Fill'IZ-ZO Fif5t and second molar::; have been lost by this 18-year-old patient. Distal extension removable partial denture may be constructed until third molar erupts and is fully formed. Tooth-supported restoration may then be considered.

Periodontal considerations
An assessment of the periodontium in general and abutment teeth in particular must be made before prosthetic restoration. One must evaluate the condition of the gingiva, looking for adequate zones of attached gingiva and the presence or absence of pockets. The condition of the supporting bone must be evaluated and mobility patterns recorded. If mucogingival involvement, osseous defects, or mobility patterns are recorded, the causes and potential treatment must be determined.

Oral hygiene habits of the patient must be determined, and efforts made to educate the patient relative to plaque control. In addition, the patient must be advised of the importance of regular maintenance appointments after treatment. The most decisive evidence of oral hygiene habits is the condition of the mouth before the initial prophylaxis. Good or bad oral hygiene is basic to the patient’s nature, and although it may be influenced somewhat by patient education, the long-range view must be taken. It is reasonably fair to assume that the patient will do little more in the long-term future than he has done in the past. In making decisions as to the method of treatment based on oral hygiene, the future in years, rather than in weeks and months, must be considered. It is probably best not to give the patient the benefit of any doubt as to future oral hygiene habits. Rather, the benefit should come from protective measures where any doubt exists about future oral hygiene habits. Therefore a maintenance schedule, where an oral prophylaxis and continued oral hygiene instruction are given, should be accomplished every 3 to 4 months. Therefore the patient must be willing to share with the dentist the responsibility for maintaining the health of the mouth after restorative and prosthodontic treatment. The remaining teeth will require meticulous plaque control after placement of a removable partial denture.

Caries activity
Caries activity in the mouth, past and present, and the need for protective restorations must be considered. The decision to use full coverage is based on the age of the patient, evidence of caries activity, the need to reshape abutment teeth to accommodate the components of the partial denture and the patient’s oral hygiene habits. Occasionally three-quarter crowns may be used where buccal or lingual surfaces are completely sound, but intracoronal restorations (inlays) are seldom indicated in any mouth with evidence of past extensive caries or precarious areas of decalcification, erosion, or exposed cementum.

Nutrition factor *
High and frequent consumption of sugars can lead to carious involvement of roots, caries around restorations, or caries associated with clasps of partial dentures. Intelligent consumption of sweets (smaller amounts and less frequent consumption) and frequent plaque removal are the recommended countermeasures. Excellent protection from caries can be provided by fluoride applications via toothpastes, mouth rinses, or (in extreme cases, such as postradiation xerostomia) 1% NaF gels applied daily with plastic trays.

Xerostomia, caused by either degeneration of salivary glands (Sjogren's syndrome) or various medications, will enhance the occurrence and severity of caries, as well as contribute to irritation of the oral mucosa. A possible way to alleviate xerostomia is the use of synthetic saliva, with a carboxymethylcellulose base, which can be enriched with fluoride in an effort to counteract caries. Frequent use provides an excellent means of maintaining high fluoride intraorally for long periods of time, thus enhancing the remineralization of incipient caries.

Although the instructions for improvement of oral hygiene are a duty of the dental team, suspected problems of dietary deficiencies should be referred to a nutritionist.

Prospective surgical preparation

Need for preprosthetic surgery or extractions must be evaluated. The same criteria apply to surgical intervention in the partially edentulous arch as in the completely edentulous arch. Grossly displaceable soft tissues covering basal seat areas and hyperplastic tissue should be removed to provide a firm denture foundation. Mandibular tori should be removed if they will interfere with the optimum location of a lingual bar connector or a favorable path of placement. Any other areas of bone prominence that will interfere with the path of placement should be removed also. The path of placement will be dictated primarily by the guiding plane of the abutment teeth. Therefore some areas may present interference to the path of placement of the partial denture by reason of the fact that other unalterable factors such as retention and esthetics must take precedence in selecting that path.

Clinical research in preprosthetic surgical concepts has contributed significant developments to management of the compromised partially edentulous patient. Bone augmentation and guided bone regeneration procedures have been used with varying degrees of success as an alternative method of improving ridge support for the denture base areas. Skill and judgment must be exercised in patient selection, procedural planning, and surgical and prosthetic management to optimize clinical results. Use of osseointegrated implants can provide a foundation for developing suitable abutment support for removable partial dentures. As in any surgical procedure, results depend on careful treatment planning and cautious surgical management.

Extraction of teeth may be indicated for one of the following three reasons:

1. If the tooth cannot be restored to a state of health, extraction may be unavoidable. Modern advancements in the treatment of periodontal disease and in restorative procedures, including endodontic therapy, have resulted in the saving of teeth that were once considered untreatable. All reasonable avenues of treatment should be considered both from prognostic and economic standpoints before recommending extraction.

2. A tooth may be removed if its absence will permit a more serviceable and less complicated partial denture design. Teeth in extreme malposition (lingually inclined mandibular teeth, buccally inclined maxillary teeth, and mesially inclined teeth posterior to an edentulous space) may be removed if an adjacent tooth is in good alignment and if good support is available for use as an abutment. Justification for extraction lies in the decision that a suitable restoration, which will provide satisfactory contour and support, cannot be fabricated or that orthodontic treatment to realign the tooth is not feasible. An exception to the arbitrary removal of a malposed tooth is when a distal extension partial denture base would have to be made rather than using the more desirable tooth-supported base of the tooth in question. If alveolar support is adequate, a posterior abutment should be retained if at all possible in preference to a tissue-supported extension base. Teeth deemed to have insufficient alveolar support may be extracted if their prognosis is poor and if other adjacent teeth may be used to better advantage as abutments. The decision to extract such a tooth should be based on the degree of mobility and other periodontal considerations and on the number, length, and shape of the roots contributing to its support.
Diagnosis and treatment planning

3. A tooth may be extracted if it is so unesthetically located as to justify its removal to improve appearance. In this situation, a veneer crown should be considered in preference to removal if the crown can satisfy the esthetic needs. If removal is advisable because of unesthetic tooth position, the biomechanical problems involved in replacing anterior teeth with a removable partial denture must be weighed against the problems involved in making an esthetically acceptable fixed restoration. Admittedly the removable replacement is commonly the more esthetic of the two, despite modern advancements in retainers and pontics. However, the mechanical disadvantage of the removable restoration often makes the fixed replacement of missing anterior teeth preferable.

Endodontic treatment

The need for prospective or planned endodontic treatment should include assessment of abutments for removable partial overdentures.

Analysis of occlusal factors

From the occlusal analysis made by evaluating the mounted diagnostic casts the dentist must decide whether it is best to accept and maintain the existing occlusion or to attempt to improve on it by means of occlusal adjustment and/or restoration of occlusal surfaces. It must be remembered that the partial denture can only supplement the occlusion that exists at the time the prosthesis is constructed. The dominant force that dictates the occlusal pattern will be the abutment teeth and their proprioceptive influence on mandibular movement. At best the artificial teeth can only be made to harmonize with the functional parameters of the existing occlusion.

Chapter 17 identifies schemes of occlusion recommended for partially edentulous configurations. A review of these recommendations will provide a guide for modifying the existing occlusion or developing the appropriate occlusal scheme for each partially edentulous configuration.

Improvements in the natural occlusion must be accomplished before the fabrication of the prosthesis, not subsequent to it. The objective of occlusal reconstruction by any means should be occlusal harmony of the restored dentition in relation to the natural forces already present or established. Therefore one of the earliest decisions in planning reconstructive treatment must be whether to accept or reject the existing vertical dimension of occlusion and the occlusal contact relationships in centric and eccentric positions. If occlusal adjustment is indicated, cuspal analysis always should precede any corrective procedures in the mouth by selective grinding. On the other hand, if reconstruction is to be the means of correction, the manner and sequence should be outlined as part of the overall treatment plan.

Fixed restorations

There may be a need to restore modification spaces with fixed restorations rather than include them in the partial denture to the detriment of isolated abutment teeth. The advantage of splinting must be weighed against the total cost, with the weight of experience always in favor of using fixed restorations for tooth-bounded spaces unless the space will facilitate simplification of the partial denture design without jeopardizing the abutment teeth. One of the least successful partial denture designs is where multiple tooth-bounded areas are replaced with the partial dentures in conjunction with isolated abutment teeth and distal extension bases. Biomechanical considerations and the future health of the remaining teeth should be given preference over economic considerations when such a choice is possible.

Orthodontic treatment

Occasionally, orthodontic movement of malposed teeth followed by retention through the use of fixed partial dentures makes it possible for a better partial denture design mechanically and esthetically than could otherwise be used.
inclusion of teeth in relation to the path of placement and the location of retentive and supportive areas are not readily interpretable during visual examination. These are established during a comprehensive analysis of the diagnostic cast with a surveyor, which should follow the visual examination.

DIFFERENTIAL DIAGNOSIS: FIXED OR REMOVABLE PARTIAL DENTURES

Total oral rehabilitation is an objective in treating the partially edentulous patient. The replacement of missing teeth by means of fixed partial dentures by the method of choice, however, there are many conditions where a removable partial denture is the better method of treatment.

There are inherent risks in the use of unilateral removable partial dentures that contraindicate their use when a fixed partial denture is indicated. Some of these risks are (1) possible aspiration, (2) lack of cross-arch stabilization, and (3) excessive stress to abutment teeth.

The dentist must follow the best procedure for the welfare of the patient, who is always free to seek more than one opinion. Ultimately, the choice of treatment must meet the economic limitations and personal desires of the patient. The exception to this guideline is the Class III arch with a modification space on the opposite side of the arch, which will provide better cross-arch stabilization and a simpler design for the removable partial denture (Fig. 12-21).

Indications for use of fixed restorations

Tooth-bounded edentulous regions Generally any unilateral edentulous space bounded by teeth suitable for use as abutments should be restored with a fixed partial denture cemented to one or more abutment teeth at either end. The length of the span and the periodontal support of the abutment teeth will determine the number of abutments required.

Lack of parallelism of the abutment teeth may be counteracted with copings or locking connectors to provide parallel sectional placement. Sound abutment teeth make possible the use of more conservative retainers, such as partial veneer crowns, or resin-bonded-to-metal restorations, rather than full crowns. The age of the patient, evidence of caries activity, oral hygiene habits, and soundness of remaining tooth structure must be considered in any decision to use less-than-full coverage for abutment teeth.

There are two specific contraindications for the use of unilateral fixed restorations. One is a long edentulous span with abutment teeth that would not be able to withstand the trauma of horizontal and diagonal occlusal forces. The other is abutment teeth, weakened by periodontal disease, that would benefit from cross-arch stabilization. In either situation a bilateral removable restoration can be used more effectively to replace the missing teeth.

Modification spaces

A removable partial denture for a Class III arch is better supported and stabilized when a modification area on the opposite side of the arch is present. Such an edentulous area need
not be restored by a fixed partial denture because its inclusion may simplify the design of the removable partial denture (Fig. 12-22). However, modification spaces, particularly those that involve single lone-standing abutments, are better restored separately by means of fixed dentures. A lone-standing abutment is thus stabilized by the splinting effect of a fixed restoration, and a possible teeter-totter effect of the denture is avoided; in addition, the denture is made less complicated by not having to include other abutment teeth for the support and retention of another edentulous space or "pac".

When an edentulous space that is a modification of either a Class I or Class II arch exists anterior to a lone-standing abutment tooth, this tooth is subjected to trauma by the movements of the splinting effect of the denture far in excess of its ability to withstand such stresses. The splinting of the lone abutment to the nearest tooth is mandatory. The abutment crowns should be contoured for support of the partial denture and, in addition, a means of supporting a "tabilizing component on the anterior abutment of the fixed partial denture or on the occlusal surface of the pontic usually should be provided.

Anterior modification spaces

Usually any missing anterior teeth in a partially edentulous arch, except in a Kennedy Class IV arch in which only anterior teeth are missing, are best replaced by means of a fixed restoration. There are exceptions. Sometimes a better esthetic result is obtainable when the anterior replacements are supplied by the removable partial denture (see Fig. 12-22). This is also true when excessive tissue and bone resorption necessitates the placement of the pontics in a fixed partial denture too far palatally for good esthetics or for an acceptable relation with the opposing teeth. However, in most instances, from a mechanical and biologic standpoint, anterior replacements are best accomplished with fixed restorations. The replacement of missing posterior teeth with a removable partial denture is then made much less complicated and gives more satisfactory results.

Nonreplacement Of missing molars

(Shortened dental arch)

Often the decision to replace unilaterally missing molars must be made. To do so with a removable denture necessitates the making of a distal extension restoration with the major connector joining the edentulous side to retentive and stabilizing components located on the nonedentulous side of the arch. Leverage factors are always unfavorable, and the retainers that must be used on the nonedentulous side are often unsatisfactory. Several factors therefore will influence the decision to make a unilateral, distal extension partial denture.

Fig. 12-22 A, Exceedingly long maxillary edentulous span restored with fixed partial denture. Note extreme labial inclinations of pontics resulting in lack of support for upper lip and compromised appearance. B, Appearance has been greatly improved by restoring edentulous span with removable restoration.
First, the opposing teeth must be considered. If they are to be prevented from extrusion and migration, some opposing occlusion must be provided. This influences the replacement of the missing molars far more than any improvement in masticating efficiency that might result. The replacement of missing molars on one side is seldom necessary for reasons of mastication alone.

Second, the future effect of a maxillary tuberosity must be considered. Left uncovered, the tuberosity frequently will seem to drop and increase in size. However, covering the tuberosity with a partial denture base, in combination with the stimulating effect of the intermittent occlusion, helps maintain the normalcy of the tuberosity. This is of considerable importance in any future denture replacements. In such an instance it may be better to make a removable partial denture with cross-arch stabilization and retention than to leave a maxillary tuberosity uncovered.

A third consideration is the condition of the opposing second molar. If this tooth is missing or can logically be ignored or eliminated, then only first molar occlusion need be supplied by using a cantilever-type fixed partial denture or an implant-supported prosthesis. Occlusion need be only minimal to maintain occlusal relations between the natural first molar in the one arch and the prosthetic molar in the opposite arch. A cantilevered pontic should be narrow buccolingually and need not occlude with more than one half to two thirds of the opposing tooth. Often such a restoration is the preferred method of treatment. However, at least two abutments should be used to support a cantilevered molar opposed by a natural molar.

Illidation for removable partial dentures
Although a removable partial denture should be considered only when a fixed restoration is contraindicated, there are several specific indications for the use of a removable restoration.

Distal extension situations
Replacement of missing posterior teeth is often best accomplished with a removable partial denture. The exception to this includes situations in which the replacement of missing second (and third) molars is either inadvisable or unnecessary or in which unilateral replacement of a missing first molar can be accomplished by means of a multiple-abutment cantilevered fixed restoration or an implant-supported prosthesis. The most common partially edentulous situations are the Kennedy Class I and Class II. With the latter an edentulous space on the opposite side of the mouth often conveniently present to aid in the required retention and stabilization of the partial denture. If no space is present, selected abutment teeth can be modified to accommodate appropriate clasp assemblies, or intracoronal retainers can be used. As previously stated, all other edentulous areas are best replaced with fixed partial dentures.

After recent extractions
The replacement of teeth after recent extraction cannot be accomplished satisfactorily with a fixed restoration. When relining will be required later or when a fixed restoration will be constructed later, a temporary removable partial denture can be used. If an all-resin denture is used rather than a cast framework partial denture, the immediate cost to the patient is much less, and the resin denture lends itself best to future temporary modifications.

Tissue changes are inevitable following extractions. Tooth-bounded edentulous areas (as a result of extractions) are best initially restored with removable partial dentures. Relining of a tooth-supported resin denture base is then possible. It is usually done to improve esthetics, oral cleanliness, or patient comfort. Support for such a restoration is supplied by occlusal rests on the abutment teeth at each end of the edentulous space.

Long span
A long span may be totally tooth supported if the abutments and the means of transferring the support to the denture are adequate and if the denture framework is rigid (Fig. 12-23). There is little if any difference between the support afforded a removable partial denture and that afforded a fixed restoration by the adjacent abutment teeth. However, in the absence of
Fig. 12-23 Class III, modification I, partially edentulous arch. Restoration of choice is removable denture rather than fixed prosthesis. Cross-arch stabilization is required for rigid frame work. Additional benefit is the opportunity to arrange anterior teeth for optimal esthetics.

Fig. 12-24 In situations involving excessive residual ridge resorption, artificial teeth supported by denture base can often provide more esthetic and functional result than fixed partial denture.

cross-arch stabilization, the torque and leverage on the two abutment teeth would be excessive. Instead, a removable denture that derives retention, support, and stabilization from abutment teeth on the opposite side of the arch is indicated as the logical means of replacing the missing teeth.

Need for effect of bilateral stabilization
In a mouth weakened by periodontal disease, a fixed restoration may jeopardize the future of the involved abutment teeth unless the splinting effect of multiple abutments is used. The removable partial denture, on the other hand, may act as a periodontal splint through its effective cross-arch stabilizing of teeth weakened by periodontal disease. When all teeth throughout the arch are properly prepared and restored, the beneficial effect of a removable partial denture can be far greater than that of a unilateral fixed partial denture.

Excessive loss of residual bone
The pontic of a fixed partial denture must be correctly related to the residual ridge and in such a manner that the contact with the mucosa is minimal. Whenever excessive resorption has occurred, teeth supported by a denture base may be arranged in a more acceptable buccolingual position than is possible with a fixed partial denture.

Unlike a fixed partial denture the artificial teeth supported by a denture base can be located without regard to the crest of the residual ridge and more nearly in the position of the natural dentition for normal tongue and cheek contacts. This is particularly true of a maxillary denture

(Fig. 12-24). Anteriorly, loss of residual bone occurs from the labial aspect. Often the incisive papilla lies at the crest of the residual ridge, Because the central incisors are normally located anterior to this landmark, any other location of artificial central incisors is unnatural. An anterior fixed partial denture made for such a mouth will have ponties resting on the labial aspect of this resorbed ridge and will be too far lingual to provide desirable lip support. Often the only way the incisal edges of the ponties can be made to occlude with the opposing lower anterior teeth is to use a labial inclination that is excessive and unnatural, and both esthetics and lip support suffer. Because the same condition exists with a
removable partial denture in which the anterior teeth are abutted on the residual ridge, a labial flange must be used to permit the teeth to be located closer to their natural position.

The same method of treatment applies to the replacement of missing mandibular anterior teeth. Sometimes a mandibular anterior fixed partial denture is made six or more units in length, in which the remaining space accessible either by virtue of the anterior tooth or using the original number of teeth but with all of them too narrow for QethQteS. In either instance the denture is nearly in a straight line because the pantries follow the form of the resorbed ridge. A removable partial denture will permit the location of the replaced teeth in a favorable relation to the lip and opposing dentition regardless of the shape of the residual ridge. When such a removable prosthesis is made, however, positive support must be obtained from the adjacent abutments.

Unusually sound abutments

If the prognosis of an abutment tooth is questionable or if it becomes unfavorable while under treatment it might be possible to compensate for its impending loss by a change in denture design. The questionable or condemned tooth or teeth may then be included in the original design and if subsequently lost, the partial denture can be modified or remade (Fig. 12-25). Most partial denture designs do not lend themselves well to later additions, although this eventuality should be considered in the design of the denture.

When the tooth in question will be used as an abutment, every diagnostic aid should be used to determine its prognosis as a prospective abutment. It is usually not as difficult to add a tooth or teeth to a partial denture as it is to add a retaining unit when the original abutment is lost and the next adjacent tooth must be used for that purpose.

It is sometimes possible to design a removable partial denture so that a single posterior abutment, about which there is some doubt, can be retained and used at one end of the tooth-supported base. Then if the posterior abutment is lost, it could be replaced by adding an extension base to the existing denture framework. Such an original design must include provisions for future indirect retention, flexible clasping of the future abutment, and provision for establishing tissue support. Anterior abutments that are considered poor risks may not be so freely used because of the problems involved in adding a new abutment retainer when the original one is lost (Fig. 12-26). It is rational that such questionable teeth be condemned in favor of more suitable abutments, even though the original treatment plan must be modified accordingly.

Economic considerations

Economics should not be the sole criterion in arriving at a method of treatment. When, for economic reasons, complete treatment is out of the question and yet replacement of missing teeth is indicated, the restorative procedures dictated by these considerations...
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PiS 12-2.5 A, Left second molar had guarded pronosis as abutment for removable partial denture. Pramc”Work “Was desciOnd as for Clu”” II modification arch u’inO lin15uoplate major connector, bar-type retainer on left lateral incisor, and wTou1Jht wire retentive ann on ri1Jht canine. Telescoping crown was fabricated over coping on left second molar and will be retained by acrylic reinf denture ba:fe. Sub:sequent 101’1’ of second molar would require only modification of denture ba:se 5e (relining to a.compli:1hI functional ba:5ing). D, Sagittal view of crown. Note cast retention pe<>d” on occlus.,<>l “urf<>cc of the crown.

CHOICE BETWEEN COMPLETE DIHURIES AND RIMOVARIHII PARTIAL DENTURES

When the diagnosis preceding prosthodontic service is made, the probable length of service that can be expected from a partial denture mUlt always be weighed against the patient’s economic status. A decision may have to be made between a partial denture and a complete denture, in either arch or in both. One patient may prefer complete dentures rather than complete oral rehabilitation, regardless of ability to pay. Others may be so determined to keep their own teeth that they will make great financial sacrifices if given a reasonable assurance of success of oral rehabilitation.

The value of listening to the patient during the examination and the diagnostic procedures should not be disregarded or treated lightly. During the presentation of pertinent facts, time should be allowed for patients to express themselves freely as to their desires in retaining and restoring their natural teeth. At this time a
treatment plan may be influenced or even drastically changed to conform to the expressed desires of the patient. For example, there may be a reasonable possibility of saving teeth in both arches through the use of partial dentures. With only anterior teeth remaining, a partial denture can be made to replace the posterior teeth by use of good palatal coverage for retention and stability. If patients express a desire to retain their anterior teeth at any cost and if the remaining teeth are esthetically acceptable and functionally sound, the dentist should make every effort to provide successful treatment. If patients prefer a mandibular partial denture because of fear of difficulty in wearing a mandibular complete denture, then, all factors being acceptable, their wishes should be respected and treatment should be planned accordingly. The professional obligation to present the fдеb and then do the best in accordance with the patients’ expressed desires still applies.

Other patients may wish to retain remaining teeth for an indefinite but relatively short period of time, with eventual complete dentures a foregone conclusion. In this instance the professional obligation may be to recommend interim partial dentures without extensive mouth preparations. Such dentures will aid in maintenance and will provide esthetic replacements, at the same time serving as conditioning restorations, which will make the later transition to complete dentures somewhat easier. Such partial dentures should be designed and fabricated with care, but the total cost of partial denture service should be considerably less.

An expressed desire on the part of patients to retain only six mandibular anterior teeth must be considered carefully before being agreed to as the planned treatment. The advantages to the patients are obvious: they may retain six esthetically acceptable teeth; they do not become totally edentulous; and they have the advantage of direct retention for the removable partial denture that would not be possible if they were completely edentulous. Retaining even the mandibular canine teeth would accomplish the latter two objectives. These advantages cannot be denied. Yet the disadvantages, which are less obvious to patients, must also be considered and explained. These are mechanical and functional considerations; that is, the edentulous maxilla anteriorly is structurally not able to withstand the trauma of balanced tooth contact against natural opposing teeth. The possible result is the loss of residual maxillary bone, loosening of the maxillary denture because of the tripping influence of the natural mandibular teeth, and the loss of basal foundation for the support of future prostheses. However, if the maxillary anteriors are arranged to contact in balanced eccentric positions and patients comply with periodic recall, these problems are minimized.

The presence of inflamed hyperplastic tissue is a frequent sequel to continued loss of support and denture movement.

The prevention of this sequence of events lies in the maintenance of positive occlusal support posteriorly and the continual elimination of traumatic influence from the remaining anterior teeth. Such support is sometimes impossible to maintain without frequent relining or remaking of the lower partial denture base.

Although some patients are able to successfully function with a lower partial denture supported only by anterior teeth against a complete maxillary denture, it is likely that unless the patient faithfully follows the instructions of the dentist, the result will be the loss of the lower partial denture. In no other situation in treatment planning is the general health of the patient and the quality of residual alveolar bone as critical as they are in this situation.

In addition to considering the age and health of patient and their ability to retain or regenerate bone in response to stress, it is well to consider why the natural teeth were extracted. In all probability any history of severe periodontal disease precludes the success of such combination dentures. On the other hand, the loss of teeth because of caries or the premature loss of teeth that might have been saved may justify the conclusion that the residual bone is probably healthy and will be able to withstand stresses within reasonable limits. The final treatment plan should represent the best possible treatment for the patient after consideration has been given to all
physical, mental, mechanical, esthetic, and economic factors involved.

FACTORS IN SELECTING METAL ALLOYS FOR REMOVABLE PARTIAL DENTURE FRAMEWORKS

Practically all cast frameworks for removable partial dentures are made from a chromium-cobalt alloy. The choice of the alloy from which the framework of a removable partial denture will be constructed is logically made during the treatment planning phase. Inherent differences in the physical properties of alloys presently available to the dental profession must be considered when making this choice. For example, mouth preparation procedure, especially the recontouring of butment teeth for the optimum placement of retentive elements, depend to a large extent on the modulus of elasticity (stiffness) of a particular alloy.

Chromium-cobalt alloys are used many times more than the gold or titanium alloys in removable partial prosthodontics. The popularity of the chromium-cobalt alloys has been attributed to their low density (weight), high modulus of elasticity (stiffness), low material cost, and resistance to tarnish. Each of the alloys has advantages under certain conditions. The material considered capable of rendering the best overall service to the patient over a period of years is the one that should be used. The choice of alloy is based on several factors: (1) weighed advantages or disadvantages of the physical properties of the alloy; (2) the dimensional accuracy with which the alloy can be cast and finished; (3) the availability of the alloy; (4) the versatility of the alloy; and (5) the individual clinical observation and experiences with alloys in respect to quality control and service to the patient.

The following are comparable characteristics of gold alloys and chromium-cobalt alloys: (1) each is well tolerated by oral tissues; (2) they are equally acceptable esthetically; (3) enamel abrasion by either alloy is insignificant on vertical tooth surfaces; (4) a low-fusing chrome cobalt alloy or gold alloy can be cast as wrought wire, and wrought-wire components may be soldered to either gold or chrome-cobalt alloys (these characteristics are important in overcoming the objection by some dentists to the increased stiffness of chromium-cobalt alloys for the portions of direct retainers that must engage an undercut of the abutment tooth); (5) the accuracy obtainable in casting either alloy is clinically acceptable under strictly controlled investing and casting procedures; and (6) soldering procedures for the repair of frameworks can be performed on each alloy.

Comparative physical properties

Chromium-cobalt alloys generally have a lower yield strength than the gold alloys used for removable partial dentures (Table 12-1). Yield strength is the greatest amount of stress an alloy will withstand and still return to its original shape in an unweakened condition. Possessing a lower proportional limit, the chromium-cobalt alloys will deform permanently at lower loads than gold alloys. Therefore the dentist must design the chromium-cobalt framework so that the degree of deformation expected in a direct retainer is less than a comparable degree of deformation for a gold component. The modulus of elasticity refers to stiffness of an alloy. Gold alloys have a modulus of elasticity approximately one half of that for chromium-cobalt alloys for similar uses. The greater stiffness of chromium-cobalt alloy is advantageous but at the same time offers disadvantages. Greater rigidity can be obtained with the chromium-cobalt alloy in reduced sections in which cross-arch stabilization is required, thereby eliminating an appreciable bulk of the framework. Its greater rigidity is also an advantage when the greatest undercut that can be found on an abutment tooth is in the nature of 0.05 inch. A gold retentive element would not be as efficient in retaining the restoration under such conditions as would the chromium-cobalt clasp arm.

A high yield strength and a low modulus of elasticity produce higher flexibility. The gold alloys are approximately twice as flexible as the chromium-cobalt alloys, which is a distinct advantage in the optimum location of retentive elements of the framework in many instances. The greater flexibility of the gold alloys usually
permits location of the tips of retainer arms in the gingival third of the abutment tooth. The stiffness of the chromium-cobalt alloys can be overcome by including wrought-wire retentive elements in the framework.

The bulk of a retentive clasp arm for a removable partial denture is often reduced for greater flexibility when chromium-cobalt alloys are used as opposed to gold alloys. This, however, is inadvisable because the grain size of the chromium-cobalt alloys is usually larger and is associated with a lower proportional limit, and a decrease in the bulk of chromium-cobalt cast clasps increases the likelihood of fracture or permanent deformation. The retentive clasp arms for both alloys should be approximately the same size, but the depth of undercut used for retention must be reduced by one half when chromium-cobalt is the choice of alloys. Chromium-cobalt alloys are reported to work-harden more rapidly than gold alloys, and this, associated with coarse grain size, may lead to failure in service. When adjustments by bending are necessary, they must be executed with extreme caution and limited optimism.

Chromium-cobalt alloys have a lower density (weight) than gold alloys in comparable sections and are therefore about one-half as heavy as the gold alloys. Weight of the alloy in most instances is not a valid criterion for selection of one metal over another because after placement of a partial denture the patient seldom notices the weight of the restoration. The comparable lightweight of the chromium-cobalt alloy, however, is an advantage when full palatal coverage is indicated for the bilateral distal extension partial denture. Weight is a factor that must be considered when the force of gravity must be overcome so that usually passive direct retainers will not be activated constantly to the detriment of abutment teeth.

The hardness of chromium-cobalt alloys presents a disadvantage when a component of the framework, such as a rest, is opposed by a natural tooth or by one that has been restored. We have observed more wear of natural teeth opposed by some of the various chromium-cobalt alloys compared to the Type IV gold alloys.

It has been observed that gold frameworks for removable partial dentures are more prone to produce uncomfortable galvanic shocks to abutment teeth restored with silver amalgam than frameworks made of chromium-cobalt alloy. This may not be a valid criterion for the selection of a particular alloy when the dentist has complete control over the choice of restorative materials.

Wrought wire: selection and quality control

Wrought-wire direct retainer arms may be attached to the restoration by embedding a portion of the wire in an acrylic resin denture base, by soldering to the fabricated framework,
or by casting the framework to the wire (Fig. 12-27). The physical (mechanical) properties of available wrought wires are most important considerations in selecting a proper wire for the desired method of attachment. These properties are yield strength or proportional limit, percentage elongation, tensile strength, and fusion temperature. After selection of the wire, the procedures to which the wire is subjected in fabricating, the restoration become critical. Improper laboratory procedures can diminish certain desirable physical properties of the wrought structure, rendering it relatively useless for its intended purpose. For example, when wrought wire is heated, as in a cast-to or soldering procedure, its physical properties and microstructure may be considerably altered depending on the temperature, heating time, and cooling operation. Each manufacturer of

<table>
<thead>
<tr>
<th>ALLOY</th>
<th>Condition</th>
<th>Lbs/in.²</th>
<th>Kg/m²</th>
<th>Lbs/in.²</th>
<th>Kg/m²</th>
<th>2 in. or 5.1 cm</th>
<th>BH N</th>
<th>HV</th>
<th>℃</th>
<th>dwt./ft.</th>
<th>gm/m</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELASTIC</td>
<td>S</td>
<td>117.5</td>
<td>397.5</td>
<td>173.0</td>
<td>567.0</td>
<td></td>
<td>190</td>
<td>900</td>
<td>226</td>
<td>125</td>
<td>310</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>125.0</td>
<td>440.0</td>
<td>125.0</td>
<td>440.0</td>
<td></td>
<td>200</td>
<td>951</td>
<td>270</td>
<td>125</td>
<td>310</td>
<td>17.8</td>
</tr>
<tr>
<td>NEYLASTIC</td>
<td>S</td>
<td>110.0</td>
<td>445.0</td>
<td>145.0</td>
<td>520.0</td>
<td></td>
<td>190</td>
<td>900</td>
<td>226</td>
<td>125</td>
<td>310</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>120.0</td>
<td>440.0</td>
<td>120.0</td>
<td>440.0</td>
<td></td>
<td>200</td>
<td>951</td>
<td>270</td>
<td>125</td>
<td>310</td>
<td>17.8</td>
</tr>
<tr>
<td>GOLD COLOR</td>
<td>S</td>
<td>120.0</td>
<td>440.0</td>
<td>120.0</td>
<td>440.0</td>
<td></td>
<td>190</td>
<td>900</td>
<td>226</td>
<td>125</td>
<td>310</td>
<td>17.5</td>
</tr>
<tr>
<td></td>
<td>H</td>
<td>100.0</td>
<td>415.0</td>
<td>100.0</td>
<td>415.0</td>
<td></td>
<td>190</td>
<td>900</td>
<td>226</td>
<td>125</td>
<td>310</td>
<td>17.5</td>
</tr>
<tr>
<td>P &amp; T</td>
<td></td>
<td>120.0</td>
<td>440.0</td>
<td>120.0</td>
<td>440.0</td>
<td></td>
<td>190</td>
<td>900</td>
<td>226</td>
<td>125</td>
<td>310</td>
<td>17.5</td>
</tr>
</tbody>
</table>

Fig. 12-27 Wrought—"#IrQ rQtainQR arm ha" bQQn contoured to design on duplicate stone cast of blocked-out ,aster cast, It ,"ill bQ transferr'd to refractory cast, will become integral part of framework pattern, and will be cast-to. Wire IS contoured in two planes and will be mechanically retained in casting,
wrought forms for dental applications furnish charts listing their products and the physical properties of each product. Two examples of such information are demonstrated in Fig. 12-28. The percentage of noble metals is given. In addition, most manufacturers designate wires that may be used in a cast-to procedure. ADA Specification No. 7 addresses itself to wrought gold wire both as to content and minimum physical properties (Table 12-2).

### Table 12-2: Physical Properties of Wrought Gold Wire

<table>
<thead>
<tr>
<th>Wire Type</th>
<th>Composition</th>
<th>Tensile Strength</th>
<th>Elongation</th>
<th>Heat Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>High Fusing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jelenko &quot;0&quot; Cast Gold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intermediate</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jelenko &quot;0&quot; Cast Gold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Low Fusing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jelenko &quot;0&quot; Cast Gold</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For legend see opposite page.
Fig. 12-29 A, Round, 15-gauge wrought wire is uniformly tapered (to 0.8 mm) to length of retainer arm contacting abutment. This is conveniently accomplished by rapidly spinning wire in "n15lcd cont’d with t."’nmn151 "br’"ive cut-off di”k in dent’l l”rhe. B, Tapered vvire i’ polished by spinning vvire in angled contact vvith fast-rurnning, mildly abrasive rubber disk in dental lathe.

<table>
<thead>
<tr>
<th>TABLE 12-2. Comparative specifications contained in ADA Specification No. 7</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>---</td>
</tr>
<tr>
<td>Content of metab of the gold, platinum group (minimum)</td>
</tr>
<tr>
<td>Minimum fusion temperature</td>
</tr>
<tr>
<td>Minimum yield point value (hardened or oven cooled) Minimum</td>
</tr>
<tr>
<td>,,lonsation (hard”ll”,d)</td>
</tr>
<tr>
<td>Minimum clon15’tion (eoftcned)</td>
</tr>
</tbody>
</table>

Craig has suggested that the tensile strength of the wrought structure is approximately 25% greater than that of the cast alloy from which it was made. The wrought structure's hardness and strength are also greater. This means that a wrought structure having a smaller crosssection than a cast structure may be used as a retainer arm (retentive) to perform the same function. Craig has also suggested that a minimum yield strength of 60,000 psi is required for the retentive element of a direct retainer. A percentage elongation of less than 6% is indicative that a wrought wire may not be amenable to contouring without attendant undesirable changes in microstructure.

Regardless of the method of attaching the wrought wire retainer, either by embedding, soldering, or cast-to, tapering the wrought arm seems most rational. A retainer arm is in essence a cantilever and can be made more serviceable and efficient by tapering. Tapering to 0.8 mm permits more uniform distribution of service stresses throughout the length of the arm, being readily demonstrated by photoelastic stress analysis. Uniform tapering of an 18-gauge, round wire arm can be accomplished, as illustrated in Fig. 12-29, before the retainer arm is contoured. The dimensions of the taper we prefer are illustrated in Fig. 12-30.

Commercially pure (CP) titanium and titanium in alloys containing aluminum and vanadium, or palladium (Ti-O-Pd), should be considered potential future materials for removable partial denture framework. Their versatility and well-known biocompatibility are promising; however, long-term clinical trials are needed to validate their potential usefulness. Currently, when CP titanium is cast under dental conditions, the material properties change dramatically. During the casting procedure, the hit5h affinity of the liquid metal for elements such as oxygen, nitrogen, and hydrogen results in their incorporation from the atmosphere. As interstitial alloying elements, their deleterious effect on mechanical properties is a problem. Also, reactions between molten titanium metal and the investment refractory produce gases, which cause porosity. In alpha-beta alloys, such as CP titanium, a surface skin of alpha titanium can form (alpha-case zone), which has a tremendous effect on the electrochemical behavior and mechanical properties. This could be important for small thin structures, such as clasp assemblies and major and minor connectors. Table 12-3 shows selected mechanical properties of commercially pure titanium and Ti-6Al-4V alloy. The CP titanium of 5 MPa of yield strength that are too low for clinical use as clasps (450 MPa minimum), although the ductility is high. The much higher yield strengths of the Ti-6Al-4V alloys are the same as that of a typical bench-cooled cobalt-chromium alloy, but with far superior ductility. The typical Young's modulus of elasticity of titanium alloy is half that of cobalt-chromium and just slightly higher than type IV gold alloys. This would require a different approach to clasp design than with cobalt-chromium alloys, and present some advantages. Wrought titanium alloy wires are also flexible because of the same low elastic modulus. Beta alloys, which are used in orthodontics, have two-thirds the elastic modulus of CP titanium and Ti-6Al-4V. The joining of titanium by brazing is a problem because like-casting inert atmospheres must be used. The corrosion and fatigue behavior of brazed joints has yet to be tested for long-term corrosion resistance and clinical efficacy.

<table>
<thead>
<tr>
<th>Properties</th>
<th>G1</th>
<th>G2</th>
<th>G3</th>
<th>G4</th>
<th>Ti-6Al-4V</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield strength MPa (min)</td>
<td>170</td>
<td>280</td>
<td>380</td>
<td>480</td>
<td>825</td>
</tr>
<tr>
<td>Tensile strength MPa (min)</td>
<td>240</td>
<td>340</td>
<td>450</td>
<td>550</td>
<td>895</td>
</tr>
<tr>
<td>Elongation (%)</td>
<td>24</td>
<td>20</td>
<td>18</td>
<td>15</td>
<td>10</td>
</tr>
<tr>
<td>Elasticity MPa (min)</td>
<td>103</td>
<td>103</td>
<td>107</td>
<td>107</td>
<td>no</td>
</tr>
<tr>
<td>Hardness</td>
<td>120 HB</td>
<td>200 HB</td>
<td>225 HB</td>
<td>245 HB</td>
<td>37 HRC</td>
</tr>
</tbody>
</table>

Ti-6Al-4V, a surface skin of alpha titanium can form (alpha-case zone), which has a tremendous effect on the electrochemical behavior and mechanical properties. This could be important for small thin structures, such as clasp assemblies and major and minor connectors.
Summary
In making a selection of materials it must be remembered that fundamentals do not change. These are inviolable. It is only methods, procedures, and substances-by which the dentist effects the best possible end result—that change. The responsibility of decision still rests with the dentist, who must evaluate all factors in relation to the results desired. In any instance therefore, the dentist must weigh the problems involved, compare and evaluate the characteristics of different potential materials, and then make a decision that leads to the greatest possible service to the patient.

SELF-ASSESSMENT AIDS
2. Meaningful treatment of a partially edentulous patient involves four fundamentally different processes. Please name these processes in chronological order of accomplishment.
3. What are the objectives of prosthodontic treatment for a partially edentulous patient?
4. In what ways does past dental experience of a patient that one is treating for the first time contribute to patient management?
5. Why should one review the present health status of the patient before conducting an oral examination?
6. Diagnostic casts should be made before definitive treatment is undertaken. What two specific purposes would they serve?
7. It is not unusual for a patient to be primarily concerned with the cosmetic implications of a missing tooth. What are the obligations of the dentist to broaden the concern of total treatment?
8. A logical sequence of a thorough oral examination includes at least eight different procedures accomplished in order. Two of the eight procedures are a thorough prophylaxis and the placement of individual temporary restorations. What are the other six factors?
9. For what reason should the definitive location of the inferior border of a mandibular major connector be ascertained as part of an oral examination?
10. Rationalize the importance of the following areas that must be ascertained by roentgenographic interpretation:
   a. Quality of alveolar support of prospective abutment teeth
   b. Interpretation of relative bone density
   c. Increased width of the periodontal space
   d. Index areas
   e. Lamina dura
   f. Root morphology
   g. Unerupted third molar
11. What is a diagnostic cast?
12. Describe the characteristic of a diagnostic cast of a partially edentulous arch that may be considered a quality cast?
13. Diagnostic casts serve oral purposes as aids in diagnosis and treatment planning. What are six different uses for them?
14. Two sets of diagnostic casts (one a duplicate set) should be made for a patient requiring treatment. Why?
15. What can be gained from a study of accurately mounted diagnostic casts on a programmed, semiadjustable articulator?
16. The base of a diagnostic cast should be prepared in a certain way before any mounting on the articulator. Describe the preparation and state its importance.
19. What four maxillomandibular records are necessary to orient cast B to an arch type of articulator and to program the articulator?
  20. What is meant by proving the articulator, and how is it accomplished?
21. Name and describe the use of at least six different materials used for recording maxillomandibular relations.
22. In relation to occlusion, one of the earliest decisions to be made in diagnosis is whether to accept or reject the existing occlusion as demonstrated by the correctly oriented and articulated diagnostic casts. True or false?
23. Improvements in the natural occlusion must be accomplished before fabrication of the denture, not subsequent to it. True or false?
24. The decision-making process in planning the restoration of a partially edentulous mouth must include a differential diagnosis of fixed or removable restorations or a combination of both as a means of restoration. Usually, where indicated, a fixed restoration is preferred to a removable restoration. True or false?

25. What are the indications for the use of fixed restorations in (1) tooth-bounded edentulous spaces; (2) posterior modification spaces; and (3) anterior modification spaces?

26. Although a removable partial denture should be considered as the means of treatment only when a fixed partial denture is contraindicated, there are several specific indications for the use of a removable restoration. Briefly discuss these indications related to (1) digital extension situations; (2) postextraction periods; (3) long tooth-bounded edentulous spans; (4) need for bilateral stabilization; (5) excessive loss of residual bone; (6) esthetics in the anterior region of the mouth; (7) abutments with guarded prognoses; and (8) economic considerations.

27. In many instances the dentist is confronted with the decision of treating the partially edentulous patient with removable partial dentures or complete dentures. Discuss the following factors that certainly have a bearing on the decision-making process: (1) economics; (2) patient preference or desires of patient; (3) age; (4) health; (5) present periodontal status; and (6) dental IQ or prospective IQ.

28. As a result of oral examination and diagnosis, certain data should be recorded, much of which is based on decisions that are the result of diagnosis, patient's attitudes, and economics. Some of these data are present and predictable health status, periodontal conditions present, oral hygiene habits, caries activity, need for extractions or surgery, need for fixed restorations, and need for orthodontic treatment. There are at least five more areas of treatment that should be recorded at this time. What are they?

29. Most frameworks for removable partial dentures today are made of some type of cobalt-chromium alloy rather than with an extra hard gold alloy. Four reasons are usually projected for this wide variation. What are they?

30. The choice of an alloy(s) is based on what factors?

31. Compare the physical properties of yield strength (proportional limit) and percentage elongation of cobalt-chromium alloy and partial denture gold alloy.

32. Which alloy is the stiffest in comparable sections—gold alloy, titanium alloy, or cobalt-chromium alloy? What are the advantages and disadvantages of comparable stiffness?

33. The retentive clasp arms for cobalt-chromium, titanium, and gold alloys should be dimensionally the same. Why or why not?

34. Many dentists prefer to use wrought-wire retentive arms in certain instances. Wrought wire may be attached to the denture by being cast-to, soldered, or embedded in the resin base. Does the method of attachment have a bearing on the selection of framework alloy and wrought wire? Why?

35. How would you go about selecting a wrought wire for a specific application of the wire?

36. There are inherent risks in the use of unilateral removable partial dentures. One is the risk of aspiration. What are some other risks?

37. Recent clinical research has contributed several significant developments to the management of compromised partially edentulous patients. Two of these developments are related to the field of implant prosthodontics. Name them.