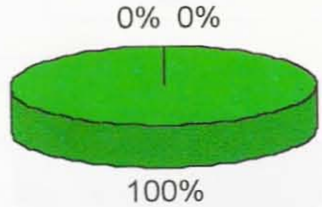
The total of the dimensions for minimal gingival clearance and the height of a sublingual bar is 5 mm. If the sulcus is shallower than this, alternative connectors (dental bar or, if it is unavoidable, lingual plate) should be considered.

***Statement 14.9 — A lingual plate is indicated if the sulcus depth is less than 5mm.***



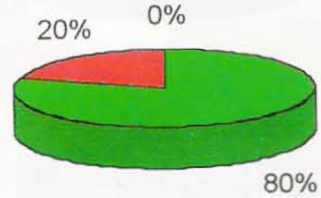

A sulcus of less than 5mm in depth is too shallow for a lingual or sublingual bar. The healthiest alternative would normally be a dental bar if the anterior crown morphology and arrangement are suitable (Figures 9.12–9.14, statements 14.13–14.17). However, if the anterior teeth are not suitable for a dental bar, a lingual plate (Figure 9.15) would have to be considered in spite of the threat it poses to oral health.

***Statement 14.10 — A lingual plate requires support at either end from occlusal rests in positive rest seats***




If a lingual plate is not supported it will tend to slip down the teeth when the saddles are loaded and traumatize the gingivae.

***Statement 14.11 — If the lower natural anterior teeth have a questionable prognosis, a lingual plate is indicated to facilitate additions to the denture should they prove necessary in the future***

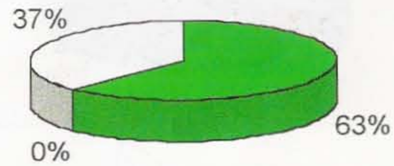



This is an illustration of the application of the important principle of contingency planning so that the failure of one aspect of treatment, in this instance the extraction of one or more teeth after the RPD has been fitted, does not result in the failure of another aspect, here the RPD. The assumption is that if a tooth needs to be added to the denture, it would be easier to do so by attaching it to a lingual plate than to a bar.

However, although the majority view of the prosthodontic experts was in favour of this design statement there were some strong reservations. One was that the situation described is unrealistic as it is unlikely that a metal denture would be provided when the remaining teeth have such a poor prognosis.

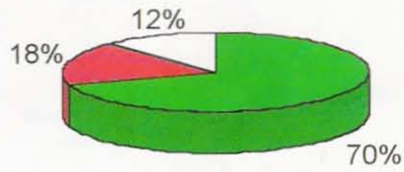
Another strongly felt concern was that the situation described presents a dilemma as the poor prognosis of the remaining teeth is likely to be due to their periodontal status and yet the use of a lingual plate, rather than a bar, will hasten further periodontal deterioration. The dentist may therefore prefer to use a bar connector uncovering the gingival margins and then, if necessary, add any teeth that subsequently need to be extracted. The introduction of 4-meta resins, which adhere to etched cobalt chromium, has made such additions simpler.

***Statement 14.12 — A lingual plate is indicated if mandibular tori are present whose surgical removal is contraindicated***

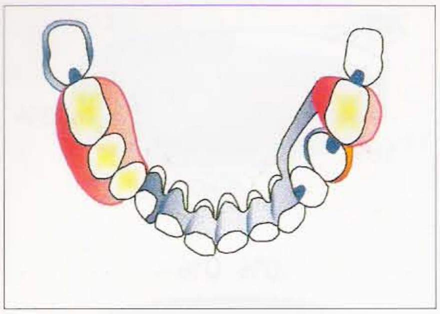


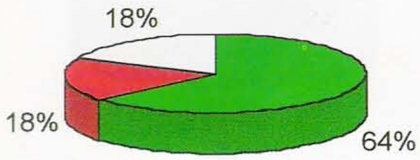

As a lingual plate is relatively thin it may be placed over mandibular tori without increasing their prominence unduly and creating problems of tolerance. However, a healthier alternative would be a dental bar.

***Statement 14.13 — A dental bar (modified continuous clasp) should be 4mm in depth and 2mm in thickness***




These are the dimensions required to ensure that a cobalt chromium dental bar functions as a rigid component.

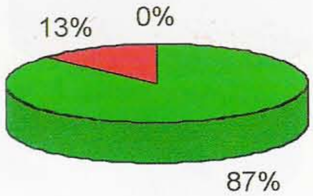





***Statement 14.14 — A dental bar requires a clinical crown height of 8 mm***

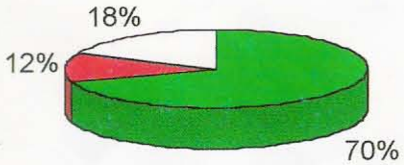
The lingual surfaces of the natural teeth must have sufficient crown height to accommodate the optimum dimensions of the dental bar and to permit the connector to be at least 1mm inferior to the incisal edges and to be clear of the gingival margins.

The anatomical constraints placed on the maximum dimensions of a dental bar should encourage caution in using this as the sole connector over more than six teeth. For lengths greater than this the strength and rigidity of the connector become questionable. Additional connectors may then need to be combined with the dental bar as shown in the figure where a sublingual bar has been used in the 34, 35 region.



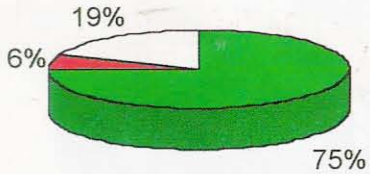

***Statement 14.15 — A dental bar requires positive rest seats***

As a dental bar commonly rests on inclined tooth surfaces it is unlikely to be able to provide efficient support for the denture. Also, if a dental bar is not supported it will tend to slip down the teeth when the saddles are loaded and so traumatize the gingivae.



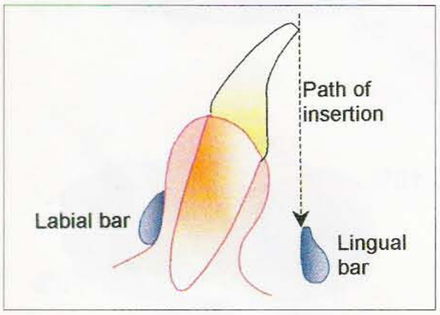

***Statement 14.16 — A dental bar should not be used if there are spaces between the anterior teeth***

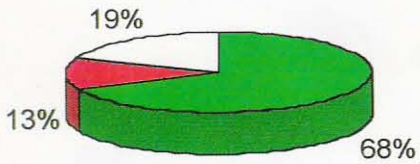
In this situation the metal of the dental bar will be visible between the teeth and the appearance may therefore be poor (Figure 9.14).




***Statement 14.17 — A dental bar should not be used if the anterior teeth show marked crowding***

This is because it can be difficult or impossible to fit a dental bar satisfactorily into the irregularities and undercuts associated with very crowded teeth. However, the crowding needs to be extreme before a dental bar is excluded.

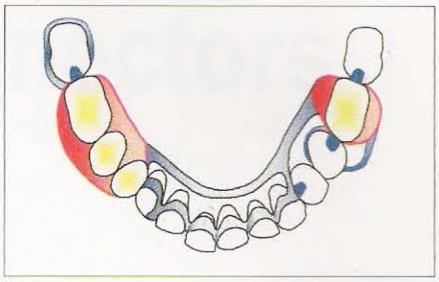



***Statement 14.18 — If the mandibular anterior teeth show marked lingual tilting, a labial bar is likely to be indicated***

If a lingual connector is used when there are lingual undercuts present, it will have to be sufficiently spaced from the lingual mucosa to clear any interference on insertion and removal. Such prominent positioning of the connector is likely to be poorly tolerated by the patient. The use of a labial bar (Figure 9.16) provides a solution to this problem.

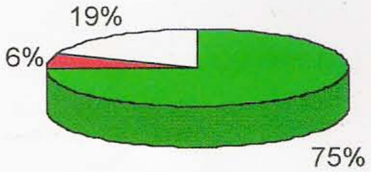
***Statement 14.19 — The combination of Kennedy bar (continuous clasp) with lingual bar is obsolete***



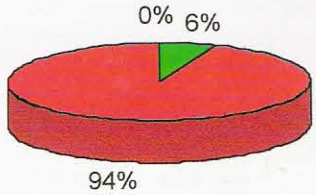
This double bar arrangement (Figure 9.13) was devised to impart sufficient rigidity to a connector made in gold alloy. It has been said to be obsolete because the improved mechanical properties of the cobalt chromium alloys allow connectors to be made with smaller cross-sections whilst retaining sufficient strength and rigidity for bars to be used singly.

Functionally the Kennedy bar with lingual bar can be regarded as a lingual plate 'with a hole', ie they provide the functions of a lingual plate while leaving the gingival margins uncovered. This combination of connectors can therefore still have a place when:

- The connector has to cross long spans.
- Additional bracing, support or indirect retention are required.
- Anatomical constraints such as a shallow lingual sulcus or short clinical crowns prevent the placement of individual bars of sufficient thickness.
- A simple means of attaching denture teeth is required if further loss of anterior natural teeth is anticipated.



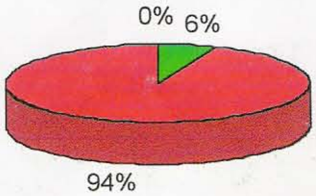

***Statement 14.20 — Stress-breaking (stress-directing, flexible major connector, movable attachment) is indicated for mandibular Kennedy Class I cases in which 47, 46, 45, 35, 36, 37 are being replaced.***




Stress-breaking has long been a controversial subject in RPD design (Figure 9.19). The flexibility of this type of connector is intended to reduce the load falling on a vulnerable abutment tooth and redirect it to the edentulous area. Some designs also aim to achieve a more favourable, uniform distribution of load over the denture-bearing mucosa. However, there is little evidence, either from *in vitro* or *in vivo* studies, that these aims can be predictably achieved. In addition, flexible connectors:

- Are more difficult and expensive to manufacture.
- Are less reliable and require more maintenance.
- Can give rise to unpredictable saddle movements resulting in damaging forces being applied to supporting structures.

***Statement 14.21 — Stress-breaking (stress-directing, flexible major connector, movable attachment) is indicated for mandibular Kennedy Class II cases in which 47, 46, 45, or 35, 36, 37 are being replaced***




Stress-breaking is just as unpopular for Kennedy II RPDs as for Kennedy I RPDs.

# 15 Maxillary connectors

## Design Statements

**15.1** A maxillary major connector should be rigid.

**15.2** A connector should be as symmetrical as possible.

**15.3** A connector should cross the mid-sagittal line of the hard palate at right angles.

**15.4** A connector should be reduced in area as much as support and strength requirements allow.

**15.5** A connector should uncover the anterior part of the hard palate if possible.

**15.6** A connector should uncover posterior part of the hard palate if possible.

**15.7** A connector crossing the anterior palate should have its borders placed in the valleys between the rugae.

**15.8** A maxillary connector should uncover gingival margins by at least 6 mm.

**15.9** A connector should cover the gingivae if there are only six anterior teeth remaining.

**15.10** A connector should cover the gingival margin of a single tooth separating two saddles.

**15.11** A connector should cross the gingival margins at right angles.

**15.12** The axes of minor connectors should be at right angles to the dental arch.

**15.13** A connector should have smooth curved outlines.

**15.14** A connector should have a simple shape.

**15.15** The connector for a distal extension saddle should be extended widely over the hard palate so that it can provide mucosal support for the saddle.

**15.16** The connector for a tooth-supported RPD should be an anterior horseshoe plate when there are saddles or minor connectors anteriorly and in the premolar and first molar regions.

**15.17** The connector for a tooth-supported RPD should be a middle palatal plate if the saddles and minor connectors are restricted to the molar and/or premolar regions.

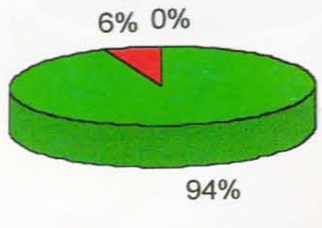
**15.18** The connector for a tooth-supported RPD should be a ring design if: -
- There are saddles or minor connectors in each of the following dental segments (876) (321) (123) (678),
- Separation of anterior and posterior plates by at least 15mm is possible.

**15.19** Where there is a palatine torus, it should be avoided by using an anterior plate, posterior plate or ring design depending on the location of the torus.

**15.20** Stress breaking (stress directing, flexible major connector, movable attachment) is indicated for a maxillary Kennedy Class I RPD replacing 17,16,15 and 25,26,27.

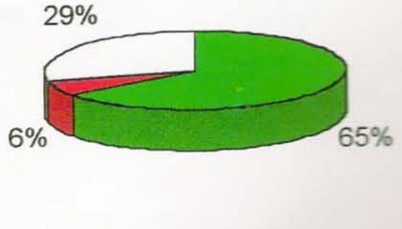
**15.21** Stress breaking (stress directing, flexible major connector, movable attachment) is indicated for a maxillary Kennedy Class II RPD replacing 17,16,15 or 25,26,27.

## Prosthodontic opinion on maxillary connector design



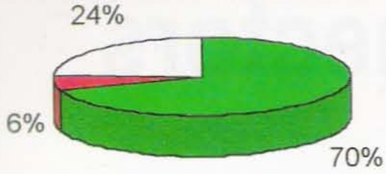

### *Statement 15.1 — A maxillary major connector should be rigid*

A rigid connector is able to distribute forces applied to one part of the denture around other supporting structures in the dental arch. This distribution lessens the risk of individual teeth or the residual ridges being overloaded, and increases the stability of the prosthesis.



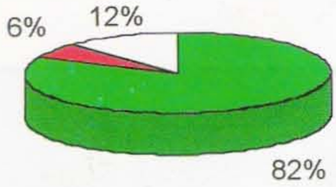

### *Statement 15.2 — A connector should be as symmetrical as possible*

Although this statement was supported in the survey, evidence to indicate that it is important in RPD design is lacking. In any event the particular distribution of edentulous areas in a patient often makes symmetry unachievable.




***Statement 15.3 — A connector should cross the mid-sagittal line of the hard palate at right angles***

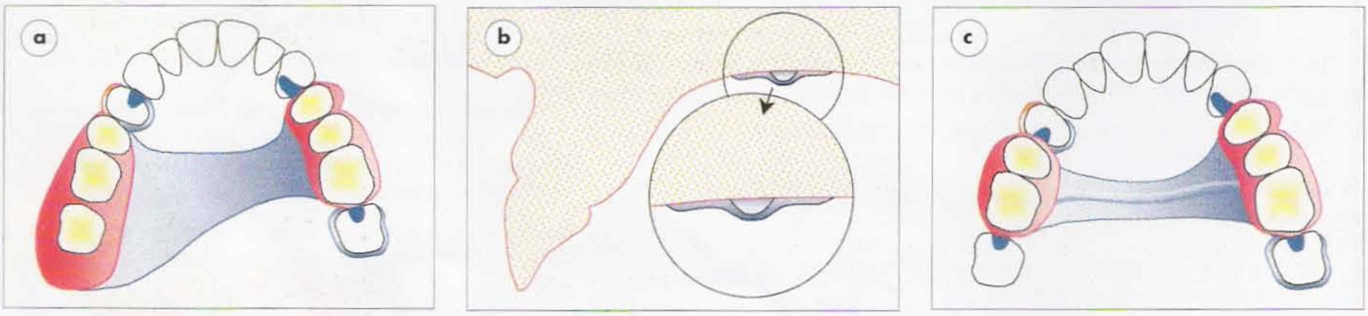
This statement was supported in the survey, but evidence to indicate that it is important in RPD design is lacking. In any event, attempting to shape the conector so that it crosses the mid-saggital line of the hard palate at right angles, when this is not required for any other reason, can unneccessarily complicate the design.

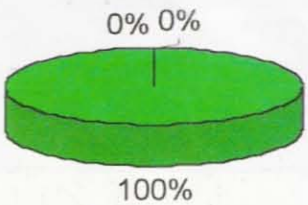



***Statement 15.4 — A connector should be reduced in area as much as support and strength requirements allow***

The connector of a tooth-supported RPD needs only to have sufficient width to ensure adequate strength. It can therefore usually be considerably narrower than the connector of a tooth- and mucosa-supported prosthesis which needs to cover enough of the denture-bearing mucosa to distribute functional loads adequately. This is illustrated in Figure 15.4a where the connector is narrow adjacent to the tooth-supported saddle but broader where it joins the tooth/mucosa supported distal extension saddle.

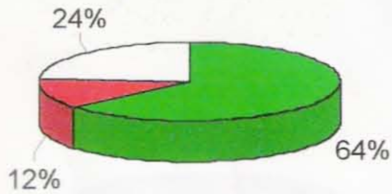
Beyond a certain point, reduction in the width of a plate has to be compensated by an increase in thickness. The plate then becomes a bar that may create problems of tolerance. Care is therefore needed to achieve an appropriate balance. A narrow plate can be strengthened with less chance of problems with tolerance if it is waxed up over a bar section making the change in contour of the connector less abrupt (Figures 15.4b and 15.4c).




***Statement 15.5 — A connector should uncover the anterior part of the hard palate if possible***

The justification for this statement is included in the discussion which follows statement 15.6




***Statement 15.6 — A connector should uncover the posterior part of the hard palate if possible***

Conforming to the principles 15.5 and 15.6 is likely to achieve the following:

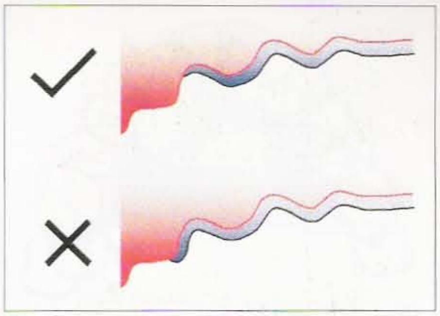
- Improve tolerance.
  The evidence from the relatively few published investigations into patients' tolerance of different maxillary connector designs is that the middle palatal plate is the most readily accepted, ie one that uncovers both anterior and posterior parts of the hard palate.
- Improve speech and increase the enjoyment of food.
  This is particularly so when the anterior palate is uncovered as this is a richly innervated area with fine sensory discrimination. In addition, it is an area of frequent tongue contact during speech so that a connector here can adversely affect speech quality.

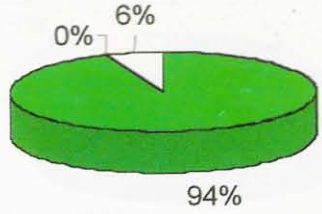
Swallowing may be affected if a bar connector is placed posteriorly across the hard palate as it can interfere with the transport of the bolus towards the oro-pharynx during swallowing.

- Improve oral health by keeping the margins of the connector away from the gingivae.

***Statement 15.7 — A connector crossing the anterior palate should have its borders placed in the valleys between the rugae***

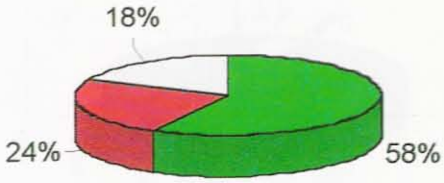
This is simply so that the borders of the connector, lying in the troughs between the rugae, are not so apparent to the tongue.






***Statement 15.8 — A maxillary connector should uncover gingival margins by at least 6 mm***

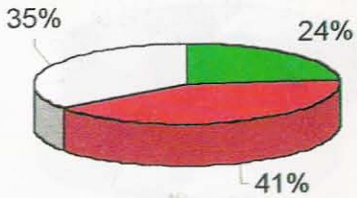
Uncovering gingival margins is widely considered to be important in maintaining oral health, as the effects of plaque accumulation and trauma from the connector are reduced. It is likely that this aim can be achieved by uncovering the gingivae by a smaller distance than that suggested in this statement. However, 3mm should be considered the minimum separation between a metal connector and gingival margins.




***Statement 15.9 — A connector should cover the gingivae if there are only six anterior teeth remaining***

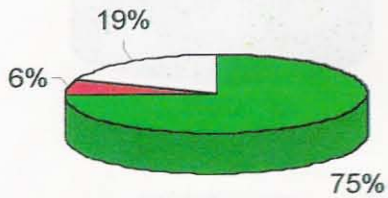
This statement is not supported in the survey; the result reflects the strength of opinion regarding the importance of uncovering gingival margins wherever possible.

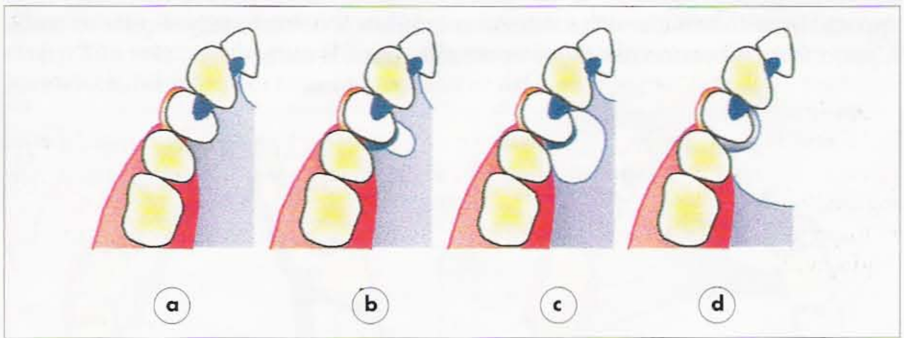
The case for covering the gingival margins and contacting the remaining teeth becomes stronger where features of the maxillary anatomy, such as a shallow palate and resorbed ridges, are unfavourable for stability and retention.

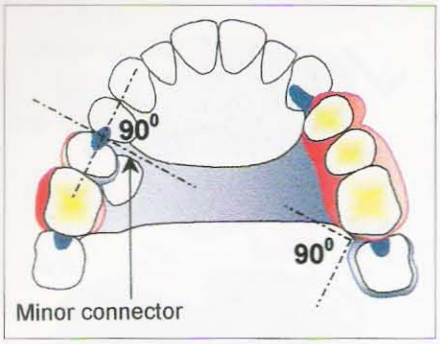



***Statement 15.10 — A connector should cover the gingival margin of a single tooth separating two saddles***

This gingival coverage (Figure 15.10a) might be the neatest solution in those cases where uncovering the gingiva around a single tooth would result in a narrow slot in the connector (Figure 15.10b). Such a narrow slot could compromise tolerance and cleanliness with only minimal benefit to gingival health. However, it is often possible to achieve adequate gingival clearance by careful shaping of the major connector and selection of an appropriate minor connector. Figure 15.10c shows reshaping of the connector to achieve generous gingival clearance around the single tooth. Figure 15.10d shows how the mesial saddle might be cantilevered from a minor connector on the palatal surface of the single tooth. This latter option requires sufficient clinical crown height to accommodate a minor connector of adequate strength.

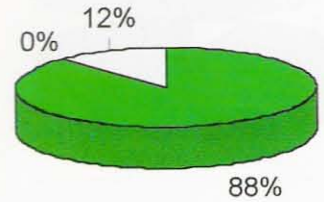


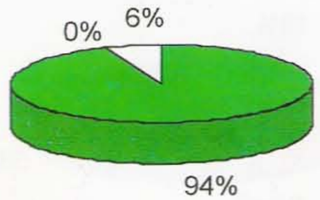






### *Statement 15.11 — A connector should cross the gingival margins at right angles*

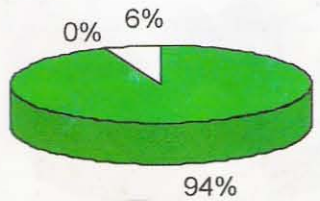
The justification for this statement is included in the discussion which follows statement 15.12



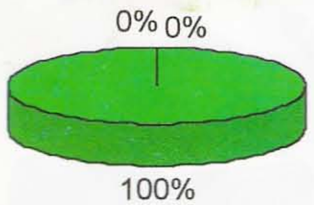

### *Statement 15.12 — The axes of minor connectors should be at right angles to the dental arch*

Conforming to statements 15.11 and 15.12 keeps the traverse of the gingivae by the connector as short as possible. It also keeps an open angle between the connector and gingivae. These features minimize the risk of the connector traumatising the gingivae and collecting food debris.



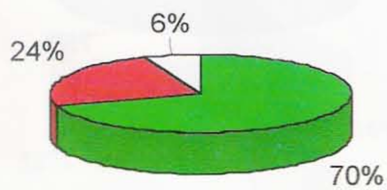

### *Statement 15.13 — A connector should have smooth curved outlines*

The justification for this statement is included in the discussion which follows statement 15.14




### *Statement 15.14 — A connector should have a simple shape*

These features mentioned in statement 15.13 and 15.14 generally contribute to tolerance and cleanliness of the connector. But in certain situations, eg when the anterior border of the connector follows the valleys of the palatal rugae, the shape of the connector can be quite complex.

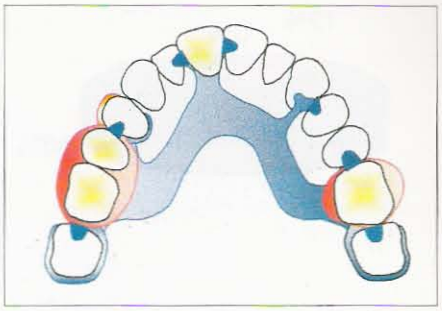


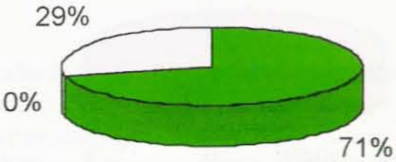

### *Statement 15.15 — The connector for a distal extension saddle should be extended widely over the hard palate so that it can provide mucosal support for the saddle*

Distal extension saddles are partially mucosally supported. Therefore extending the plate connector will improve this aspect of support (Figure 15.4a). The importance of incorporating this principle will depend on the size of the occlusal loads that are applied to the saddle and on the extent of the saddle. An estimate of these loads therefore forms an important part of the clinical assessment of the case, eg a maxillary RPD opposed by a mandibular distal extension saddle will not normally require so much support from the connector as one opposed by natural teeth.

***Statement 15.16 — The connector for a tooth-supported RPD should be an anterior horseshoe plate when there are saddles or minor connectors anteriorly and in the premolar and first molar regions***

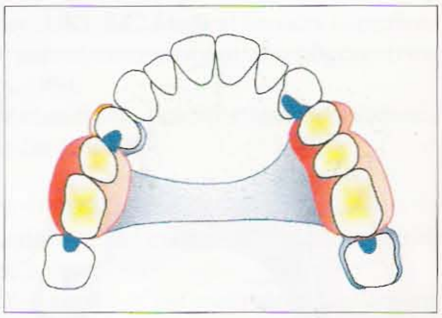
In this example the horseshoe plate connects the saddles and minor connector in an economical manner while maintaining gingival clearance and minimizing palatal coverage.

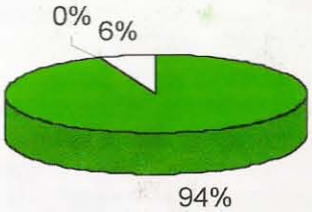





***Statement 15.17 — The connector for a tooth-supported RPD should be a middle palatal plate if the saddles and minor connectors are restricted to the molar and/or premolar regions***

This type of commector has been shown to be one of the best tolerated designs. Its potenial benifits are discussed in more detail in statement 15.6



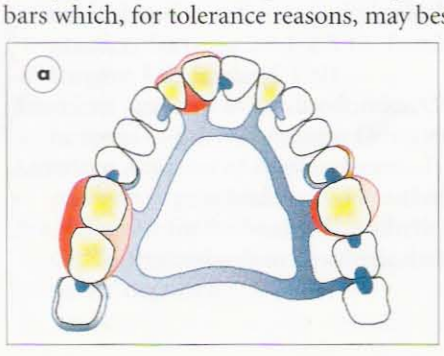


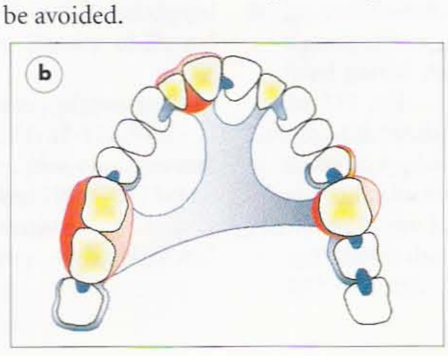

***Statement 15.18 — The connector for a tooth-supported RPD should be a ring design if:***

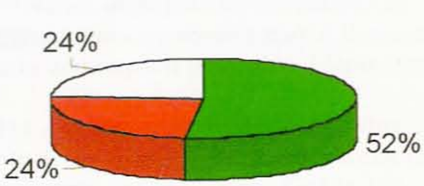
- ***there are saddles or minor connectors in each of the following dental segments (876) (321) (123) (678);***
- ***separation of anterior and posterior bars by at least 15mm is possible.***

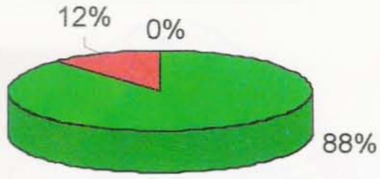
The shape of a connector for a tooth supported maxillary RPD is strongly influenced by the number and distribution of saddles. But although the design statements 15.16-15.18 attempt to describe certain saddle distributions that determine specific connector types, in reality the situation is not clear-cut. For example, the linking of saddles with the ring connector in Figure 15.18a might be achieved more simply and hygienically using the inverted 'T'-shaped connector shown in Figure 15.18b

It is worth noting that palatal ring connectors are quite common in practice even when the distribution of anterior and posterior saddles does not make this design necessary. This results in the patient being encumbered with anterior and posterior palatal bars which, for tolerance reasons, may best be avoided.



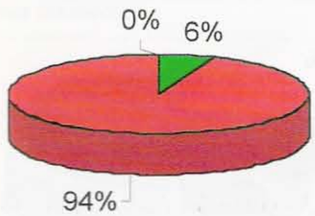






***Statement 15.19 — Where there is a palatine torus, it should be avoided by using an anterior plate, posterior plate or ring design depending on the location of the torus***

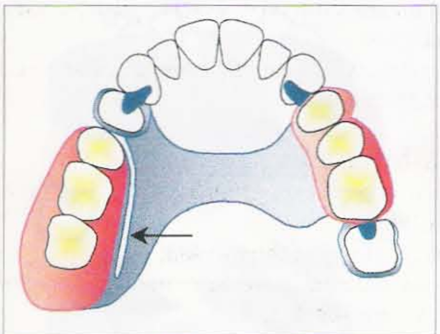
Uncovering a torus has two effects:

- It avoids the problem of discomfort being caused by pressure from the plate falling on the relatively thin mucosa covering the torus.
- It reduces difficulties with tolerance caused by the thickness of the connector being added to the prominence of the torus.



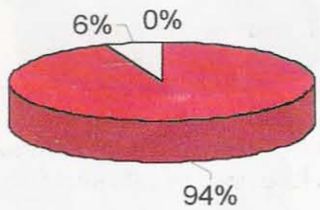

***Statement 15.20 — Stress-breaking (stress-directing, flexible major connector, movable attachment) is indicated for a maxillary Kennedy class I RPD replacing 17, 16, 15 and 25, 26, 27***

This controversial topic is discussed with Figures 9.19, and statements 14.20 and 14.21.



***Statement 15.21 — Stress-breaking (stress-directing, flexible major connector, movable attachment) is indicated for a maxillary Kennedy class II RPD replacing 17, 16, 15 or 25, 26, 27***

In the example shown in the diagram the split palatal plate is intended to allow the saddle to move under occlusal loads to a greater extent than the tooth-borne components. If the design works as intended, the loading of the abutment tooth is reduced and that of the edentulous area increased. In practice, the resulting movement of the saddle may have a lateral component that could be damaging.



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