# DIMENSIONAL ANALYSIS OF FURCAL ENTRANCES IN MANDIBULAR MOLARS

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# ABSTRACT

# AIM:

To analytically determine the furcation entrance dimensions of extracted permanent mandibular first, second and third molar teeth with relation to periodontal instruments used in the furcation.

# MATERIALS AND METHODS:

114 extracted permanent mandibular molars were collected and segregated into first, second and third molars post decontamination and debridement. Each tooth was placed on a 1mm paper grid and photographs of the buccal and lingual aspects were taken using a DSLR camera. The furcal entrances were measured using Adobe photoshop wherein circles of 0.25mm diameter were drawn to scale to the grid. These circles were drawn adjacent to each other in one plane to measure the mesiodistal aspect at the highest aspect of the furcation. The values obtained were compared to that of the diameters of the working ends of periodontal instruments commonly used in the furcation.

# **RESULTS:**

13% of mandibular first molars and 51.7% of mandibular second molars had furcation entrance dimension less than 0.75mm which is lesser than the blade width of standard curettes. Only ultrasonic scaler tips would fit in the furcations of 34.5% of mandibular second molars. All mandibular third molars evaluated in this study had fused roots with fluting and only Naber's probe and ultrasonic tips would engage the furcations.

# **CONCLUSION:**

The complexity of molar furcation areas provides a challenge for periodontal treatment that can lead to increased tooth loss compared to other tooth types. Standard hand curettes generally advocated for root surface instrumentation are standardized based on Caucasian populations and thus may show variation while instrumenting. An under instrumented furcation entrance provides a nidus for plaque accumulation and periodontal infection, greatly affecting the prognosis and treatment outcomes.

# Keywords: Furcation entrance dimensions, mandibular molars, root morphology, periodontal instruments

# INTRODUCTION

Destructive periodontal disease is an inflammatory condition of infectious primary cause that leads to marginal alveolar bone resorption and attachment loss.<sup>(1)</sup> The tooth type that demonstrates a high rate of periodontal destruction in untreated disease <sup>(2)</sup> and that which suffers a high frequency of tooth loss owing to periodontal reasons are the molars.<sup>(3,4)</sup> As the destruction progresses from the periodontium towards the apical region, the furcation areas of multirooted teeth gets exposed, resulting in irreversible bone loss in the inter-radicular area.<sup>(5)</sup> Molar root morphology influences the diagnosis, prognosis and treatment of periodontal disease.<sup>(6)</sup> The morphology of the furcation region provides an environment favorable for the retention of bacterial plaque which hinders dental plaque control and thereby contributes to the pathogenesis of periodontal destruction.<sup>(7)</sup> The presence of root concavities further complicates the diagnosis of furcation involvement and restricts access of periodontal instruments, resulting in incomplete treatment. Greater furcal concavities are frequently exhibited in mesial roots of mandibular molars when compared to distal roots.<sup>(8)</sup> Furcation involvement refers to the bone resorption and attachment loss in the inter-radicular area that results from plaque-associated periodontal disease and such a condition is reported to markedly increase the risk for tooth loss.<sup>(9,10)</sup> Poorer prognosis is

often seen in teeth with furcation involvement when compared to teeth that are not involved.<sup>(11)</sup> This has been attributed to the limited access of furcation entrances, largely associated with the complex anatomy and morphology of molar teeth.<sup>(12,13)</sup> The response to periodontal therapy in multi-rooted teeth may be complicated due to greater radicular surface areas that favours the growth and entry of bacterial toxins and calculus buildup, when compared to defects involving single-rooted teeth. Once the lesion is established, the dissimilarity between the root surfaces and the periodontal soft tissues that faces the bacterial insult may be accountable for the reduced healing response. The anatomical location of both the mandibular molars and their respective furcations are difficult to access, impairing both self-performed and professional plaque control procedures in the furcation area, thus limiting the effectiveness of periodontal treatment.<sup>(14)</sup> Furcation involvement can occur at early stages of periodontal disease in mandibular first molars as the buccal aspect has a short root trunk. Cervical enamel projections(CEP) and enamel pearls are characteristic morphological features of molar teeth. These developmental anomalies create furrows and recesses which are pathways for bacterial invasion and subsequent periodontal infection. Teeth exhibiting cervical enamel projections(CEP) were also found to have deeper root concavities compared to teeth without CEP.<sup>(15)</sup> Cementum inherent channels with small and large openings and thick central cementum ridges can offer uncontrollable bacterial retention and colonisation and may even lead to pulpal infection from the furcation.<sup>(16)</sup> The effectiveness to instrument the furcation entrance area is compromised because such curettes do not fit in this area. Furcation entrances smaller than the width of common curettes fall short of debriding the site appropriately.<sup>(17,18)</sup> Therefore, this study was performed to determine the morphology of furcation entrances of mandibular molars and compare these dimensions to the width of standard curettes used in periodontal instrumentation.

# MATERIALS AND METHODS

A convenient sample size of 130 extracted human permanent mandibular molars were obtained from Saveetha Dental College and Hospital, Chennai.

#### **Inclusion criteria:**

- Molars with intact furcations and complete roots
- Absence of fractures, caries, restorations or tooth wear at the furcations
- Absence of internal or external root resorption defects areas.

#### Sample preparation

After exclusion, a total of 114 extracted molars were washed in tap water and hydrogen peroxide and the tooth type determined After extraction, the teeth were fixed and stored in 10% formalin solution. Any hard and soft deposits near the furcations were removed with ultrasonic scalers.

### FED calculation

Photographs of the first, second and third molar teeth were taken over a 1mm grid paper using a DSLR camera. (Fig 1.1,1.2). These were uploaded to Adobe Photoshop to measure the furcal dimensions using 0.25mm diameter circles drawn to scale between the furcal entrances. The number of 0.25mm circles that could be accommodated mesiodistally at the furcal entrances were used to determine the distance between the roots at each the buccal and lingual furcations for the mandibular molars.

# **Blade width calculation**

The width of the working end of the most oftenly used periodontal instruments was also measured. These included Hu Friedy Gracey curettes blades, ultrasonic scaler tips and Naber's probe which were also measured photographically over the 1mm grid paper. (Fig 2.1,2.2) The mean blade widths were assessed and compared to the furcal entrance dimensions (FEDs) of the molars.





# RESULTS

The photographs of 46 mandibular first molars, 58 mandibular second molars and 9 mandibular third molars were uploaded on Adobe Photoshop with 0.25mm circles drawn at the furcal entrances on both the buccal and lingual aspects. The number of circles that fit mesiodistally within the most coronal part of the furcation was taken as the furcation entrance dimension. These furcation entrance dimensions of the mandibular first and second molar are tabulated (table 1) according to the site of furcation entrance.

Furaction	entrance	First molar		Second molar	
dimension mm		Buccal	Lingual	Buccal	Lingual
0.25		0	0	2	2
0.5		0	0	8	13
0.75		2	6	10	9
1.00		10	_16	7	11
1.25		17	11	18	8
1.5		12	9	5	5
1.75		4	4	2	5
2		1	0	1	0

# Table 1: Distribution of molars based on site for given FED

Of the collected mandibular third molars, all the molars had fused roots with mild fluting. The furcation entrance dimensions of these teeth were within the range of 0-0.5mm. The mean furcation entrance dimension based on the site of furcation entrance for the first and second mandibular molars is summarised in table 2. The distribution of mandibular first, second and third molars according to minimum furcation entrance dimension on each tooth type is described in table 3

# Table 2: Mean FED of 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> molars based on site

Tooth type	Mean (mm)	
	Buccal	Lingual
First molar	1.29	1.19
Second molar	0.93	0.87
Third molar	0.19	0.30

# Table 3: Distribution of molars based on minimum FED

Minimum furcation entrance size (x) mm	First molar %	Second molar %	Third molar %
$0.25 \le x \le 0.5$	0	34.5	100
$0.5 < x \le 0.75$	13	17.2	0
$0.75 < x \le 1$	34.8	19	0
$1 < x \le 1.25$	37	31	0
$1.25 < x \ge 1.5$	39	43	0

The blade widths of ten new Gracey curettes were measured on each side and average values tabulated. Similarly blade widths of five ultrasonic scaler tips and Naber's probe was measured and average values calculated. A summary of the average blade widths of these periodontal instruments is shown in table 4.

# Table 4: Average blade widths of standard periodontal instruments

Instrument	Side 1	Side 2
2R/2L	1	1
4R/4L	1	1
1/2	1	0.75
3/4	0.75	0.75
5/6	0.75	1
7/8	0.75	1
9/10	0.75	1
11/12	1	1
13/14	0.75	1
Ultrasonic scaler	0.5	-
Naber's probe	0.45	0.45

The mean periodontal blade widths range from 0.75 - 1 mm in curettes. Ultrasonic scaler was found to be sharply tapered and was 0.5mm at its tip and Naber's probe had a blade width of 0.45mm.

# **DISCUSSION:**

A relevant clinical dilemma exists around the predictable successful treatment outcome of periodontitis involving the furcations of multirooted teeth.<sup>(19)</sup> A thorough understanding of molar root morphology is essential for the diagnosis and subsequent periodontal therapy. The length of the root trunk, furcation entrance width, root separation, the presence of root concavities, cervical enamel projections, bifurcation ridges, enamel pearls, accessory pulp canals and root surface area are some of the morphological factors

that can affect the etiology, diagnosis and consequently choosing the appropriate therapy for molars with furcal involvement.<sup>(20)</sup> 61.94% of buccal and 50.75% of lingual molar surfaces have demonstrated cervical enamel projections (CEPs), while the second molars have presented with the highest frequency of CEPs.<sup>(21)</sup> Despite a low frequency of radicular morphological abnormalities, the dentist must keep in mind the possibility that a tooth can have altered root morphology or supernumerary roots. One study reported an uncommon case where a maxillary lateral incisor had two roots.<sup>(22)</sup> Complete knowledge of molar root anatomy is mandatory in periodontal therapies as it is closely associated with the process of establishing an accurate diagnosis and also in choosing the appropriate treatment modality and hence provide adequate long-term prognosis of the teeth. In the present study furcation entrances were measured in both the buccal and lingual aspects based on an important finding in a study by Marcaccini in mandibular first molars, which demonstrated anatomical variations between the lingual and buccal furcations with a possible consequence to the disease process and prognosis.<sup>(23)</sup>

The furcation involvement or furcation invasion has been recognized as an important risk factor that results in tooth loss. This is due to a general rule that the presence of furcation invasion can lower the long-term prognosis of a tooth. Various studies also indicate that patients who comply with periodontal maintenance treatment which included complete furcation debridement, lose fewer teeth when compared to patients who do not receive regular periodontal maintenance therapy.<sup>(24,25)</sup> The furcation entrance dimension is very important in anticipating the successful outcome of periodontal therapy. A narrow furcation also increases the difficulty for complete root debridement due to the limited access through furcation entrances, compromising periodontal therapy.<sup>(26,27)</sup>

Furcation involvement is more severe and commonly seen in first molars than in second molars. Notably, normal to mild furcation involvement is observed during the third decade of life while moderate and severe involvement is seen in the fifth, sixth, and seventh decades.<sup>(28)</sup> A study by Ross and Thompson that looked at a number of patients in common periodontal practice provides more awareness regarding the prevalence of furcation invasions and the methods that help identify the presence of furcal involvement <sup>(28)</sup>. Clinical examinations has showed furcal involvement in 90% of the maxillary molars and in 35% of the mandibular molars.<sup>(29)</sup>

A number studies show that in molars with furcation involvement, halting a disease process through means of periodontal therapy was not as satisfactory as those obtained for single-rooted teeth or non-furcated molars.<sup>(30,31)</sup> Two 2-year prospective studies demonstrated the effects of root debridement and plaque control in periodontitis, wherein molar furcation sites had a less favourable response to treatment compared to that of molars with flat surfaces and non-furcated teeth.<sup>(32,33)</sup> This was in accordance with studies with Kaldahl et al., who demonstrated similar results in molars with furcation involvement in terms of attachment level measurements, independent of the initial probing depth, to surgical periodontal therapy.<sup>(34)</sup> Wang et al. reported that molars with furcation involvement during 8 years of supportive periodontal therapy, showed loss in attachment level of an average of 1.24 mm, while molars without furcation involvement lost only 0.6 mm.<sup>(35)</sup> A study conducted by Loos et al observed the microbiological outcome after periodontal therapy indicated the comparatively poorer clinical response of furcated molars.<sup>(36)</sup> The conservative approach in the treatment of furcation involvement resulted in reduced rate of success owing to the incomplete removal of hard and soft debris present in the inter-radicular area because of the peculiar anatomy of the furcation space.<sup>(37,38)</sup> Bower observed that the furcal aspect presented with concavities in 100% and 99% of mandibular mesial and distal roots respectively.<sup>(39)</sup> These studies imply that the furcation configurations render the periodontal cleansing procedures quite difficult once the plaque front has reached the furcal areas of the molars. Furcation entrance dimension influences the feasibility of gaining access to the interradicular area with mechanical instruments. The width of the furcation entrance and the amount of residual calculus are interrelated. This can be correlated to the results found in studies by Matia et al.<sup>(40)</sup> and Parashis et al.<sup>(41)</sup>

Furcation entrances that are not accessible by means of mechanical instruments are quite common. During periodontal therapy curettes are the manual instruments commonly used to produce a smooth and biologically acceptable surface and help result in satisfactory healing.<sup>(42,43)</sup> The blades of these periodontal instruments play a significant role as they must present a blade width that allows effective root debridement. Narrow furcation entrance dimensions can complicate the periodontal therapy of teeth with furcation involvements as the active tip of commonly used periodontal instruments such as Gracey curettes, present a blade width of 0.95-1.2 mm and hence do not fit in the furcation region.<sup>(44)</sup> In the current study new Gracey curettes, ultrasonic scaler tips and Naber's probe tip were measured for blade width. On comparing the FED to the blade width of various periodontal instruments, studies have found difficulties in periodontal therapy in molars with furcation involvement <sup>(26,27)</sup>.

Bower et al measured furcation entrance dimension of 103 mandibular first molar teeth and found that for adequate root preparation in the furcal area, the use of curettes alone might not be adequate <sup>(45)</sup>. These results by Bower were in accordance to the present study. The presence of a smaller furcation dimension implies a poorer prognostic indication because of difficult instrumentation while all other factors are constant. In addition, a lack of correlation between the furcation entrance measure and mesiodistal width at the CEJ among first molar teeth indicated that large teeth do not necessarily tend to have large furcation entrance dimensions.<sup>(46)</sup> Chiu et al studied FEDs in 178 mandibular first molars and found that 49% of the overall furcation entrance, was  $\leq$  36% of buccal and 47% lingual furcation entrances, and lesser than 0.075mm. One half of all first molars that were examined had an FED which was less than the blade width of new Gracey Curettes.<sup>(47)</sup> The results of the present study is in contrast with this as only 13% of mandibular first molars had furcation entrance dimension less than 0.75mm which is lesser than the blade tips of standard currettes. However 51.7% of mandibular second molars presented with FED < 0.75mm.

A study by Leon and Vogel showed that in a Class I furcation, treatment was equally successful when either a curette or an ultrasonic scaler was used.<sup>(48)</sup> Whereas in Class II or Class III furcations, treatment with an ultrasonic tip was found to have more favourable outcomes.<sup>(48)</sup> Otero-Cagide and Long through their studies showed that mini-bladed curettes were more effective for scaling the

furcations on comparison to a thin ultrasonic tip.<sup>(49,50)</sup> A report by Wylam et al. demonstrated the insufficiency of root planing with or without surgical access in grade II and III furcation areas of furcated teeth and residual plaque and calculus in 89% and 95% of surgically and non-surgically treated molars.<sup>(51)</sup> Later studies reported that deposits of residual calculus covered an average of 93.2% after closed instrumentation and 91.1% after open instrumentation of furcal root surfaces.<sup>(52)</sup> This was in contrast to Matia et al,<sup>(40)</sup> who reportedly found more residual calculus after closed root planning which was significantly higher than that found in open root planing in furcated molars with deep lesions and also no difference was observed between the use of ultrasonic scalers and curettes in both groups. Parashis et al. gave detailed descriptions on the efficacy of calculus removal in class II and class III furcations accomplished by scaling and root planing with or without surgical access. A third approach consisted of the use of a rotary diamond bur for the removal of calculus deposits in the furcal areas after surgical exposure. This combined treatment proved to be the best in the removal of calculus from furcations, especially in areas with fluting and when the furcation entrance dimension was lesser than or equal to 2.4 mm.<sup>(41,53)</sup> Although scaling and root planing in combination with flap surgery is more effective at calculus removal, the clinical evaluations does not signify an obvious difference between surgical and nonsurgical treatments irrespective of the degree of furcation involvement. Nevertheless closed scaling and root planing proved to be more effective at preserving the existing attachment level and helps produce a more immediate bone remineralization, even though these changes are accompanied by a lesser reduction in pocket depth. The clinical efficacy between closed and open procedures is significantly equivalent and it may be attributed to the procedure, operator variables, compliance with professional recommendations, the initial risk of the patient or a combination of these factors.<sup>(54)</sup> Studies show that the antimicrobial photodynamic therapy (aPDT) is an effective adjunct to non-surgical treatment along with scaling and root planing in the treatment of chronic periodontitis in terms of gain of clinical attachment level and reduction of probing depth.<sup>(55)</sup> Molars with furcation involvement can be successfully maintained despite having a compromised prognosis by employing fairly conservative treatment followed by regular maintenance.<sup>(56)</sup> Therefore, further studies to detect other morphological variations in the molar teeth among the Indian sub-population with modifications to instrumentation may be required to determine the success of periodontal therapy.

# CONCLUSION

Furcal involvement in molars can pose a risk of tooth loss as it negatively affects the periodontal treatment outcomes and prognosis. A thorough knowledge of the molar root morphology is essential for successful root surface debridement. Standard periodontal hand curettes may require modifications to adequately engage and debride the furcal areas of mandibular molars, especially the second mandibular molars. A combination of ultrasonic scalers with standard Gracey's curettes can be beneficial in successful periodontal therapy and prevent tooth loss.

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