Brief Report:

Maxillary Second Premolars with Paramolar Tubercles

Robert A. Turner and Edward F. Harris*

Department of Orthodontics, The Health Science Center, University of Tennessee, Memphis, TN 38163

This communication describes the unusual morphology of maxillary second premolars (Fig. 1) that were encountered in an otherwise normal young adult. These teeth are distinctive because of the large accessory cusp that occurs bilaterally on the buccal surface of each maxillary second premolar. We present this case in hopes of stimulating discussion about similar teeth that other researchers have encountered and to solicit suggestions of likely causes of this variant.

The case is an 18-4 year old African American male who presented for routine orthodontic treatment. By our inspection (Figs. 1, 2) this young male is phenotypically normal aside from the uncommon premolars. All 32 permanent teeth are present, including the third molars where the maxillary teeth have initiated root formation and the mandibular teeth have their crowns mostly formed (Fig. 3). The orthodontic issues were (1) a palatally impacted right canine with just 2.5 mm of space between the lateral incisor and first premolar in this quadrant, (2) an anterior openbite with the right central and left lateral incisors in crossbite, and (3) tongue-thrust on swallowing. There is a Class I molar relationship (Angle) bilaterally. The young man was unaware of his unusual premolars. He did not have a regular dentist, though there are occlusal amalgams on his left and right mandibular first molars (all other teeth are noncarious).

These accessory cusps arise from the buccal cingulum. Apart from lingual cingula on the lingual aspects of incisors and canines, basal developments are uncommon in humans. The obvious exception is Carabelli's trait that occurs on the protocone of maxillary molars. Carabelli's complex has been amply described (*e.g.*, Kraus, 1959; Korenhof, 1960; Turner and Hawkey, 1998), and it is one of the few morphological variants commonly discussed in clinical dental texts (Zeisz and Nuckolls, 1949; Ash, 1993). Other cingular traits include (1) the paramolar tubercle of Bolk (Dahlberg, 1945) and (2) and talon cusps that arise from the lingual cingulum of incisors (*e.g.*, Harris and Owsley, 1991; Lorena *et al.*, 2003; Segura-Egea *et al.*, 2003; Dash *et al.* 2004). Dahlberg (1950) suggests that paramolar cusp is a term applied to "any stylar or anomalous cusps, supernumerary inclusion or eminence occurring on the buccal surfaces of both upper and lower premolars and molars. Dahlberg used the term protostylid to distinguish just those cusp-like features occurring on the protoconid of lower molars near the buccal groove.

Various authors have commented on the association between Carabelli's cusp and size of the crown of the rest of the tooth (Garn, 1977; Hsu *et al.*, 1997). Scott has reported positive statistical associations between various cingular elements, notably (1) among the expressions of lingual tubercles on the maxillary incisors and canines

Fig. 1. Occlusal intraoral view of the young adult African-American described here. By our inspection, the accessory cusps on the second premolars are the only dental features outside normal limits.

*Correspondence to: Edward Harris, Department of Orthodontics, College of Dentistry, The Health Science Center, University of Tennessee, Memphis, TN 38163
E-mail: eharris@utmem.edu

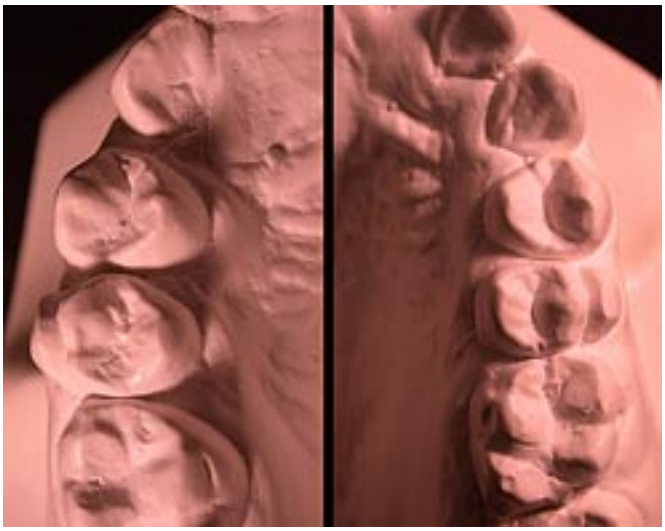

Fig. 2. Close-up occlusal views of the second premolars. Arch lengths are different in the two quadrants because of the unerupted (impacted) canine on the man's right.

TABLE 1. Crown dimensions[1]

Tooth	Mesiodistal Right	Mesiodistal Left	Buccolingual Right	Buccolingual Left
		Maxilla		
I1	9.4	9.4	6.7	6.6
I2	7.7	7.4	6.4	6.4
C	U	7.9	U	8.4
P1	8.5	8.2	10.7	10.7
P2	7.6	7.8	11.3	11.0
M1	11.1	11.1	12.4	12.5
M2	11.4	11.5	12.1	11.4
		Mandible		
I1	6.0	6.0	4.5	4.8
I2	6.8	6.8	5.8	5.8
C	7.4	7.9	7.5	7.5
P1	8.4	8.1	8.3	8.6
P2	8.3	7.8	9.1	9.6
M1	13.5	13.0	12.2	12.3
M2	IE	12.4	11.6	11.8

[1]U = unerupted; IE = incompletely erupted.

(Scott, 1977), (2) between Carabelli's complex and size of the hypocone (Scott, 1979; also see review in Keene, 1968), and (3) between Carabelli's complex—on the lingual aspect of maxillary molars—and the protostylid—on the buccal aspect of mandibular molars (Scott, 1978).

Noteworthy features of the accessory cusps (Fig. 2) are their size and bilateral symmetry. There is no trace of this feature on the first premolar. Crown diameters (Table 1) were compared to a sample of American blacks (Richardson and Malhotra, 1975) but these standards are only available for mesiodistal diameters (Fig. 4). Comparisons also were made to the American white standards reported by Harris and Burris (2003). Our case possesses small mandibular incisors and large mandibular molars, but the UP2 with the accessory cusps is unremarkable in these comparisons. This suggests, along with the raw data, that the accessory cusp constitutes part of the normal tooth's buccolingual width; the cusp is not simply added on to it. This agrees with the observation (Fig. 2) that the occlusal tables of the P2s are somewhat compressed buccolingually. Normally, the P2 dimension is at least as large as the

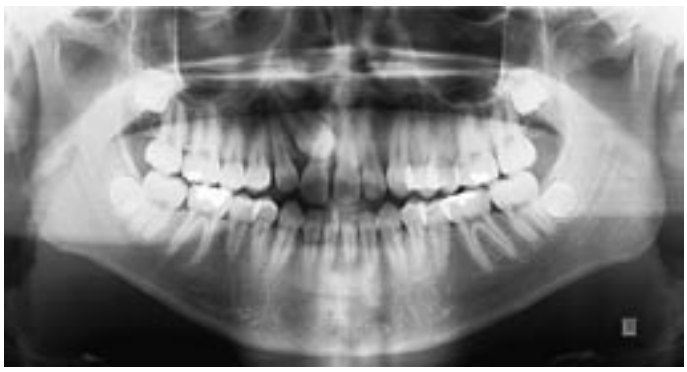

Fig. 3. Panoramic radiograph. The palatally impacted right canine is noteworthy, but other features appear to be within normal limits.

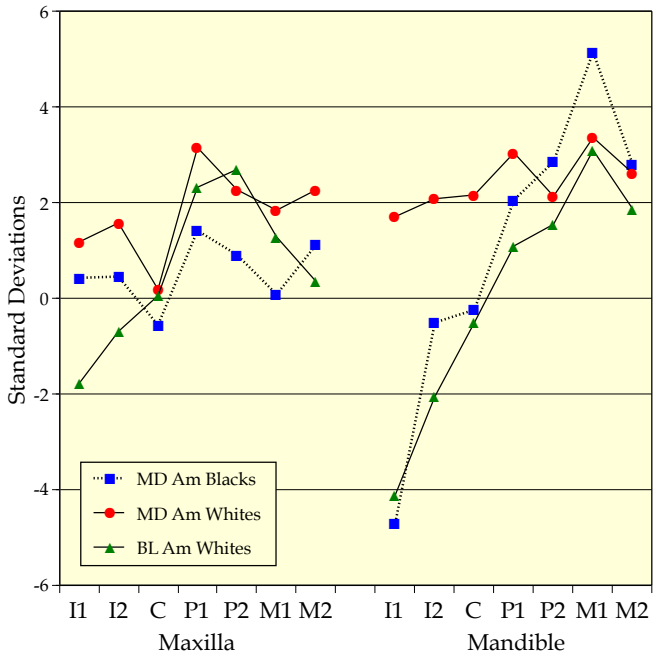

Fig. 4. Plots of z-scores for this case compared to mesiodistal diameters of American blacks (Richardson and Malhotra, 1975) and mesiodistal and buccolingual dimensions of American whites (Harris and Burris, 2003).

P1, but, on the left, the paracone-protocone distance is 6.0 mm on P1 and 5.9 on P2. On the right where the accessory cusp is slightly larger, the intercusp distance is 6.8 mm on P1 but just 5.8 on P2—again indicating that part of the normal tooth mass has been recruited for production of the extra cusp.

Periapical radiographs of these premolars (Fig. 5) are unremarkable. Both of these second premolars possess just one root, as is the norm (Ash, 1993), and there appears to be just a single, normal pulp chamber.

Crown morphology of the second premolars is not unusual. There are two main cusps separated by a central developmental groove. There are moderate-size mesial and distal ridges. The right UP2, that is slightly larger than its antimere, has a distal protocone ridge that is absent on the left tooth. The accessory cusp has a lunate (curvilinear) cross-section; it is so large mesiodistally that it essentially "wraps onto" the curvature of the buccal margin of the paracone (buccal cusp). The buccal aspect of the cusp itself is smooth and featureless, descending straight to the cementoenamel junction.

The accessory cusp has a single elevation (cusp) with the apex located exactly buccal of the paracone's apex. Distance between these cusp tips is 1.25 mm on both the right and left tooth.

Notably, these accessory cusps would never enter occlusion. That is, one might suppose that the cusp might be adaptive by contributing to the crown's overall occlusal area. As is normal, though, the paracone (buccal cusp) of the maxillary premolar overhangs the buccal cusp of the lower premolar and the maxillary premolar's lingual cusp (protocone) occludes into the lower premolar's central fossa. Consequently, regardless of how worn these premolars might become, the accessory cusp will always be buccal of the mandibular tooth—with nothing to occlude against. It seems doubtful, then, that this morphological variant has any adaptive significance, at least functionally.

Heights of the accessory cusps are about ½ mm short of the apices of the paracones, and these cusps have free apices that jut about 2 mm occlusal of where the accessory cusp melds into the paracone. This anatomy is relevant because it means that the cusp developed from its own enamel knot rather than proliferating at a later time from the paracone. Enamel knots are sites of nondividing cells that form during the bell stage of tooth formation. They occur in the stellate reticulum as projections from the inner enamel epithelium (Bhaskar, 1980). Enamel knots have been recognized for over a century (reviewed in Butler, 1956), though their function was unknown. Recent work by molecular biologists (Jernvall *et al*., 1994; Thesleff *et al*., 2001) has shown that knots produce

Fig. 5. Periapical radiographs of the maxillary second premolars.

substances that promote mitotic growth in the adjacent IEE. Since the knots themselves are nondividing, this creates irregularities in the IEE that become cusps (Jernvall *et al*., 1994, 1998; Jernvall, 2000). It seems that the primary enamel knot, which is the most obvious on light microscopy and the earliest to form, determines the site of the tooth's occlusal table (or its counterpart in the simpler anterior teeth), while later-forming 'secondary' enamel knots coincide with formation of the individual cusps (Thesleff and Jernvall, 1997; Thesleff *et al*., 2001; Thesleff, 2003). Separate enamel knots seem to coincide with separate centers of enamel formation since amelogenesis invariably progresses gingivally (Hillson and Bond, 1997). In the present case, it seems that an "accessory" enamel knot developed buccal to the presumptive paracone on the left and right second premolars, but not on the earlier-forming first premolars mesial to them.

We have contacted a few experts in the field concerning these teeth. Some have not encountered such a variant. Others stated that they have seen similar cases, but did not bother to record them. Certainly, the frequency of this variant is rare. Readers who have seen similar cases—or have comments on this report—are encouraged to contact the authors.

LITERATURE CITED

Ash MM Jr. 1993. Wheeler's dental anatomy, physiology and occlusion, 7th ed. Philadelphia: WB Saunders.

Bhaskar SN. 1980. Orban's oral histology and embryology, 9th ed. St Louis: CV Mosby Company.

Butler PM. 1956. Ontogeny of the molar pattern. Biol Rev 31:30-70.

Dahlberg AA. 1945. The paramolar tubercle (Bolk). Am J Phys Anthropol 3:9-103.

Dahlberg AA. 1950. The evolutionary significance of the protostylid. Am J Phys Anthropol 8:15-25.

Dash JK, Sahoo PK, Das SN. 2004. 2004. Talon cusp associated with other dental anomalies: a case report. Int J Paediatr Dent 14:295-300.

Garn SM. 1977. Genetics of tooth development. In: McNamara JA, editor. The biology of occlusal

development. Ann Arbor, MI: Craniofacial Growth Series, p 61-88.
Harris EF, Burris BG. 2003. Contemporary permanent tooth dimensions, with comparisons to G.V. Black's data. J Tenn Dent Assoc 83:25-29.
Harris EF, Owsley DW. 1991. Talon cusp: a review with three cases from native North America. J Tenn Dent Assoc 71:20-22.
Hillson S, Bond S. 1997. Relationship of enamel hypoplasia to the pattern of tooth crown growth: a discussion. Am J Phys Anthropol 104:89-103.
Hsu JW, Tsai P, Liu K, Ferguson D. 1997. Logistic analysis of shovel and Carabelli's tooth traits in a Caucasoid population. Forensic Sci Int 89:65-74.
Jernvall J. 2000. Linking development with generation of novelty in mammalian teeth. Proc Natl Acad Sci 97:2641-5.
Jernvall J, Aberg T, Kettunen P, Keranen S, Thesleff I. 1998. The life history of an embryonic signaling center: BMP-4 induces p21 and is associated with apoptosis in the mouse tooth enamel knot. Development 125:161-169.
Jernvall J, Kettunen P, Karavanova I, Martin LB, Thesleff I. 1994. Evidence for the role of the enamel knot as a control center in mammalian tooth cusp formation: non-dividing cells express growth stimulating Fgf-4 gene. Int J Dev Biol 38:463-469.
Keene HJ. 1968. The relationship between Carabelli's trait and the size, number and morphology of the maxillary molars. Arch Oral Biol 13:1023-1025.
Korenhof CAW. 1960. Morphogenetical aspects of the human upper molar. Utrecht: Uitgeversmaatschappij Neerlandia.
Kraus BS. 1959. Occurrence of the Carabelli trait in Southwest ethnic groups. Am J Phys Anthropol 17: 117-123.
Lorena SC, Oliveira DT, Odellt EW. 2003. Multiple dental anomalies in the maxillary incisor region. J Oral Sci 45:47-50.
Richardson ER, Malhotra SK. 1975. Mesiodistal crown dimension of the permanent dentition of American Negroes. Am J Orthod 68:157-164.
Scott GR. 1977. Lingual tubercles and the maxillary incisor-canine field. J Dent Res 56:1192.
Scott GR. 1978. 1978. The relationship between Carabelli's trait and the protostylid. J Dent Res 57: 570.
Scott GR. 1979. Association between the hypocone and Carabelli's trait of the maxillary molars. J Dent Res 58:1403.
Segura-Egea JJ, Jimenez-Rubio A, Rios-Santos JV, Velasco-Ortega E. 2003. Dens evaginatus of anterior teeth (talon cusp): report of five cases. Quintessence Int 34:272-277.
Thesleff I. 2003. Developmental biology and building a tooth. Quintessence Int 34:613-620.
Thesleff I, Jernvall J. 1997. The enamel knot: a putative signaling center regulating tooth development. Cold Spring Harb Symp Quant Biol 62:257-267.
Thesleff I, Keranen S, Jernvall J. 2001. Enamel knots as signaling centers linking tooth morphogenesis and odontoblast differentiation. Adv Dent Res 15:14-18.
Turner CG II, Hawkey DE. 1998. Whose teeth are these? Carabelli's trait. In: Lukacs JR, editor. Human dental development, morphology, and pathology: a tribute to Albert A. Dahlberg. Eugene: University of Oregon Anthropological Papers, no 54, p 41-50.
Zeisz RC, Nuckolls J. 1949. Dental anatomy. St Louis: CV Mosby Company.