Fixed Prosthodontics

Lecture No:6

DESIGNING AND PLANNING OF BRIDGE

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Design of fixed partial denture

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1. Introduction

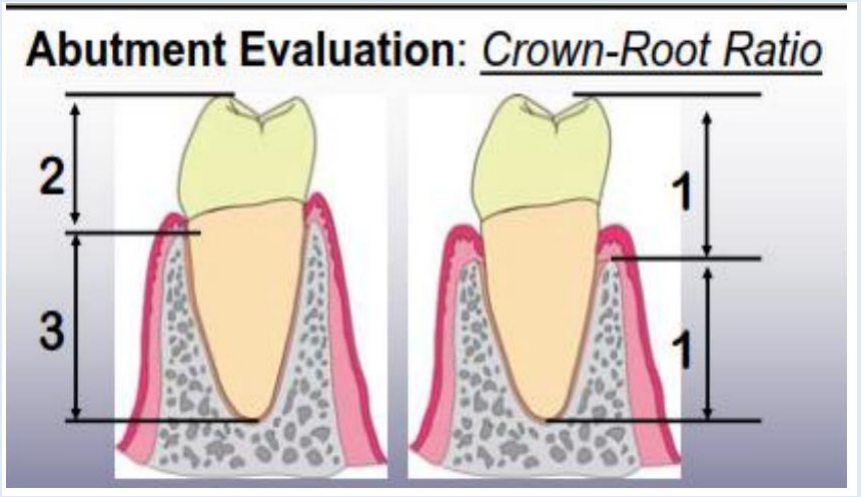
As a proper treatment plan, it is very important to design a prosthesis customised for each patient. The designs of the individual component parts have been discussed to a certain extent in Chapter 25. In this section, we shall discuss about the factors that affect the design of the entire prosthesis.

Johnston proposed that the following factors influence the design of a fixed partial denture.[1] They are:

1. Crown length
2. Crown form
3. Degree of mutilation
4. Root length and form
5. Crown-root ratio
6. Ante's law
7. Periodontal health
8. Mobility
9. Span length
10. Axial alignment
11. Arch form
12. Occlusion
13. Pulpal health
14. Alveolar ridge form
15. Age of the patient
16. Phonetics
17. Long-term abutment prognosis
18. Aesthetics
19. Psychological factors.

Crown-root ratio

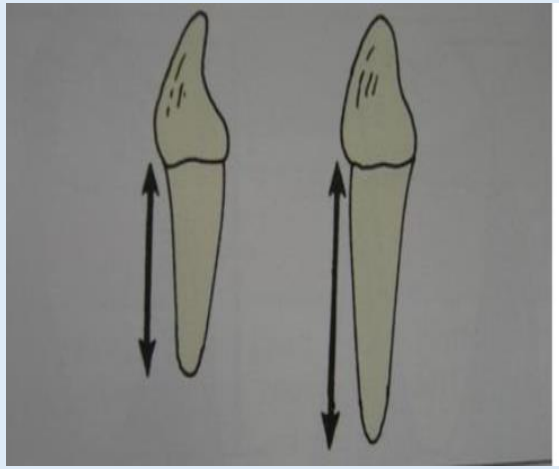
- The crown root ratio is defined as the physical relationship between the portion of teeth within the alveolar bone compared to the portion not within the alveolar bone, as determined radiographically.[2,3]
- The optimum crown root ratio for teeth to be utilized as a fixed partial denture abutment is 2:3.
- A ratio of 1:1 is the minimum ratio that is acceptable for a prospective abutment under normal circumstances.

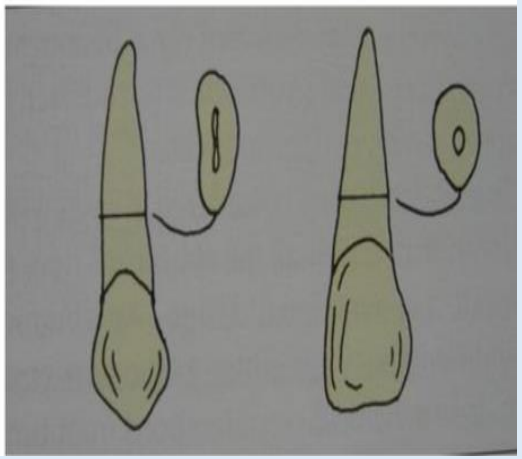


Root length and form

- Root configuration is an important assessment of an abutment selection from a periodontal stand point.

- Roots that are broader labiolingually and mesiodistally are preferable to roots that are in round cross section.
- Multi-rooted posterior teeth with widely separated roots offer better periodontal support than roots which converge, fuse or those with a conical configuration.
- A single rooted tooth with curvature in the apical third of root is preferable.
- An abutment tooth with a greater root length serves as a better abutments.



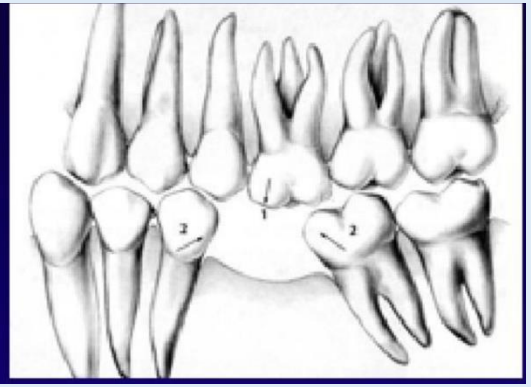


Periodontal health[5]

- The area of periodontal ligament attachment of the root to the bone is an important assessment in the abutment teeth selection.
- Larger teeth have greater surface area and are better able to bear added stress.

Span length[6,7]

- In conventional fixed partial denture posterior span of 2 or fewer teeth is usually ideal.
- In resin bonded fixed partial denture a single tooth may be replaced usually in the incisors region.
- An implant supported fixed partial denture may have a 2 to 6 unit span.
- Fixed partial dentures with short pontic span have a better prognosis than those with an excessively long span.



Span configuration[6]

- In conventional fixed partial denture a distal abutment is present.
- If a distal abutment is not present a distal pontic can be cantilevered.
- In resin bonded fixed partial denture the abutments may be either mesial or distal to the pontic.
- In implant supported fixed partial denture no distal abutment is necessary.

Axial alignment

- In conventional fixed partial denture less than 25° inclination (lesser than 15° inclination in resin bonded fixed partial denture) can be accommodated by preparation modification.[8]

Abutment condition/degree of mutilation

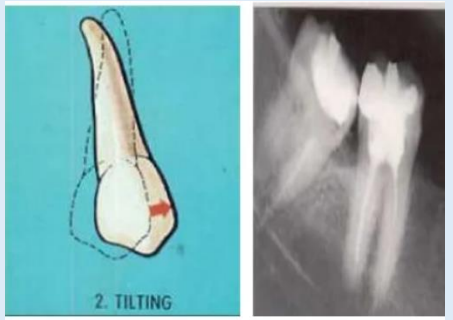
- In conventional fixed partial denture non-vital teeth can be used as abutments if there is sufficient coronal tooth structure.
- Defect free abutments are ideal for resin bonded and tooth - implant supported FPD.

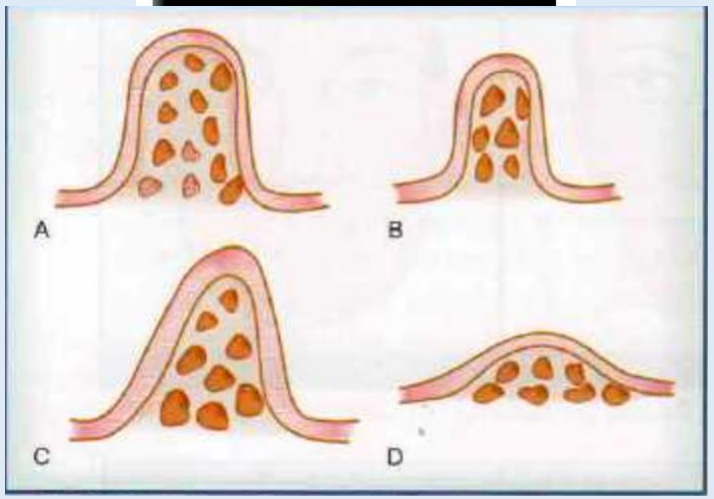
Occlusion

- Resin bonded fixed partial denture cannot be used for the replacement of incisors in the presence of vertical overload.
- In implant supported fixed partial denture the occlusal forces must be as vertical as possible to prevent unfavourable lateral loading of implants.

Alveolar ridge form

- There is moderate resorption in conventional and resin bonded fixed partial denture.
- In implant supported fixed partial denture a broad flat ridge is usually seen.





General features

- Age of the patient.
- Resin bonded fixed partial denture are well suited for young patients.

Most of these factors are used for abutment selection.

The major factors to be considered while designing a fixed partial denture include:

1. Primary requirement
2. Bio-mechanical considerations
3. Abutment selection
4. Residual ridge of the patient
5. Occlusion with the opposing teeth.

2. Design Considerations for Individual Conditions

The purpose of fabrication of a prosthesis is different for each patient. For example, a crown may be needed to restore decayed teeth, whereas in others, a crown may be needed to prevent further occurrence of caries. In some cases a crown may be needed to protect a weakened or malformed tooth and in many cases prosthesis may be needed to restore aesthetics or support a fixed partial denture. Hence, we should understand that the prosthesis should be designed such that it best fulfills its primary requirement.

3. Material Selection

The type of material used for the restoration of prosthesis can be determined based on the following factors:

- Age (Younger patients need stronger materials like metal crowns)
- Amount of occlusal load (Full veneer crowns are preferred for areas under high stress)
- Amount of remaining tooth structure (Partial veneer crowns are preferred for teeth with minimal destruction)
- Existing state of oral hygiene (Fluoride releasing materials can be used for patients with high caries index)
- Viscosity of saliva
- Type of opposing teeth (Stronger materials are needed for restorations opposing natural teeth).

In the following section we shall study about the properties of different materials, which affect the design of an FPD. Specific design concepts and tooth preparation should be followed for each material to improve the success of the prosthesis.

3.A. Plastic Materials

These materials require considerably less amount of tooth preparation. But their success is limited due to their poor strength, e.g. resins.[9]

3.B. Cast Metal[10]

The material is strong and provides a very good fit and finish. They have an excellent success rate and hence are most commonly used . Cast metals are generally classified as intracoronal and extracoronal replacements.

3.C. Intracoronal Replacements[11]

Gold is the metal most commonly used for intracoronal restorations. It gives an excellent fit and finish. The major disadvantage is that they require extensive tooth preparation even for small lesions.

3.D. Extracoronal Replacements[12,13]

They are used for teeth with extensive carious lesions. The material requires extensive tooth preparation. Since the margins are placed near the gingival margin, periodontal health may be affected.

3.E. Metal Ceramics[14]

These materials require extensive tooth reduction, and are unesthetic due to the visible metal-ceramic junction. The junction has to be placed below the gingival margin in order to hide the unaesthetic junction; this may lead to periodontal disease.

Metal ceramics can be modified such that the facial/ buccal surface is made only of ceramic for enhanced aesthetics.

3.F. Resin Veneer[15,16]

This material was widely used before the arrival of porcelain. Lately, methacrylate in this material has been replaced by Bis-GMA. Bis-GMA improves strength and wear resistance.

3.G. Fibre-Reinforced Resin

This is a type of fibre-reinforced composite. It provides a good fit and finish and is very aesthetic. Long-term results are yet to be seen.

3.H. Complete Ceramic[17-20]

It has the best aesthetics but the worst marginal finish. Another major disadvantage is that it requires maximum tooth reduction. It is a very brittle material (due to low elastic strain) hence, the restoration should be more bulky to attain sufficient strength. Recent systems with high strength fillers like alumina and zirconia promise to improve the tensile strength of porcelain.

4. Biomechanical Considerations

The design of a fixed partial denture is determined by the physical factors affecting the prosthesis. The major biomechanical factors which affect the design of an FPD are:

- Length of the edentulous span
- Occlusogingival height of the pontic.
- Arch curvature.
- The direction of forces acting on the FPD.

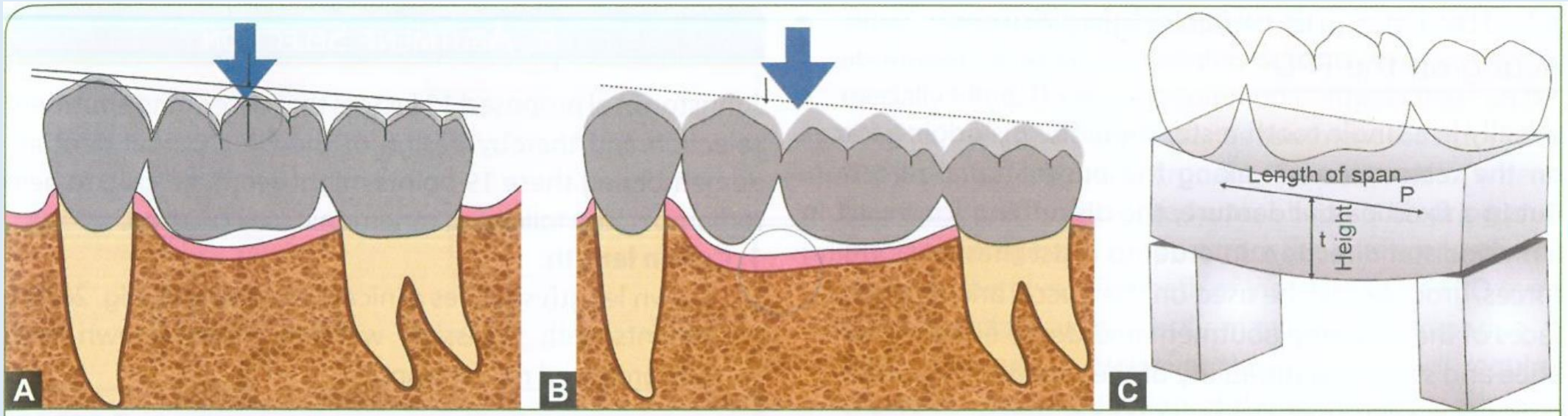
4.A. Length of the Edentulous Span and Occlusogingival Height of the Pontic[21]

A long span fixed partial denture transfers excessive load to the abutment and also tends to flex to a greater extent. Longer the span, more is the flexion of the FPD. The flexion of an FPD varies as follows:

$$\text{Flexion} = \frac{(\text{Length of the Fixed Partial Denture})^3}{(\text{Occlusogingival Height of the Pontic})^3}$$

For example a span of two pontics will flex eight times more than a single pontic FPD (Figs. 26.1A to C). Hence, the flexion of a long span fixed partial denture can be decreased by increasing the occlusogingival height of the pontic or by using high strength alloys like nickel chromium.

Sometimes double abutments (primary and secondary) should be used to overcome long edentulous spans and inadequate crown root ratio of the abutment.



Figs. 26.1A to C: (A) A bridge of short length will flex less compared to a longer bar with the same dimension; (B) The true 'crown length indicates the clinical crown height and not anatomical crown height. (C) Length of pontic/occlusogingival height of pontic.

4.B. Arch Curvature[22]

The curvature of the arch increases the stress developed within a fixed partial denture. If the pontic lies outside the interabutment axis, then it will behave like an arm of a lever. In such cases forces acting on the pontic will produce torquing forces around the abutment (Fig. 26.2). To prevent trauma to the abutment, a secondary abutment should be chosen. For example, in a case replacing the four maxillary anteriors, a premolar secondary abutment should be added to the canine.

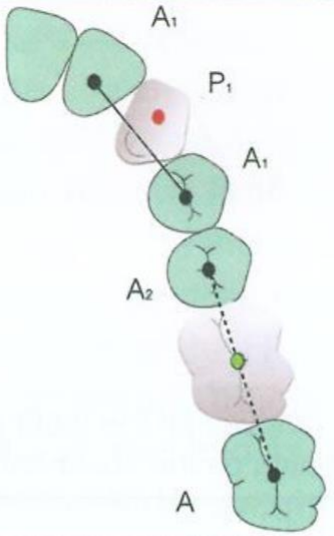
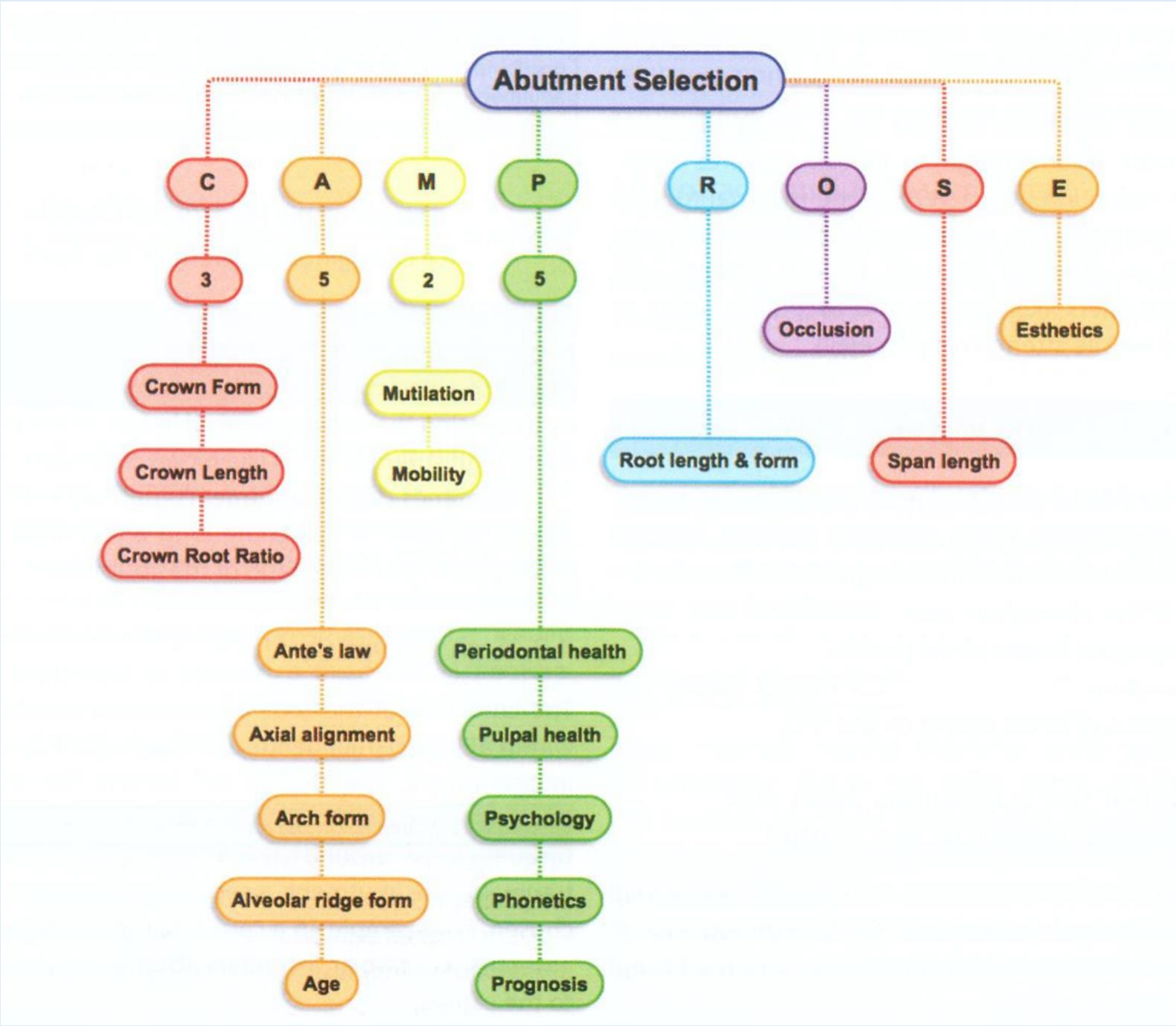


Fig. 26.2: The pontic should lie within the interabutment axis to best distribute forces acting on it. If the pontic is located outside inter-abutment axis, undue stress will be developed within it.

4.C. The Direction of Dislodging Forces Acting on the FPD[23]

Usually in a single tooth restoration, the dislodging forces on the restoration act along the buccolingual direction. But in a fixed partial denture, the dislodging forces act in a mesiodistal direction. In order to resist these dislodging forces, grooves may be used on the buccal and lingual surfaces of the prepared abutment in order to enhance resistance and structural durability of the retainer (Fig. 26.3).

Fig. 26.3: Placing axial grooves on the tooth preparation helps it to resist rotational forces acting on the abutment.


Abutment Selection
C
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3
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2
5
Occlusion
Esthetics
Crown Form
Mutilation
Crown Length
Mobility
Root length & form
Span length
Crown Root Ratio
Ante's law
Periodontal health
Axial alignment
Pulpal health
Arch form
Psychology
Alveolar ridge form
Phonetics
Age
Prognosis

5. Abutment Selection

Johnston et al proposed 19 factors that determine abutment selection and thereby design of the fixed partial denture. Remembering these 19 points might seem difficult, to help remember, the following mnemonic may be used.

1. Crown length

- Crown length signifies clinical crown length (Fig. 26.7)
- Patients with recession will have taller crown with compromised root support

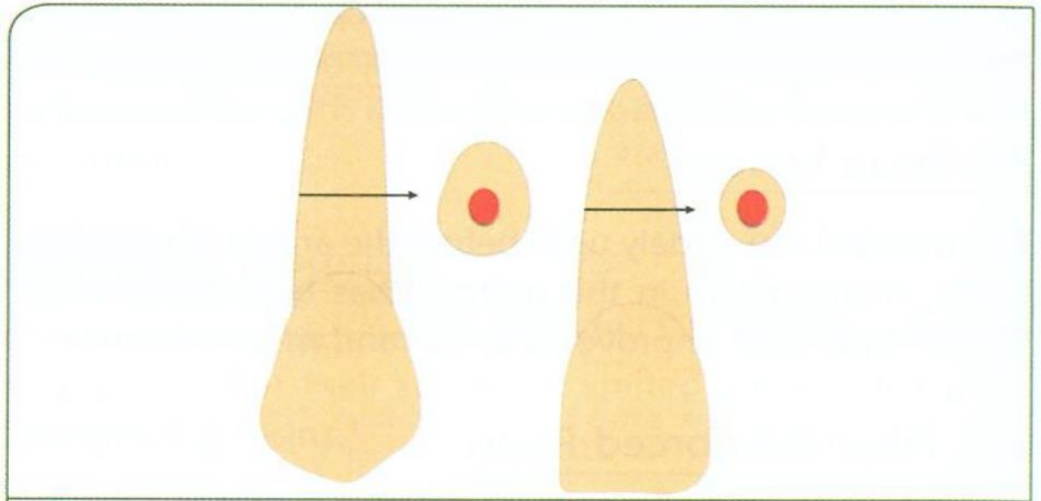


Fig. 26.4: Teeth with flat roots resist rotation and hence are preferred to as abutments.

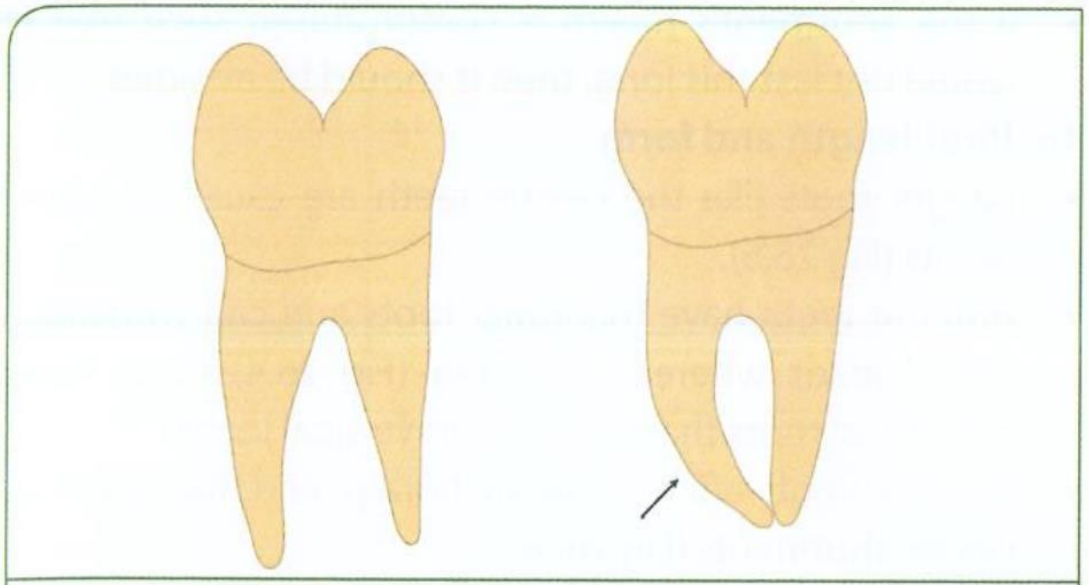


Fig. 26.5: Teeth with root curvatures are preferred as better abutments.

- Taller the crown, more the torsional load; so more stress is expected on the abutments
- Hence pontics with increased occlusogingival height will require additional abutments
- If the abutment teeth have less than 4mm of crown structure additional support by splinting multiple abutment teeth may be required

2. Crown form

- If the neighbouring teeth has tall cusps and well designed morphology then we should anticipate additional lateral loads on the abutment teeth.
- If the pontics have a larger occlusal table than the abutment teeth then additional abutments may be required to evenly distribute the load.

3. Crown-root ratio

- The root support should be greater than the crown height.
- Ideally the crown-root ratio should be 2:3 (Fig. 26.8)
- The least accepted crown root ratio is 1:1
- But this has been disproved by Nyman and Ericsson (1974-82)

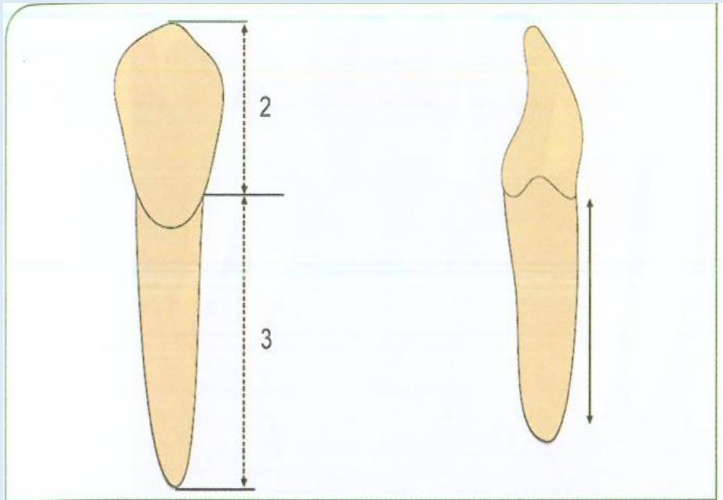


Fig. 26.6: Teeth with longer roots act as good abutments.

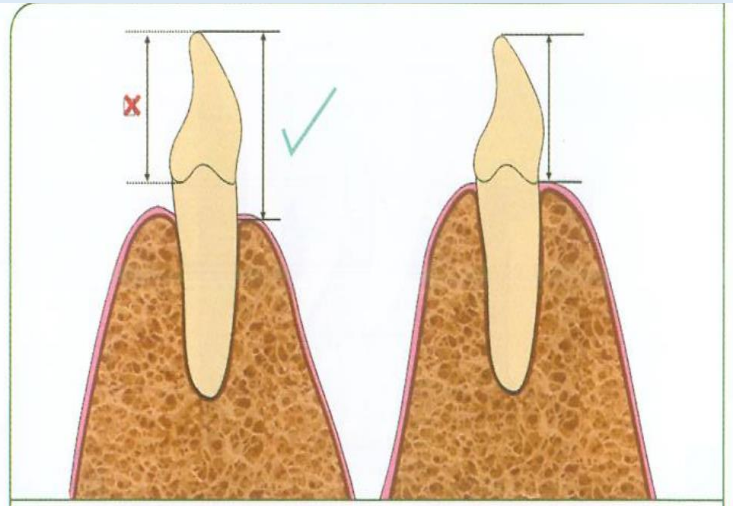


Fig. 26.7: The true "crown length" indicates the clinical crown height and not anatomical crown height.

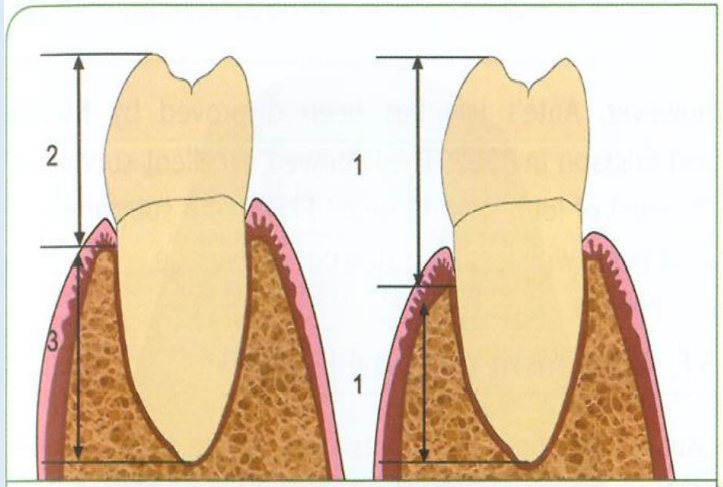


Fig. 26.8: Ideally the root should be longer than the crown (3:2) for the tooth to act as a good abutment. Ratio up to 1:1 is acceptable for a tooth to act as an abutment.

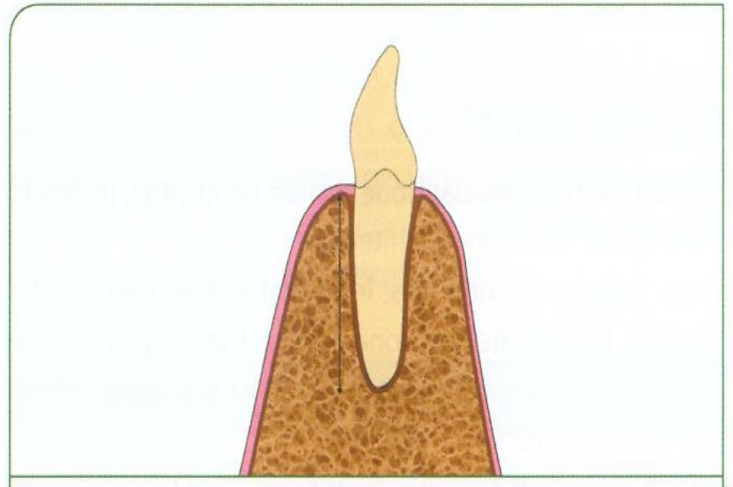
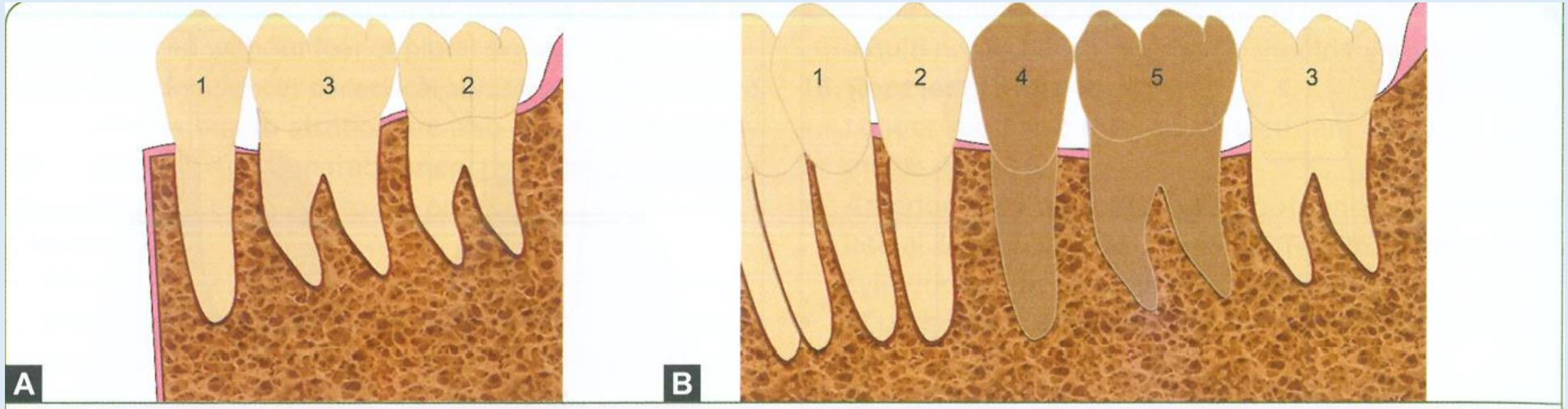


Fig. 26.9: The abutment should have sufficient bone support. The alveolar bone should show good trabecular pattern.

4. Ante's law

- In 1926, Irwin H.Ante made a statement which was popularised as "Ante's Law" by Johnston in 1971.
- According to Ante, the total pericemental area of the abutment teeth should be equal to or greater than the pericemental area of the missing teeth (Figs. 26.10A and B).
- If the pericemental area of the abutment teeth were less then additional abutments were chosen to provide support.



Figs. 26.10A and B: (A) According to Ante's law the total pericemental surface area of abutments (1+2) should equal to or greater than that of the missing teeth (3); (B) When two teeth are to be replaced (4+5) the pericemental areas of the primary abutments (2+3) may not be equal to that of missing teeth (4+5). In such cases, support from additional tooth (1) should be taken. So that the pericemental areas of the abutments (1+2+3) is equal to or greater than pericemental areas of teeth to be replaced (4+5).

5. Axial alignment

- The term axial alignment refers to the alignment of the long axis of the abutment teeth to each other.
- A tilt of upto 25º can be accommodated by modifying tooth preparation for full veneer preparations and a tilt of upto 15º can be accommodated in case of resin bonded bridges.

- Tilted molar abutments: Selecting mandibular molar abutments is more challenging because they are often mesially tilted. There are 4 common methods that can be used to manage a tilted molar as abutment tooth for FPD
- Orthodontic treatment: Arguably the best option where the molar can be uprighted with a band and spring and with anchorage and support from the anterior teeth
- Mesial half crowns: The path of insertion of an FPD over a tilted molar can be easily managed by preparing a mesial half crown; However these crowns will require excessive mesial reduction of the abutment tooth and could result in pulpal involvement
- Telescopic crowns: Here the restoration is made of two crowns. The primary coping will be inserted parallel to the long axis of the tilted abutment. The morphology of this crown would be designed such that the occlusal table is parallel to the neighbouring abutment teeth. The FPD retainer can be cemented on to the primary coping along a common path of insertion.
- Cross pin & Wing pontic: Split pontic connectors like the cross pin and wing can be used to create the FPD in two parts. The posterior part of the FPD can be first cemented over the tilted abutment and then anterior part of the FPD can be cemented such that it locks on to the split pontic.
- Crowding and rotation: if the abutment teeth are crowded and out of the arch, then either a partial veneer crow should be placed or the crown should be modified after root canal therapy. in sever cases, the tooth should be extracted adn replaced with support from he next eligible abutment.

6. Arch form

- Cornerstone teeth like the canine and first molar can be used as abutments for distributing forces in wider arches
- Acutely curved arches require additional abutment teeth to dissipate the lateral stresses occurring in two directions at the region of curvature (Fig.26.11)

7. Alveolar ridge form

- Wide and flat ridges are ideal for FPD
- Thin and low ridges due to severe resorption increase the pontic height and increase torsional loads on the abutment teeth.
- The abutment teeth should show good trabecular pattern. (Fig 26.9)

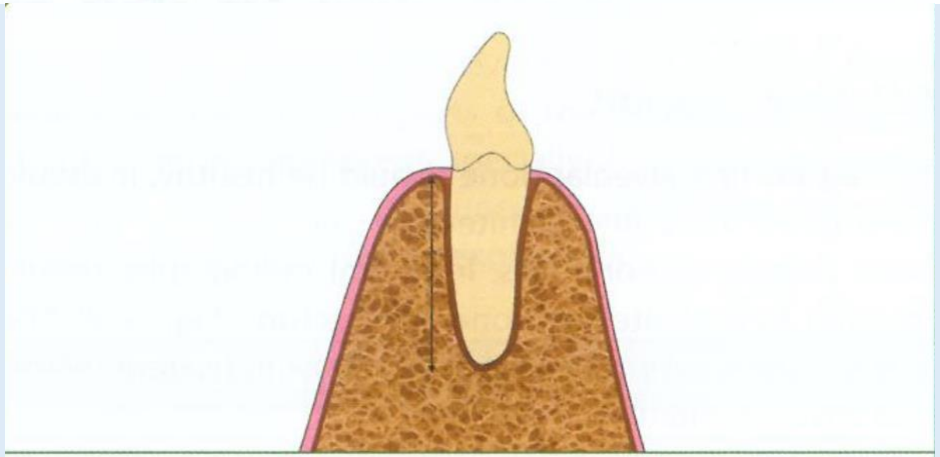


Fig. 26.9: The abutment should have sufficient bone support. The alveolar bone should show good trabecular pattern.

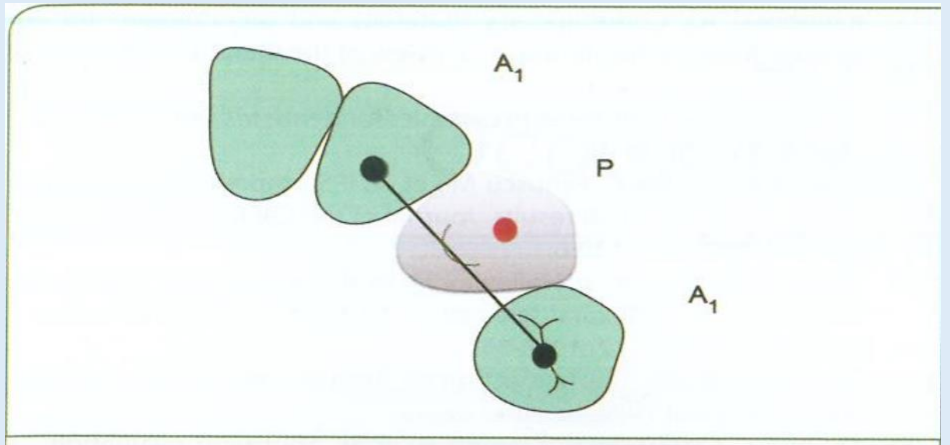


Fig. 26.11: A canine replacement fixed partial denture is subjected to more forces because the canine forms the curve of the arch and tends to lie outside the interabutment axis.

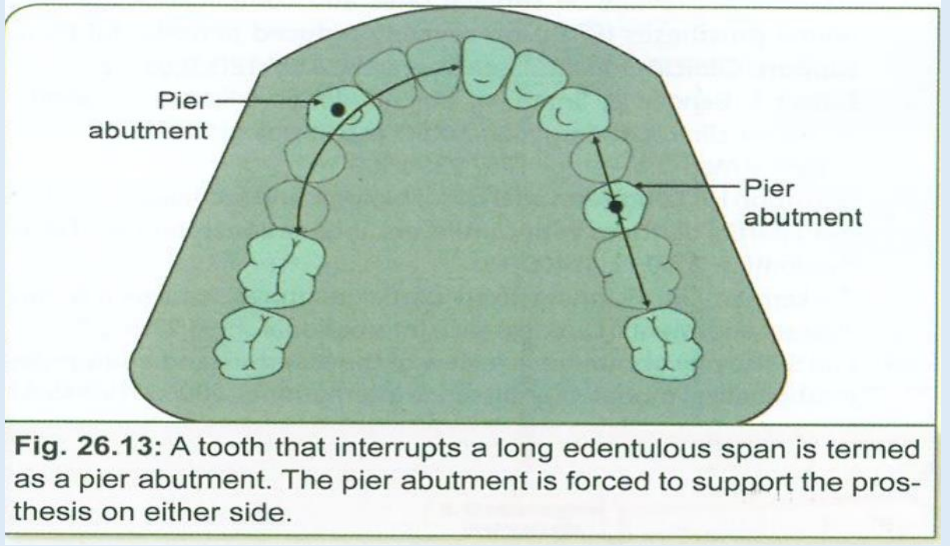


Fig. 26.13: A tooth that interrupts a long edentulous span is termed as a pier abutment. The pier abutment is forced to support the prosthesis on either side.

8. Age

- Young patients:
  - A high degree of aesthetics is required for young patients
  - Resin bonded bridges can be provided for such patients
  - Young individuals have teeth with large pulp chambers and are more prone to pulpal exposure during tooth preparation
- Elderly patients:
  - Older individuals have darker with layers of reparative and sclerotic dentin with reduced pulp chambers; More amount of tooth structure can be reduced without fear of plural exposure
  - More incidences of cervical abrasions and shortened crowns due to attrition are also observed in elderly patients; Additional abutment teeth may be required to provide support to the prostheses

9. Mutilation

- Abutment teeth should have a height of atleast 4mm
- If the occlusogingival height is less than 4 mm core build up with composite resin should be done to increase crown height
- If the occlusogingival height is less than 2mm, post and core along with crown lengthening should be considered
- If the decay extends into the root surface the abutment should be extracted and should NEVER be used for FPD

10. Mobility

- Teeth with firm periodontal support are ideal abutments
- In case the abutment tooth has grade 1 mobility it can be splinted with additional abutments for support
- Teeth with grade 2 mobility are contraindicated as abutments for FPD

11. Periodontal health

- Periodontally compromised teeth should not be selected as abutments for FPDs.
- If the tooth had bone loss but the periodontal condition is stabilised and it is not mobile, then it can be used as an abutment even if it does not have a 1:1 crown root ratio.

12. Pulpal health

- FPD abutments should preferably be vital teeth to have better proprioception.
- If there is severe attrition, many doctors prefer to do prophylactic root canal therapy before abutment preparation. This process depends not he clinical judgments.
- Partial veneer crowns are preferred for vital abutments so that vitality testing and plural health can be evaluated after cementation of the prosthesis.

13. Psychology

- Patient with mental disability may require multiple splintered abutments rather than individual crowns because they may not have the dexterity to floss and maintain gingival hygiene.
- Patient with neurogenic stress are more prone to Bruxism. In such clinical scenarios, splinted abutments may be required to distribute the para functional forces.

14. Phonetics

- Abutment with FPD retainers are generally bulkier than their natural counterparts.
- This can affect the phonetics of the patient. in such conditions it may be beneficial to avoid an anterior abutment and build a spring cantilever FPD using a posterior abutment.

15. Prognosis

- Generally FPDs are designed to last 60% of the time over a period of 20 years.
- If the abutment's health is compromised such that it would not last this long, then it should be avoided.

16. Root length and form

- Longer roots like the canine teeth are excellent abutments (Fig 26.6).
- Anterior teeth have triangular roots and can withstand lateral loads whereas posterior (Fig 26.4) teeth have cylindrical roots that can take up vertical loads.
- • Curved roots offer better anchorage and may serve as better abutments (Fig 26.5).

17. Occlusion

- Based on each scheme of occlusion, the abutment can be selected.
- For FPDs with mutually protected occlusion, minimal lateral load is expected and so a single abutment should be sufficient on either side.
- If group function is planned and if the patient has para-functional habits, it may be advisable to have an secondary abutment splinted to the FPD to improve load distribution.
- If the patient has trauma from occlusion then the abutment should be splinted with secondary retainers to support the FPD.

18. Span length

- Long span FPDs undergo greater flexion as described in Section 4.
- A 5 unit FPD will flex 27 times more than a 3-unit FPD.
- When more than 3 posterior teeth are to be replaced, the FPD should be supported by additional secondary abutments.

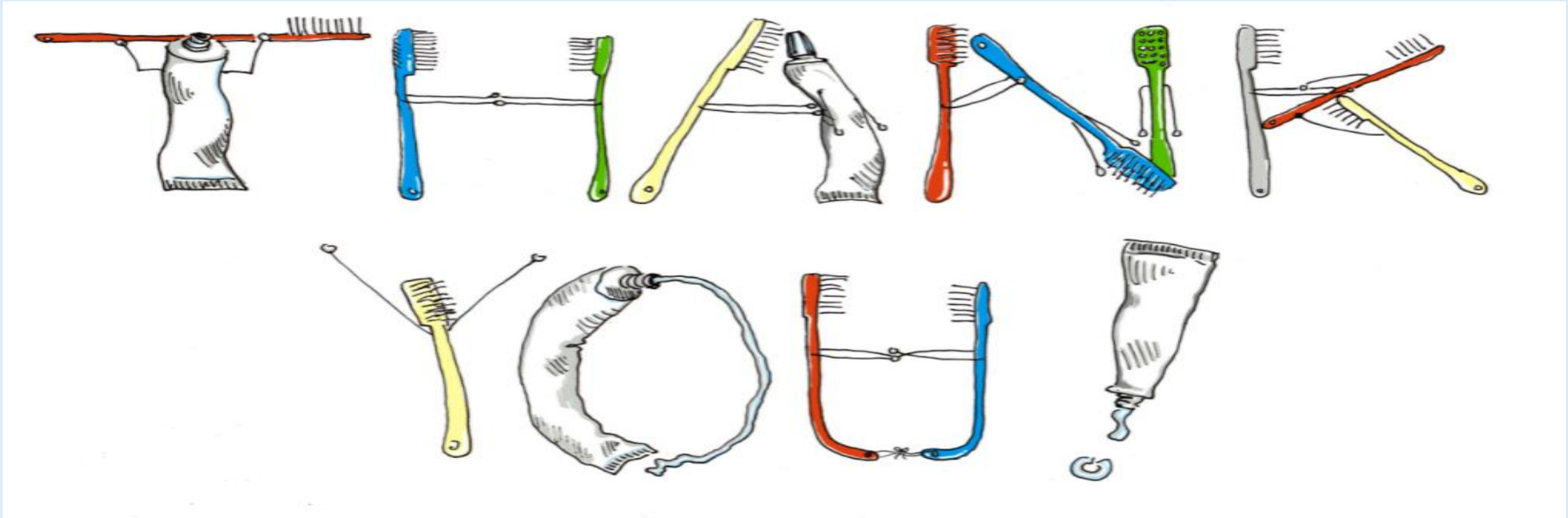
19. Esthetics

- Long connectors in anterior abutments can be aesthetically compromising.
- Resin bonded retainers may have unesthetic metal show-through.
- If there is a diastema then loop connectors can be used to join adjacent abutments.
- If the anterior abutments are compromised good aesthetics can also be obtained with a spring cantilever bridge.

The most important factor to be considered in the design of a fixed prosthesis is the location and the characteristics of the abutment.[21]

An abutment can be defined as *"A tooth, a portion of a tooth or that portion of an implant used for the support of a fixed or removable prosthesis"*—GPT.

The role of an abutment is very crucial in accepting the load acting on a fixed partial denture. The choice of a suitable abutment is important because the abutment has to withstand both the forces acting on it and the forces acting on the pontic. Johnston proposed 19 different factors that control the design of a fixed partial denture (enlisted in the introduction of this chapter). Most of these factors can also be used to select abutments.


THANK
YOU