one of the biomechanical considerations of removable partial denture design were presented in Chapter 4. The strategy of selecting component parts for a partial denture, to help control the movement of the prosthesis, has been highlighted as a method to consider for logical partial denture design. There are many factors that affect the movement potential of a partial denture. Factors that are within the same arch and related both to the existing teeth and the mucosa to be used for support can have a significant effect on prosthesis movement and the required design. Also, factors related to the opposing arch, tooth position, the existence and nature of remaining support in the opposing arch, and the potential for establishing a harmonious occlusal can greatly influence the partial denture design.

**CTORS INFLUENCING DESIGN**

A direct result of examination and diagnosis design of the removable partial denture components of partial denture design additional considerations influencing design self-assessment aids
bases are involved, the following must be considered:

a. Clasp designs that will best minimize the forces applied to the abutment teeth during function

b. Secondary impression method to be used

c. Need for indirect retention

d. Need for later rebasing, which will influence the type of base material used

4. Need for abutment tooth modification or restorations, which may influence the type of clasp arms to be used and their specific design.

5. Type of major connector indicated, based on existing and correctable situations.

6. Materials to be used, both for the framework and for the bases.

7. Type of replacement teeth to be used, which may be influenced by the opposing dentition.

8. Patient's past experience with a removable partial denture and the reasons for making a new denture. If, for example, a lingual bar has been objectionable, was it because of design, fit, or the patient's inability to accept it? Frequently an appraisal of these factors alone justifies the use of a contoured lingual plate rather than a lingual bar. If an anterior palatal bar has proved objectionable, was it because of bulk, location, flexibility, or tissue irritation? A design using a thin palatal major connector located more posteriorly may be preferable to an anterior bar or a palatal V-shaped design located anteriorly.

9. Method to be used for replacing single teeth or missing anterior teeth. The decision to use fixed restorations for these spaces rather than replacing them with the removable partial denture must be made at the time of treatment planning. Such a decision will influence the design of the denture framework.

DIFFERENTIATION BETWEEN TWO MAIN TYPES OF REMOVABLE PARTIAL DENTURES

It is clear that two distinctly different types of removable partial dentures exist. Certain points of difference are present between the Class I and Class II types of partial dentures on the one hand and the Class III type of partial denture on
Chapter 10
Principles of removable partial denture design

Fig. 10-2 A, Kennedy Class I partially edentulous arch. Major support for denture bases must come from residual ridges, tooth support from occlusal rests being effective only at anterior portion of each base. B, Kennedy Class III, modification 1, partially edentulous arch, which provides total tooth support for prosthesis. Removable partial denture made for this arch is totally supported by rests on properly prepared occlusal rest seats on four abutment teeth.

the other. The first consideration is the manner in which each is supported. The Class I type and the distal extension side of the Class II type derive their primary support from the tissues underlying the base and only limited support from the abutment teeth (Figs. 10-2, A, and 10-3). The Class III type derives all of its support from the abutment teeth at each end of the edentulous space (Figs. 10-2, B, and 10-3).

Second, for reasons directly related to the manner of support, the method of impression registration required for each type will vary.

Third, the need for some kind of indirect retention exists in the distal extension type of partial denture, whereas in the tooth-supported, Class III type there is no extension base to lift away from the supporting tissues because of the action of sticky foods and movements of the tissues of the mouth against borders of the denture. This is because each end of each denture base is secured by a direct retainer on an abutment tooth. Therefore the tooth-supported partial denture does not rotate about a fulcrum as does the distal extension partial denture.

Fourth, the manner in which the distal extension type of partial denture is supported often necessitates the use of a base material that can be relined to compensate for tissue changes. Acrylic resin is generally used as a base material for distal extension bases. The Class III partial denture, on the other hand, being entirely tooth supported, does not require

Fig. 10-3 Distortion of tissues over edentulous ridge will be approximately 500 μm under 4 newtons of force, whereas abutment teeth will demonstrate approximately 20 μm of intrusion under the same load.
relining except when it is advisable to eliminate an unhygienic, unesthetic, or uncomfortable condition resulting from loss of tissue contact. Metal bases therefore are more frequently used in tooth-supported restorations, since relining is not as likely to be necessary with them.

**Differences in support**

The distal extension partial denture derives its major support from the residual ridge with its fibrous connective tissue covering. The length and contour of the residual ridge significantly influence the amount of available support and stability (Fig. 10-4). Some areas of this residual ridge are firm, with limited displaceability, whereas other areas are displaceable, depending on the thickness and structural character of the tissues overlying the residual alveolar bone. The movement of the base under function determines the occlusal efficiency of the partial denture and also the degree to which the abutment teeth are subjected to torque and tipping stresses.

**Impression registration**

An impression registration for the fabrication of a partial denture must fulfill the following two requirements:

1. The anatomic form and the relationship of the remaining teeth in the dental arch, as well as the surrounding soft tissues, must be recorded accurately so that the denture will not exert pressure on those structures beyond their physiologic limits. A type of impression material that can be removed from undercut areas without permanent distortion must be used to fulfill this requirement. The elastic impression materials such as irreversible hydrocolloid (alginate), mercaptan rubber base (Thiokol), silicone impression materials (both condensation and addition reaction), and the polyethers are best suited for this purpose.

2. The supporting form of the soft tissues underlying the distal extension base of the partial denture should be recorded so that firm areas are used as primary stress-bearing areas and readily displaceable tissues are not overloaded. Only in this way can maximum support of the partial denture base be obtained. An impression material capable of displacing tissue sufficiently to register the supporting form of the ridge will fulfill this second requirement. A fluid mouth temperature wax or any of the readily flowing impression materials (rubber base, the silicones, or the polyethers in an individual, corrected tray) may be employed for registering the supporting form. Zinc

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![Diagram](image)
oxide-eugenol impression paste can also be used when only the extension base area is being impressed (see Chapter 15).

No single impression material can satisfactorily fulfill both of the previously mentioned requirements. Recording just the anatomic form of both teeth and supporting tissues will result in inadequate support for the distal extension base of the partial denture.

Differences in clasp design
A fifth point of difference between the two main types of partial dentures lies in their requirements for direct retention.

The tooth-supported partial denture, being totally supported by abutment teeth, is retained and stabilized by a clasp at each end of each edentulous space. The only requirement of such clasps is that they flex sufficiently during placement and removal of the denture to pass over the height of contour of the teeth in approaching or escaping from an undercut area. While in its terminal position on the tooth, a retentive clasp should be passive and should not flex except when engaging the undercut area of the tooth for resisting a vertical dislodging force.

Cast retentive arms are generally used for this purpose. These may be either of the circumferential type, arising from the body of the clasp and approaching the undercut from an occlusal direction, or of the bar type, arising from the base of the denture and approaching the undercut area from a gingival direction. Each of these two types of cast clasps has its advantages and disadvantages.

The direct retainer adjacent to a distal extension base must perform still another function in addition to that of resisting vertical displacement. Because of the lack of tooth support distally, the denture base will move tissueward under function proportionate to the quality of the supporting tissues, the accuracy of the denture base, and the total occlusal load applied. Because of this tissueward movement, those elements of the circumferential clasp that lie in a mesial undercut area must be able to flex sufficiently to dissipate stresses that otherwise would be transmitted directly to the abutment tooth as leverage. On the other hand, a bar-type retainer placed to take advantage of a distal undercut moves farther into the undercut and may not transmit as much stress to the abutment tooth.

Structurally the cast circumferential clasp cannot effectively act to dissipate this stress for two reasons. First, the material itself has only a limited flexibility. The only variable factors are the cross-sectional form, the length, and the diameter used in each component part. Second, and probably more important, the cast circumferential clasp is of necessity made half-round. Because edgewise flexing is negligible, the clasp can flex in only one direction and therefore is limited in its ability to dissipate the torque stresses. For this reason some torque will inevitably be transmitted to the abutment tooth and is magnified by the length of the lever arm.

Immediately there comes to mind stress breakers, which are often incorporated into the partial denture design for this reason. Some dentists strongly believe that a stress-breaker is the best means of preventing leverage from being transmitted to the abutment teeth. Others believe just as strongly that a wrought-wire or bar-type retentive arm more effectively accomplishes this purpose with greater simplicity and ease of application. A retentive clasp arm made of wrought wire can flex more readily in all directions than can the cast half-round clasp arm. Thereby it can more effectively dissipate those stresses that would otherwise be transmitted to the abutment tooth. A discussion of the limitations of stress-breakers has been presented in Chapter 9.

Only the retentive arm of the circumferential clasp, however, should be made of wrought metal. Reciprocation and stabilization against lateral movement must be obtained through the use of the rigid cast elements that make up the remainder of the clasp. This is called a combination clasp because it is a combination of both cast and wrought materials incorporated into one direct retainer. It is frequently used on the terminal abutment for the distal extension partial denture and is indicated where a mesiobuccal but no distobuccal undercut exists or where a gross tissue undercut, cervical and buccal to the abutment tooth, exists. It must always be remembered that the factors of length...
and material contribute to the flexibility of clasp arms. A short wrought-wire arm can be a destructive element because of its reduced ability to flex compared with a longer wrought wire arm. However, in addition to its greater flexibility compared with the cast circumferential clasp, the combination clasp has further advantages of adjustability, minimum tooth contact, and better esthetics, which justify its occasional use in tooth-supported designs.

The amount of stress transferred to the supporting edentulous ridge(s) and the abutment teeth will depend on: (1) the direction and magnitude of the force; (2) the length of the denture base lever arm(s); (3) the quality of resistance (support from the edentulous ridges and remaining natural teeth); and (4) the design characteristics of the partial denture. As stated in Chapter 7, the location of the rest, the design of the minor connector as it relates to its corresponding guiding plane, and the location of the retentive arm are all factors that influence how a clasp system functions. The greater the surface area contact of each minor connector to its corresponding guiding plane, the more horizontal the distribution of force (Fig. 10-5).

**ESSENTIALS OF PARTIAL DENTURE DESIGN**

Design of the partial denture framework should be systematically developed and outlined on an accurate diagnostic cast.

To develop the design it is first necessary to determine how the partial denture is to be...
supported. In an entirely tooth-supported partial denture the most ideal location for the support units (rests) is on prepared rest seats on the occlusal, cingulum, or incisal surface of the abutment adjacent to each edentulous space (see Fig. 10-2, B). The type of rest and amount of support required must be based on interpretation of the diagnostic data collected from the patient. In evaluating the potential support that an abutment tooth can provide, consideration should be given to (1) periodontal health; (2) crown and root morphologies; (3) crown-to-root ratio; (4) bone index area (how tooth has responded to previous stress); (5) location of the tooth in the arch; (6) relationship of the tooth to other support units (length of edentulous span); and (7) the opposing dentition. (For more in-depth understanding of these considerations, review Chapters 6 and 12.)

In a tooth- and tissue-supported partial denture, attention to these same considerations must be given the abutment teeth. However, equitable support must come from the edentulous ridge areas. In evaluating the potential support available from the edentulous ridge areas, consideration must be given to (1) the quality of the residual ridge, which includes contour and quality of the supporting bone (how the bone has responded to previous stress) and quality of the supporting mucosa; (2) the extent to which the residual ridge will be covered by the denture base; (3) the type and accuracy of the impression registration; (4) the accuracy of the denture base; (5) the design characteristics of the component parts of the partial denture framework; and (6) the anticipated occlusal load. A full explanation of tissue support for extension base partial dentures is found in Chapter 16.

Denture base areas adjacent to abutment teeth are primarily tooth supported. As you proceed away from the abutment teeth, they become more tissue supported. Therefore it is necessary to incorporate characteristics in the partial denture design that will distribute the functional load equitably between the abutment teeth and the supporting tissues of the edentulous ridge. Locating tooth support units (rests) on the principal abutment teeth and designing the minor connectors that are adjacent to the edentulous areas to contact the guiding planes in such a manner that they disperse the functional load equitably between the available tooth, and tissue supporting units will provide designs with controlled distribution of support (see Fig. 10-5).

The second step in systematically developing the design for any removable partial denture is to connect the tooth and tissue support units. This connection is facilitated by designing and locating major and minor connectors in compliance with the basic principles and concepts presented in Chapter 5. Major connectors must be rigid so that forces applied to any portion of the denture can be effectively distributed to the supporting structures. Minor connectors arising from the major connector make it possible to transfer functional stress to each abutment tooth through its connection to the corresponding rest and also to transfer the effect of the retainers, rests, and stabilizing components to the remainder of the denture and throughout the dental arch.

The third step is to determine how the partial denture is to be retained. The retention must be sufficient to resist reasonable dislodging forces. As stated in Chapter 7, retention is accomplished by mechanical retaining elements (clasps) being placed on the abutment teeth and by the intimate relationship of the denture bases and major connectors (maxillary) with the underlying tissues. The key to selecting a successful clasp design for any given situation is to choose one that will (1) avoid direct transmission of tipping or torquing forces to the abutment; (2) accommodate the basic principles of clasp design by definitive location of component parts correctly positioned on abutment tooth surfaces; (3) provide retention against reasonable dislodging forces; and (4) be compatible with undercut location, tissue contour, and esthetic desires of the patient. Location of the undercut is the most important single factor in selecting a clasp. Undercut location, however, can be modified by recontouring or restoring the abutment tooth to accommodate a clasp design better suited to satisfy the criteria for clasp selection. A 5-year randomized clinical trial of two basic removable partial denture designsone with rest, proximal plate and I-bar (RPI)
design and one with circumferential clasp design—demonstrated no discernible changes in nine periodontal health components of the abutment teeth with either of the two designs after 60 months. The results indicated that the two designs did not differ in terms of success rates, maintenance, or effects on abutment teeth. A well-constructed removable partial denture with either design, supported by favorable abutments that are properly prepared and maintained and accompanied by good tissue support and good oral hygiene offers a satisfactory treatment modality. If it is indicated, the design must also include provision for adequate indirect retention that will function to counteract any lifting of a distal extension base away from the supporting tissues.

The fourth step is to connect the retention units to the support units. If direct and indirect retainers are to function as designed, each must be rigidly attached to the major connector. The criteria for selection, location, and design are the same as those indicated for connecting the tooth and tissue support units.

The fifth and last step in this systematic approach to design is to outline and join the edentulous area to the already established design components. Strict attention to detail of the design characteristics outlined in Chapter 9 is necessary to ensure rigidity of the base material without interfering with tooth placement.

COMPONENTS OF PARTIAL DENTURE DESIGN

All partial dentures have two things in common: (1) they must be supported by oral structures and (2) they must be retained against reasonable dislodging forces.

In the Class III partial denture, three components are necessary: support provided by rests, the connectors (stabilizing components), and the retainers.

The partial denture that does not have the advantage of tooth support at each end of each edentulous space still must be supported, but in this situation, the support comes from both the teeth and the underlying ridge tissues rather than from the teeth alone. This is a composite support, and the prosthesis must be fabricated so that the resilient support provided by the edentulous ridge is coordinated with the more stable support offered by the abutment teeth. The essentials-support, connectors, and retainers—must be more carefully designed and executed because of the movement of tissuesupported denture base areas. In addition, provision must be made for three other factors, as follows:

1. The best possible support must be obtained from the resilient tissues that cover the edentulous ridges. This is accomplished by the impression technique more than by the partial denture design, although the area covered by the partial denture base is a contributing factor in such support.

2. The method of direct retention must take into account the inevitable tissueward movement of the distal extension base(s) under the stresses of mastication and occlusion. Direct retainers must be designed so that occlusal loading will result in the direct transmission of this load to the long axis of the abutment teeth instead of as leverage.

3. The partial denture, with one or more distal extension denture bases, must be designed so that movement of the unsupported and unretained end away from the tissues will be prevented or minimized. This is often referred to as indirect retention and is best described in relation to an axis of rotation through the rest areas of the principal abutments (see Chapter 8). However, retention from the partial denture base itself frequently can be made to help prevent this movement and, in such instances, may be discussed as direct-indirect retention.

Tooth support

The support of the partial denture by the abutment teeth is dependent on the alveolar support of those teeth, the rigidity of the partial denture framework, and the design of the occlusal rests. Through clinical and roentgenographic interpretation the dentist may evaluate the abutment teeth and decide whether they will provide adequate support. In some instances the splinting of two or more teeth is advisable,
either by fixed partial dentures or by soldering two or more individual restorations together. In other instances a tooth may be deemed too weak to be used as an abutment, and extraction is indicated in favor of obtaining better support from an adjacent tooth.

Having decided on the abutments, the dentist is responsible for the preparation and restoration of the abutment teeth to accommodate the most ideal design of the partial denture. This includes the form of the occlusal rest seats. These modifications may be prepared either in sound tooth enamel or in restorative materials that will withstand the functional stress and wear of the component parts of the removable partial denture. The technician cannot be blamed for inadequate abutment tooth preparation, such as occlusal rest support. On the other hand, the technician is solely to blame if he or she extends the casting beyond, or fails to include, the total prepared areas. If the dentist has sufficiently reduced the marginal ridge area of the rest seat to avoid interference from opposing teeth and if a definite occlusal rest seat is faithfully recorded in the master cast and delineated in the penciled design, then no excuse can be made for poor occlusal rest form on the partial denture.

Ridge support

Support for the tooth-supported denture or the tooth-supported modification space comes entirely from the abutment teeth by means of rests. Support for the distal extension denture base comes primarily from the overlying soft tissues and the residual alveolar bone of the distal extension base area. In the latter, rest support is effective only at the abutment end of the denture base.

The effectiveness of tissue support depends on six things: (1) the quality of the residual ridge; (2) the extent to which the residual ridge will be covered by the denture base; (3) the accuracy and type of impression registration; (4) the accuracy of the denture bases; (5) the design characteristics of the component parts of the partial denture framework; and (6) the occlusal load applied.

The quality of the residual ridge cannot be influenced, except to improve it by tissue conditioning, or to modify it by surgical intervention. Such modifications are almost always needed but are not frequently done.

The accuracy of the impression technique is entirely in the hands of the dentist. Maximum tissue coverage for support that encompasses the primary stress-bearing areas should be the primary objectives in any partial denture impression technique. The manner in which this is accomplished should be based on a biologic comprehension of what happens beneath a distal extension denture base when an occlusal load is applied.

The accuracy of the denture base is influenced by the choice of materials and by the exactness of the processing techniques. Inaccurate and warped denture bases adversely influence the support of the partial denture. Materials and techniques that will ensure the greatest dimensional stability should be selected.

The total occlusal load applied to the residual ridge may be influenced by reducing the occlusal area. This is done by the use of fewer, narrower, and more effectively shaped artificial teeth (Fig. 10-6).

The distal extension partial denture is unique in that its support is derived from abutment teeth, which are comparatively unyielding, and from soft tissues overlying bone, which may be comparatively yielding under occlusal forces. Resilient tissues, which are displaced by occlusal load, are unable to provide support for the denture base comparable with that offered by the abutment teeth. This problem of support is further complicated by the fact that the patient may have natural teeth remaining that can exert far greater occlusal force on the supporting tissues than would result if the patient were completely edentulous. This fact is clearly evident from the damage often occurring to an edentulous ridge when it is opposed by a few remaining anterior teeth in the opposing arch and especially when the opposing occlusion of anterior teeth has been arranged so that contact exists in both centric and eccentric positions.

Ridge tissues recorded in their resting or nonfunctioning form are incapable of providing the composite support needed for a denture that derives its support from both hard and soft tissue. Three factors must be considered in the
acceptance of an impression technique for distal extension partial dentures: (1) the material should record the tissues covering the primary stress-bearing areas in their supporting form; (2) tissues within the basal seat area other than primary stress-bearing areas must be recorded in their anatomic form; and (3) the total area covered by the impression should be sufficient to distribute the load over as large an area as can be tolerated by the border tissues. This is an application of the principle of the snowshoe.

Anyone who has had the opportunity to compare two master casts for the same partially edentulous arch—one cast having the distal extension area recorded in its anatomic or resting form and the other cast having the distal extension area recorded in its functional form—has been impressed by the differences in the topography (Fig. 10-7). A denture base processed to the functional form is generally less irregular and has greater area coverage than does a denture base processed to the anatomic or resting form. Moreover, and of far greater significance, a denture base made to anatomic form exhibits less stability under rotating forces than does a denture base processed to functional form and thus fails to maintain its occlusal relation with the opposing teeth. By having the patient close onto strips of soft wax, it is evident that occlusion is maintained at a point of equilibrium over a longer period of time when the denture base has been made to the functional form. In contrast, evidence exists that there has been a rapid settling of the denture base when it has been made to the anatomic form, with an early return of the occlusion to natural tooth contact only. Such a denture not only fails to distribute the occlusal load equitably but also allows rotational movement, which is damaging to the abutment teeth and their investing structures.
superiorly with a half-pear shape in cross section and should be relieved sufficiently but not excessively over the underlying tissues when such relief is indicated. The addition of a continuous bar retainer or a lingual apron does not alter the basic design of the lingual bar. These are added solely for support, stabilization, rigidity, and protection of the anterior teeth and are neither connectors nor indirect retainers. The finished inferior border of either a lingual bar or a linguoplate should be gently rounded to avoid irritation to subjacent tissues when the restoration moves even slightly in function.

The use of a linguoplate is indicated when the lower anterior teeth are weakened by periodontal disease. It is also indicated in Class I partially edentulous arches when the need for additional resistance to horizontal rotation of the denture is required because of excessively resorbed residual ridges. Still another indication is in those situations in which the floor of the mouth so closely approximates the lingual gingiva of anterior teeth that an adequately inflexible lingual bar cannot be positioned without impinging on the gingival tissues.

Experience with the linguoplate has shown that with good oral hygiene the underlying tissues remain healthy and there are no harmful effects to the tissues from the metallic coverage per se. However, adequate relief must be provided whenever a metal component crosses the gingival margins and the adjacent gingivae. Excessive relief should be avoided because tissues tend to fill a void, resulting in the overgrowth of abnormal tissue. The amount of relief used, therefore, should be only the minimum necessary to avoid gingival impingement.

It does not seem that there are many advantages to be found in the use of the continuous bar retainer versus the linguoplate. In rare instances, when a linguoplate would be visible through multiple interproximal embrasures, the continuous bar retainer may be preferred for esthetic reasons only. In other instances, when a single diastema exists, a linguoplate may be cut out in this area to avoid display of metal, without sacrificing its use when otherwise indicated.

**Major and minor connectors**

Major connectors are the units of a partial denture that connect the parts of the prosthesis located on one side of the arch with those on the opposite side. Minor connectors arise from the major connector and join it with other parts of the denture; thus they serve to connect the tooth and tissue support units together. A major connector should be properly located in relation to gingival and moving tissues and should be designed to be rigid. Rigidity in a major connector is necessary to provide proper distribution of forces to and from the supporting components.

A lingual bar connector should be tapered
Rigidity of a palatal major connector is just as important and its location and design just as critical as for a lingual bar. A U-shaped palatal connector is rarely justified except to avoid an inoperable palatal torus that extends to the junction of the hard and soft palates. Neither can the routine use of a narrow, single palatal bar be justified. The combination anterior-posterior palatal strap-type major connector is mechanically and biologically sound if it is located so that it does not impinge on tissues. The broad, anatomic palatal major connector is frequently preferred because of its rigidity, better acceptance by the patient, and greater stability without tissue damage. In addition, this type of connector may provide direct-indirect retention that may sometimes, but rarely, eliminate the need for separate indirect retainers.

Direct retainers for tooth-supported partial dentures
Retainers for tooth-supported partial dentures have only two functions, and these are to retain the prosthesis against reasonable dislodging forces without damage to the abutment teeth and to aid in resisting any tendency of the denture to be displaced in a horizontal plane. The prosthesis cannot move tissueward because each terminus is supported by a rest. There should be no movement away from the tissues, and therefore no rotation about a fulcrum, because each terminus is secured by a direct retainer.

Any type of direct retainer is acceptable as long as the abutment tooth is not jeopardized by its presence. Intracoronal (frictional) retainers are ideal for tooth-supported restorations and offer esthetic advantages that are not possible with extracoronal (clasp) retainers. Nevertheless the circumferential and bar-type clasp retainers are mechanically effective and are more economically constructed than are intracoronal retainers. Therefore they are more universally used.

Vulnerable areas on the abutment teeth must be protected by restorations with either type of retainer. The clasp retainer must not impinge on gingival tissues. The clasp must not exert excessive torque on the abutment tooth during placement and removal. It must be located the least distance into the tooth undercut for adequate retention, and it must be designed with a minimum of bulk and tooth contact.

The bar clasp arm should be used only when the area for retention lies close to the gingival margin of the tooth and little tissue blockout is necessary. If the clasp must be placed high, if the vestibule is extremely shallow, or if an objectionable space would exist beneath the bar clasp arm because of blockout of tissue undercuts, the bar clasp arm should not be used. In the event of an excessive tissue undercut, consideration should be given to recontouring the abutment and using some type of circumferential direct retainer.

Direct retainers for distal extension partial dentures
Retainers for distal extension partial dentures, while retaining the prosthesis, must also be able to flex or disengage when the denture base moves tissueward under function. Thus the retainer may act as a stress-breaker. Mechanical stress-breakers accomplish the same thing, but they do so at the expense of horizontal stabilization. When some kind of mechanical stressbreaker is used, the denture flange must be able to prevent horizontal movement. Clasp designs that allow for flexing of the retentive clasp arm may accomplish the same purpose as that of mechanical stress-breakers, without sacrificing horizontal stabilization and with less complicated techniques.

In evaluating the ability of a clasp arm to act as a stress-breaker, one must realize that flexing in one plane is not enough. The clasp arm must be freely flexible in any direction, as dictated by the stresses applied. Bulky, half-round clasp arms cannot do this and neither can a bar clasp engaging an undercut on the side of the tooth away from the denture base. Round, tapered clasp forms offer advantages of greater and more universal flexibility, less tooth contact, and better esthetics. Either the combination circumferential clasp with its tapered wrought-wire retentive arm or the carefully located and properly designed circumferential or bar clasp can be considered for use on all abutment teeth adjacent to extension denture bases if the abutment teeth have been properly prepared, the tissue support effectively achieved, and the patient exercises good oral hygiene.
Stabilizing components

Stabilizing components of the partial denture framework are those rigid components that assist in stabilizing the denture against horizontal movement. The purpose of all stabilizing components should be to distribute stresses equally to all supporting teeth without overworking any one tooth. The minor connectors that join the rests and the clasp assemblies to the major connector serve as stabilizing components.

All minor connectors that contact vertical tooth surfaces (and all reciprocal clasp arms) act as stabilizing components. It is necessary that minor connectors have sufficient bulk to be rigid, and yet present as little bulk to the tongue as possible. This means that they should be confined to interdental embrasures whenever possible. When minor connectors are located on vertical tooth surfaces, it is best that these surfaces be parallel to the path of placement.

When cast restorations are used, these surfaces of the wax patterns should be made parallel on the surveyor before casting.

A modification of minor connector design has been proposed that places the minor connector in the center of the lingual surface of the abutment tooth (Fig. 10-8). Proponents of this design claim that it reduces the amount of gingival tissue coverage and provides enhanced bracing and guidance during placement. Increased encroachment on the tongue space, more obvious borders, and potentially greater space between the connector and the abutment tooth may be disadvantageous. This proposed variation, however, when combined with thoughtful design principles, may provide some benefit to the periodontal health of the abutment teeth and may be acceptable to some patients.

Reciprocal clasp arms also must be rigid, and they must be placed occlusally to the height of contour of the abutment teeth, where they will be nonretentive. By their rigidity, these clasp arms reciprocate the opposing retentive clasp, and they also prevent horizontal movement of the prosthesis under functional stresses. For a reciprocal clasp arm to be placed favorably, some reduction of the tooth surfaces involved is frequently necessary to increase the suprabulge area.

When crown restorations are used, a lingual reciprocal clasp arm may be inset into the tooth contour by providing a ledge on the crown on which the clasp arm may rest. This permits the use of a wider clasp arm and restores a more nearly normal tooth contour, at the same time maintaining its strength and rigidity (see Chapter 14).

Guiding plane

The term guiding plane is defined as two or more parallel, vertical surfaces of abutment teeth, so shaped to direct a prosthesis during placement and removal. After the most favorable path of placement has been ascertained, axial surfaces of abutment teeth are prepared, parallel to the path of placement and therefore become parallel to each other. Guiding planes may be contacted by various components of the partial denture—the body of an extracoronal direct retainer, the stabilizing arm of a direct retainer, the minor connector portion of an indirect retainer or by a minor connector specifically designed to contact the guiding plane surface.

The functions of guiding plane surfaces are as follows: (1) to provide for one path of placement and removal of the restoration (to eliminate detrimental strain to abutment teeth and framework components during placement and removal); (2) to ensure the intended actions of reciprocal, stabilizing, and retentive components (to provide retention against dislodgement
Fig. 10-9 Prospective guiding plane surfaces are indicated by wires placed on abutment teeth. These surfaces, when used, can be made vertically parallel to path of placement. However, by including guiding plane surfaces, which are not in the same parallel plane horizontally (arrows) out are divergent, crossarch resistance to horizontal rotation of denture is enhanced.

of the restoration when the dislodging force is directed other than parallel to the path of removal and also to provide stabilization against horizontal rotation of the denture; and (3) to eliminate gross food traps between abutment teeth and components of the denture.

Guiding plane surfaces need to be created so that they are as nearly parallel to the long axes of abutment teeth as possible. Establishing guiding planes on several abutment teeth (preferably more than two teeth), located at widely separated positions in the dental arch, provides for a more effective use of these surfaces. The effectiveness of guiding plane surfaces is enhanced if these surfaces are prepared on more than one common axial surface of the abutment teeth (Fig. 10-9).

As a rule, proximal guiding plane surfaces should be about one-half the width of the distance between the tips of adjacent buccal and lingual cusps or about one third of the buccal lingual width of the tooth and should extend vertically about two thirds of the length of the enamel crown portion of the tooth from the marginal ridge cervically. In preparing guiding plane surfaces, care must be exercised to avoid creating buccal or lingual line angles (Fig.10-10).

Assuming that the stabilizing or retentive arm of a direct retainer may originate in the guiding plane region, a line angle preparation would weaken either or both components of the clasp assembly.

A guiding plane should be located on the abutment surface adjacent to an edentulous area. However, excess torquing is inevitable if the guiding planes squarely facing each other on a lone standing abutment adjacent to an extension area are used (Fig. 10-11).

**Indirect retainers**

An indirect retainer must be placed as far anteriorly from the fulcrum line as adequate tooth support permits if it is to function with the direct retainer to restrict movement of a distal extension base away from the basal seat tissues. It must be placed on a rest seat prepared in an
Fig. 10-11 Guiding planes squarely facing each other should not be prepared on lone standing abutment. Minor connectors of framework (hatched areas) would place undue strain on abutment when denture rotated vertically either superiorly or inferiorly. Such unfavorable leverage could be avoided by simply preparing guiding plane surfaces to slightly diverge in buccal direction (inset).

abutment tooth that is capable of withstanding the forces placed on it. An indirect retainer cannot function effectively on an inclined tooth surface, nor can a single weak incisor tooth be used for this purpose. Either a canine or premolar tooth should be used for the support of an indirect retainer, and the rest seat must be prepared with as much care as is given any other rest seat. An incisal rest or a lingual rest may be used on an anterior tooth, provided a definite seat can be obtained either in sound enamel or on a suitable restoration.

A second purpose that indirect retainers serve in partial denture design is that of support for major connectors. A long lingual bar or an anterior palatal major connector is thereby prevented from settling into the tissues. Even in the absence of a need for indirect retention, provision for such auxiliary support is sometimes indicated.

Contrary to common use, a cingulum bar or a linguoplate does not in itself act as an indirect retainer. Because these are located on inclined tooth surfaces, they serve more as an orthodontic appliance than as support for the partial denture. When a linguoplate or a cingulum bar is used, terminal rests should always be provided at either end to stabilize the denture and to prevent orthodontic movement of the teeth contacted. Such terminal rests may function as the indirect retainers, but these would function equally well in that capacity without the continuous bar retainer or linguoplate.

Some applications of the systematic approach to designs and placement of component parts are as follows.

Class III removable partial denture
The Kennedy Class III removable partial denture (Figs. 10-12 through 10-15) entirely tooth supported, may be made to fit the prepared surfaces of the anatomic form of the teeth and surrounding structures. It does not require an impression of the functional form of the ridge tissues, nor does it require indirect retention. Cast clasps of either the circumferential, the bar type, or the combination clasp may be used depending on how one can modify the surfaces of the abutment teeth (guiding planes, rests, contours for proper location of clasp arms). Unless a need for
Class I, bilateral, distal extension partial dentures

The Class I, bilateral, distal extension partial denture is as different from the Class III type as any two dental restorations could be (see Fig. 10-2). Because it derives its principal support from the tissues underlying its base, a Class I partial denture made to anatomic ridge form cannot provide uniform and adequate support. Yet, unfortunately, many Class I mandibular partial dentures are made from a single irreversible hydrocolloid impression. In such situations, both the abutment teeth and the residual ridges suffer because the occlusal load placed on the remaining teeth is increased by the lack of adequate posterior support.

Many dentists, recognizing the need for some type of impression registration that will record the supporting form of the residual ridge, attempt to record this form with a metallic oxide, rubber base, or one of the silicone impression materials. Such materials actually only record the anatomic form of the ridge.
Fig. 10-16 Mandibular Class II partial denture with metal distal extension base. Acrylic resin attachment of prosthetically supplied teeth to metal base is with suitable mechanical retention (nailheads, loops, or spurs, plus undercut finishing line). Embrasure clasp arms are used on nonedentulous side, with indirect retainer located favorably in relation to fulcrum line. Because of tissue undercut cervical to buccal surface of right second premolar and lack of distobuccal undercut, wrought-wire (tapered) retainer arm was used.

**Class II partial dentures**

The Kennedy Class II partial denture (Figs. 10-16 and 10-17) actually may be a combination of both tissue-supported and tooth-supported restorations. The distal extension base must have adequate tissue support, whereas tooth-supported bases elsewhere in the arch may be made to fit the anatomic form of the underlying ridge. Indirect retention must be provided for; however, occasionally the anterior abutment on the tooth-supported side will satisfy this requirement. If additional indirect retention is needed, provisions must be made for it.

Cast clasp arms are generally used on the tooth-supported side, however, a clasp design using wrought wire may reduce the application of torque on the abutment tooth adjacent to the distal extension should be considered (Fig. 10-16). The use of a cast circumferential clasp engaging a mesiobuccal undercut on the anterior abutment of the tooth-supported modification space may result in a Class I leverlike action if the abutment teeth have not been properly prepared and/or if the tissue support from the extension base area is not adequate. It seems rational under these circumstances to use a bar-type retainer engaging a distobuccal undercut (Fig. 10-17). Should the bar-type retainer be contraindicated because of a severe tissue undercut or the existence of only a mesiobuccal undercut on the anterior abutment, then a combination direct retainer with the retentive arm made of tapered wrought wire should be used. A thorough understanding of the advantages and disadvantages of various clasp designs is necessary.
to determine the type of direct retainer that is to be used for each abutment tooth.

The steps in the fabrication of the Class II partial denture closely follow those of the Class I partial denture, except that the distal extension base is usually made of an acrylic resin material, whereas the base for any tooth-supported area is frequently made of metal. This is permissible because the residual ridge beneath tooth-supported bases is not called on to provide support for the denture, and later rebasing is not as likely to be necessary.

**ADDITIONAL CONSIDERATIONS INFLUENCING DESIGN**

Every effort should be made to gain the greatest support possible for removable prostheses by use of abutments bounding edentulous spaces. This will not only relieve the residual ridges of some of their obligation for support but also may allow the design of the framework to be greatly simplified. To this end, use of splint bars, internal clip attachments, overlay abutments, overlay attachments, a component partial, and implants should be considered.

**Use of a splint bar for denture support**

In the Chapter 14 discussion of missing anterior teeth, mention is made of the fact that missing anterior teeth are best replaced with a fixed partial denture. The following is quoted from that chapter: "From a biomechanical standpoint, . . . a removable partial denture should replace only the missing posterior teeth after the remainder of the arch has been made intact by fixed restorations."

Occasionally a situation is found in which it is necessary that several missing anterior teeth be replaced with the removable partial denture rather than by fixed restorations. This may be because of the length of the edentulous span, the loss of a large amount of the residual ridge by resorption, accident, surgery, or the result of a situation in which too much vertical space prevents the use of a fixed partial denture or in which esthetic requirements can better be met through the use of teeth added to the denture framework. In such instances it is necessary that the best possible support for the replaced anterior teeth be provided. Ordinarily this is done through the placement of occlusal or lingual rests, or both, on the adjacent natural teeth, but when the edentulous span is too large to ensure adequate support from the adjacent teeth, other methods must be used. This is included here only because it influences the design of the major connector that must then be used.

An anterior splint bar may be attached to the adjacent abutment teeth in such a manner that a fixed splint results, with a smooth, contoured bar resting lightly on the gingival tissues to support the removable partial denture (Fig. 10-18, A). As with any fixed partial denture, the type of abutment retainers and the decision to use multiple abutments will depend on the length of the span and the stability of the teeth being used as abutments. Regardless of the type of abutment retainers used, the connecting bar may be cast of a rigid alloy, or a commercially available bar may be used and attached to the abutments by soldering.

The length of the span influences the size of a splint bar. Long spans require more rigid bars (10-gauge) than short spans (13-gauge). If the bar is to be soldered, it is best that recesses be formed in the proximal surfaces of the abutments and that the connecting bar, which rests lightly on the tissues, be cast or made to fit into these recesses and then attached by soldering.

Because of the greater rigidity of the chromium-cobalt alloys, the splint bar is preferably cast in one of these materials and then attached to the abutments by soldering. The complete assembly (abutments and connecting bar) is then cemented permanently to the abutment teeth, the same as a fixed partial denture. The impression for the partial denture is then made, and a master cast is obtained that accurately reproduces the contours of the abutments and the splint bar. The denture framework work is then made to fit the abutments and the bar by extending the major connector or minor connectors to cover and rest upon the splint bar. Retention for the attachment of a resin base, or any other acceptable means of attaching the replaced anterior teeth, is incorporated into the denture design (Fig. 10-18, B and c). In those situations wherein the removable partial denture will be tooth supported, the splint bar may be curved to follow the crest of the residual ridge.
Fig. 10-18 A, Splint bar attached to double abutments on either side of arch. Although this may be made of hard gold alloy, its rigidity is better assured by making bar of base-metal alloy. Bar can be made to fit into recesses prepared in abutments, attaching it by electric soldering. Band C, Denture framework designed to fit and be supported by splint bar.

ridge, as seen in Fig. 10-18, A. However, in a distal extension situation, because of the vertical rotation of the denture, caution must be exercised to form the splint bar so that excessive torque will not accrue to its supporting abutments (Fig. 10-19). The proximal contours of abutments adjacent to splint bars should be parallel to the path of placement. This serves three purposes: (1) it permits a desirable arrangement of artificial teeth; (2) it aids in resisting horizontal rotation of the restoration; and (3) they act as guiding planes to direct the partial denture to and from its terminal position.

The splint bar must be positioned antero posteriorly just lingual to the residual ridge to allow an esthetic arrangement of artificial teeth. The resulting partial denture will have esthetic advantages of removable anterior replacements and positive support, retention, and stability from the underlying splint bar (Fig. 10-20).

**Internal clip attachment**

The internal clip attachment differs from the splint bar in that the internal clip attachment provides both support and retention from the connecting bar (Fig. 10-21).

Several preformed connecting bars are commercially available in plastic patterns. These can
Override abutment as support for a denture base

Every consideration should be directed to preventing the need for a distal extension removable partial denture. In many instances it is possible to salvage the roots and a portion of the crown of a badly broken-down molar through endodontic treatment. A periodontally involved molar, otherwise indicated for extraction, may sometimes be salvaged by periodontal and endodontic treatment accompanied by reduction of the clinical crown almost level with gingival tissues. In another situation an unopposed

be customized for length and cast in the metal alloy of choice. Internal clip attachments are also commercially available in various metal alloys and durable nylon. To fabricate a custom-made connecting bar and clip, the bar should be cast from 10- or 13-gauge sprue wax. The cast bar should rest lightly or be located slightly above the tissues. Retention is provided by one of the commercial preformed metal or nylon clips, which is contoured to fit the bar and is retained in a preformed metal housing or partially embedded by means of retention spurs or loops into the overlying resin denture base.

The internal clip attachment thus provides support, stability, and retention for the anterior modification area and may serve to eliminate both occlusal rests and retentive clasps on the adjacent abutment teeth.

Overlay abutment as support for a denture base

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Fig. 10-19 A, Insofar as possible, the splint bar should be round or ovoid. Provision must be made in construction and location of bar so that dental floss may be threaded underneath bar to allow proper cleaning by patient. H, As viewed from above, bar is in straight line between abutments. This is especially critical for distal extension partial dentures to avoid excess torque on abutments as denture rotates in function. C, Sagittal section through bar demonstrates rounded form of bar making point contact with residual ridge. Entire tissue surface of bar is easily accessible for cleaning with dental floss. Pear-shaped bar (in cross section) will permit rotation of removable partial denture without appreciable resistance or torque.

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Fig. 10-20 A, Lower canines splinted together with splint bar. Longevity of these teeth is greatly enhanced by splinting. Tissue surfaces are minimally contacted by rounded form of lower portion of bar. Anterior and posterior slopes of splint bar must be compatible with path of placement of denture. H, Floss is used by patient to clean inferior portion of splint bar.

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molar may have overly erupted to such an extent that restoring the tooth with a crown is inadequate to develop a harmonious occlusion. Then too, it is not unusual to encounter a molar that is so grossly tipped anteriorly that it cannot serve as an abutment unless the clinical crown is reduced drastically.

Such teeth should be considered for possible support for an otherwise distal extension denture base. Endodontic treatment and preparation of the coronal portion of the tooth as a slightly elevated dome-shaped abutment often offer an alternative to a distal extension base (Fig. 10-22). The student is referred to the

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Fig. 10-21 A, Canines have been endodontically treated and are splinted together with round, straight connecting bar, slightly elevated from residual ridge. Retaining left molar as abutment will immeasurably contribute to stability of removable partial denture. B, Tissue surface of completed mandibular restoration containing internal clip attachment. C, Complete denture and removable partial denture have been initially placed for patient. (Courtesy Dr. Bernard Wilkie, Charlotte, Nc.)

Fig. 10-22 A, Master cast has been prepared for duplicating in refractory investment to develop wax pattern for removable partial denture framework, supported by overlay on second molar abutment. Molar could not be restored by conventional means. It was endodontically treated, and crown was reduced to slightly elevated dome shape. Pulp chamber was filled with silver amalgam alloy. B, Wax pattern has been developed on investment cast, and provision has been made to attach properly extended acrylic resin denture base. Bilateral distal extension denture has been avoided by planning overlay prosthesis.
Fig. 10-23  A, Design of component part partial denture.  B, Tooth support component individually fabricated and fit to the master cast.  C, Tissue support component individually fabricated and fit to the master cast.  D, Tooth and tissue support components assembled on cast.  E, Components joined with high-impact resin. (Photographs courtesy BT Cecconi, San Antonio, Tex.)
Selected Reading Resources section (textbooks; abutment retainers) for sources of information on overdenture abutments and overlay-type prostheses.

Use of a component partial to gain support
A component partial is a removable partial denture in which the framework is designed and constructed in separate parts. The tooth support component is individually fabricated, and the two are joined with a high-impact acrylic resin to become a single rigid functioning unit (Fig. 10-23).

SELF-ASSESSMENT AIDS

1. The text suggests at least nine factors that will influence the design of a removable partial denture. Please list them.
2. How is the design of a denture influenced by the classification of the arch being restored?
3. There are really only two types of removable partial dentures. What are they?
4. Because there are two basic types of removable partial dentures, it is evident that a dentist must consider (1) the manner in which each is supported; (2) the method of impression registration; (3) the need or lack of need for indirect retention; and (4) the use of a base material that can be readily relined. Write a meaningful essay of 100 words or less about each of these listed considerations.
5. What is a guiding plane?
6. What are the three main functions of guiding plane surfaces contacted by minor connectors?
7. Should guiding planes prepared on enamel surfaces of abutment teeth be rounded or flat? Why?
8. Give a rule of thumb for the dimensions of proximal guiding planes.
9. Direct retainers for tooth-supported dentures differ in design from those used in extension base-type dentures. What requirement, in relation to an undercut, exists for the direct retainer (clasp) on a terminal abutment of an extension denture when the denture base is forced into heavier contact with the residual ridge?
10. Name the component(s) of a removable partial denture that must be rigid. Name the component(s) in which flexibility is desirable.
11. Would you agree that a fixed partial denture where indicated, should be the restoration of choice, in lieu of a removable partial denture? Give an example and explain.
12. What method should usually be used to replace single missing teeth or missing anterior teeth? Justify your answer.
13. When confronted with a Kennedy Class I arch in which all molars and first premolars are missing, should one consider replacing the first premolars with fixed partial dentures rather than restoring the spaces with removable restoration? Why?
14. The amount of stress transferred to the supporting edentulous ridges and the abutment teeth in extension base partial dentures is dependent on four factors. One is the length of the lever arm(s) or denture bases. Identify the other three and describe how each influences this stress transfer.
15. A systematic approach to developing the design for any removable partial denture was presented and discussed. Outline the steps presented in this approach.
16. In evaluating the potential support that abutment teeth can provide, what specific characteristics of the teeth should you consider?
17. In evaluating the potential tissue support that the edentulous ridges can provide in extension base situations, what specific characteristics should be considered?
18. In developing the design for an extension base removable partial denture, what component parts are used to connect the supporting units? What specific characteristics should each of these components have to effectively distribute functional stresses to the supporting units?
19. In developing a design for an extension base removable partial denture, when does one determine how the denture is to be retained? What are the keys to selecting successful clasp designs?
20. How does one know if indirect retention needs to be incorporated into the design? If needed, where should it be located, and what component parts would be included in the design to serve as indirect retainers?

21. What is the final step in the proposed systematic approach to design? Should this design characteristic have any special requirements? If so, what are they?

22. What is a splint bar?

23. Draw a splint bar from a frontal, horizontal, and sagittal view. Label the dimensions and relationship of the bar to the tissues and the abutments.

24. What purposes are served by use of splint bars where indicated?

25. A decision has been made to use a splint bar from canine to canine. Will this decision influence the design of the framework? If so, how?

26. For what reasons must a splint bar be convex, rather than concave, adjacent to the residual ridge?

27. Is a 13-gauge splint bar adequate for a span from canine to canine? Why or why not?

28. Define and describe an internal clip attachment.

29. The internal clip attachment must be used in conjunction with some type of bar supported by abutment teeth. What is the cross-sectional shape of such a bar? What advantages accrue from using such a design for a restoration?

30. You are confronted with a mandibular arch with only the six anterior teeth and two second molars remaining. The maxillary arch is edentulous. The anterior teeth are restorable individually and show no mobility or periodontal involvement. The molars, however, are grossly involved with caries; in fact most of the clinical crown is gone. They also show a Miller mobility classification of 1 and exhibit a 5- to 6-mm gingival crevicular depth. They can be treated periodontally and endodontically. In such a situation, if finances were not a factor, would you: (1) extract both molars? (2) prepare the molars for an overlay prosthesis? (3) extract all the mandibular teeth and treat the patient with complete dentures?

31. If the molars mentioned in the preceding section were prepared for an overlay prosthesis, state the reasons for doing so in terms of benefits to the patient.