Topographic Study of Extracted Molars with Advanced Furcation Involvement: Furcation Entrance Dimension and Molar Type

Guey-Lin Hou, Chun-Cheng Hung, Yi-Hsin Yang,[1] Chi-Cheng Tsai,
Ping-Ho Chen, and Tien-Yu Shieh[1]
Graduate Institute of Dental Sciences and Department of Periodontology,
and [1]Graduate Institute of Oral Health Sciences, School of Dentistry,
Kaohsiung Medical University, Taiwan.

This study investigated the topography of the furcation entrance dimension (FED) on molars with advanced furcation involvement (FI). The sample pool consisted of 169 maxillary and mandibular molars from a group of 165 individuals with severely advanced periodontal destruction. The subjects included men and women aged 24 to 84 years (mean, 47.8 ± 7.2 years). The FEDs of the maxillary buccal, mesial, and distal surfaces as well as the mandibular buccal and lingual surfaces were measured under a stereomicroscope and clarified into grades I (FED < 0.55 mm), II (0.55–0.75 mm), and III (> 0.75 mm) using automatic grading system software designed by our research associates. The differences and relationships among molar location, furcation site, and FED grade were analyzed using the chi-square test. There was a significant difference among buccal (BFED), mesial (MFED), and distal (DFED) FEDs in both the maxillary first ($\chi^2_4 = 58.915$, $p < 0.001$) and second ($\chi^2_4 = 66.839$, $p < 0.001$) molars. The relationship between molar type and FED grade was statistically significant for both the BFED ($p < 0.001$) and the DFED ($p < 0.001$) of maxillary molars, as well as for both the BFED ($p < 0.0001$) and LFED ($p < 0.0001$). The difference in FED grade between the first and second molars was statistically significant in both maxillary ($p < 0.001$) and mandibular ($p < 0.0001$) molars. There was a significant relationship between FED grade and tooth location at molars with advanced FI.

Key Words: furcation entrance, dimension, furcation involvement, molar loss
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Many studies have addressed the intimate anatomical topography relative to periodontal therapy in molar furcation involvement (FI) [1–11], and show that the tortuous regions inaccessible to cleaning and proximity to the furcation entrance are risk factors in successfully treating periodontally involved furcation areas. Recently, our research group documented the detailed topography of furcation entrance architecture and the correlation between variations in molar root trunks and molar location, type, and dimensions [11–14]. In addition, based on our data for types A and C first and second molars with Class III FI, there is a greater difference (3 times) in periodontal attachment loss (PAL) between types A and C when the molars are affected by Class III FIs [12]. More recently, our study on root trunk types and dimensions with respect to PAL revealed that these data may be used as an aid in diagnosing Class III FIs and PAL. The combination of the types of root trunks and the degree of molar FI is also useful in the clinical evaluation of molar diagnosis,

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Address correspondence and reprint requests to: Dr. Guey-Lin Hou, 100 Shieh-Chuan 1st Road, Kaohsiung City, Taiwan.
E-mail: houkl@kmu.edu.tw

prognosis, and treatment plan for FIs [13, 14]. All earlier reports concluded that a better understanding of the molar root surface areas, including a combination of furcation entrance dimension (FED) and type of root trunk correlation with the FI of the periodontally involved molars, may be more important in the diagnosis, prognosis, and treatment plan [3, 4, 8, 10, 12, 15].

Although molars with long root trunks do not easily develop FI compared to molars with short root trunks, the periodontal implications, such as severe PAL with resultant molar loss, may occur when such molars with type B or C root trunks develop Class III molar FI [10, 13, 14, 16]. Our earlier report showed that different dimensions in the buccal, mesial, and distal root trunk of maxillary molars, as well as in the buccal and lingual root trunks of mandibular molars, may be useful in assessing a diagnosis of Class III FI [14, 16].

There is limited information regarding the types and dimensions of molar root trunks with variations in FED associated with Class II and III FIs. The purpose of this study was to investigate the relation between topography of the FED and molar type of extracted teeth with advanced FIs.

Materials and Methods

The study sample consisted of 169 maxillary (103) and mandibular (66) first and second molars extracted due to a final diagnosis of severely advanced periodontal destruction with Class III molar FI and more than 75% axiobuccolingual (ABL) in a group of 165 individuals. The subjects included males and females, aged 24 to 84 years (mean, 47.8 ± 7.2 years) receiving periodontal therapy at the Department of Periodontics, Kaohsiung Medical University. The collected molars had not been restored with crowns or bridges or otherwise damaged, so that an exact assessment of the vertical dimensions of the root trunk and root length could be made. Extracted molars were washed in tap water, the tooth type determined, and then fixed in formalin solution after hard root deposits were removed with curettage and ultrasonic scaling.

Clinical records were made after extraction, and included age, gender, FI class assessed by routine periapical radiography and clinical probing, and FED, defined as grade I (FED < 0.55 mm), II (0.55–0.75 mm), and III (> 0.75 mm).

Statistical analysis

The prevalence and distribution of, and relationship among, FED grade, molar location and furcation site between maxillary and mandibular molars were analyzed using the chi-square test.

Results

Table 1 presents the distribution and grade of FED for buccal, mesial, and distal furcation sites in maxillary molars. On the maxillary first molar, buccal FED was more frequently grade I, while mesial and distal FEDs were more commonly grade III. The differences in FED grade and molar type at buccal and distal furcation sites were statistically significant ($p < 0.001$).

A similar trend was noted in maxillary second molars. Buccal FED was most commonly grade I, while mesial and distal FEDs were more commonly grade III. The differences in FED grade and molar type among furcation sites (buccal, mesial, and distal) were statistically significant ($p < 0.001$). In addition, grade I buccal FED was more common in second molars (77.6%) than in first molars (46.7%).

The distribution and grade of FED at furcation sites on mandibular molars are shown in Table 2. For the first molar, grade III FED was more common (61.6%) than grade II FED (11.6%) and grade I FED (3.5%). Grade III FED occurred more frequently in the first molar (61.6%) than in the second molar (13.2%). The difference in FED grade between buccal and lingual surfaces of the first molar was not statistically significant ($p > 0.05$).

For the second molar, grade I FED (51.9%) occurred more commonly than grade II (35.0%) and grade I (13.2%). Grade I FED occurred more frequently in the second molar (51.9%) than in the first molar (3.5%). The difference in FED grade between buccal and lingual surfaces in the second molar was not statistically significant ($p > 0.05$).

Table 3 lists the distribution of, and differences between, FED grade and furcation site on maxillary molars. In both the first and second molars, the FED was more commonly grade I (46.7% and 77.6%) than grade II (22.2% and 10.3%) and grade III (31.1% and 12.1%). Grade I FED was more common among buccal furcations than mesial and distal furcations, whereas grade III FED was more common mesially and distally than buccally. In addition, grade I FED was more

Table 1. Prevalence and distribution of furcation entrance dimension (FED) grade on buccal, mesial, and distal surfaces of extracted maxillary molars with Class III furcation involvement

Molar location	Furcation site	*n*	FED grade, n (%)			Significance (χ^2 test)
			I	II	III	
16 & 26	Buccal	45	21 (46.7)	10 (22.2)	14 (31.1)	df = 4
	Mesial	45	1 (2.2)	4 (8.9)	40 (88.9)	P = 58.915
	Distal	45	1 (2.2)	1 (2.2)	43 (95.6)	$p < 0.001$
	Total	135	23 (17.0)	15 (11.1)	97 (71.9)	
17 & 27	Buccal	58	45 (77.6)	6 (10.3)	7 (12.1)	df = 4
	Mesial	58	7 (12.1)	7 (12.1)	44 (75.9)	P = 66.839
	Distal	58	12 (20.7)	8 (13.8)	38 (65.5)	$p < 0.001$
	Total	174	64 (36.8)	21 (12.1)	89 (51.1)	

Table 2. Prevalence and distribution of furcation entrance dimension (FED) grade on buccal and lingual surfaces of extracted mandibular molars with Class III furcation involvement

Molar location	Surface	*n*	FED grade, n (%)			Significance (χ^2 test)
			I	II	III	
36 & 46	Buccal	33	1 (3.0)	3 (9.1)	29 (87.9)	df = 2
	Lingual	33	2 (3.8)	7 (13.2)	24 (45.3)	P = 2.310
	Total	66	3 (3.5)	10 (11.6)	53 (61.6)	$p > 0.05$
37 & 47	Buccal	53	29 (54.7)	18 (34.0)	6 (11.3)	df = 2
	Lingual	53	26 (49.1)	19 (35.8)	8 (15.1)	P = 0.437
	Total	106	55 (51.9)	37 (35.0)	14 (13.2)	$p > 0.05$

Table 3. Distribution of and relationship between furcation entrance dimension (FED) grade and furcation site on maxillary molars with Class III furcation involvement

Molar type	Furcation site	n	FED grade, n (%)			Significance (χ^2 test)
			I	II	III	
16 & 26	Buccal	45	21 (46.7)	10 (22.2)	14 (31.1)	df = 2
17 & 27	Buccal	58	45 (77.6)	6 (10.3)	7 (12.1)	P = 10.589
	Total	103	66 (64.1)	16 (15.5)	21 (21.4)	$p < 0.001$
16 & 26	Mesial	45	1 (2.2)	4(8.9)	40 (88.9)	df = 2
17 & 27	Mesial	58	7 (12.1)	7 (12.1)	44 (75.9)	P = 3.931
	Total	103	8 (7.8)	11 (10.7)	84 (81.6)	$p > 0.05$
16 & 26	Distal	45	1 (2.2)	1 (2.2)	43 (95.6)	df = 2
17 & 27	Distal	58	12 (20.7)	8 (13.8)	38 (65.5)	P = 13.429
	Total	103	13 (12.6)	9 (8.7)	81 (78.6)	$p < 0.001$

commonly observed on the second molar (77.6%) than on the first molar (46.7%). The differences in FED grade at buccal and distal furcations between maxillary first and second molars were statistically significant (buccal: $p < 0.001$; distal: $p < 0.001$).

Table 4 describes the difference in and distribution of FED grade at buccal and lingual sites between mandibular first and second molars. Buccal and lingual FEDs were more commonly grade I (54.7% and 49.1%) than grade II (34.0% and 35.8%) and grade III (11.3%

and 15.1%). For buccal furcation sites, most grade III FEDs were found in the first molar (87.9%), while most grade I FEDs were noted in the second molar (54.9%). The difference in FED grade at buccal sites was statistically significant between the first and second molars ($p < 0.0001$). For lingual furcation sites, most grade III FEDs were found in the first molar (72.7%), while most grade I FEDs were noted in the second molar (49.1%). The difference in FED grade at lingual sites was statistically significant between the first and second molars ($p < 0.0001$).

Table 5 illustrates the distribution and relationship between FED and molar type. Most FEDs on maxillary first (71.4%) and second (51.2%) molars were grade III, followed by grade I (17.6% and 36.8%) and grade II (11.0% and 12.1%). Only 4.5% of grade I FEDs were noted in the mandibular first molar, while most FEDs (80.3%) were grade III. Most mandibular second molars had grade I FEDs (51.9%), while 34.9% had grade II FEDs and 13.2% had grade III FEDs. The differences between molar type and FED grade were statistically significant for both mandibular ($p < 0.001$) and maxillary molars ($p < 0.0001$).

Discussion

Bower [1] and Chiu et al [9] documented FEDs in the first molar using machined metal gauges. Neither actually discussed the relationship between FED and molars with periodontal disease and the measurements of FEDs on buccal, mesial, and distal furcations. In recent studies [10, 16], we showed that mesial FEDs (1.04 mm and 0.9 mm) were widest, followed by distal (0.99 mm and 0.67 mm) and buccal (0.74 mm and 0.63 mm). Furthermore, an interesting finding was that 63% and 62% of all FEDs in both maxillary and mandibular second molars, respectively, were narrower than 0.75 mm, which is the narrowest blade width of new curettes. This suggests that most second molars are at high risk for continued periodontal breakdown because of the difficulty of gaining access to most furcations with standard scaling and root planing instruments when the molars are affected by FI.

To our knowledge, few or no reports have documented the relationship between FED grade and loss of molars with FIs. The present results suggested a significantly higher prevalence of grade I FED (FED

Table 4. Distribution and relationship between furcation entrance dimension (FED) grade and furcation site on mandibular molars with Class III furcation involvement

Molar type	Furcation site	n	FED grade, n (%)			Significance (χ^2 test)
			I	II	III	
36 & 46	Buccal	33	1 (3.0)	3 (9.1)	29 (87.9)	df = 2
37 & 47	Buccal	53	29 (54.7)	18 (34.0)	6 (11.3)	P = 50.016
	Total	86	30 (34.9)	3 (3.5)	35 (40.7)	$p < 0.0001$
36 & 46	Lingual	33	2 (6.1)	7 (21.2)	24 (72.7)	df = 2
37 & 47	Lingual	53	26 (49.1)	19 (35.8)	8 (15.1)	P = 31.143
	Total	86	28 (32.6)	26 (30.2)	32 (37.2)	$p < 0.0001$

Table 5. Distribution and relationship between furcation entrance dimension (FED) grade and molar type

Molar location	FED grade, *n* (%)			*n*	Significance (χ^2 test)
	I	II	III		
16 & 26	24 (17.6)	15 (11.0)	97 (71.4)	136	df = 2
17 & 27	64 (36.8)	21 (12.1)	89 (51.2)	174	P = 15.095
Total	88 (28.4)	36 (11.6)	186 (60.0)	310	$p < 0.001$
36 & 46	3 (4.5)	10 (15.2)	53 (80.3)	66	df = 2
37 & 47	55 (51.9)	37 (34.9)	14 (13.2)	106	P = 79.849
Total	58 (33.7)	47 (27.3)	67 (39.0)	172	$p < 0.0001$

≤ 0.55mm) at buccal sites of both first (46.7%) and second molars (77.6%) as compared to those at mesial (2.2% and 12.1%, respectively) and distal sites (2.2% and 20.7%, respectively). This finding appears to be consistent with our previous conclusion and supports the hypothesis that the topography of FEDs in second molars leads to a higher risk than that in first molars when the molars are affected by advanced FI [10, 12, 13, 16].

Results also showed that grade III FED (wide dimension ≥ 0.75 mm) was more frequent at mesial (88.9% and 75.9%, respectively) and distal sites (95.9% and 65.5%, respectively) than at buccal sites (31.1% and 12.1%, respectively) of both first molar and second molars.

The prevalence of grade I FED (narrow dimension ≤ 0.55mm) in the first molar was less than that in the second molar, irrespective of furcation site. This finding is in close agreement with our earlier reports [10, 14, 17] and supports the speculation that the second molar, at diseased furcation sites, not only had a high prevalenceof long root trunk but also had a narrower FED than the first molar. In addition, second molars had more attachment loss, unfavorable crown-to-root ratio, short root length, and taper-shaped root and poorer prognosis when compared to first molars [11, 12, 17, 18].

The present finding also unexpectedly revealed a higher prevalence of grade I FED in the mandibular second molar (54.7% and 49.1%) than in the first molar (3.0% and 3.8%), irrespective of furcation site. A similar result was found in grade II FEDs for the second molar as compared to the first molar. These findings suggest that second molars with a higher prevalence of long root trunk and narrower FED may be at higher risk for molar loss than the first molar when molars with narrow FEDs are affected by through-and-through FIs. Grade I FED occurred more frequently in second molars than in first molars, in particular, at buccal furcation sites of maxillary molars and mandibular second molars.

This study is the first to describe the relationship between FED and molar location. Monitoring FED grades in various molar teeth has shown that most grade III FEDs were found at mesial and distal furcation sites of maxillary first and second molars as well as at buccal furcation sites of mandibular first molars, whereas most grade I FEDs were noted at buccal sites on maxillary first and second molars as well as at buccal and lingual sites of mandibular second molars (Tables 1 and 2). Results indicated that extracted molars with Class III FI appear to have narrower FEDs in the mandibular second molar than in other molars.

As far as is known, few or no published data are available to compare the difference in FED grade at buccal or lingual sites between first and second molars. A strongly significant relationship existed between FED grade and molar type in both the buccal ($p < 0.0001$) and lingual ($p < 0.0001$) furcation sites.

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