FURCATION MANAGEMENT

OUTLINE

Periodontal disease may be defined as “Inflammation of the supporting tissues of the teeth. Usually, a progressively destructive change leads to loss of bone and periodontal ligament. An extension of inflammation from gingiva into the adjacent bone and ligament,” is affected by age, gender, ethnicity, income, social class, and educational status. The degree to which a lesion progresses is affected by several factors; such as inflammatory response, type of bacteria present, and local factors which cause plaque accumulation. In the posterior segments of dentition, the progress of the inflammatory periodontal disease, if unabated, ultimately results in attachment loss sufficient enough to affect the bifurcation or trifurcation of multi-rooted teeth and this is one of the most serious sequels of periodontitis. Furcation maybe defined as the anatomic area of a multi-rooted tooth where the roots diverge. It has a complex anatomic morphology that may be difficult or impossible to debride during routine periodontal instrumentation, and routine home care methods also may not keep the furcation area free of plaque. “Furcation involvement may be defined as the invasion of the bifurcation and trifurcation of multirooted teeth by periodontal disease.” Involvement of the furca in multi-rooted teeth by chronic periodontitis is a common event resulting from loss of bone adjacent to and within the furca. Some authors recommended extraction of the teeth with furcation invasions rather than trying to retain them. Long-term studies on treated periodontal patients have reported that molar teeth with prior furcation involvement were the most frequently lost teeth, probably because of their complex anatomy. Nevertheless, these same studies showed that in the majority of patients who responded well to treatment, many molar teeth with furcation involvement were retained for periods as long as 40–50 years. Furcation involvement, therefore, presents both diagnostic and therapeutic dilemmas

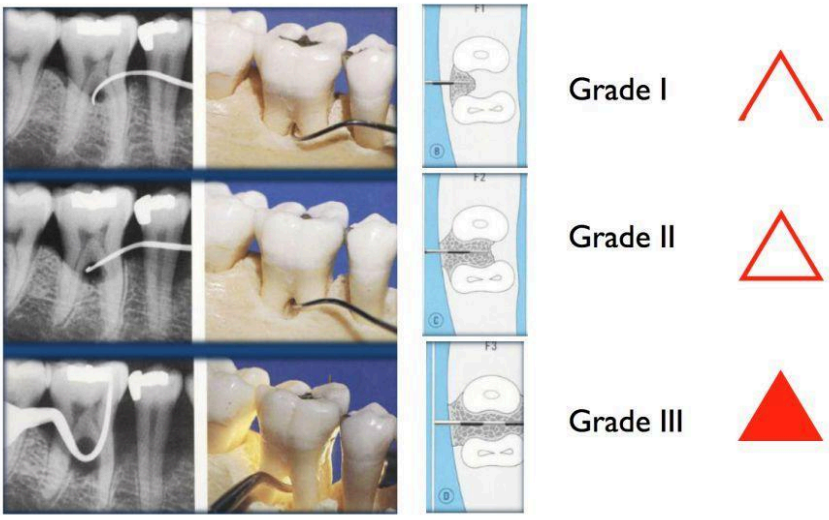
INTRODUCTION

Periodontal disease is a polymicrobial disease characterized by gingival inflammation, formation of periodontal pocket, loss of connective tissue attachment and alveolar bone. As the disease progresses, the severity of attachment loss increases and disease process extends into deeper part of the periodontium. Ultimately it leads to involvement of bifurcation and trifurcation of multirooted teeth “FURCATION INVOLVEMENT”

Long term follow-up of periodontal treatment indicates periodontal lesions in the majority of patients will respond well with one of exception to be lesions in multi-rooted teeth that have advanced into the furcation area between the roots. (Hirschfield 1978, McFall 1982, Goldman 1986.) In teeth with furcation lesions a tooth mortality rate for periodontal reasons of 31%-57% over periods of 20 years compared to an overall tooth mortality for all teeth of only 7%-10%.(Hirschfield 1978,McFall 1982).

FURCATION INVOLVEMENT

A furcation is defined as "the anatomic area of a multi-rooted tooth where the roots diverge". Furcation invasion refers to "pathologic resorption of bone within a furcation". The term furcation involvement refers to commonly occurring conditions in which the bifurcation & trifurcation of multirooted teeth are denuded by periodontal disease. (American academy of periodontology 1992)



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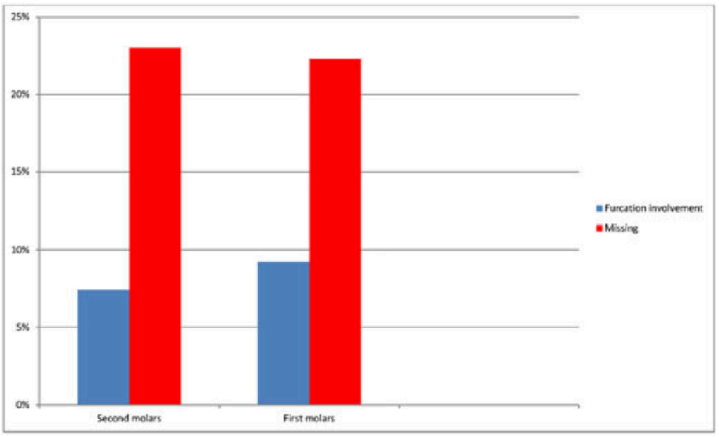
PREVALENCE OF FURCATION INVOLVEMENT

Maxillary molars (distal) > mandibular molars > Max. Premolars *(Larrato et al 1970)*. Tends to be age related. It has also been demonstrated that molars with crowns or proximal restorations have significantly higher percentages of furcation involvement (52–63%) compared with molars without restorations (39%) Wang et al. 1993. Incidence of 35% in

Mandibular Molars and 90% in Maxillary Molars *(Ross & Thompson 1980)* Furcation involvement is more frequently detected in smokers (72%) than in nonsmokers (36%) Mullaly et al. 1996



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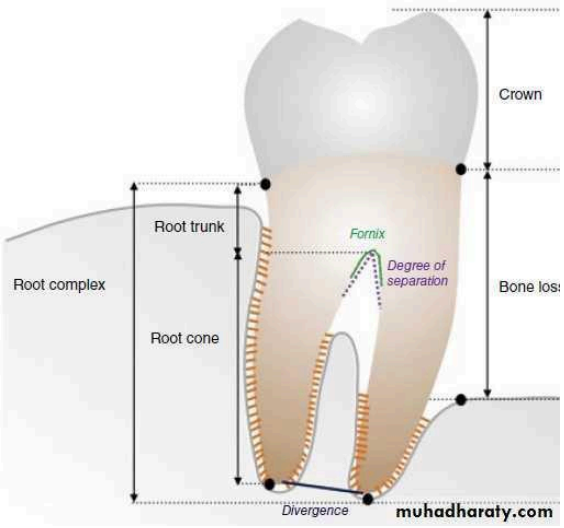
BASIC TERMINOLOGY

- ***Root Complex:*** is the portion of a tooth that is located apical to the CEJ. It is divided into two parts: the root trunk and the root cone.
- ***Root trunk:*** it represents the undivided region of the root.
- ***The height of the root trunk -*** the distance between the CEJ and the separation line(furcation) between two root cones.
- ***Root cone:*** is included in the divided region of the root complex.
- Two or more root cones make up the furcated region of the root complex.
- ***Furcation:*** is the area located between individual root cones.
- ***Furcation entrance:*** is the transitional area between the undivided and the divided part of the root.
- ***Furcation Fornix:*** is the roof of the furcation.
- ***Degree of separation:*** is the angle of separation between two roots.

- ***Divergence:*** is the distance between two roots; this distance normally increases in apical direction.
- ***Coefficient of separation:*** is the length of the root cones in relation to the length of the root complex.



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ETIOLOGY & CONTRIBUTING FACTORS

Plaque-associated origin, contributing anatomical factors, Endodontic origin, Occlusal origin, Iatrogenic origin, Combined origin, Plaque Associated Origin. Loss of attachment on radicular flat surface or in furcation is strongly correlated with subgingival plaque. (Kornman 1987) Extension of inflammatory disease processes into the furcation area leads to furcation defects. No unique histological features suggest they were an extension of existing periodontal pocket. *(Glickman 1950)*

CONTRIBUTING ANATOMICAL FACTORS

Furcation entrance diameter, Root trunk length, Presence of root concavities, Cervical enamel projections, Bi-furcation ridges, Enamel pearls. They cause plaque retention. Connective tissue does not attach to cervical enamel projections.

Furcation entrance diameter

- Furcation entrance dimension is of paramount importance for successful therapy, as it influences the feasibility of gaining access to the interradicular with mechanical instrument.
- 81% of all furcation entrance diameters: <1mm and 58% of all furcation entrance diameters: < 0.75mm (63% of maxillary molars and 50% of mandibular molars were 0.75 mm).
- Considering that the average width of a curette blade face ranges between 0.75–1.10 mm, the authors concluded that the use of curettes alone might not be suitable for root preparation in the furcal area.
- They also found no association between the mesio-distal width of 1st molars and furcation entrance diameter. *(Bower et al 1979)*
- Maxillary molars: Mesial > Distal > Buccal and Mandibular molars: Buccal < Lingual
- **Matia et al. and Parashis et al**. found that the amount of residual calculus was related to the width of the furcation entrance when open root planing was performed

Root Trunk Length

The root trunk surface area for mandibular and maxillary molars averages 31% and 32% of the total root surface area respectively. Short root trunk early involvement but more accessible. Longer root trunk with short roots late invasion but less accessible and may not be a candidate for root resection **(Dunlap & Gher 1985, Gher & Dunlap 1985**). 1st molars < 2nd molars usually

Root concavities

Present on proximal root surfaces may make instrumentation almost impossible. ↑plaque retention present esp. in MB root – maxillary molar & mesial root of mandibular molar. **Bower (1979),** reported a 17–94% incidence of root depressions in maxillary roots and 99–100% in mandibular roots. In a study of 50 maxillary first molars, **Booker & Loughlin (1985**), reported the presence of mesial root concavities in 100% of examined teeth.

Maxillary molar teeth:

Mesiobuccal roots are comparatively wide in the bucco-palatal direction, and frequently have marked concavities. Distobuccal roots are smaller in dimension, more rounded in outline and less frequently have distinct concavities. *Palatal roots are wider in the mesio-distal than in the buccopalatal direction*

Maxillary premolar teeth:

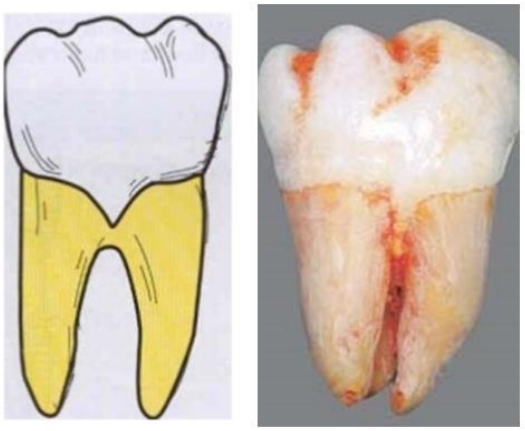
Most maxillary first premolars are bifurcated at the middle third of the root trunk. Canine fossa creates a deep concavity on the mesial root that merges with the opening of the furcation

Mandibular molar teeth:

Generally have two roots of similar size and length. Mesial root is usually barbell-shaped due to mesial and distal concavities

Cervical Enamel Projections

Ectopic deposits of enamel apical to the level of normal CEJ with a tapering form and extending towards or into the furcation areas are called cervical enamel projections. 8.6 – 28.6% of molars. Mand. & Max. 2nd molars



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Enamel pearls:

Defined as an ectopic globule of enamel that is often connected to coronal enamel by CEP **SHILOAH J, 1979**. Predilection is for maxillary third and second molars. The prevalence is less than that of cervical enamel projections. Like CEPs, enamel pearls contribute to the etiology of furcation involvement by preventing connective tissue attachment.

Bifurcation Ridges

Everett (1958), was the first to describe the incidence of bifurcation ridges, mandibular first molar> mandibular 2nd molar. Formed mostly of cementum. **2 types of bifurcation ridges**: Intermediate and buccal /lingual ridges.

- **Intermediate bifurcation** ridges connect the mesial and distal roots, and are composed primarily of cementum.
- **Buccal and lingual** ridges are composed primarily of dentin with overlying thin layers of cementum. 73% incidence of intermediate ridges in mandibular first molars, of which 60% were considered prominent. Buccal and lingual ridges were found in 63% of the mandibular molars.

Occlusal origin

- Excessive occlusal forces inflammation & tissue destruction in furca.

Glickman (1966) Rat molars in hyperfunction PDL, bone & cementum in furca most susceptible. The occlusal traumatic lesion in a multirooted tooth is characterized histologically within the inter radicular area, vascular changes that lead to periodontal space remodeling and bone demineralization. A radiolucency in the inter radicular space in conjunction with increased tooth mobility with probable furcation involvement is the typical signs of excessive occlusal forces applied to the molar. *(Glickman 1982)*

TWO CONCEPTS PREVAIL

- Furcation areas are more sensitive to injury by TFO
- Inflammation & edema in the furcation area tend to extrude the tooth, which then becomes traumatized.

Pulpal pathology

Pulpal pathosis in a multirooted tooth can cause furcation invasion. (Lowman et. al,1973). The presence of accessory pulp canals in the furcation area may extend pulpal inflammation into the furcation. Incidence of accessory canals (36% of maxillary first molars, 12% of maxillary second molars, 32% of mandibular first molars, 24% of mandibular second molars). In the absence of established periodontal involvement -- sinus tracts RCT complete resolution

Treatment:

- RCT
- Re-evaluation at 3-4 weeks
- Periodontal therapy

Root fractures involving furcation

- Rapid, localized, alveolar bone loss - often seen associated with vertical root fractures
- If root fractures involve the trunk of a multi-rooted molar and extend into a furcation rapidly forming isolated furcation defect
- Prognosis Poor and usually results in the loss of such a tooth

Iatrogenic factors

- Faulty dentistry like perforations during RCT & poorly contoured restorations can lead to attachment loss in furca area
- Overhanging margins
- Pin & endodontic perforations

AGE

- The prevalence and extent of attachment loss increases with age & hence severity of furcation problems tends to be related to age.

Combined origin:

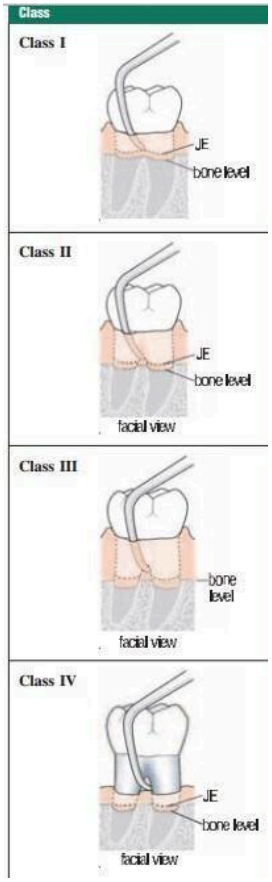
- Pulpal and periodontal disease may occur independently or concomitantly in the same tooth.

- The endodontic lesion may progress to establish communication with the oral cavity by extending coronally along the periodontal ligament and out through the gingival sulcus or periodontal pocket in an inter radicular area. once the endodontic and periodontal lesions join, they are clinically indistinguishable. (Harrington, Simon).

CLASSIFICATION

Glickman (1953)

- Pocket formation into the flute, but intact inter-radicular bone (incipient)
- Loss of inter radicular bone & pocket formation but not through and through (CUL –DE- SAC), vertical bone loss may be present, (partial penetration of the probe)
- Interradicular bone is totally absent (through & through) but the furcation orifice is occluded by gingival tissue, (full penetration of the probe)
- Interradicular bone is totally absent and gingival tissue is also receded apically so that furcation opening is clinically visible, (full penetration of probe)



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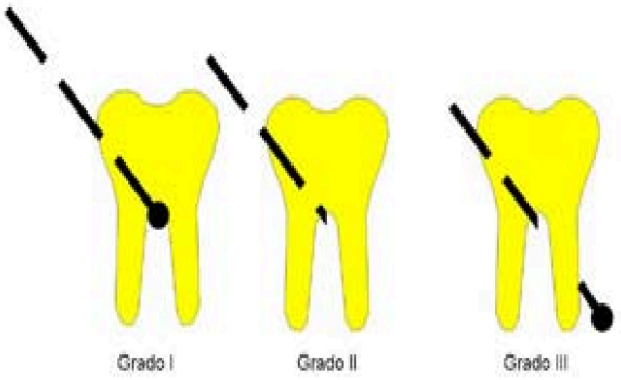
Goldman (1958)

Incorporated a descriptive classification of furcation involvement as follows:

- **GRADE I**: Incipient
- **GRADE II**: Cul- de- sac
- **GRADE III**: Through and through



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Hamp et al 1975 (horizontal component)

- F 0 - No furcation involvement
- F1- Probed 3mm in horizontal direction
- F2 -Probed deeper than 3mm
- F4 – through and through

Fedi (1985)

Combined the Glickman and Hamp classifications

- Same Glickman grades I through IV, but
- Grade II furcation are subdivided into degree I (< 3 mm) or degree II (>3 mm)

Ramjford and Ash in 1979 (horizontal component)

Classified similarly but instead of 3 mm increments, they utilized 2 mm increments.

- **Class I**: Beginning Involvement*:*

The tissue destruction should not extend more than 2 mm [or not more than 1/3rd of the tooth width] into the furcation.

- **Class II**: Cul-de-sac Involvement:

Tissue destruction extends deeper than 2 mm [or more than 1/3rd of the tooth width] into the furcation opening.

- **Class III**: Through and through.

Tissue destruction extends throughout the entire length of furcation, so that an instrument can be passed between the roots and emerges on the other side of the tooth

Based on vertical component of FI:

Tarnow and Fletcher classified it in mm: 1984

- Subclass A: vertical destruction to one-third of the total interradicular height (1- 3 mm).
- Subclass B: Vertical destruction reaching two thirds of the interradicular height (4-6 mm).
- Subclass C: Interradicular osseous destruction into or beyond the apical third (>7 mm).

Furcations would thus be classified as IA, IB, IC, IIA, IIB, IIC, IIIA, IIIB, IIIC, IVA, IVB, IVC.These sub classifications are an aid in prognosis and treatment planning.

Hou et al. (1998):(horizontal &vertical component)

- In 1998 Hou et al. presented a new classification of furcation involvement based on -- **root trunk, horizontal and vertical bone loss**.
- The types of root trunk were classified on the basis of the ratio of the vertical dimension of the root trunk to root length as type A, B and C where
- **Type A** – Root trunk involving the cervical third of root length.
- **Type B** - Root trunks involving the cervical 2/3rd of the root length.
- **Type C** - Root trunks involving more than the cervical 2/3rd root length.

Easley and Drennan's classification of FI 1969

- *Normal anatomy*: no FI.

- *Class I:* incipient involvement in which the fluting coronal to the furcation entrance is affected but there is no definite horizontal component to the furca.
- *Class II:*
    - *Type 1*- a definite horizontal loss of attachment into the furcation, but the pattern of bone loss is essentially horizontal. There is no definite buccal or lingual ledge of bone.
    - *Type 2*- there is a buccal or lingual bony ledge and a definite vertical component to the attachment loss.
- *Class III:* A through and through loss of attachment in the furcation. As with class II furcation defects, the pattern of attachment loss may be horizontal(1) or there may be a vertical component of varying depth.

Lindhe (1989)

- Degree I – Loss of inter-radicular bone less of than or equal to one-third the inter-radicular bone
- Degree II – Loss more than one-third of inter-radicular bone, but not through and through loss
- Degree III - Through and through loss of inter-radicular bone

Glossary of Periodontal Terms -AAP

- Class I - Indicating minimal, but notable, loss of bone in a furcation
- Class II - Displaying a variable degree of bone destruction in a furcation but not exceedingly completely through the furcation
- Class III - In which bone resorption extends completely through the furcation.

CLINICAL FEATURES

Tooth may or may not be mobile & is usually symptom free but occasionally

1. Sensitivity to thermal changes caused by caries or lacunar resorption of root in furcation area.
2. Recurrent or constant throbbing pain caused by pulp changes.
3. Sensitivity to percussion caused by acute inflammatory involvement of periodontal ligament.
4. Acute periodontal or periapical abscess formation

DIAGNOSIS

- Clinical Probing
- Trans gingival probing
- Radiographs

The extent of furcation invasion is often difficult to diagnose, and therefore a combination of radiographs, clinical probing using a curved Naber's probe, and Trans gingival probing must be utilized simultaneously.

CLINICAL PROBING

- Careful clinical examination should be performed to detect the furcation problems before a significant amount of attachment is lost.
- *Naber's curved* 1 & 2 probes with Gradation 3, 6,9,12 mm.
- No 23 explorer
- The buccal furca of maxillary molars & buccal & lingual furca of mandibular molars normally accessible for examination by clinical probing

MAXILLARY MOLARS

Probing furca - approximal tooth surfaces – is difficult when neighboring teeth are present, especially if the contact area between them is large or close proximity of roots

Distal furcation - located midway buccolingual - probing from both sides

Mesial furcations- located 2/3rd towards palate - **probed from the palatal aspect**

Due to anatomic variations and limited access, the clinical assessment of furcation involvement in maxillary premolars is often difficult.

Transgingival Probing

It is also called as bone sounding. It determines the contour of underlying bone

- Reduces the underestimation following normal probing
- ***Greenberg et al (1976)*** □ sounding yielded accurate measurements when compared to surgical reentry measurements
- Diagnosing furcation invasion is therefore best accomplished using a combination of radiographs periodontal probing with a curved explorer or Naber's probe (Ross & Thompson 1988)

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Perioscope

- Introduced subgingivally to visualize furcation.
- Consist of re-usable fiber optic endoscope which fits onto the periodontal probes & ultrasonic instruments that have been designed to accept it.

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Computed tomography

- Thin fan of x- ray beam rotates around the patient to get multiple axial slice of the area of interest . These slices are merged to get the final image.

Radiographs

- Furcation Involvement is often first detected in radiographs if they are made before probing measurements are obtained.
- Both paralleling “periapical” and vertical “bite-wing” radiographs should be taken.
- Sometimes superimposition of palatal root or thick bone may obscure furcation.
- In the radiographs the location of the interdental bone as well as bone level within the root complex should be examined.
- Highest frequency of involvement, distal furcation of maxillary first molar (**Svardstrom & Wennström** 1996)

DIAGNOSTIC CRITERIA FOR RADIOGRAPHIC DETECTION OF FURCATION

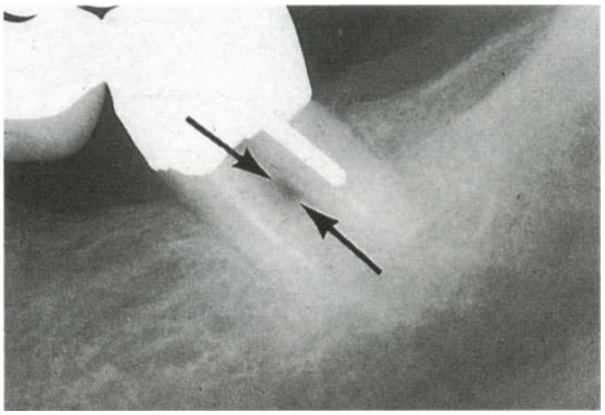
- Slightest radiographic change in furcation area
- Diminished radio density in furcation area in which outlines of bony trabeculae are visible.

- Whenever there is marked bone loss in relation to a single molar root, it may be assumed that the furcation is also involved.

“Furcation arrow"

- In maxillary molars, a small, triangular, radiolucent shadow is sometimes seen over the mesial or distal roots in the proximal furcation areas, which has been called as the furcation arrow. (Hardekopf, Dunlap).Ii indicates Class II or Class III involvement. Lack of arrow does not preclude furcation invasion. (Hardekopf et al. 1987)

  CBCT Data provided Substantial Information regarding Complete Furcation Anatomy, Furcation Involvement. CBCT Analysis revealed discrepancies in treatment recommendations for the majority of molars.



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The prognosis for individual teeth depends on:

1. Morphology of the bone deformity.

2. Root anatomy

3. Tooth morphology: Prognosis is poor for short, tapered roots and relatively large crowns. Because of the disproportionate crown-to-root ratio and reduced root surface available for periodontal support, the periodontium is more susceptible to injury by occlusal forces.

4. Chronicity of the destructive process.

5. Clinical crown to clinical root ratio.

6. Mobility: Tooth mobility caused by inflammation and trauma from occlusion may be correctable, but mobility resulting from loss of alveolar bone alone is not likely to be corrected.

7. Patients age and general health.

8. Therapists knowledge and skill.

- ❑ Grade I & II Furcation ----- Good Prognosis.
- ❑ Grade III (early stage) ----- Fair Prognosis
- ❑ Grade III (advanced) & IV -- Poor Prognosis

FURCATION THERAPY

OBJECTIVES:

- Elimination of microbial plaque from the exposed surfaces of the root complex.
- Establishment of anatomy of the affected surfaces that facilitates proper self-performed plaque control and maintenance
- Prevent further attachment loss
- Obliterate the furcation defects to reduce periodontal maintenance problem.

RECOMMENDED THERAPY:

- *1.Degree I:* SRP and furcationplasty.
- *2.Degree II:* furcation plasty, tunnel preparation, root resection, tooth extraction, GTR at mandibular molars.
- *3.Degree III:* tunnel preparation, root resection, tooth extraction.

Grade I Furcation

- Scaling, Root planing & Curettage with slim tips and Queitin Furcation Curettes resolves inflammation & prevent further progression

- Scaling and curettage, gingivectomy, odontoplasty: These procedures are used for incipient lesions in which no interradicular bone involvement exists (grade I) and the pockets are suprabony.
- Treatment is limited to pocket reduction, gingivectomy, reshaping of tooth structure, odontoplasty to widen the narrow furca entrance.
- The therapy required is dependent not only on the presence of disease but on the local dental/periodontal anatomy associated with the disease. (Glickman,Goldman).

EFFECTIVENESS OF NON-SURGICAL THERAPY

- Non-Surgical Root Debridement of Furcally involved teeth
- The width of the furcation entrance and internal morphology limit the access for instruments for appropriate mechanical debridement. Matia et.al. 1986;
- Several longitudinal studies have established thorough root debridement as the key to successful periodontal therapy.
- However, reduced efficacy has been reported in the treatment of multirooted teeth (Ramfjord et al. 1987, Kalkwarf et al. 1988).
- Studies specifically assessing the response of furcation sites to mechanical non-surgical treatment have all reported decreased clinical response over non-furcated counterparts (Nordland et al. 1987, Loos et al. 1988).
- Fleischer et al. (1989), found surgical access and operator experience were found to increase the efficacy of calculus removal in furcation areas, although total calculus removal was rare with any of the examined approaches.
- Wylam et al. (1993), found no statistical difference with respect to the effectiveness of calculus removal in furcations between non-surgical (93.2% residual plaque and calculus) and surgical access (91.1%).

Efficacy of hand and ultrasonic instrumentation:

- 50 hopeless mandibular molars were selected 20 teeth were instrumented with curettes, 10 with and 10 without surgical exposure. Twenty more teeth were instrumented with ultrasonic scalers, 10 with and 10 without surgical access, with the

remaining 10 teeth served as controls. The teeth were then extracted and the amount of residual calculus was assessed via stereomicroscopy. **(Matia et al)**

- Results demonstrated that surgical access was more effective than closed instrumentation with ultrasonic scalers
- Ultrasonic Scalers were more effective than curettes in narrow furcations treated with surgical access. However even with surgical access, only 7/60 surfaces was calculus free.
- **Leon Vogel et al observed** no difference between hand and ultrasonic debridement for class I but ultrasonic debridement was significantly more effective in class II and III furcations than debridement with hand instruments.
- **Auplish et al** on comparing diamond coated ultrasonic tips to traditional ultrasonic tips to Gracey's Curettes on a mannequin found the diamond coated ultrasonic tips to be the most efficient at debriding furcations followed by traditional ultrasonic tips followed by Gracey's curettes.

CHEMOTHERAPY

- The difficulties of performing adequate debridement in furcations by mechanical means have prompted experimentation with chemotherapeutic agents in these areas.
- *Needleman & Watts (1997) - 1% metronidazole gel irrigation into furcation areas with grade II and III involvements during periodontal maintenance + subgingival scaling.*
- Result- Clinically, no further improvement was seen for the furcations treated with metronidazole.
- *Nylund & Egelberg (1993):* Subgingival irrigation with tetracycline for 3 months + mechanical debridement in furcations with grade I, II and III involvements.
- Result - One-year evaluation of attachment levels and pocket depths showed *clinically negligible (1 mm) variation* in both tetracycline and saline-irrigated furcations.
- Tonetti et al (1992 *:* Tetracycline fibers exert a significant adjunctive pocket depth and bleeding / reduction over that produced by scaling & root planing alone, although this finding is confined only to the first 3 months following fiber insertion. No difference between treatments was observed at the 6-month follow-up visit. Overall, the results from the studies above do not lend clear acceptance to the implementation of

adjunctive local drug therapy in furcation involvements, regardless of the degree of severity.

SURGICAL PERIODONTAL THERAPY

Indications for surgical approach:

1. A significant horizontal involvement of one or more furcations of a multirooted teeth
2. Inability to adequately instrument the furcation by routine scaling and root planing through the gingival sulcus.
3. Persistence of inflammation or exudation after instrumentation in the presence of good oral hygiene.

Surgical debridement of furcations

- The reflection of a flap provides access and visibility to the furcation which facilitates thorough removal of plaque, calculus and any bacterial contaminants from the root surfaces of the furcation which results in a resolution of inflammation and potentially to reduction in pocket depth.

Furcationplasty - Odontoplasty and Osteoplasty:

- Furcationplasty is a resective treatment modality which should lead to the elimination of the inter-radicular defect.
- Tooth substance is removed (odontoplasty) and the alveolar bone crest is remodelled (Osteoplasty) at the level of the furcation entrance.
- The addition of odontoplasty and osteoplasty to surgical debridement provides a means of altering the physical dimension of the furcation defects. (Lindhe, Friedman)
- ***Odontoplasty*** provides a means of reducing the intermediate bifurcation ridge and the extent of dome over the furcation, thereby reducing the volume of the furcation defect.
- ***Osteoplasty*** reduces the physical dimension of bony ledges and placement of strategic grooving allows the therapist to reduce both the soft and hard tissue component of the furcation.

ROOT RESECTION AND HEMISECTION

- Process by which one or more roots of a tooth are removed at the level of furcation while leaving the crown & remaining roots in function. Indicated in advanced grade II to grade IV furcation.

Clinical terminology

- *Tooth sectioning:* is defined as the division of the tooth into its individual roots.
- *Root resection:* removal of part of the tooth.
- Mandibular molars are usually treated by hemisection (also termed bicupidization or separation with or without root removal).
- Maxillary molars are generally treated by root amputation.
- ROOT RESECTION was introduced by Farrar in 1884
- The detailed process of root separation/resection was first described in 1915 by GV Black, and reintroduced by Messinger & Orban in 1954.

Objectives:

- To resect the open root furcation area and make possible debridement of the residual root.
- To eliminate the periodontal pocket by removing the furcation.
- To improve the furcation form for dental hygiene.
- To preserve maximum periodontal tissue of the residual root.
- To control interdental space in the area adjacent to the root.
- To treat multirooted teeth where endodontics is impossible.
- To treat teeth with severe caries.

Indications :(Bassaraba N 1969)

1. Severe vertical bone loss on one root of a multirooted tooth not amenable to regeneration/reattachment.

2. Furcation invasion not correctable by odontoplasty.

3. Proximal furcation invasion in combination with root approximation.

4. Furcation invasion that is not maintainable.

5. Periodontally involved abutment teeth with a hopeless prognosis associated with one root.

6. Vertical or horizontal root fracture.

7. Uncorrectable root dehiscence.

8. When endodontic therapy is impossible on one root of a multirooted tooth.

Contraindications to root resection

1. Advanced bone loss with an unfavorable crown-to-root ratio.
2. Fused roots that cannot be separated.
3. If an endodontically inoperable canal would be retained.
4. If the remaining root(s) would be inadequate to serve as a prosthetic abutment.

5. If indicated splinting cannot be performed.

6. When periodontal support after resection is inadequate to withstand normal occlusal forces.

7. Inability to create a good postsurgical gingival environment.

8. Socioeconomic conditions.

9. In the presence of inadequate oral hygiene.

WHICH ROOT AND WHY?

1. The root that has the least amount of remaining bony support.
2. Remove the Root with greatest number of anatomic problems like severe curvature, developmental grooves or accessory and multiple canals.
3. Will obliterate the furcation and contribute to the elimination of any associated periodontal defect.

4. Provides postsurgical maintainable architecture.
5. Is the most difficult for the endodontist or restorative dentist to treat.
6. Least complicates future periodontal maintenance.

The most commonly resected Root is distobuccal of maxillary first molar due to less surface area and divergence.

VITAL versus NON VITAL ROOT RESECTION

Completing endodontic therapy before RSR has the following advantages:

1. Facilitates the surgical removal of the root, because it allows more extensive odontoplasty to be performed. (Lindhe)

2. It reduces the potential contamination of them surgical field by metallic fragments from a restoration.

3. Minimizes the potential for postoperative pain. (Smukler, Tagger).

4. Removal of Radicular pulp and sealing of Root orifices prevent contamination of pulp chamber by oral fluids during Root resection.

When furcation involvement is first identified during periodontal surgery RSR can be done first but canal entrances of the remaining roots must be properly sealed. Definitive root canal therapy should be completed within 2 weeks. (Smukler & Tagger 1976).

Hemisection:

It is the surgical process by which a two rooted tooth, usually a mandibular molar is converted into a single rooted tooth by the removal of one root and the associated portion of the crown.(Gargiulo, Wentz, Orban 1961). The economic consequences of hemisection and the advent of other therapeutic methods such as dental implant placement have resulted in a reduction in the frequency of hemisection.

Indications:

1. Patients who experience vertical root fracture or root perforation during endodontic therapy.

2. Patients who have endodontically treated mandibular molars with advanced bone loss on only one root that is serving as terminal abutments of prosthesis.

3. Patients who have local anatomy that precludes extraction and simple implant placement.

4. Grossly decayed one portion of crown with calcified corresponding root.

BICUSPIDIZATION

BICUSPIDIZATION Is the splitting of a Mandibular molar & retaining both the fragments so as to change the molar into two separate units.

INDICATIONS

Mandibular molars with Buccal & Lingual Class II or III Furcation involvements.

For prognostication, the following factors should be considered before RSR and Hemisection:

Periodontal considerations:

1. A long and wide root with a large crown is the ideal form.
2. After root resection or hemisection, the crater like osseous defect around the residual root is removed by osseous resection and the periodontal pocket eliminated. A form that facilitates plaque control to be achieved.
3. In class III furcation involvement, a good prognosis is unlikely unless the root morphology is favorable. If a tooth is used as an abutment in an edentulous area, root resection or hemisection at the stage of class II is best. Bone destruction of the residual root is suppressed and periodontal tissue recovered with a good long-term prognosis is expected.
4. The patient must be capable of thorough hygiene and follow through with scheduled professional care and management.

Endodontic consideration:

- In root canal preparation, excessive enlargement of the root canal must be avoided to reduce the possibility of thin walls.

Restorative considerations

1. A post and core should be used only if the residual tooth structure is fragile and the crown will not adhere.Post and core are the main causes of root fractures.(Kastenbaum 1986).

2. All root resected teeth should be reinforced with copings, if possible.

3. Occlusion should be balanced to avoid a force that might be detrimental to the root resected tooth. If possible, achieve minimal occlusal contact.

4. The restoration form must be easily cleansable for the patient's convenience.

Guidelines for Endodontic Therapy

Phase 1 Endodontic treatment

- Root canal therapy that preserves as much healthy tooth structure as possible.

Phase 2 Crown build-up

- The crown of the molar, the pulp chamber, and the coronal third of the canals are slightly prepared and filled with a chemically cured composite by using a dentin adhesive to improve the retention of the material. The restoration should be retentive in each single root

Phase 3a Root resection or root separation during preliminary prosthetic preparation

- Performing a root resection during this phase of treatment can be considered a strategic extraction and, because it creates access for oral hygiene in an area otherwise inaccessible, enhances the healing of the infrabony lesions that might be present in the interradicular area at the extraction site resulting in an osseous morphology more favourable to correct at the time of resective surgery

Phase 3b Relining and insertion of a prefabricated shell provisional restoration

Phase 3c Impression for a metal reinforced provisional restoration

Phase 4 Insertion of the reinforced provisional restoration

Phase 5a periodontal surgery

Phase 5b Root resection or root separation if not previously executed

Phase 5c Tooth preparation during surgery

Phase 5d relining of the reinforced provisional restoration

Phase 6 Clinical and radiographic re-evaluation

Phase 7 Final prosthetic tooth preparation and impressions

Phase 8 Insertion of the definitive prosthetic reconstruction.

TUNNEL PREPARATION

- It is the surgical exposure of the furcation which is indicated for advanced grade II and III lesions in which resection is not possible.
- To convert deep Grade II and III into Grade IV – better maintenance
- The rationale for this is to provide ready access for plaque removal and to facilitate instrumentation and the application of topical medicaments like fluorides.
- It requires roots that are long and divergent and is generally indicated for the mandibular molars. It often fails because of decay in the furcation area (Lindhe 1983).
- This type of resective therapy can be offered at mandibular molars which have a short root trunk, a wide separation angle, and long divergence between the mesial and distal root.
- The procedure includes the surgical exposure and management of the entire furcation area of the affected molar.
- Hellden (1989) reported that teeth with tunnel preparations have considerably better prognosis than that previously reported.
- Tunnelling - Studies
- **Hamp et al**. found that 4 of 7 teeth treated with this technique developed root caries, and 3 of them had been extracted during the observation time.
- During maintenance the exposed root surfaces should be treated by topical application of chlorhexidine digluconate and fluoride varnish.

- This surgical procedure should be used with caution, because there is a pronounced risk for root sensitivity and for carious lesions developing on the denuded root surfaces within artificially prepared tunnels

REGENERATION OF FURCATION DEFECTS:

- Furcation defects treated by GTR were demonstrated with histologic documentation of new attachment formation (Gottlow et al. 1986).
- Predictable outcome of GTR therapy was demonstrated only in grade II furcation involved mandibular molars showing significant bone fill and attachment gain reported at re-entry (Pontoreiro 1988, Lekovic 1989, Caffese 1990).
- The reason for the limited predictability of GTR in furcation-involved teeth may be due to the morphology of the periodontal defect, which in the root complex often has character of a horizontal lesion. Hence new attachment formation is dependent on coronal upgrowth of periodontal tissue. Limited access for instrumentation. Exposure of the membrane material and the fornix of the furcation. Morphology of osseous defects and bone regeneration:
- The number of bony walls surrounding the defects influences the predictability of regeneration in furcation defects.
- In class II furcation involvement, predictability is high if the inter dental bone level is coronal to the furcation. The length of the root trunk influences attachment gain in the furcation.

GTR FOR GRADE II furcations:

- GTR is consistently more effective than simple open flap debridement in reducing horizontal furcation depths vertical component levels and pocket depths for mandibular and maxillary class II furcations.
- Horizontal probing attachment level measurements within the furcation area at the 6-month re-examination showed a mean clinical gain of attachment of 4.1 mm in the buccal and 3.3 mm in the lingual defects treated by guided tissue regeneration therapy and 1.9 mm in the buccal and 2.2 mm in the lingual defects treated by open flap debridement alone. Pontoriero 1988

- Becker et al. presented the results of guided tissue regeneration therapy in the treatment of 6 class II furcation-involved molars.
- The authors reported, at the 5 months examination, 2.3 mm of clinical attachment gain at furcation sites; they also measured at the re-entry procedure a gain in "open probing attachment level" of 1.8 mm within the previously exposed furcation area.

BONE GRAFTS

- The furcation area is characterized by defects, the walls of which are primarily of tooth structure. Therefore, although the area is capable of holding a graft, it has little or no vascularity to support the graft, due to this reason the success of graft is limited in furcation defects(Sepe, Saunders)
- Grafts are indicated where destruction of furcation is only partial (grade I or II) or where deep vertical lesions have still left some bone on the inner aspects of the roots.(Bowers and Colleagues,2003).
- Combination of GTR and Various bone substitutes in molar class II furcations resulted in more pronounced bone fill and attachment gain than GTR alone. Lekovic et.al 1990;
- The predictability of connective tissue attachment gain is high using GTR for furcation involvement, but new bone formation is not predictable in the same area. (Schallhorn, Becker).
- Reports have shown that bone regeneration is increased by the use of bone grafts in combination with GTR for new bone formation.(Schallhorn and McClain).
- The success is likely due to the fact that bone grafts facilitate space making and membrane placement.

Murphy described the indications of GTR combined bone grafts as follows:

- 1. Osseous defects of 7-8mm depth. With deeper osseous defects, the effect of combining GTR with bone grafts diminishes because of spontaneous bone fill.
- 2. Deep osseous defects where space must be formed and maintained under the membrane.

Sites that work best

- Grade II Furcations
- Defect greater than 3 mm horizontal
- Facial maxillary molars
- Facial and lingual Mandibular molars
- A vertical defect in Furcations
- Furcation area in middle 1/3 of root (allows for flap Coverage)

Sites that do not work well

- Grade III & IV Furcations
- Proximal Furcations on maxillary molars - Difficult to adapt membrane
- Maxillary premolars
- Furcation area too coronal (defect exposes during healing)

Patient Factors that affect GTR based regeneration in Furcations

- Smoking
- Stress
- Diabetes Mellitus
- Immune Deficiency
- Presence of multiple Deep Periodontal defects

Defect Characteristics that has a bearing on regeneration in Furcal Defects

- Horizontal Probing Level
- Vertical Probing Level
- Distance of Crest to Base of Defect
- Distance of Furcation roof to Crest of Defect

- Inter-proximal Bone Height
- Root Divergence
- Horizontal Defect Depth
- Thickness of Gingiva at Defect site
- Tooth Mobility

Surgical Factors Affecting Successful Regeneration at the Furcal Region

- Infection Control
- Bone grafts combined with GTR membranes versus GTR alone
- Type of Membrane
- Surgical competence
- Space Maintenance
- Membrane Stability

Class II Furcations where Regerative Therapy is Not Indicated

1. Advanced Maxillary Class II furcation that is inaccessible for debridement of roots
2. Class II Maxillary Furcation involvement, with inadequate bony support of remaining roots
3. Root fracture, perforation, resorption, or deep root caries
4. Close root proximity with adjacent teeth compromising the periodontal prognosis of the adjacent tooth
5. Failed endodontic treatment or inoperable or calcified canals.

The **WWP** and the **AAP** paper on periodontal regeneration in furcations found the following: (Murphy and Gunsolly 2003; Wang 2005)

1. GTR provided additional benefits over OFD in CAL, reduced probing in furcations.

2. Bone replacement grafts enhance GTR treatment outcomes in furcations.

3. Bioabsorbable and nonabsorbable membranes provide similar outcomes in horizontal probing attachment level furcations.

4. Only e-PTFE membranes significantly enhanced the vertical probing attachment level in furcations.

5. Coronally positioned flaps with CA are associated with better clinical outcomes in furcation defects.

6. Clinically GTR procedures should be limited to mandibular and maxillary buccal grade II furcation defects.

Assessing Prognosis for Class III molar furcation involvement

- Becker et al. gave a tooth a hopeless prognosis if it had a class III furcation in combination with one or more of the following:
- Loss of over 75% of supporting bone.
- Pocket depths great than or equal to 8 – 10 mm,
- Hyper-mobility,
- Poor crown to root ratio
- Severe root proximity or
- A history of repeated periodontal disease.
- **McGuire** in1991 classified teeth with a class III furcations as having Questionable Prognosis

EXTRACTION

- Extraction of a furcation involved tooth must be considered when there is extensive attachment loss; so that no root can be maintained or when the treatment will not result in a tooth/gingival anatomy which allow proper self-performed plaque-control measures.
- Implants in place of furcation involved tooth should be considered only if implant therapy will improve the prognosis of the overall treatment.

TOOTH-RELATED FACTORS

1. Degree of furcation involvement.
2. Amount of remaining periodontal support.
3. Probing depth.
4. Tooth mobility
5. Endodontic conditions and root/root-canal anatomy.
6. Available sound tooth substance.
7. Tooth position and occlusal antagonisms.

PATIENT RELATED FACTORS

1. Strategic value of the tooth in relation to the overall plan.
2. Patients functional and esthetic demands.
3. Patients age and health conditions.
4. Oral hygiene capacity. (Hamp, Carnevale and Svardstrom).

CONCLUSION

- Molars with varying degrees of FI can be effectively treated and preserved similar to that of teeth with intact furcations.
- Effective management of furcation defects requires knowledge of the anatomic problems associated with FI and the application of treatment methods that are consistent with the nature and extent of the involvement.
- The keys to successful treatment of molar FI are early diagnosis, thorough treatment planning, and good oral hygiene by the patient, careful technical execution of the therapeutic modality and a well designed and implemented program of periodontal maintenance.

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