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Designing of Cast Partial Denture-A Review

Shefali Singh Malik[1], Narendra Singh Khuswaha[1], Abhishek Avasthi[1]
[1]Senior Lecturer, Department Of Prosthodontics, Bhojia Dental College, Tehsil- Baddi, District- Solan, Himachal Pradesh.

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ABSTRACT

Loss of teeth has a negative impact on the oral health as well as the emotional wellbeing of an individual. Partial denture base must cover as much area as possible, accurately fitting the tissue surface without contacting free gingival margin. The principles of occlusion should be followed as closely for removable partial dentures as for complete dentures. Design of a partial denture is a part of treatment, itself a product of diagnosis. Important diagnostic factors include analysis of vertical dimensions, occlusion, neuromuscular function and periodontium. This review deals with classification of edentulous arch, surveying and designing of cast partial dentures.

Keywords: Edentulous, Esthetics, Partial Denture, Retention, Stability.

INTRODUCTION

Despite the decreasing rate of tooth loss, owing to the dental awareness and the access to preventive dental care, still the demand for removable prosthodontic treatment remains high.[1] Not only does the partial loss of teeth affect the remaining teeth, but the associated parts may change adversely in contour. The muscles of mastication may lose their tonus, may atrophy and suffer loss of traction power. Nervous habits may be induced by poor esthetics or function; in turn digestion, speech, and facial expression may be affected.[2]

Partial dentures must be designed with consideration for forces exerted in function, and for the effect of these forces on the health of the remaining teeth. The amount of bony support of the abutment teeth and the health of the supporting tissues must be evaluated carefully.[3] The successful partial denture cannot be produced by the skilful application of techniques alone. It must be conceived and constructed upon the knowledge of oral and dental anatomy, biology, histology, pathology, physics, and their allied sciences if the oral tissues are to be preserved and the missing teeth properly restored. The successful denture complements the remaining natural teeth, cooperates with them in function, and extends their useful life. It acts as a physiologic part of the masticatory mechanism.[4]

Name & Address of Corresponding Author
Dr. Shefali Singh Malik
Senior Lecturer
Department Of Prosthodontics
Bhojia Dental College
Tehsil- Baddi, District- Solan
Himachal Pradesh.

Any consideration of the logical design of a partial denture necessitates that, first of all, we must establish the basic requirements of such a restoration. The objectives we should obtain in partial denture prosthesis are support, stability, retention, function, and esthetics.[3] Any restoration, however great its ability to function during mastication, cannot do so effectively if the appliance induces discomfort. Thus, the design of any restoration should be such as to result in comfort to the teeth, their associated parts, and the mucosa at all times. The problem is to restore the function of the masticatory apparatus and to maintain it in comfort to the patient.[2,3]

Professional partial denture service may be divided into three phases: the planning phase (often referred to as diagnosis), the preparation of the mouth, and the designing of the partial denture. This discussion is limited to the designing phase, but the importance of the first two phases should be emphasized. Planning, or making the diagnosis, involves the use of complete mouth roentgenograms and study casts which should be mounted. A tentative design must be worked out in the planning phase, and the necessary extractions, restorations, and modification of tooth contours planned. The preparation phase is then carried out according to this plan. When it is complete, the master casts are made, and the designs are made on the master casts. Designing in any field-architecture, engineering, etc.-consists of making a careful drawing and writing exact specifications. Similar procedures should be the professional responsibility in partial denture work.[2-4]

Classification of Partially Dentulous Arches:

The most familiar classifications are those originally proposed by Kennedy, Cummer, and Bailyn. Also, Beckett, Godfrey, Swenson, Friedman, Wilson,

Skinner, Applegate, Avant have proposed classifications. It is evident that an attempt should be made to combine the best features of all classifications so that a universal classification can be adopted.[5]

Kennedy's Classification System:

Kennedy's system makes it possible to place any partially dentulous arch into one of the four groups with a few subdivisions under each group. It is based on the relationship of the edentulous spaces to the abutment teeth [Figure 1].[5]

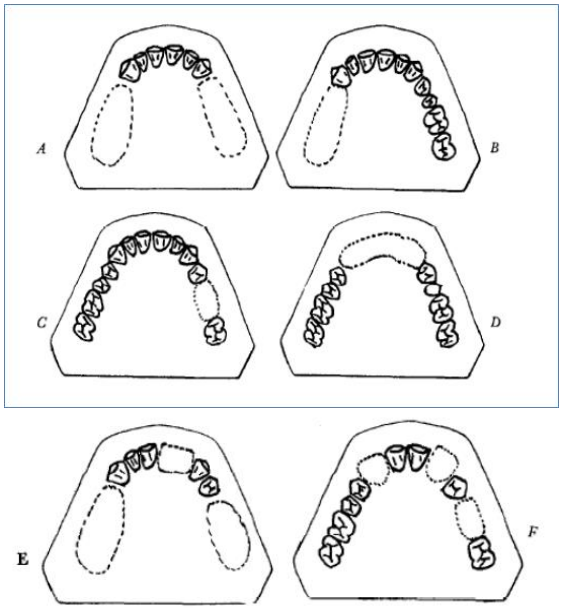

Figure 1: A, Class I of the Kennedy classification-bilateral edentulous regions posterior to the remaining teeth. B, Class II-unilateral edentulous region posterior to the remaining teeth. C, Class III-unilateral edentulous region bounded anteriorly and posteriorly by natural teeth. D, Class IV-edentulous region anterior to the remaining teeth. Modification spaces-all partially dentulous jaws can be classified into one of the above primary categories although some may have one or more edentulous regions in addition to the one(s) which dictated the primary class. Thus, a Class I with one anterior edentulous region would be classified as a Class I Modification I (E) . A Class III with two edentulous regions as a Class III Modification II (F)

The Kennedy's method of classification is the best known of all systems that have been proposed through the years, and is more widely used than any other.

Components of removable partial dentures:

A removable partial denture will have following components:-

1. Major connectors
2. Minor connectors
3. Rests
4. Direct Retainers
5. Indirect Retainers
6. One or more dentures bases

Maxillary Majors Connectors:

Six basic types of maxillary major connectors are considered:

1. Single palatal strap
2. Combination anterior and posterior palatal strap type connectors.
3. Palatal plate – type connectors
4. U- shaped palatal connectors
5. Single palatal bar
6. Anterior – posterior palatal bars

Fig. 2: Single Palatal Strap

Fig. 3: Anterior posterior palatal-strap type Major Connector.

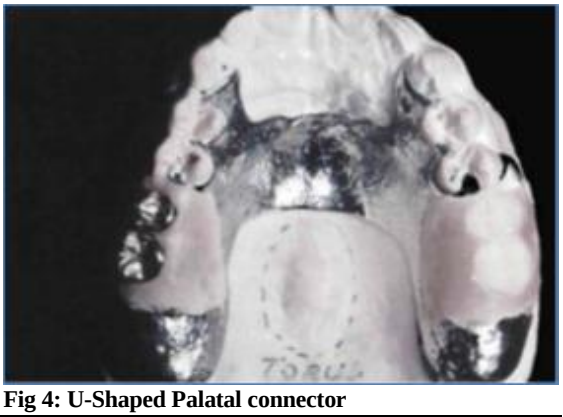

Fig 4: U-Shaped Palatal connector

Mandibular Major Connectors

Six types of mandibular major connectors are:

1. Lingual bar

2. Linguoplate
3. Sublingual bar
4. Lingual bar with cingulum bar (continuous bar)
5. Cingulum bar (continuous bar)
6. Labial bar

Figure 5: Lingual Bar

Figure 6: Linguoplate

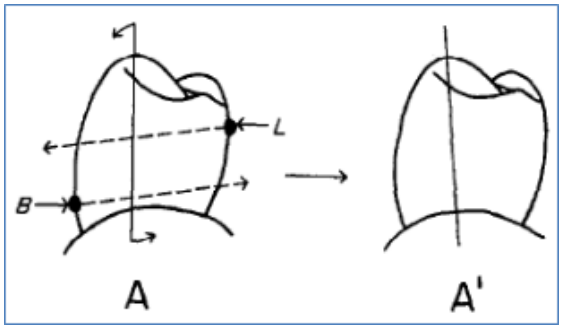

Figure 7: Clasping with lack of vertical reciprocation of the clasp arms causes pressures as indicated by arrows at L (lingual) and B (buccal) during the transmission of lateral forces. These forces tend to rotate the tooth from position A to position A'. The rotational force is diminished if B and L are on the same level and are directly opposed to each other.

Stabilization:

The rigid elements of the clasp must be completely rigid in construction, rest passively against the tooth occlusal to the height of contour, and encircle more than180 degrees of the circumference of the tooth (horizontal reciprocation) to attain the utmost in stability. The rigid elements must be placed as closely to the gingivae as possible so that lateral stresses on the denture will have the shortest possibletorque fulcrum. In addition, the clasp elements should be on the same level on bothsides of the tooth (vertical reciprocation). The amount of vertical disparity between clasp elements on opposite sides of a tooth is related to the tendency of clasps to tilt the abutment tooth buccally or lingually under lateral stress on the denture [Figure 7 & 8].

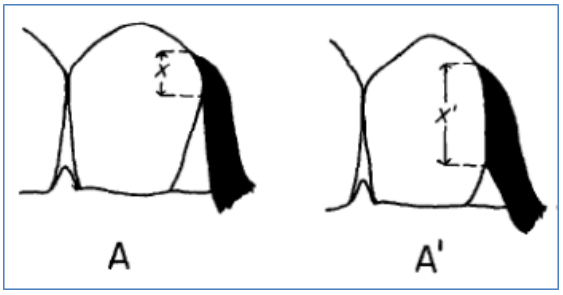

Figure 8: A tooth without a recontoured proximal surface; x is the length of tooth surface that is in intimate contact with the upright. A', A tooth with a recontoured proximal surface: x' is markedly longer than 3, which provides additional stability and acts as a truss and a plane for a precise path of insertion.

Retention

The flexible clasp elements must terminate on the abutment tooth gingivally to the height of contour to retain a denture. The exact point of termination of the clasp is related to the retentive needs of the denture, the contour of the abutment, the length and cross-sectional area of the clasp, the material from which the clasp is made, and the direction from which the clasp approaches the tooth.

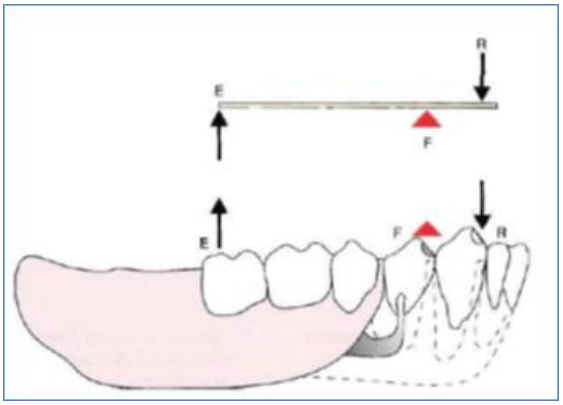

Figure 9: Mandibular distal extension removable partial denture showing distal extension base being lifted from the ridge, the clasp assembly being activated and engaged, with the indirect retainer providing stabilization against dislodgement.

Indirect Retainer

The indirect retainer limits the vertical displacement of a removable partial denture. It supplies retention against vertical displacing forces, such as the pull of sticky foods acting on partial denture at each end of

the edentulous space or spaces. The indirect retainer components should be placed as far as possible from the distal extension base, which provides the best leverage advantage against dislodgment [Figure 9].[6]

Occlusal Rest:

This is the most commonly used indirect retainer. It should be located on an occlusal surface and as far away from the distal extension base as possible. In a mandibular Class I arch, this location is usually on the mesial marginal ridge of the first premolar on each side of the arch. Indirect retainers for Class II partial dentures are usually placed on the marginal ridge of the first premolar tooth on the opposite side of the arch from the distal extension base.

Canine Rests:

When the mesial marginal ridge of the first premolar is too close to the fulcrum line or when the teeth are overlapped so that the fulcrum line is not accessible, a rest may be used on the adjacent canine tooth. Such a rest may be made more effective by placing the minor connector in the embrasure anterior to the canine, either curving back onto a prepared lingual rest seat or extending to a mesioincisal rest.[2,6]

Denture Base:

The base is the most important unit in partial denture, because through it the principle support is to be gained from the underlying rigde structures. The supplied teeth are carried by it with the resulting work load being passed on by a direct comprehensive impact to the ridge structures, when the base is of the extension type. However, if the edentulous segment is bounded by remaining teeth which are able to serve as abutments, the functional stresses are passed on to the abutment teeth through the base, minor connectors and occlusal rests. The extension, or tissue borne, base also stimulates those structures covered by it, thus encouraging tissue tone. Given the stability achieved through adequate courage, the base aids in lessening the twisting and/ or tilting force inherent in an extension base partial dentures. In this way the stress loads which reach the abutment teeth are most effectively minimized.

Surveying:

Surveyor is a paralleling instrument used in constructionof a dental prosthesis to locate and delineate the contours and relative positions of abutment teeth and associated structure.[7]

Purposes of Surveyor:

a.) To determine the most desirable path of placement that will eliminate or minimize interference to placement and removal.
b.) To identify proximal tooth surfaces that need to be made parallel as that they can act as guiding planes during placement and removal.
c.) To locate and measure areas of teeth that may be used for retention.
d.) To determine whether tooth and bony areas of interference will need to be eliminated surgically or by selecting a different path of placement.
e.) To determine the most suitable path of placement that will permit locating retainers and artificial teeth to the best aesthetic advantage.
f.) To permit an accurate charting of the mouth preparations to be made. This includes the preparation of proximal tooth surfaces to provide guiding planes and the reduction of excessive tooth contours to eliminate interferences and to permit a more acceptable location of reciprocal and retentive clasp arms.
g.) To delineate the height of contour on abutment teeth and to locate areas of undesirable undercuts that is to be avoided, eliminated or blocked out.
h.) To record the cast position in relation to the selected path of placement for future references.

Recent Innovations:[8]

Lasers: surveyor dramatically exposes undercut areas by projecting a beam of laser light. A beam of laser light projects vertically downward from the distal end of the horizontal arm to serve as the surveying arm. No visible "survey line" is produced at the height of contour of the teeth [Figure 10].

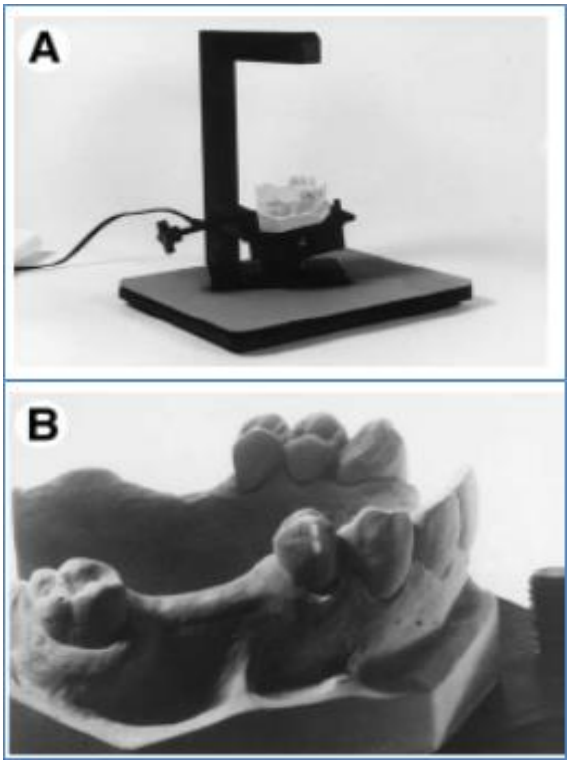

Fig. 10: A beam of laser light projects vertically downward from the distal end of the horizontal arm to serve as the surveying arm.

Electronic Surveyor:

Developed at the United States Air Force School of Aviation Medicine at Randolph Air Force Base

(1958) [Figure 11]. Powered by dry cell batteries and was capable of passing a week current through the surveying tool to the cast surface. Casts were treated with phenolphthalein, and contact with the surveying tool produced a fine, red survey line.[6-8]

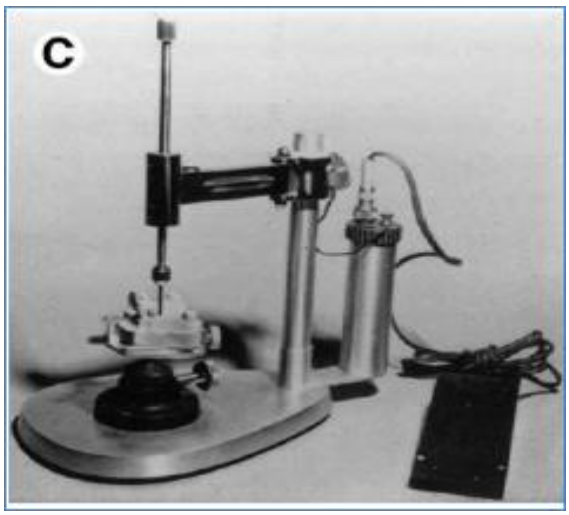

Figure 11: Electronic surveyor

3-D Computer Aided Design

Electronically survey the cast. The depth of undercut is determined from the definitive cast. Programs were written for this technique using mathematic software (MatLab; the Math Works, Inc, Natick, Mass). Identification of a surveyline was done with a mathematic program that identified all downward facing surface triangles on scan. The software was developed using a simple "barrel" shape. The program defined the surface area of teeth apical to the survey line by identifying the downward facing triangles. The upper boundary of this area defined the survey line.[9]

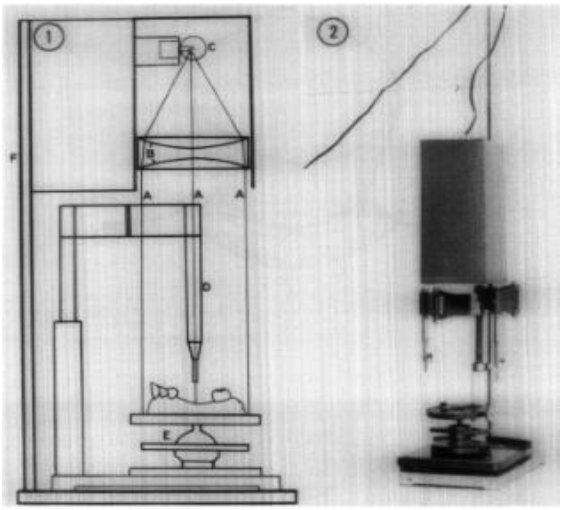

Figure 12: Diagrammatic drawing of optical surveyor: (A) light beams, (B) condenser lenses, (C)the small, dense filament-type light bulb, (D) the vertical rod of the surveyor, (E) the movablesurveyor table, and (F) the holding bar. The optical surveyor is used with a conventional surveyor.

Optical Surveyor

Casts can also be surveyed by parallel light beams instead of the vertical rod, after selecting the path of insertion. Parallel light beams are produced by light bulbs with small, dense filaments and condenser lenses contained in a box. The beams are made parallel with the vertical rod of the conventional surveyor by fixing the box firmly to an iron bar.[9,10]

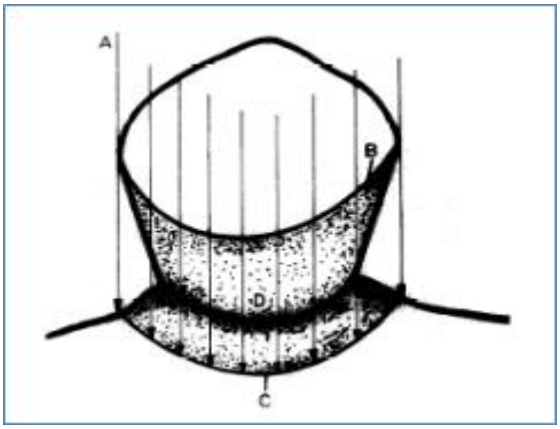

Figure 13: The survey line produced by the optical surveyor on apremolar when its axis is vertical: (A) the light beam, (B) the survey line indicated by theborder of bright and dark zones. (C) the vertical projection of the survey line, and (D) undercutsurfaces.

Designing of cast partial denture:

During the survey process, the practitioner determines the most favorable tilt for a dental cast, completes the tripoding process, place the survey lines and accurately marks the desired mechanical undercuts. At this stage, the practitioner is ready to begin the design process. The control of potentially damaging forces is the primary goal of removable partial design. When subjected to intraoral forces, a removable partial denture can perform the actions of two simple machines.

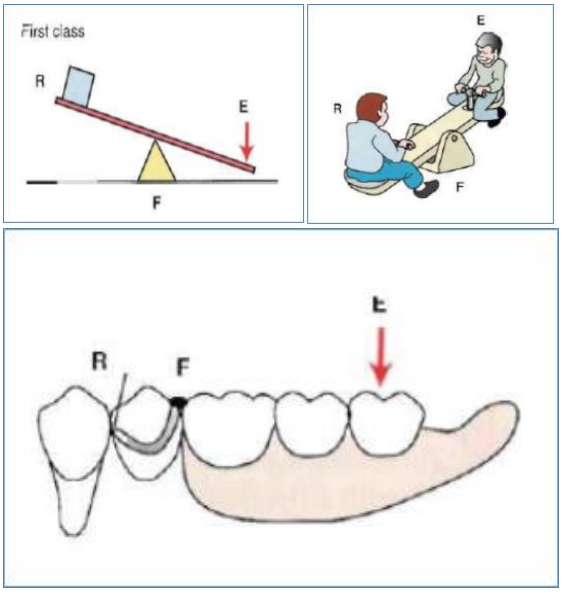

Figure 14: Class I Lever

Lever

A simple machine consisting of a rigid bar pivoted on a fixed point and used to transmit force, as in raising or moving a weight at one end by pushing down on the other. Three classes of levers (based on location of fulcrum, resistance and direction of effort) include:[2,9-11]

Class I lever

Fulcrum lies in the centre, resistance is at one end and force at the other [Figure 14].

Class II lever

Fulcrum is at one end, effort at the opposite end and resistance in the centre. [Figure 15]

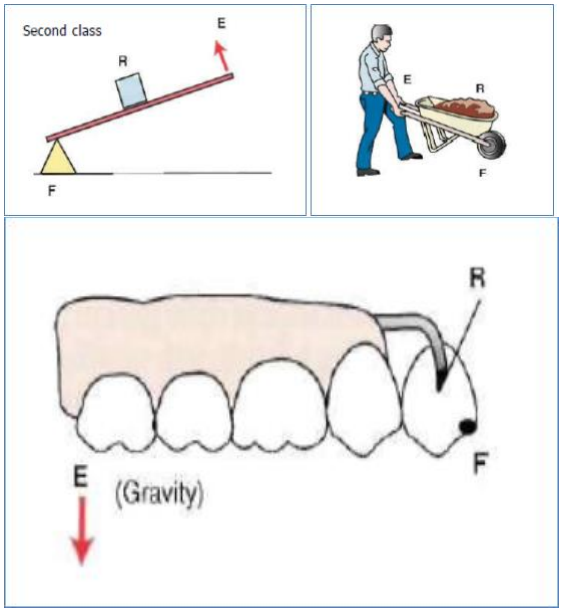

Figure 15: Class II Lever

Class III

Fulcrum is at one end, resistance at opposite end and effort is in the centre.36 [Figure 16]

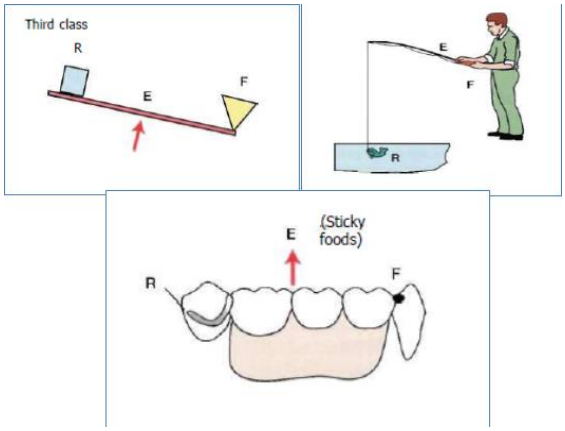

Figure 16: Class III Lever

Design Concepts:

1. The I- bar partial denture components will be discussed in the order of the design sequence advocated by Kratochvil and Vig: rests, proximal plates, major connectors, denture base connectors and retainers. Kratochvil must be credited with locating the I-bars in a midbuccal position where they are free to disengage from the tooth when rotation occurs around a more anterior point-the mesilly placed rest. He demonstrated that the I-bar must contact the tooth at or slightly anterior to the point of greatest buccolingual diameter for such rotation to occur.
2. While I-bars generally are considered more esthetic than circumferential forms, this is not necessarily so if the connectors are visible. Satisfactory undercuts are not always available at the midbuccal position and frequently the buccal surface may present no undercut at all.[4-6]

Rest, proximal plate and I-bar (RPI):

This concept of clasping abutment teeth is a modification of the concept presented by Kratochvil. The entire clasp is composed of a rest with its minor connector, proximal plate and an "I" bar clasp arm. The RPI clasp fulfils the requirements of proper clasp design and minimizes stress on the abutment tooth. The rest located on the mesial occlusal surface of the abutment tooth, acts as the point of rotation and exerts a mesial force on the tooth rather than a distal displacing force, pressure exerted on the extension base moves the proximal plate tissueward without torquing the tooth. The I-bar also moves mesiogingivally away from the tooth under masticatory load.

Design of the RPI clasp:

Mesial rest: The abutment tooth contains the mesioocclusal rest with the minor connector placed into the mesiolingual embrasure but not contacting the adjacent tooth.

Proximal plate: when viewing a mandibular partial denture on the master cast, the superior edge of the proximal plate is located at the bottom of the prepared guide plane which should be at the junction of the occlusal one third and middle one third of the tooth (the remainder of the proximal plate lies below the guide plane).

RPI clasp contacts the tooth minimally and is advantageously used on caries prone patients.[8-11]

RPA clasp:

RPA clasp is similar to RPI clasp except that in place of the I bar a circumferential Akers clasp arm arises from the proximal plate. RPA clasp may be used in place of RPI clasp when there is insufficient depth in the buccal vestibule or when the buccal tissue undercut is too great. The shoulder of the clasp arm must be constructed so that only its occlusal border contacts the tooth at the height of contour. The undercut area in that portion of the clasp arm must be blocked out.

Basic principles given by Dr. A.H. Schmidt in 1953 are as follows:[8-12]

1. The dentist must have a thorough knowledge of both the mechanical and biological factors involved in removable partial denture design. In addition, the dentist must have a background in the basic and applied sciences and a working knowledge of the laws of physics and engineering, particularly as they relate to levers.
2. Treatment plan must be based on a complete examination and diagnosis of the individual patient.
3. The dentist must correlate the pertinent factors and determine a proper plan of treatment.
4. A removable partial denture should restore form and function without injury to the remaining oral structures. In restoring occlusion, the prosthesis should also restore a normal or desirable facial contour and not impede the normal movement of the tongue and other tissues. The prosthesis must be planned so the remaining oral structures are not stressed beyond their physiologic capabilities.
5. A removable partial denture is a form of treatment and not a cure. The responsibility of a dentist does not end with the final placement of the prosthesis in the patient's mouth. Oral tissues never remain static, but are constantly undergoing change, reflecting the general health and age of the patient. The patient should be recalled periodically to prevent any deleterious changes from taking place. The prosthesis should be planned with the knowledge that future corrections may be required. The design should be such that modifications may be made to compensate for changes that can be expected in oral tissues.

Philosophy of Design:

In partial dentures, the main concern is for Class I, Class II and long spans Class IV applications. The debate is on the amount of support that should be derived from the edentulous ridge and that which should be derived from the remaining teeth. Hence, difference in opinion, have given rise to variety of design philosophies. These philosophies are based upon three approaches to the force distribution. These are:[13-15]

1. Stress equalization
2. Physiologic basing
3. Broad stress distribution.

Stress equalization: advocates of the stress equalization approach to partial denture design emphasize that vertical displace ability of a natural tooth is not as great as that of soft tissues covering the edentulous ridge.

Physiologic stress-equalizer:

a) The stress placed upon the abutment teeth and the edentulous areas should be equalized as closely as possible, so the work load for each will approach their physiologic tolerance.
b) The extent of the movement of the saddle in relation to the abutment teeth should be controllable by the operator.
c) The cost of the material should be low.
d) The method of construction should consume as little time as possible.

Physiologic basing: Proponents of physiologic basing believe in disparity between the apical displacebility of teeth and the compressibility of the soft tissues but not that stress directors are needed to account for this difference. Equalization by recording the anatomy of the edentulous ridge in its functional form & ensuring that denture base reflects this anatomy. This is accomplished by:[15]

1. Depressing the mucosa during the impression making procedure.
2. Relining the denture base after it has been constructed.

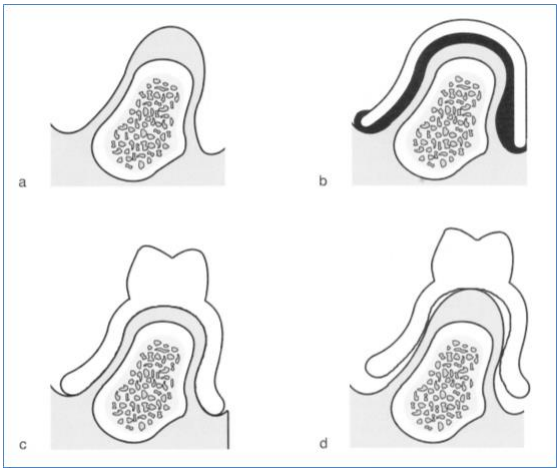

Figure 17: (a) Cross sectional view of the mandibular ridge in its anatomic form
(b) Functional form of the mandibular ridge during impression procedure (physiologic basing philosophy)
(c) Adaptation of denture base during function
(D) Adaptation of denture base at rest. When at rest the denture base is displaced occlusally.

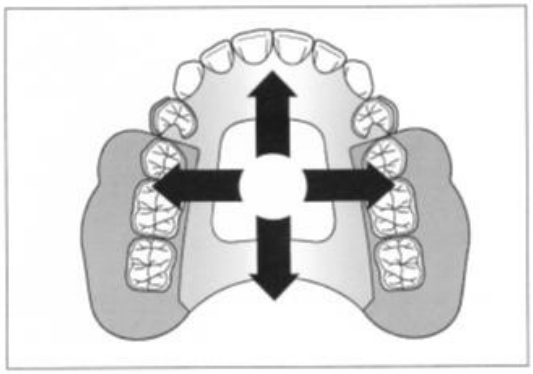

Figure 18: Broad stress distribution distribute applied forces over a large area.

Broad stress distribution: Advocates of Broad stress distribution have presumed absolute rigidity of all parts of the partial denture framework except the retentive arm of the direct retainer assembly. All vertical and horizontal forces applied to the artificial teeth are thus distributed throughout the supporting

portions of the dental arch. Board distribution is accomplished through the rigidity of the major and minor connectors. Also by using additional rests and clasp assemblies and by ensuring that the associated denture bases provide broad denture coverage [Figure 18].[12-15]

In distal extension restoration, strain on abutment teeth is minimized through the use of functional basing, broad coverage, harmonious occlusion and correct choice of retainers.

CONCLUSION

Design of a partial denture is a part of treatment, itself a product of diagnosis. Important diagnostic factors include analysis of vertical dimensions, occlusion, neuromuscular function and periodontium. There should be rationale to design with priorities yielding a sequence of design procedures using some basic principles. An ideal design is followed by surveying, then modifications to the ideal design are made as needed. Thus when certain biomechanical principles are applied to the design of all removable partial dentures, there will be preservation of remaining structures as well as replacement of lost structures on a frequent and consistently successful basis is likely embracing a comprehensive philosophy of removable partial denture.

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