Development of Caries in Permanent First Molars Adjacent to Primary Second Molars With Interproximal Caries: Four-year Prospective Radiographic Study

Apostole P. Vanderas, DDS, JD, MPH, MDS, Dr Dent Katerina Kavvadia, DDS, MDS, Dr Dent
Lisa Papagiannoulis, DDS, MSc, Dr Dent

Dr. Vanderas is associate professor, Dr. Kavvadia is lecturer, and Dr. Papagiannoulis is professor and head, Department of Pediatric Dentistry, School of Dental Medicine, University of Athens, Athens, Greece.
Correspond with Dr. Vanderas at avanderas@dent.uoa.gr

Abstract

Purpose: This study investigated the effect of the primary second molars' distal surface caries on the incidence of the permanent first molars' mesial surface caries in 613 paired tooth surfaces of children ages 6 to 8 years at baseline examination.

Methods: Proximal caries and its progression were diagnosed by bite-wing radiographs taken at a 1-year interval over a period of 4 years. The permanent first molars' mesial surfaces and primary second molars' distal surfaces were examined. Recorded were: (1) sound surfaces; (2) carious lesions on the enamel's external and internal half and on the dentin's external, middle, and internal third; (3) filled, extracted, and exfoliated teeth. The logistic model for panel data was employed to estimate the effect of proximal caries of the primary second molars' distal surfaces on the incidence of the permanent first molars' mesial surface caries. The 95% confidence interval probability was used. Sensitivity and specificity as well as the positive and negative predictive rates were computed.

Results: The results showed that the presence of proximal caries on each primary second molars' distal surfaces significantly affected the development of proximal caries on the corresponding permanent first molar's mesial surfaces. Age was estimated to exert a positive and highly significant impact, while gender had no effect. The odds ratio values ranged from 4.86 to 63.43. The values of sensitivity and specificity ranged from 45% to 97% and 80% to 89%, respectively, while the positive and negative rates ranged from 40% to 56% and 90% to 99%, respectively.

Conclusions: Proximal caries present on the primary second molars' distal surfaces increases the risk of developing caries on the permanent first molars' mesial surfaces. This risk, however, is different among the paired surfaces studied. (*Pediatr Dent.* 2004;26:362-368)

KEYWORDS: PROXIMAL CARIES, PRIMARY SECOND MOLARS, PERMANENT FIRST MOLARS

Received August 9, 2003 Revision Accepted March 18, 2004

It has been reported that permanent first molars' mesial surfaces are more susceptible to developing dental caries than permanent teeth's other proximal surfaces.[1-3] One factor that could influence the development of these carious lesions during the mixed dentition period is the presence of dental caries on the primary second molars' distal surfaces. Thus, a retrospective study[4] found that the risk of developing dental caries on the mesial permanent first molar surface due to enamel/enamel-dentin border carious lesions of the primary second molar's distal surfaces was 15 times greater than that for the sound surfaces. The relationship between dental caries of the mesial permanent first molar surfaces and distal primary second molar surfaces, however, has not been adequately studied.

The purpose of this study was to investigate the effect of the presence of the primary second molars' distal surface caries on the development of the permanent first molars' mesial surface caries.

Methods

Study population

The original sample consisted of bite-wing radiographs from 314 children—161 boys and 153 girls, ages 6 to 8 years—at baseline examination from 5 public schools. The parents were invited to the schools, and the investigators explained the study's procedures to them. A consent form, signed by the parent, was returned to the investigators. Children were followed up to 10 to 12 years of age. Two bite-wing radiographs were taken annually for each child with the aid of a film holder. During this study, 39 children refused to have radiographic examinations, 41 were moved out of the district, and 38 were absent during the examinations. Therefore, the final sample consisted of 196 children—102 boys and 94 girls. Table 1 shows the distribution of children by age and gender. These children had complete sets of radiographs for all examinations. Permission to use human subjects in this study was obtained from the appropriate health ministry and school district authorities.

The number of paired surfaces examined radiographically at baseline was 784, of which were excluded from the analysis due to extraction, exfoliation or restoration of the primary second molars' distal surfaces, decay on the permanent first molars' mesial surfaces at baseline examination, and unreadable cases. Thus, only sound mesial surfaces of the permanent first molars at baseline were included in the analysis. The final sample consisted of 613 paired surfaces.

Radiographic classification of proximal caries

All radiographs by subject were read in succession in a view box by a qualified pediatric dentist. The permanent first molars' mesial surfaces, primary molars' mesial and distal surfaces, and primary canines' distal surfaces were examined. According to the radiographic appearance, one of the following codes was assigned to each surface:

1. 1= carious lesion on the enamel's external half;
2. 2= carious lesion on the enamel's internal half;
3. 3= carious lesion on the dentin's external third;
4. 4= carious lesion on the dentin's middle third;
5. 5= carious lesion on the dentin's internal third;
6. 0= sound surface.

Missing and restored teeth as well as unreadable surfaces and exfoliated teeth had separate codes. Small radiolucencies that disappeared on subsequent radiographs were coded as sound surfaces.

Preventive measures

All children lived in an area with less than 0.03 ppm water fluoride content. The subjects received a 4-minute topical application of acidulated phosphate-fluoride gel contained in trays, as well as oral hygiene instructions, once a year for 4 consecutive years. Also, toothpaste with fluoride was distributed to them at each examination. A letter was sent to parents to inform them about the child's dental needs.

Table1. Distribution of Children by Age and Gender

Groups	Age				
	10	**11**	**12**	**13**	**Total**
Boys	20	76	5	1	102
Girls	16	71	7	0	94
Total	36	147	12	1	196

Intraexaminer reliability test

The radiographs of 15 children were randomly re-examined within 15 days from the first examination, and an intraexaminer reliability test was carried out.

Statistical methods

The data were analyzed using the statistical package of STATA 5.1 (Stata Corp, College Station, Tex). A logistic model was employed to predict the probability that the permanent first molars' mesial surfaces would become carious, depending on the presence of proximal caries on the primary second molars' distal surfaces. To estimate this probability, a binary variable was constructed taking the value of 0 if the permanent first molars' mesial surfaces remained sound between examinations and the value of 1 if it became carious. The explanatory variable was also a dummy taking the value of 1 in the case of proximal caries on the primary second molars' distal surfaces and 0 otherwise. Finally, age and gender were used as additional explanatory variables of the logistic model.

The methodology of logistic analysis for panel data was calculated to estimate the aforementioned model. The 95% confidence interval probability was calculated. Based on the estimates obtained from the logistic model, the odds ratios were computed to see how a 1-unit change in the explanatory variable affected the risk of caries. Odds ratios greater than 1 implied a positive association, while ratios lower than 1 implied a negative one. Finally, sensitivity and specificity as well as the positive and negative predictive rates were computed.

Results

Tables 2 and 3 show the distribution of the permanent first and primary second molars' mesial and distal surfaces, respectively, in each examination. The logistic multiple regression analysis showed that the presence of caries on the primary second molars' distal surfaces significantly affected dental disease development in the permanent molars' mesial surfaces. The effect was also significant when maxillary and mandibular teeth were analyzed separately. Furthermore, it was found that the presence of caries on each primary second molars' distal surfaces significantly affected the development of dental disease in each permanent molars' mesial surfaces (Table 4). Age was estimated to exert a positive and highly significant impact, while gender had no effect.

Table 2. Distribution of Permanent First Molars' Mesial Surface Caries

State of surfaces	Examinations																			
	Baseline no. of tooth distal surfaces				First no. of tooth distal surfaces				Second no. of tooth distal surfaces				Third no. of tooth distal surfaces				Fourth no. of tooth distal surfaces			
	3	14	19	30	3	14	19	30	3	14	19	30	3	14	19	30	3	14	19	30
Sound	144	130	144	137	154	142	148	142	135	133	112	132	89	101	79	85	55	67	43	49
External 1/2 enamel	-	-	-	-	8	3	7	9	19	11	26	18	25	16	30	22	22	13	26	24
Internal 1/2 enamel	-	-	-	-	-	-	-	-	-	1	1	1	-	-	-	-	6	3	-	3
External 1/3 dentin	-	-	-	-	-	-	-	-	-	-	-	-	1	1	1	-	1	1	1	-
Middle 1/3 dentin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-
Internal 1/3 dentin	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-
Restored	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-
Not erupted	18	15	11	14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	162	145	155	151	162	145	155	151	154	145	145	151	115	118	110	109	84	84	72	76

Table 3. Distribution of Primary Second Molars' Distal Surface Caries

State of surfaces	Examinations																			
	Baseline no. of tooth distal surfaces				First no. of tooth distal surfaces				Second no. of tooth distal surfaces				Third no. of tooth distal surfaces				Fourth no. of tooth Distal surfaces			
	A	J	K	T	A	J	K	T	A	J	K	T	A	J	K	T	A	J	K	T
Sound	148	135	128	126	139	130	115	113	128	117	97	111	88	97	69	79	65	72	49	60
External 1/2 enamel	7	10	16	16	10	12	14	18	11	17	22	14	12	9	13	8	7	3	10	5
Internal 1/2 enamel	1	-	3	5	7	3	10	9	5	5	6	9	6	6	14	7	5	5	4	1
External 1/3 dentin	2	-	5	3	1	-	9	9	5	6	10	13	6	5	8	10	5	3	3	6
Middle 1/3 dentin	1	-	1	-	2	-	5	1	1	-	6	2	1	1	2	4	-	-	3	1
Internal 1/3 dentin	3	-	2	1	3	-	2	1	4	-	4	2	2	-	4	1	2	1	3	3
Restored	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Exfoliated	-	-	-	-	-	-	-	-	8	-	10	-	47	27	45	42	78	61	83	75
Extracted	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	162	145	155	151	162	145	155	151	162	145	155	151	162	145	155	151	162	145	155	151

Table 4. Logistic Multiple Regression of Effect of Primary Second Molars' Distal Surface Caries on Permanent First Molars' Mesial Surfaces

Independent variables*	Dependent variable: Mesial surface of the permanent first molars dummy							
	Tooth no. 3		Tooth no. 14		Tooth no. 19		Tooth no. 30	
	Regression coefficient (SD)	*P*	Regression coefficient (SD)	*P*	Regression coefficient (SD)	*P*	Regression coefficient (SD)	*P*
Constant	-7.49 (1.09)*	.00	-7.39 (1.57)	.00	-10.30 (1.49)	.00	-9.23 (1.42)	.00
Age	0.39 (0.09)	.00	0.54 (0.14)	.00	0.74 (0.13)	.00	0.63 (0.12)	.00
Sex	0.78 (0.51)	.12	-0.47 (0.51)	.35	-0.64 (0.47)	.17	0.29 (0.45)	.52
Ad	1.58 (0.58)	.007						
Jd			2.14 (0.51)	.00				
Kd					4.15 (0.60)	.00		
Td							2.51 (0.47)	.00

*The capital letters in variables Ad, Jd, Kd, and Td indicate the corresponding tooth. The letter d indicates the same tooth's distal surface.

The odds ratios of developing dental caries on the permanent first molars' mesial surfaces as well as the 95% confidence intervals of the corresponding logistic regressions are presented in Table 5. The sensitivity and specificity values ranged from 45% to 97% and 80% to 89%, respectively, while the positive and negative predictive rates ranged from 40% to 56% and 90% to 99%, respectively (Table 6). The intraexaminer reliability test showed that the kappa statistic's value for the permanent teeth was 0.87, with a confidence interval ranging between 0.78 and 0.96. For the primary teeth, the corresponding value was 0.86, with an interval between 0.82 and 0.89.

Discussion

The present prospective study investigated the effect of the primary second molars' distal surface caries on the development of permanent first molars' mesial surface caries. The tested hypothesis was that the presence of dental caries on the primary second molars' distal surfaces does not affect significantly the development of the dental disease on the permanent first molars' mesial surfaces. The logistic multiple regression analysis rejected this null hypothesis for each pair of teeth, implying that a significant relationship exists between the dependent and independent variables (Table 4).

The significance remained unchanged after the inclusion of the child's age and gender in the statistical analysis. An explanation for this finding is that dental caries is an infectious disease, and it is likely that the permanent first molars' mesial surfaces are colonized by bacteria from the carious lesions of the primary second molars' distal surfaces as soon as the surfaces come in contact resulting in the development of carious lesions. Also, the significant positive relationship between the child's age and permanent first molars' mesial surface caries implied that as age increases and, consequently, the time period of mesial surfaces exposed to the primary second molars' carious distal surfaces increases, the probability of developing caries is greater.

To further evaluate the relationship between the presence of dental caries on the primary second molars' distal surfaces and the development of carious lesions on the permanent first molars' mesial surfaces, the odds ratios of the explanatory variables from the corresponding logistic regressions were calculated. The odds ratio is a measure of association showing how much more likely (or unlikely) it is for the aforementioned outcome to be present among surfaces with caries on the primary second molars' distal surfaces than those without caries on the tooth's corresponding surfaces.

As shown in Table 5, the odds ratio values were greater than 1 for each pair of tested teeth. This implied that the risk of developing caries on the permanent first molars' mesial surfaces is higher in children with caries on the primary second molars' distal surfaces than in those with radiographically sound surfaces. Besides, the values of odds ratios presented a great variability, ranging from 4.86 to 63.43, showing that the risk of developing caries on the permanent first molars' mesial surfaces is different among the studied paired teeth. This finding may be attributed to the different cariogenic conditions present between the studied teeth's surfaces.

It has been reported[5,6] that the progression of proximal caries from one state to another is extremely variable not only between individuals but also between carious lesions of the same individual, indicating different cariogenic conditions. Overall, the odds ratio results strengthened the correlations found between the presence of primary second molars' distal surface carious lesions and the development of permanent first molars' mesial surface caries.

In a retrospective study,[4] it was reported that the risk of developing dental caries on mesial permanent first molar surfaces, due to enamel/enamel-dentin border carious lesions of the primary second molars' distal surfaces, was 15 times greater than that for sound surfaces. In the aforementioned study, however:

Table 5. Odds Ratios

Tooth no.	Coefficient (SD)	95% confidence interval	
		Upper	Lower
3			
Age	1.48 (0.14)	1.23	1.79
Ad	4.86 (5.33)	1.55	15.25
14			
Age	1.72 (0.24)	1.31	2.26
Jd	8.5 (4.31)	3.15	22.97
19			
Age	2.1 (0.28)	1.62	2.73
Kd	63.43 (38.1)	19.56	205.96
30			
Age	1.88 (0.22)	1.50	2.36
Td	12.35 (5.75)	4.96	30.72

1. surfaces with dental caries on the enamel's outer half were considered sound;
2. all tooth surfaces were analyzed together;
3. relative risk was calculated in enamel and dentin carious lesions separately.

Therefore, a direct comparison with the present investigation's findings is not feasible. Nevertheless, it can be concluded that the results of both studies are in the same direction.

To make the results more clinically meaningful, sensitivity, specificity, and positive and negative predictive rates were calculated using the:

1. presence of dental caries on the primary second molars' distal surfaces as screening criterion;
2. development of caries on the permanent first molars' mesial surfaces as validation criterion.

The sensitivity rate showed the screening criterion's ability to identify those surfaces that truly developed carious lesions, while specificity indicated its ability to identify as negative those surfaces that truly did not develop dental caries. The positive predictive rate revealed the screening criterion's ability to identify surfaces that developed dental caries among high-risk surfaces. The negative predictive rate, on the other hand, indicated the screening criterion's ability to identify surfaces with a low risk of developing dental disease among those considered at low risk. Ideally, the values of all indices should be 100% to identify all high-risk and low-risk surfaces correctly and indicate a perfect screening test. Unfortunately, no such screening criterion is available. Thus, a certain amount of error has to be accepted.

The sensitivity results indicated that:

1. of the upper-right and upper-left side surfaces with a true high risk of developing dental disease that were studied, 1 of 3 and nearly 3 of 5, respectively, would remain undetected in a risk-assessment procedure;
2. almost all true high-risk surfaces of the lower-right and lower-left sides would be detected.

Table 6. Sensitivity, Specificity, and Positive and Negative Predictive Values

Indices	Teeth surfaces*			
	Ad–3m (%)	Jd–14m (%)	Kd–19m (%)	Td–30m (%)
Sensitivity	65	45	97	88
Specificity	89	88	80	83
Positive predictive value	50	40	56	51
Negative predictive value	93	90	99	97

*The letters d and m indicate the distal and mesial surfaces, respectively, of the corresponding teeth.

In other words, a high percentage of the permanent maxillary first molars' mesial surfaces develops dental caries without the presence of carious lesions on the primary second molars' distal surfaces, while the corresponding percentage in the mandibular teeth is very low. This finding may be attributed to the fact that maxillary and mandibular permanent first molars present different pathways of eruption. Actually, the lower teeth erupt mesially and lingually, resulting in a direct contact between the mesial and distal surfaces upon permanent molar eruption. The upper teeth, meanwhile, erupt distally and buccally—implying that the contact between surfaces is established after the eruption's completion.[7]

It is likely, therefore, that the main source of infection of the permanent mandibular first molars' mesial surfaces is distal surface carious lesions of the primary second molars, due to direct surface contact. In the maxillary teeth, however, a source of infection acts before the surfaces come in contact, resulting in the development of mesial surface caries without the presence of distal surface carious lesions.

The positive predictive rates for all paired surfaces revealed that almost 1 out of 2 surfaces considered high risk according to the screening criterion would not develop dental disease. This finding implied that the presence of carious lesions on the primary second molars' distal surfaces does not always cause the development of the permanent first molars' mesial surface caries. Combining the results of sensitivity and positive predictive values, however, the following should be pointed out: if carious lesions develop on permanent first molars' mesial surfaces, then the mandibular teeth's carious lesions are mainly due to the primary second molars' distal surface caries. In maxillary teeth, distal surface caries as well as other factors should also be taken into consideration.

Finally, the values of specificity and negative predictive rates showed that the identification of low-risk surfaces is satisfactory for all paired surfaces. This implied that, if the primary second molars' distal surfaces are sound, the

possibility of having mesial surface caries of the permanent first molars is low.

What is the clinical implication of the present investigation's results? Since the dental caries present on the primary second molars' distal surfaces increases the risk of developing dental disease on the permanent first molars' mesial surfaces, the prevention of carious lesion development on the primary second molars' distal surfaces should be of primary concern. In cases where the dental disease is already established, the most desirable intervention is elimination of the carious lesion. Some investigators[6,8-10] have suggested using remineralizing rather than restorative measures to monitor proximal enamel and dentin carious lesions in permanent teeth. Although the application of such preventive measures results in a retardation of proximal caries progression, it remains to be investigated whether the retarded carious lesions increase the risk of developing dental disease on the adjacent tooth's sound surfaces.[11]

Additionally, the information provided regarding the preventive treatment's effectiveness in primary teeth is inconclusive.[11] A traditional way of dealing with the dental disease is the surgical removal of carious lesions and the tooth's restoration. It has been reported, however, that the permanent first molars' mesial surfaces can be damaged during cavity preparation of the primary second molars' distal surfaces, resulting in an increased risk of developing dental disease.[12,13] It is likely, therefore, that the use of a matrix during cavity preparation to avoid damage to the adjacent tooth's proximal surfaces and/or a combination of restorative and preventive treatment would reduce the risk of developing carious lesions. This approach, however, needs investigation.

In the present study, proximal caries and its progression were diagnosed via bite-wing radiographs. Bite-wing radiographs are a useful tool in the clinical practice to diagnose proximal caries, but some intraexaminer and interexaminer variability is inevitable.[14-16] In this study, the intraexaminer reliability test showed high reproducibility in diagnosing proximal carious lesions.

The present study's results showed that the presence of distal surface caries of the primary second molars had a significant impact on the development of dental disease on the permanent first molars' mesial surfaces. Also, the time period that a sound surface was exposed to caries significantly affected the development of caries lesions on the sound surfaces. Finally, the odds ratios showed that the risk of developing caries on the permanent first molars' mesial surfaces due to the primary second molars' distal carious surfaces was different among the studied paired surfaces.

Conclusions

Based on this study's results, it can be concluded that:

1. The presence of primary second molars' distal surface caries increases the risk of developing mesial surface caries lesions on the permanent first molars.
2. The risk of developing caries on the permanent first molars' mesial surfaces, due to primary second molars' distal carious surfaces, is different among the studied paired surfaces.

Acknowledgments

This study was funded in part by Unilever Hellas Corporation. The authors would like to thank Dr. S. Dimelis, Department of Informatics, Athens University of Economics and Business, for the statistical analysis.

References

1. Dummer PMH, Addy M, Oliver SJ, Hicks R, Kingdon A, Shaw WC. Changes in the distribution of decayed and filled tooth surfaces and the progression of approximal caries in children between the ages of 11-12 years and 15-16 years. *Br Dent J*. 1988;164:277-282.
2. Mejare I, Kallestal C, Stenlund H, Johansson H. Caries development from 11 to 22 years of age: A prospective radiographic study–prevalence and distribution. *Caries Res*. 1998;32:10-16.
3. Flink A, Kallestal C, Holm AK, Allebeck P, Wall S. Distribution of caries in 12-year-old children in Sweden. Social and oral health-related behavioural patterns. *Community Dent Oral Epidemiol.* 1999;16:160-165.
4. Mejare I, Stenlund H, Julihn A, Larsson I, Permert L. Influence of approximal caries in primary molars on caries rate for the mesial surface of the permanent first molar in Swedish children from 6 to 12 years of age. *Caries Res*. 2001;135:178-185.
5. Shwartz M, Grondahl HG, Pliskin JS, Boffa J. A longitudinal analysis from bite-wing radiographs of the rate of progression of approximal carious lesions through human enamel dentin. *Arch Oral Biol*. 1984;29:529-536.
6. Mejare I, Kallestal C, Stenlund H. Incidence and progression of approximal caries from 11 to 22 years of age in Sweden: A prospective radiographic study. *Caries Res.* 1999;33:93-100.
7. Ranley DM. Development of the dentition. In: *A Synopsis of Craniofacial Growth*. Ranly DM, ed. New York, NY: Appleton-Century Crofts; 1980:139-160.
8. Heidmann J, Holund U, Poulsen S. Changing criteria for restorative treatment of approximal caries over a 10-year period. *Caries Res.* 1987;21:460-463.
9. Bille J, Carstens JC. Approximal caries progression in 13- to 15-year-old Danish children. *Acta Odontol Scand.* 1989;47:347-354.
10. Lith A, Pettersson LG, Grondahl H-G. Radiographic study of approximal restorative treatment in children and adolescents in two Swedish communities differing in caries prevalence. *Community Dent Oral Epidemiol*. 1995;23:211-216.

11. Vanderas AP, Skamnakis J. Effectiveness of preventive treatment on proximal caries progression in posterior teeth: A review. *Eur J Paediatr*. 2003;4:9-15.
12. Qvist V, Johannessen L, Bruun M. Progression of approximal caries in relation to iatrogenic preparation damage. *J Dent Res.* 1992;71:1370-1373.
13. Medeiros VAF, Seddon RP. Iatrogenic damage to approximal surfaces in contact with class II restorations. *J Dent*. 2000;28:103-110.
14. Grondahl HG. Some factors influencing observer performance in radiographic caries diagnosis. *Swed Dent J.* 1979;3:157-172.
15. Machiulskiene V, Nyvad B, Baelum V. A comparison of clinical and radiographic caries diagnoses in posterior teeth of 12-year-old Lithuanian children. *Caries Res.* 1999;33:340-348.
16. Nyvad B, Machiulskiene V, Baelum V. Reliability of a new caries diagnostic system differentiating between active and inactive caries lesions. *Caries Res.* 1999;33:252-260.

Abstract of the Scientific Literature

Frictional Forces in Orthodontic Brackets and Archwires

Ceramic brackets were developed to address the aesthetic concern of traditional metallic brackets, but its treatment efficacy might be compromised due to the amount of frictional forces generated. In this study, the fictional force between 3 different types of orthodontics brackets and archwires were evaluated. All brackets were .022-inch × .028-inch standard edgewise canines, with no built-in torque or tip. The stainless steel bracket demonstrated the lowest frictional force values, followed by ceramic bracket with metal-reinforced slot, while the traditional ceramic bracket displayed the highest value of frictional resistance. Among the archwires, the stainless steel wires had the lowest frictional force values compared to nickel-titanium and beta-titanium archwires. These differences were statistically significant at $P<.05$.

Comments: With an esthetic appearance and comparable frictional forces, ceramic brackets with a metal-reinforced slot might provide a viable alternative to the traditional metallic brackets. The authors provided meticulous details on the study design. Readers, however, should keep in mind the limitations implicated in an in vitro study. **BL**

Address correspondence to Dr. Clarice Nishio, Rua Sacopa 209/501–Lagoa, Rio de Janeiro RJ, Brazil 22471-180.

Nishio C, Jardim da Motta AF, Elias CN, Mucha JN. In vitro evaluation of frictional forces between archwires and ceramic brackets. *Am J Orthod Dentofacial Orthop*. 2004;125:56-64.

36 references