

Classification of Furcation Involvement - A Literature Review

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DOI: <https://doi.org/10.52403/ijrr.20220302>

ABSTRACT

Inflammatory periodontal disease, if unabated, ultimately progresses to attachment loss sufficient to affect the bifurcation or trifurcation of multirooted teeth. In multi-rooted teeth, the bone destruction can reach the area of root separation, thus exposing it to microbial colonization. In this occurrence, a “furcation involvement” is created. This article reviews several classifications that have been proposed in an attempt to describe the anatomy of the furcation involvement which could be important for prognosis and diagnosis of the involved teeth and for the treatment planning.

Keywords: Classification of furcation involvement, Inflammatory periodontal disease, Periodontitis

INTRODUCTION

Periodontitis affects the supporting apparatus of the teeth, leading to apical migration of the epithelial attachment and resorption of connective tissue and alveolar bone, often resulting in early tooth loss.[1] Inflammatory periodontal disease, if unabated, ultimately progresses to attachment loss sufficient to affect the bifurcation or trifurcation of multirooted teeth.[2,3,4] In multi-rooted teeth, the bone destruction can reach the area of root separation, thus exposing it to microbial colonization. In this occurrence, a “furcation involvement” is created. A furcation (Furca) is “the anatomic area of a multirooted tooth where the roots diverge.”[5]

The furcation lesion has been defined by the American Academy of Periodontology as ‘the pathologic resorption of bone in the anatomic area of a multirooted tooth where the roots diverge’. It is the anatomic location of the pathology that defines the lesion and hence it is essential to have a good knowledge of the anatomy to ensure the correct diagnosis and optimal treatment planning and to understand how these anatomic factors may influence the etiology and pathogenesis of this lesion.[6]

Several classifications have been proposed in an attempt to describe the anatomy of the furcation involvement. The purpose of this review is to present the all proposed clinical classifications of furcation involvements, which could be important for prognosis and diagnosis of the involved teeth and for the treatment planning.

CLASSIFICATION OF FURCATION INVOLVEMENT

Glickman was the first who suggested classification and it defines the main characteristics of furcation lesions based on horizontal attachment loss.[7]

1. Glickman, et al. in (1953) was the first to classify furcation according to grades.[8]

Grade I: Early lesion. The pocket is suprabony, involving the soft tissue. There is slight bone loss in the furcation area and no radiographic evidence of bone loss

Grade II: The bone is destroyed in one or more aspects of the furcation, but a portion of the alveolar bone and periodontal ligament remain intact, permitting only partial penetration of the probe. The radiograph may or may not reveal the grade II furcation involvement.

Grade III: Destruction of the connective tissue and bone wall all the way through the furcation. It is clearly shown in the radiographs as a radiolucent area between the roots

Grade IV: Interdental bone is destroyed and the soft tissues recede apically. The furcation opening is visible

2. In 1958 Goldman et al classified furcation as follows.[9]

Grade I: Incipient lesion.

Grade II: Cul-de-sac lesion

Grade III: Through-and-through lesion

3. Staffileno, H.J. (1969) classified furcation as follows.[10]

Class I: Furcation with a soft tissue lesion extending to furcal level but with minor degree of osseous destruction.

Class II: Furcation with a soft tissue lesion and variable degree of osseous destruction but not a through-and-through communication through the furcation.

Class II furcation is further classified as -

Class II L: Furcation with osseous destruction from lingual aspect only.

Class II M: Furcation with osseous destruction from mesial aspect only.

Class II D: Furcation with osseous destruction from distal aspect only.

Class III: Furcation with osseous destruction with through-and-through communication

4. In 1969 Easley and Drennan gave morphological classification of furcation. [11]

Class I. Incipient involvement, entrance of the furcation detectable with no horizontal bone loss.

Class II. Type 1. Horizontal bone loss, but no vertical component.

Class II. Type 2. Horizontal and vertical bone loss.

Class III. Type 1. Through-and-through loss of attachment into the furcation with no vertical component

Class III. Type 2. Through-and-through loss of attachment into the furcation with vertical component

5. Hamp et al. (1975) classified furcation as follows. [12]

Degree I: Horizontal attachment loss < 3 mm

Degree II: Horizontal attachment loss > 3 mm not encompassing the width of the furcation area

Degree III: Horizontal through-and-through destruction of the periodontal tissue in the furcation area

6. Rosenberg, M.M. (1978) classified furcation as follows. [13]

Horizontal

- **Degree I.** When the result of probing is not greater than 4 mm.
- **Degree II.** When probing shows a value greater than 4 mm (i.e., the bifurcation lesion has already passed the center of the trifurcation).
- **Degree III.** Two or three furcations classified as degree II are found.

Vertical

- **Shallow:** Slight lateral extension of an interradicular defect, from the center of the furcation in a horizontal direction, toward one or both adjacent furcations.
- **Deep:** Internal furcation involvement denotes the greater lateral extension of the interradicular defect into but not penetrating the adjacent furcation

7. In 1979 Ramfjord & Ash classified furcation as follows. [14]

Class I. Beginning involvement. Tissue destruction

Class II. Cul-de-sac, tissue destruction >2 mm (>1/3 of tooth width), but not through-and-through.

Class III. Through-and-through involvement.

8. Goldman and Cohen (1980) classified furcation as follows. [15]

Degree I. Involves furcation entrance.

Degree II. Involvement extends under the roof of furcation but not through-and-through.

Degree III. Through-and-through involvement.

9. In 1982 Ricchetti, P.A. gave furcation classification based upon pulp chamber relationships and vertical radiographic bone loss. [16]

Class I. 1 mm of horizontal measurement, the root furrow.

Class Ia. 1–2 mm of horizontal invasion, earliest damage.

Class II. 2–4 mm of horizontal invasion.

Class IIa. 4–6 mm of horizontal invasion.

Class III. >6 mm of horizontal invasion

10. In 1982 Tal and Lemmer. [17]

Classified furcation based on degree of severity of the furcation defects affecting each molar is assigned to one of four groups designated 1, 2, 3 and 4, referred to as furcation involvement index (FII) scores

Furcal rating 1. Depth of the furcation is 0 mm.

Furcal rating 2. Depth of the furcation is 1 to 2 mm.

Furcal rating 3. Depth of the furcation is 3 mm.

Furcal rating 4. Depth of the furcation is 4 mm or more

11. In 1984 Tarnow & Fletcher gave the classification of vertical component of furcation involvement. [18]

Furcation involvements would consequently be classified as Grade I, subclass A, subclass or subclass C; Grade II A, or C or Grade III A, or C. The system would thus be descriptive of both the horizontal and vertical components of furcation bone loss.

Subclass A: 0-3 of the furca.

Subclass B: 4-6 of the furca.

Subclass C: 7 mm or greater probeable depth from the roof of the furca.

12. Eskow RN, Kapin SH in 1984 studied Furcation invasions: correlating a classification system with therapeutic considerations. Part I. Examination, diagnosis, and classification. [19]

grade I subclasses A, B, and C (vertical involvement):

Subclass A: Vertical destruction > 1/3.

Subclass B: Vertical destruction of 2/3.

Subclass C: Vertical destruction beyond the apical third of interradicular height.

13. Fedi, P.F. in 1985 Combined Glickman and Hamp classifications. [20]

Grade II is subdivided into degrees I and II.

Degree I. Vertical bone loss 1–3 mm.

Degree II. Vertical bone loss > 3 mm, not communicate through-and-through.

14. In 1988 Grant, D.A. et al. classified furcation as follows. [21]

Class I: Involvement of the flute only

Class II: Involvement partially under the roof

Class III: Through-and-through loss

15. Basaraba, N in 1990 classified furcation as follows. [22]

Class I. Initial/incipient furcation involvement.

Class II. Partial furcation involvement.

Class III. Communicating furcation involvement

16. Svårdström and Wennström in 1996 classified furcation as follows. [23]

Proposed another classification that does not count millimetres but estimates horizontal probing:

Degree 0=the furcation site not probeable;

Degree 1=the root trunk coronal to the furcation entrance probeable;

Degree 2=the tip of the probe passes horizontally into the furcation but does not reach the centre of the furcation area;

Degree 3=the tip of the probe reaches to or beyond the centre of the furcation area.

17. In 1997 Carnevale, G. et al modified Hamp et al.(1975) classification. [24]

Degree I: Horizontal attachment loss < 1/3
Degree II: Horizontal attachment loss > 1/3.
Degree III: Horizontal through-and-through destruction

18. Nevins and Capetta (1998) classified furcation as follows. [25]

Class I: Incipient or early loss of attachment.

Class II: A deeper invasion and loss of attachment that does not extend to a complete invasion.

Class III: Complete loss of periodontium extending from buccal to lingual surface. Diagnosed radiographically and clinically

19. Hou GL, Chen YM, Tsai CC Weisgold AS in 1998 gave a new classification of molar furcation involvement based on the root trunk and horizontal and vertical bone loss. [26]

Types of root trunk:

- Type A: Furcation involving cervical third of root length
- Type B: Furcation involving cervical third and cervical two-thirds of root length.
- Type C: Furcation involving cervical two thirds of root length

Classes of furcation:

- Class I: Horizontal loss of 3 mm.
- Class II: Horizontal loss > 3 mm.
- Class III: Horizontal-through-and-through loss.

Subclasses by radiographic assessment of the periapical view:

- Sub-class a. - Suprabony defect.
- Sub-class b -Infrabony defect.

Classification of furcation:

- AI, AII, AIII. Type A root trunks with class I, class II and class III furcations.
- BI, BII, BIII. Type B root trunks with class I, class II and class III furcations.
- CI, CII, CIII. Type C root trunks with class I, class II and class III furcations.

20. In 2000, Fedi, et al. [27]

Modified Glickman's classification includes:
Grade II degree I - exists when furcal bone loss possesses a vertical component of >1 but 3mm,

Grade II degree II - exists when furcal bone loss possesses a vertical component of >3mm, but still does not communicate through-and-through

21. Glossary of periodontal terms in 2001 gave classification as follows. [5]

Class I: Minimal but notable bone loss in furcation.

Class II: Variable degree of bone destruction but not extending completely through furcation.

Class III: Bone resorption extending completely through furcation

22. In 2009 Walter, C. et al characterized the defect according to Hamp et al. (1975) using a modification of the furcation classification degree II, which was divided into degrees II and II. [28]

Degree 0: furcation not accessible with a periodontal probe

Degree I: horizontal loss of periodontal tissue support up to 3 mm

Degree II: horizontal loss of support exceeding 3 mm, but no more than 6 mm

Degree II-III: horizontal loss of support exceeding 6 mm, but no detectable "through and through" destruction

Degree III: horizontal "through and through" destruction of the periodontal tissue in the furcation

23. Carnevale, G. et al. (2012) classified furcation as follows.[24]

Degree I: Horizontal attachment loss < 1/3

Degree II: Horizontal attachment loss > 1/3

Degree III: Horizontal through-and-through destruction

24. Consensus report of workgroup 2 of the 2017 World Workshop on the Classification of Periodontal and Peri-Implant Diseases and Conditions.[29]

Classification of periodontitis based on stages defined by severity (according to the

level of interdental clinical attachment loss, radiographic bone loss and tooth loss), complexity in which furcation involvement is included and extent and distribution

PERIODONTITIS: STAGING

Staging intends to classify the severity and extent of a patient's disease based on the measurable amount of destroyed and/or damaged tissue as a result of periodontitis and to assess the specific factors that may attribute to the complexity of long-term case management

Periodontitis Stage I

Severity

Interdental CAL at site of greatest loss - CAL 1 – 2 mm

Radiographic bone loss - Coronal third (<15%)

Tooth loss - No tooth loss due to periodontitis

Complexity

Local - Maximum probing depth ≤ 4 mm
Mostly horizontal bone loss

Extent and distribution

For each stage, describe extent as localized (<30% of teeth involved), generalized, or molar/incisor pattern

Periodontitis Stage II

Severity

Interdental CAL at site of greatest loss - 3 to 4 mm

Radiographic bone loss- Coronal third (15% to 33%)

Tooth loss-No tooth loss due to periodontitis

Complexity

Local - Maximum probing depth ≤ 5 mm
Mostly horizontal bone loss

Extent and distribution

For each stage, describe extent as localized (<30% of teeth involved), generalized, or molar/incisor pattern

Periodontitis Stage III

Severity

Interdental CAL at site of greatest loss - ≥ 5 mm

Radiographic bone loss - Extending to mid-third of root and beyond

Tooth loss - Tooth loss due to periodontitis of ≤ 4 teeth

Complexity

Local - In addition to stage II complexity: Probing depth ≥ 6 mm Vertical bone loss ≥ 3 mm Furcation involvement Class II or III Moderate ridge defect

Extent and distribution

For each stage, describe extent as localized (<30% of teeth involved), generalized, or molar/incisor pattern

Periodontitis Stage IV

Severity

Interdental CAL at site of greatest loss - ≥ 5 mm

Radiographic bone loss - Extending to mid-third of root and beyond

Tooth loss - Tooth loss due to periodontitis of ≥ 5 teeth

Complexity

Local - In addition to stage III complexity: Need for complex rehabilitation due to: Masticatory dysfunction Secondary occlusal trauma (tooth mobility degree ≥ 2) Severe ridge defect Bite collapse, drifting, flaring Less than 20 remaining teeth (10 opposing pairs)

Extent and distribution

Add to stage as descriptor - For each stage, describe extent as localized (<30% of teeth involved), generalized, or molar/incisor pattern

PERIODONTITIS: GRADING

Grading aims to indicate the rate of periodontitis progression, responsiveness to standard therapy, and potential impact on systemic health

Progression Grade A: Slow rate of progression

Primary criteria

Direct evidence of progression,

Longitudinal data (radiographic bone loss or CAL) - Evidence of no loss over 5 years

% bone loss/age - < 0.25

Indirect evidence of progression

Case phenotype - Heavy biofilm deposits with low levels of destruction

Risk factors

Smoking - Non-smoker

Diabetes - Normoglycemic/ no diagnosis of diabetes

Progression Grade B: Moderate rate of progression

Primary criteria

Direct evidence of progression,

Longitudinal data (radiographic bone loss or CAL) - < 2 mm over 5 years

% bone loss/age - 0.25 to 1.0

Indirect evidence of progression

Case phenotype - Destruction commensurate with biofilm deposits

Risk factors

Smoking - < 10 cigarettes/day

Diabetes - HbA1c < 7.0% in patients with diabetes

Progression Grade C: Rapid rate of progression

Primary criteria

Direct evidence of progression,

Longitudinal data (radiographic bone loss or CAL) - ≥ 2 mm over 5 years

% bone loss/age > 1.0

Indirect evidence of progression

Case phenotype - Destruction exceeds expectation given biofilm deposits; specific clinical patterns suggestive of periods of rapid progression and/or early onset disease (e.g., molar/incisor pattern; lack of expected

response to standard bacterial control therapies)

Risk factors

Smoking - Smoker ≥ 10 cigarettes/day

Diabetes - HbA1c $\geq 7.0\%$ in patients with diabetes

25. In 2018 Piloni A., Rojas, M.A. Proposed Classification System for Furcation Lesion.[30]

Furcation lesions are divided into two main groups according to the following criteria
NE – non exposed (Figure 1) E – exposed (Figure 6)

NEI: The furcation lesion is not clinically exposed. The horizontal attachment loss is 2 mm or less .(Figure2,3)

NEII: The furcation lesion is not clinically exposed. The horizontal attachment loss is 3 mm or more. .(Figure4)

NEIII: The furcation lesion is not clinically exposed. The horizontal attachment loss is total, with through and through opening of the furcation.(Figure5)

EI: The furcation lesion is clinically exposed. The horizontal attachment loss is 2 mm or less. (Figure7)

EII: The furcation lesion is clinically exposed. The horizontal attachment loss is 3 mm or more. (Figure8)

EIII: The furcation lesion is clinically exposed. The horizontal attachment loss is total, with through and through opening of the furcation.(Figure 9)

Non exposed furcation lesions

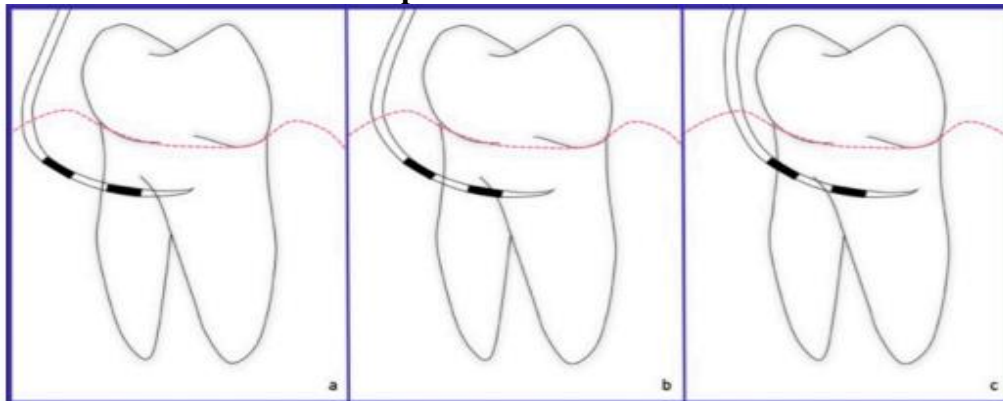


Figure 1: Non-exposed furcation lesion (NE): (a) Class I: Incipient lesion. Horizontal attachment loss of 2 mm or less; (b) Class II: Horizontal attachment loss of 3 mm or more; (c) Class III: Total horizontal attachment loss (through and through)



Figure 2: Non-exposed furcation lesion-Class I (NEI): (a) First maxillary molar; (b) Buccal furcation lesion. Horizontal attachment loss of 2 mm.



Figure 3: Non-exposed furcation lesion-Class II (NEII): (a) Second mandibular molar; (b) Buccal furcation lesion. Horizontal attachment loss of 4 mm



Figure 4: Non-exposed furcation lesion-Class II (NEII): (a) Second mandibular molar; (b) Buccal furcation lesion. Horizontal attachment loss of 4 mm



Figure 5. Non-exposed furcation lesion Class III (NEIII): First mandibular molar. Total horizontal attachment loss (through and through)

Exposed (E): Clinically exposed furcation lesion

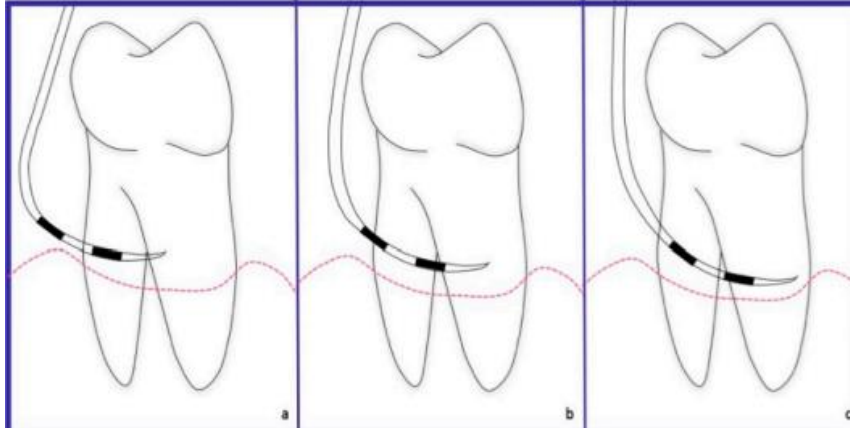


Figure 6: Exposed furcation lesion (E): (a) Class I: Incipient lesion. Horizontal attachment loss of 2 mm or less; (b) Class II: Horizontal attachment loss of 3 mm or more; (c) Class III: Total horizontal attachment loss (through and through.)

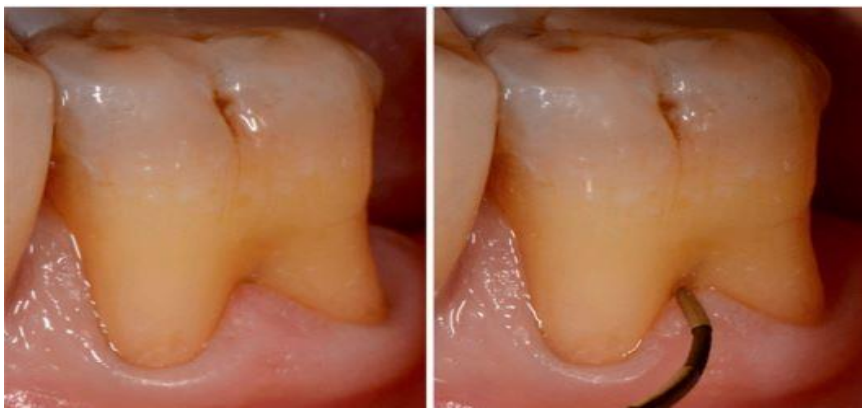


Figure 7: Exposed furcation lesion-Class I (EI): (a) First mandibular molar; (b) Buccal furcation lesion with horizontal attachment loss of 1 mm.



Figure 8: Class II (EII): First maxillary molar. Buccal furcation lesion with horizontal attachment



Figure 9: Exposed furcation lesion-Class III (EIII): First mandibular molar

26. Kolte, A.P. et al. in 2018 gave the classification as follows.[31]

Grade I- This type of furcation involvement is an inchoate lesion which develops by mild to moderate and uniform periodontal destruction extending into the flute of the furcation, and manifesting itself with increased probing depth (Figure 10)

Grade Ia: It comprises of all the features of Grade I FI, with the normal position of gingival margin which is slightly coronal to the CEJ.

Grade Ib: It comprises of all features of Grade I FI, with the position of gingival margin, 0-3 mm apical to CEJ.

Grade Ic: It comprises of all features of Grade I FI, with the position of gingival margin which is more than 3 mm apical to CEJ and may lead to mucogingival problem

Grade II: This type of FI is a confined lesion which develops by moderate periodontal destruction of varying amount extending into the inter-radicular area, with

an arched roof created by the furca and bordered by roots and bone. (Figure11)

Grade II type1a-It comprises of all the features of Grade II Type 1 FI with the normal position of gingival margin which is slightly coronal to the CEJ.

Grade II type1b-It comprises of all the features of Grade II Type 1 FI with the position of gingival margin which is 0-3 mm apical to the CEJ.

Grade II type1c-It comprises of all the features of Grade II Type 1 FI with the position of gingival margin which is more than 3 mm apical to the CEJ and may lead to mucogingival problem.

Grade II type2a-It comprises of all the features of Grade II Type 2 FI with the normal position of gingival margin which is slightly coronal to the CEJ.

Grade II type2b-It comprises of all the features of Grade II Type 2 FI with the position of gingival margin which is 0-3 mm apical to the CEJ.

Grade II type2c-It comprises of all the features of Grade II Type 2 FI with the position of gingival margin which is more than 3 mm apical to the CEJ and may lead to mucogingival problem

Grade III-This type of FI is a complete lesion which develops by moderate to severe periodontal destruction in the

furcation area permitting the passage of a probe bucco-lingually on the mandibular molars and bucco-mesially and bucco-distally on the maxillary molars. (Figure12)

Grade III type1a-It comprises of all the features of Grade III Type 1 FI with the normal position of gingival margin which is slightly coronal to the CEJ.

Grade III type1b-It comprises of all the features of Grade III Type 1 FI with the position of gingival margin which is 0-3 mm apical to the CEJ.

Grade III type1c-It comprises of all the features of Grade III Type 1 FI with the position of gingival margin which is more than 3 mm apical to the CEJ and may lead to mucogingival problem.

Grade III type2a-It comprises of all the features of Grade III Type 2 FI with the normal position of gingival margin which is slightly coronal to the CEJ.

Grade III type2b-It comprises of all the features of Grade III Type 2 FI with the position of gingival margin which is 0-3 mm apical to the CEJ.

Grade III type 2c-It comprises of all the features of Grade III type 2 FI with the position of gingival margin which is more than 3 mm apical to the CEJ and may lead to mucogingival problem.

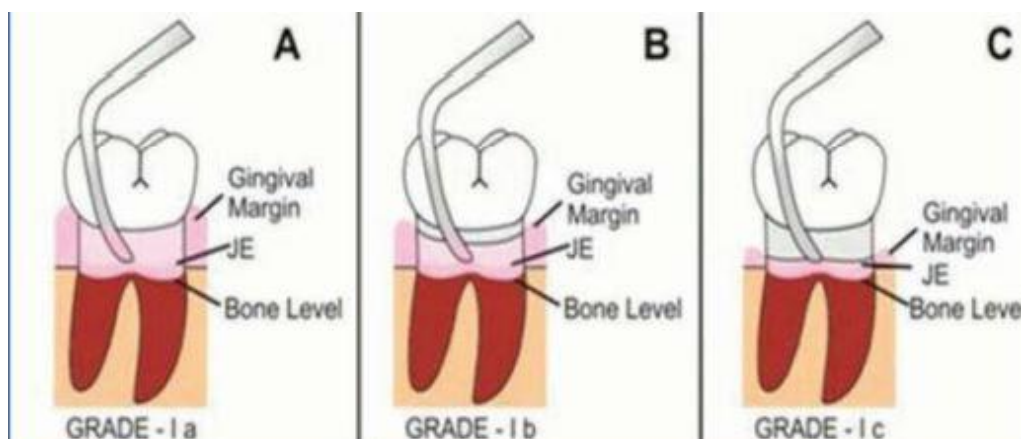


Figure 10. Grade I furcation involvement: A) Grade Ia; B) Grade Ib; C) Grade Ic

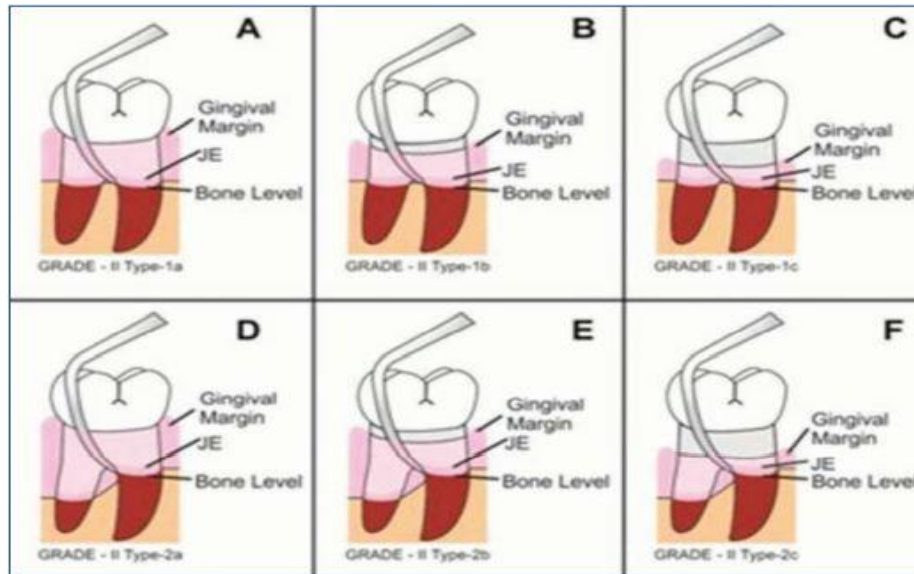


Figure 11: Grade II furcation involvement: (A) Grade II Type 1a; (B) Grade II Type 1b; (C) Grade II Type 1c; (D) Grade II Type 2a; (E) Grade II Type 2b; (F) Grade II Type 2c

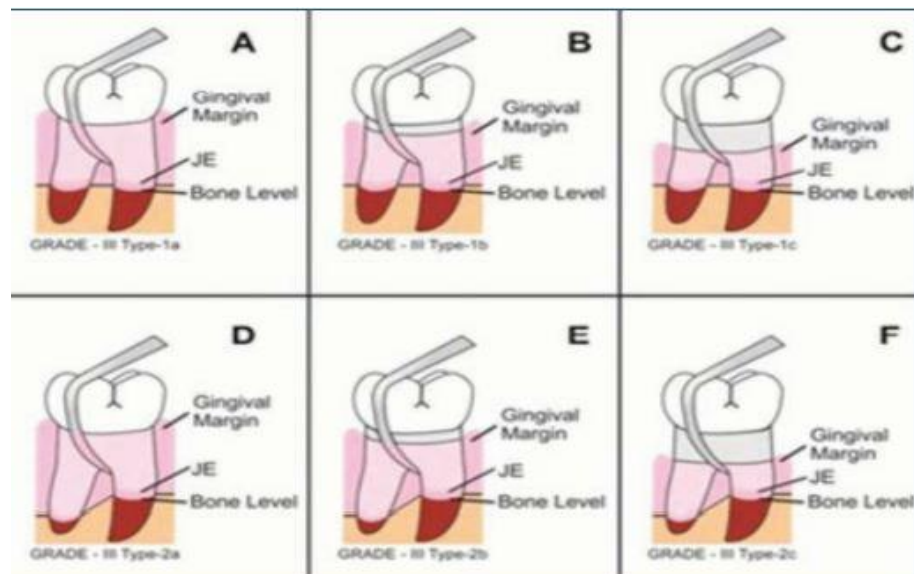


Figure 12: Grade III furcation involvement: (A) Grade III Type 1a; (B) Grade III Type 1b; (C) Grade III Type 1c; (D) Grade III Type 2a; (E) Grade III Type 2b; (F) Grade III Type 2c

DISCUSSION

Classification of diseases or conditions is known to be useful for the purpose of diagnosis, establishing prognosis and treatment planning. Till date, a number of classifications have been proposed to categorise furcation involvements which are based either on the extent of horizontal probing depths[8-14] or the vertical extent of loss of alveolar bone or a combination of the two. [18,32] All of them present limitations, because of varied anatomy of the furcation defects which makes it almost impossible to correlate all possible clinical scenarios in a comprehensive and concise

manner. [33] Currently, the proposed classifications are based on the extension of the defect and the degree of horizontal/vertical attachment loss. Glickman in 1953 [8] developed a classification system in order to describe the extension and main characteristics of the furcation defect (Grade I-IV). Hamp [12] Nyman and Lindhe and Tarnow and Fletcher [18] proposed to measure the horizontal/vertical attachment loss, respectively. Moreover, other classifications have been proposed in an attempt to describe the anatomy of the furcation more completely, describing the number of

remaining bony walls[34], the morphology of the existing bone[11] and the relationship between root trunk and vertical/horizontal attachment loss.[25] The aim of periodontal therapy in furcation involvement is to control the inflammatory process and to stop the progression of periodontal destruction, to restore clinical attachment level loss and to maintain the health and function of the affected molar teeth. The proposed classification by Kolte et al. (2018) is one of the first attempts to develop a system that relates the extent of alveolar bone damage horizontally as well as vertically in the furcation and gingival positions. This classification system is probably the only one which takes into account the hard and soft tissue conditions around molars in periodontal diseases and can provide meaningful guidelines into advising a complete therapeutic correction of the defects.[31] Also in Pilloni A., Rojas, M.A., in 2018 [30] proposed a classification system that included the marginal tissue position and its relationship with the furcation involvement (clinically exposed/non-exposed furcation). This information could be important for diagnosis, prognosis and treatment planning as well as for the communication between clinicians and researchers.

CONCLUSION

Furcation areas, if affected with periodontal diseases, present some of the greatest challenges to the success of periodontal therapy owing to its complex anatomic morphology that is immensely strenuous and frequently inappropriate for adequate debridement, hence it is essential to have a good knowledge of the anatomy of the furcation involvement. Several classifications have been proposed in an attempt to describe the anatomy of the furcation involvement, which could be important for prognosis and diagnosis of the involved teeth and for the treatment planning

Acknowledgement: None

Conflict of Interest: None

Source of Funding: None

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How to cite this article: Aishwarya Patil, Sarika Shetty. Classification of furcation involvement-a literature review. *International Journal of Research and Review*. 2022; 9(3): 6-17. DOI: <https://doi.org/10.52403/ijrr.20220302>
