

MATERIALS AND METHODS

Study Sample

The prevalence data for dental traits in the primary dentition were based on plaster casts of 936 children (443 girls and 493 boys), which had been obtained from a randomly selected sample of 5 years old southern Chinese children in Hong Kong. The sampling method was described fully in Part III of this series of papers.

Method of Examination

During the studying of the dental casts, individual teeth were examined under an illuminated magnifying glass (x3) to diagnose the presence or, absence of a trait. The illustrated versions of the various classifications of the twelve traits, and a list of the teeth upon which they could be expected to occur, was prepared to enhance the accuracy of the diagnoses and to maintain the level of examiner reliability. The reasons for omitting some teeth from the investigation were: (i) poor quality or of the study cast; (ii) chipped or broken teeth; (iii) wear or attrition; (iv) gross caries; and (v) restorations.

Method of Counting

All of the teeth were examined for evidence of each dental trait. Following statistical analysis, if no statistically difference was found between the data for the right and the left sides, the analysis was made using tooth on the right side; only if a tooth was absent, or omitted were data used for the tooth on the left side.

Reproducibility

Approximately 10% (n=93) of the casts were randomly selected by a computer programme for re-examination three months after the first examination. All of the examinations were conducted by one previously trained and calibrated examiner.

Diagnostic Criteria

There were twelve dental traits which, according to the published literature, can be expected to be found in the primary dentition:

Shovelling

Shovelling was expressed as a prominence of the proximal marginal ridges in relation to the lingual fossa, or a concavity of the lingual surface between the marginal ridges and the linguo-gingival ridges or cingulum of the incisor or canine teeth. Shovelling was classified according to Hanihara [4], in which the maxillary central and lateral incisors, and the maxillary and mandibular canines were considered separately.

Classification for the Maxillary Central Incisor

Type 0 – No shovelling: Only slight, or no marginal ridges. May be manifest weakly on both mesial and distal aspects or occasionally only on the distal aspect. The latter two variants should not have a concavity between the ridges on the lingual surface.

Type 1 – Semi-shovelling: Lingual ridges present on both mesial and distal sides, but disappearing mid-way in their

course so the length is usually about one half the crown height. Concavity of the lingual surface is slight.

Type 2 – Shovelling: Lingual marginal ridges are well developed, clearly defined and reaches closer to the lingual tubercle. Concavity on the lingual surface is distinct.

Type 3 – Shovelling: Lingual marginal ridges and the concavity of the lingual surface are well developed.

Classification for the Maxillary Lateral Incisor

Type 0 – No shovelling: Lingual marginal ridges are slightly developed. The borders between the ridges and the lingual surface are not clear. Concavity of the lingual surface is indistinct.

Type 1 – Semi-shovelling: Lingual marginal ridges and the concavity of the lingual surface are not clear but the ridge may not extend all the way from the incisal edge to the lingual tubercle.

Type 2 – Shovelling: Shovelling is defined by well developed lingual marginal ridges and the concave lingual surface. The ridges are usually thicker than Type 0 and Type 1.

Type 3 – Shovelling: Marginal ridges are thicker and the concavity of the lingual surface is greater than Type 2.

Classification of Maxillary Canine

Type 0 – No shovelling: Variation includes, (a) no trace of the lingual marginal ridge; (b) only one lingual marginal ridges; (c) three ridges, weak marginal ridges and well developed central ridge; (d) any combination of these.

Type 1 – Semi-shovelling: Lingual ridges are distinctly developed and the central ridge is weakly developed. Lingual surface has limited concavity.

Type 2 – Shovelling: Lingual ridges are well developed and the central ridge is weakly developed. The lingual surface has a distinct concavity.

Classification for the Mandibular Canine

Type 0 – No shovelling: Lingual marginal ridges if present are only very slight.

Type 1 – Semi-shovelling: Lingual marginal ridges are clearly developed but interrupted by well developed grooves or depressions. Concavity of the lingual surface is shallow.

Type 2 – Shovelling: Lingual marginal ridges are clearer than in Type 1. Lingual surface is completely encircled by well defined marginal ridge. The depth of the inner part of the lingual surface is deeper than Type 1.

Type 3 – Shovelling: The development of the lingual ridges is similar to Type 2, but the depression of the lingual surface is deeper.

Lingual Tubercle

Lingual tubercle is considered to be a single, or double protuberance arising from the cingulum of the lingual surface of the primary maxillary canine and extending less than half the distance from the cemento-enamel junction to the incisal edge. When a double tubercle is present, the distal tubercle is usually slightly larger than the mesial tubercle [3].

Double Fold

Double fold on the primary maxillary canine is formed by the groove separating the distal marginal ridge and an accessory ridge where the accessory ridge is located between the median ridge and the distal marginal ridge. The groove commences at the basal junction of the accessory and distal marginal ridge and extends towards and terminates at the distal incisal edge. The general appearance is that of a folded and enlarged distal marginal ridge [3].

Carabelli's Trait

Carabelli's trait occurs on the lingual surface of the protocone of the primary maxillary second molar and is expressed as either a tubercle of varying size, or as a groove, or pit. The classification of Carabelli's trait of the primary maxillary second molar was based upon the variation reported by Hanihara [4]:

Type 0 – No Carabelli cusp is recognized.

Type 1 – Shallow groove on mesial of lingual surface suggestive of a trace of the pit.

Type 2 – Shallow depression or groove exists without any change in the curvature of the lingual surface.

Type 3 – Depression or pit deeper than Type 2 but no bulge observed.

Type 4 – Expression similar to that of Type 3 but slight eminence on the lingual surface of protocone.

Type 5 – Eminence greater than Type 4. However, the Carabelli cusp extends smoothly onto the rest of lingual surface without interruption.

Type 6 – Carabelli cusp is completely encircled by a groove forming a 5th cusp.

Type 7 – Carabelli cusp well developed and might be larger than the hypocone.

Protostylid

The protostylid was expressed as an accessory cusp located on the buccal surface of the protoconid of the primary mandibular second molar. The classification for the protostylid, of the mandibular second molar, was based upon that of Hanihara [4]:

Type 0 – Absent: Buccal groove is straight and no trace of irregularity.

Type 1 – Absent: No evidence of protostylid, but the beginning of one is suggested by the curvature and branching of the buccal groove. There may be a small, but distinct pit at the lower end of the buccal groove separating protoconid from the hypoconid and the buccal groove is slightly bent in a distal direction at the point of the pit.

Type 2 – Present 1: Divergence of buccal groove is more developed than Type 3. Small triangular area with tip downwards between the branches of the buccal groove.

Type 3 – Present 2: The two branches of the buccal groove are more developed than Type 3. Small triangular area with tip downwards between the branches of the buccal groove.

Type 4 – Present 3: A very shallow groove appears at the corner of the buccal surface. The area between this groove and mesial branch of the buccal groove bulges slightly and gives triangular shape with its tip upwards.

Type 5 – Present 4: Triangular area is more strongly developed than Type 5.

Type 6 – Present 5: Protostylid is strongly developed so that the tooth seems to have an extra cusp on the buccal surface.

Occlusal Groove Pattern

The dryopithecus occlusal groove pattern of the primary mandibular second molar is formed by the relationship of the basal contacts of the central ridges of the protoconid, metaconid, hypoconid and the entoconid. The classification for the occlusal groove pattern, of the primary mandibular second molar, was adapted from those of Hellman [10] and Jørgensen [11].

Type 1 – “Y” pattern: The metaconid is in basal line contact with the hypoconid.

Type 2 – “+” pattern: Formed by the basal point shaped contact between the protoconid-entoconid and metaconid-hypoconid. It cannot be determined with certainty which of the two diagonal pairs of cusps has the most basal contact, or that this contact does not exceed 0.2 mm.

Type 3 – “X” pattern: Formed by the basal linear contact between the protoconid and entoconid.

Sixth Accessory Cusp

The sixth accessory cusp is the accessory cusp located on the distal surface between the entoconid and the hypoconid of the primary mandibular second molar [5].

Seventh Accessory Cusp

The seventh accessory cusp is the accessory cusp located on the lingual surface between the metaconid and the entoconid of the primary mandibular second molar. The classification for the seventh accessory cusp, of the primary mandibular second molar, was based upon that of Hanihara [4].

Type 0 – Absent: No trace of the seventh cusp.

Type 1 – Present 1: A very weak and short groove which extends downwards from the lingual ridge of the metaconid.

Type 2 – Present 2: Groove on the metaconid is more definite. Small cusp-like formation is present.

Type 3 – Present 3: Seventh cusp is well developed and looks like an independent accessory cusp. It is small when compared with either metaconid or entoconid.

Deflecting Wrinkle

The deflecting wrinkle is formed by the configuration of the median ridge of the metaconid which shows a strong development in both length and breadth and curves distally in the central part of the occlusal surface to contact the hypoconid of the primary mandibular second molar [5].

Distal Trigonid Crest

The distal trigonid crest is the structure which connects, without interruption, the tip of the metaconid with the proto-

conid on the primary mandibular second molars. Thus, the occlusal surface is clearly divided into two parts, the trigonid and the talonid [4].

Metaconid Ridge

The metaconid ridge is formed by the well developed central ridge in both length and breadth of the metaconid on the primary mandibular second molar [4].

Triangular Shape

The triangular shape trait occurs in the primary mandibular first molar. The occlusal surface pattern is triangular in shape due to the fusion of the metaconid and the entoconid [4].

Prevalence Data Review

In order to compare the prevalence data from this study with those of other studies the literature and data from studies published between 1930 and 2009, which were related to dental traits in the primary dentition, were sourced using PubMed and hand searches. The key words used for the PubMed searches were dental traits, primary dentition, shovelling, lingual tubercle, double fold, Carabelli's trait, protostylid, occlusal groove pattern, sixth accessory cusp, seventh accessory cusp, deflecting wrinkle, distal trigonid crest, metaconid ridge and triangular shape. The reference lists of the articles retrieved from the electronic database were subsequently hand searched to identify additional articles that might provide information relevant to the objectives of this

study. It was impractical to perform a systematic review because the methodology used in the published studies varied, thus preventing valid statistical analyses.

RESULTS

A total of 93 of the casts were re-examined to measure the examiner reliability for the diagnoses of the various dental traits. The Kappa coefficients were in the range from 0.55 (deflecting wrinkle) to 0.92 (triangular shape). As there was no statistically significant difference between the prevalence figures for the dental traits on the right and the left sides of the jaws, the various analyses were made based on the teeth on the right side, unless these teeth were absent or damaged, in which case the teeth of the left side were used.

Of the twelve dental traits, occlusal groove pattern trait in the primary mandibular second molars occurred in all of the subjects (100%). Shovelling was the second commonest trait and occurred in 99.3% of the girls and 96.8% of the boys; whereas, double fold occurred in only 11.1% of the girls and 11.4% of the boys (Table 1). The comparison of the prevalence figures of the various dental traits observed in this study, with those of other studies are shown in Tables 2 to 13. There were higher prevalence figures for shovelling, protostylid, seventh accessory cusp, deflecting wrinkle, distal trigonid crest, metaconid ridge and triangular shape for Mongoloids groups, including southern Chinese, than for Caucasians. The prevalence figures for seventh accessory cusp (89.0%), distal trigonid crest (33.5%) and metaconid

Table 1. The Mouth Prevalence of the Various Dental Traits in the Primary Dentition of 936 Five Years Old Southern Chinese Girls and Boys in Hong Kong

Dental trait	Tooth type examined	Girls (N=443)		Boys (N=493)	
		n	%	n	%
Shovelling	i ^{1,2} , c ¹ , c	440	99.3	477	96.8
Lingual tubercle					
single	c ¹	94	21.2	103	20.9
double	c ¹	100	22.6	111	22.5
Double fold	c	49	11.1	56	11.4
Carabelli's trait	m ²	361	81.5	391	79.3
Protostylid	m ₂	405	91.4	453	91.9
Occlusal groove pattern					
Y	m ₂	360	81.2	390	79.1
+	m ₂	42	9.5	55	11.2
X	m ₂	41	9.3	48	9.7
Sixth accessory cusp	m ₂	147	33.2	232	47.1
Seventh accessory cusp	m ₂	388	87.6	445	90.3
Deflecting wrinkle	m ₂	239	54.0	351	71.2
Distal trigonid crest	m ₂	168	37.9	146	29.6
Metaconid ridge	m ₂	367	82.8	444	90.1
Triangular shape	m ₁	49	11.1	115	23.3

ridge (86.6%) for the southern Chinese children were higher than reported for the other ethnic groups (Tables 9, 11 and 12). Moreover, the prevalence figures for distinct and strong types of protostylid (13.7% and 0.9%) in this study were found to be higher than for other populations (Table 6). Although deflecting wrinkle was regarded as characteristic of Mongoloids, the prevalence in southern Chinese children was the lowest among the various Mongoloid populations, at 63.0% (Table 10). The prevalences of double lingual tubercle (22.5%) and the “Y” type of occlusal groove pattern (80.1%) in southern Chinese children were even lower than for other ethnic groups (Tables 3 and 7).

DISCUSSION

This study was based on the high quality plaster study casts of a randomly selected representative sample of southern Chinese children. The disadvantage of examining casts of teeth, rather than the actual teeth is that the trait may be obscured by damage cause during storage, or due to a poor quality impression. Therefore, skillful impression taking and careful storage of casts are important to preserve the size of the sample. However, the advantages were that all of the tooth surfaces could be observed easily and there were no time constraint, or patient co-operation problems involved as can occur in an oral examination of a young child. Moreover, the examination of casts under an illuminated magnifying glass made some of the traits, especially the weakly-developed types, much easier to see than they would have been in the mouth; for example the pit type of Carabelli’s trait. Consequently, it is theoretically possible that the magnification and ease of examination may have led to the recording of a greater number of characteristics.

In an attempt to allow for comparison with published data of dental traits in the primary dentition, as far as possible, the classification of, or one closely based upon that of Hanihara [4] were used rather than trying to modify other classifications for the permanent teeth. The diagnostic criteria and classification used for the lingual tubercle, Carabelli’s trait, protostylid, occlusal groove pattern, seventh accessory cusp, distal trigonid crest, metaconid ridge and triangular shape were satisfactory because they were clear and easy to apply; thus, they can be recommended for use in future investigations.

However, some problems did occur with the diagnosis of shovelling. No observations were made on the primary mandibular incisors because the characteristics in these teeth were usually too weak to be classified into the different types of shovelling. In many instances a clear diagnosis could not be made, even for the maxillary incisors and maxillary and mandibular canines, due to the numerous intermediate types and the weak expression of the shovelling trait, especially in the mandibular canines.

The findings of this study support the suggestion of Scott [12], for the permanent dentition, that double fold is an example of a dental trait that exhibits a continuous size variation on the accessory ridge. Therefore, it would seem appropriate that a classification be developed to record the variation in size of the accessory ridge rather than simply to record it as absent or present, for this may have evolutionary implications.

No attempt was made to classify the sixth accessory cusp trait into different types, based upon the size of the cusp and, as yet, no reliable method has been found to distinguish the presence of the entoconid in the absence of the hypococonid. Moreover, deflecting wrinkle was not classified into the different types, based on the size of the ridge, because difficulties were experienced in trying to differentiate between the intermediate types.

The methods used to count dental traits in a population are based upon a count per tooth, or per individual. Most investigators have used the individual count method, as proposed by Scott (1980) [13], which records the fullest expression of a given trait on either the right or left side of the jaw. When a tooth was missing or damaged the degree of expression on the other side was scored. In this study, the data for the right and left side were tested statistically in the same manner as reported by Hanihara [6] and Kuusk [14]. Since there were no statistically significant differences between the two sides, the data for the right side were used in the final analysis. Thus, the data from this study are comparable to those of the majority of the published studies. This approach which was justified on a statistical basis, avoided arbitrarily deciding to use only the data for one side. Thus, it overcame the rather inconsistent approach of Scott (1980) [13] who also examined all of the teeth, but then discard data for the less severely affected side. It also avoided the adverse effects on the data of traits that were asymmetrically distributed.

The various traits will be discussed by first considering the physical characteristic, followed by the prevalence of that anomaly, among different populations, in order to identify any distinctive features in the data for the primary dentition of the southern Chinese.

Shovelling

This trait is said to be present when the palatal surface of an incisor resembles a shovel due to the combination of a concave lingual surface in association with elevated marginal ridges. The marginal ridges, also called dentales, are usually found on the maxillary incisors, but they can also be found on mandibular incisors [15]. Shovelling is more common in the permanent dentition than the primary dentition [16], and is more frequently observed on the maxillary than the mandibular incisors with the lateral incisors being affected more often than the central incisors in the primary dentition [9].

Some investigators, who have studied shovelling, have used the subjective scale proposed by Hrdlička [15], in which there are four degrees: no shovelling, trace shovelling, semi-shovelling and shovelling. The classifications based on the relative variability of the primary maxillary incisors and canine, and mandibular canines were proposed by Hanihara [4]. Hanihara [3] found that the shovelling trait occurred frequently and was relatively well developed in the Japanese, Pima Indians and Eskimos. The reverse situation was found for American whites, American negroes and Australian Aborigines. However, it should be noted that the prevalence figures given by Hanihara [3, 8], Kuusk [14], Lukacs and Walimbe [17], and Sciulli [18] may not be representative of the populations as a whole because they were derived from small, non-representative samples, most especially those of Lukacs and Walimbe [17] and Sciulli [18].

Table 2. The Prevalence, Expressed as a Percentage, of the Different Degrees of Shovelling in the Primary Dentition in Published Studies

Ethnic group	Author	Tooth type	Number of subjects examined	Shovelling type			
				0	1	2	3
Southern Chinese	Present study	i ¹	936	0	23.4	75.9	0.7
		i ²	936	0	4.9	93.1	2.0
		c [•]	936	10.5	68.2	21.3	0
		c.	936	13.4	70.2	16.4	0
Mongoloid							
Japanese	Hanihara 1963, 1965 [3, 8]	i ¹	124	0	23.4	76.6	0
		i ²	163	0	6.7	89.6	3.7
		c [•]	197	5.6	85.8	8.6	0
		c.	199	32.7	61.8	5.5	0
Native American	Sciulli 1990 [18]	i ¹	24	0	20.8	-	-
		i ²	26	0	7.7	-	-
		c [•]	25	0	12.0	-	-
		c.	30	0	3.3	-	-
Caucasian							
American white	Hanihara 1963, 1965 [3, 8]	i ¹	20	50.0	50.0	0	0
		i ²	24	54.2	45.8	0	0
		c [•]	52	90.4	9.6	0	0
		c.	49	75.5	22.4	2.1	0
Inamgaon Indian	Lukacs and Walimbe 1984 [17]	i ¹	39	33.3	51.3	15.4	0
		i ²	26	15.5	53.8	19.2	11.5
American white	Edgar and Lease 2007 [30]	i ¹	53	32.0	40.0	19.0	9.0
		i ²	52	13.0	42.0	19.0	25.0
		c [•]	51	18.0	31.0	33.0	18.0
Negroid							
American black	Hanihara 1963, 1965 [3, 8]	i ¹	10	80.0	10.0	10.0	0
		i ²	21	57.1	33.3	4.8	4.8
		c [•]	51	76.5	23.5	0	0
		c.	47	70.2	27.7	2.1	0
Hybrid							
Japanese-American white	Hanihara 1963, 1965 [3, 8]	i ¹	65	7.7	55.4	36.9	0
		i ²	50	2.0	38.0	60.0	0
		c [•]	79	20.3	78.5	1.1	0
		c.	78	52.6	44.9	2.6	0
Japanese-American black	Hanihara 1963, 1965 [3, 8]	i ¹	35	0	42.9	57.1	0
		i ²	40	0	30.0	70.0	0
		c [•]	46	10.9	89.1	0	0
		c.	45	48.9	46.7	4.4	0
Others							
Australian Aboriginal	Kuusk 1973 [14]	i ¹	58	100.0	0	0	0
		i ²	108	78.8	21.3	0	0
		c [•]	206	100.0	0	0	0
		c.	177	95.5	4.5	0	0

0 = no shovel shape, 1 = semi-shovel shape, 2 = shovel shape, 3 = well-developed shovel shape.

Shovelling and semi-shovelling were found in the maxillary incisors and canines of both jaws. Shovelling was found more frequently in maxillary incisors whereas semi-shovelling was found more frequently in the canines. Marked shovelling was found to occur only on the maxillary incisors (Table 2). The prevalence of shovelling for southern Chinese children was similar to that for Japanese children [3, 8]. It appears that shovelling occurs much more frequently in Mongoloids than in Caucasians and other populations (Tables 2 and 13). The study of skeletal remains of a late Archaic of Ohio (native American), in which the prevalence of shovelling was found to be even higher than in some Mongoloids, indicated they were a population of northern Asian descent [18]. The findings from the present study support the statement made by Hanihara [5] that shovelling can be considered to be a Mongoloid dental characteristic.

Lingual Tubercle

Lingual tubercle is a slight rounded elevation on the linguo-gingival ridge of an anterior tooth. Because the lingual tubercle is more frequently observed, and better developed in archaeological remains than in modern man, it is believed to be a derivative of the cingulum and many have significances in the evolution of primates [19, 20]. Variation of lingual accessory tubercles were described by Hrdlička [21] as being either single, double or multiple; long and narrow; or short and stumpy [3]. They occur most frequently on canines and to a lesser extent on maxillary incisors [21]. When the trait is expressed as two tubercles the distal one is usually larger than the mesial [3]. Multiple tubercles are rare on the incisors. Jørgensen [11] reported that the tubercle always presented as two short projections, one on either side of the lingual ridge, while the mandibular canine almost never exhibited tubercles.

Although the lingual tubercle is found in all ethnic groups, the degree of development shows marked racial variation. Furthermore, the prevalence of the single tubercle

variation has been shown to decrease as the prevalence of double tubercle increases in a population [6, 22]. Population differences for double tubercle are an invariable population characteristic in which the prevalence figures are within the range 43.8% to 58.8% [3]. However, the results of Kuusk's [14] study showed that the double tubercle can be regarded as a racial trait of the Australian Aboriginals due to the high prevalence of 75.1%. In the present study, double tubercle occurred slightly more frequently than single tubercle, at 22.5% and 21.0% respectively. The prevalence figure for double tubercle in southern Chinese children was lower than for any other populations, see Table 3.

Double Fold

The double fold characteristic was reported on the distal border of the lingual surface of the both primary and permanent mandibular canines in *Sinanthropus pekinensis* [20]. This trait makes the distal marginal ridge appear double because of a groove running between the middle of the two ridges [20]. However, Robinson [23] described a well-defined distal lingual groove and a slight ridge running immediately on the mesial side to the groove on the mandibular canines of *Australopithecines*.

In the primary mandibular canines of modern man, the lingual ridges are generally poorly developed; but the mesial and distal marginal ridges are slightly better defined than the median ridge. In addition to this, an extra ridge located between the median and the distal marginal ridges may be found. When present, the extra ridge can be better developed than all of the other ridges. A groove separating these two ridges, running up to the distal end of the incisal edge, emerges from a point where the lower terminals of the ridge join together [3].

In the permanent dentition, Scott [12] proposed a classification based upon size. However, in the classification for primary mandibular canines no attempt was made to classify

Table 3. The Prevalence, Expressed as a Percentage, of the Lingual Tubercle Trait on the Primary Maxillary Canines in Published Studies

Ethnic group	Author	Number of subjects examined	Tubercle type		
			Absent	Single	Double
Southern Chinese	Present study	936	56.5	21.0	22.5
Mongoloid					
Japanese	Hanihara 1965 [3]	194	4.1	52.1	43.8
Caucasian					
American white	Hanihara 1965 [3]	50	-	-	48.0
Negroid					
American black	Hanihara 1965 [3]	51	-	-	58.8
Hybrid					
Japanese-American white	Hanihara 1965 [3]	72	18.6	35.6	45.8
Japanese-American black	Hanihara 1965 [3]	46	28.5	25.8	45.7
Others					
Australian Aboriginal	Kuusk 1973 [14]	210	26.6	1.9	71.5

according to size because the relief on the lingual surface of the primary canine is less well developed than that of the permanent canine [3].

The prevalence of double fold is relatively low in primary mandibular canines showing little variance within the range 3.8% to 9.0% [3, 14, 18]. Although the southern Chinese exhibited a slightly higher prevalence figure of 11.2% in this study (Table 4), the data indicate that the inter-population difference seems to be insignificant; thus, the trait can be considered to be an invariable inter-population characteristic [3, 14]. Moreover, it has been suggested that as the evolution of the human dentition has proceeded, double fold has become increasingly rare [3]. However, no truly representative epidemiological studies have been reported prior to the current study; moreover, the samples from previous studies are generally too small to provide accurate data, especially the skull samples used in the study of native Americans by Sciuilli [18].

Carabelli's Trait

Carabelli's cusp is an additional cusp on the mesiolingual surface of the crown of a maxillary molar. This cusp is found to have variable expressivity such as lobular, cuspid, ridged and pitted. Morphologically, it varies from an indented surface (ridges and pits) to a full cusp. Although several classifications have been developed to characterize the different expression of Carabelli's trait [4, 11, 24-27], most are for the maxillary first permanent molar which was the key tooth in Dahlberg's classification [28]. Nevertheless, the maxillary second primary molar can also exhibit Carabelli's trait.

Most of the classifications for Carabelli's trait are based on the size of the cusp; hence, there are problems when a variety of grooves, furrows or pits occur. In order to over-

come this problem Dahlberg [29] proposed a classification with eight types, ranging from a completely smooth uninvolved surface to a single furrow, a pit, a double furrow, a Y-form and three grades based upon size. Hanihara [4] proposed a classification which also had eight types ranging from groove, pit to cusp. Unfortunately, the different criteria are not directly comparable due to slightly different groupings of the various forms of the trait.

It is difficult to directly compare data from the different published studies because of the differences in the sample sizes and the classifications that were used. Although the findings of Hanihara [8] are frequently quoted they were not from an epidemiological study. Nevertheless, from the summarized data in Table 5 it can be seen that the prevalence of Carabelli's cusp is higher in Caucasians than Mongoloids, including southern Chinese, with the highest prevalence of 39.0% being for American whites [30]. Due to the higher prevalence in Caucasians, Carabelli's cusp has been considered to be characteristic of the Caucasoid dentition [5].

Protostylid

The protostylid trait which was first reported by Bolk [31] is seen most commonly on the buccal surface of the mesiobuccal cusp of both primary and permanent molars. The term protostylid or parastyle has been proposed for any anomalous cusps on the buccal surface of maxillary and mandibular premolars and molars [28]. In the primary dentition, the protostylid is found on the buccal surface of the protoconid of the mandibular second molar. The protostylid trait occurs more frequently on the primary than permanent molars [4]. Whenever the protostylid is found on a permanent molar the trait was reportedly present on the primary second molar; however, the reverse situation does not always occur [4, 32]. The classification of Hanihara [4] recognized

Table 4. The Prevalence, Expressed as a Percentage, of the Double Fold Trait on the Primary Mandibular Canines in Published Studies

Ethnic group	Author	Number of subjects examined	Double fold	
			Present	Absent
Southern Chinese	Present study	936	11.2	88.8
Mongoloid				
Japanese	Hanihara 1965 [3]	200	9.0	91.0
Native American	Sciuilli 1990 [18]	28	7.1	92.9
Caucasian				
American white	Hanihara 1965 [3]	48	4.2	95.8
Negroid				
American black	Hanihara 1965 [3]	47	6.4	93.6
Hybrid				
Japanese-American white	Hanihara 1965 [3]	78	3.8	96.2
Japanese-American black	Hanihara 1965 [3]	45	8.9	91.1
Others				
Australian Aboriginal	Kuusk 1973 [14]	175	5.7	94.3

Table 5. The Prevalence, Expressed as a Percentage, of the Carabelli's Trait on the Primary Maxillary Molars in Published Studies

Ethnic group	Author	Number of subjects examined	Carabelli's trait		
			Absent (0)	Groove+pit (1+2+3)	Cusp (4+5+6+7)
Southern Chinese	Present study	936	19.7	65.2	15.1
Mongoloid					
Japanese	Hanihara 1963 [8]	185	32.4	55.7	12.9
Queckchi Indian	Escobar <i>et al.</i> 1977 [51]	183	77.0	21.9	1.1
Native American	Sciulli 1990 [18]	29	27.6	62.0	10.4
Japanese	Ooshima <i>et al.</i> 1996 [52]	905	-	-	12.0
Caucasian					
Danes	Jørgensen 1956 [11]	696	13.1	77.6	9.3
American white	Hanihara 1963 [8]	56	5.4	59.0	35.6
Inamgaon Indian	Lukacs and Walimbe 1984 [17]	45	33.3	57.9	8.8
Hindu Indian	Joshi 1975 [53]	211	12.3	65.9	21.8
Jat Indian	Kaul and Prakash 1981 [45]	149	17.5	67.1	15.4
Canadian	Saunders and Mayhall 1982 [36]	827	4.2	62.2	33.6
Hindu Indian	Reddy 1983 [54]	1560	-	-	38.4
Caucasoid	Kieser 1984 [55]	240	21.3	49.6	29.1
Hindu Indian	Kannapan and Swaminathan 2001 [56]	648	32.5	-	-
Northern American	Edgar and Lease 2007 [30]	53	17.0	44.0	39.0
Negroid					
American black	Hanihara 1963 [8]	51	19.6	68.6	11.8
South African	Grine 1986 [9]	32	21.9	75.5	3.1
Hybrid					
Japanese-	Hanihara 1963 [8]	71	14.1	62.0	23.9
American white					
Japanese- American black	Hanihara 1963 [8]	41	17.1	63.4	19.5
Others					
Australian Aboriginal	Kuusk 1973 [14]	226	20.4	70.4	9.2
Australian Aboriginal	Townsend and Brown 1981 [57]	237	13.9	75.1	11.0

seven types of protostylid which can occur on the primary mandibular second molars.

In Mongoloid populations the protostylid trait occurs in more than 40% of individuals, while in non-Mongoloid populations the prevalence is generally below 20% (Table 6). Therefore, the protostylid trait has been regarded as a charac-

teristic feature of the Mongoloid dentition [7]. The prevalence of protostylid trait was 91.7% in this study which was slightly higher than for Pima Indian at 89.0% [7], which is the highest prevalence figure among other Mongoloids. The distinct type of protostylid is rare and the strong type has not been reported in American whites, Negroes or their hybrids (Table 6). However, the distinct and strong types of

Table 6. The Prevalence, Expressed as a Percentage, of the Protostylid Trait on the Primary Mandibular Second Molars in Published Studies

Ethnic group	Author	Number of subjects examined	Protostylid trait			
			Absent	Present		
			0+1	2+3	4+5	6
Southern Chinese	Present study	936	8.3	77.1	13.7	0.9
Mongoloid						
Japanese	Hanihara 1968 [7]	152	55.3	41.4	3.3	0
Pima Indian	Hanihara 1968 [7]	118	11.0	-	-	-
Eskimo	Hanihara 1968 [7]	52	32.7	-	-	-
Japanese	Ooshima <i>et al.</i> 1996 [52]	905	-	-	-	0.7
Caucasian						
Danes	Jørgensen 1956 [11]	37	97.3	-	-	-
Dutch	Jørgensen 1956 [11]	127	98.4	-	-	-
American white	Hanihara 1968 [7]	54	87.0	13.0	0	0
Inamgaon Indian	Lukacs and Walimbe 1984 [17]	61	98.4	-	-	-
Northern American	Edgar and Lease 2007 [30]	52	90.0	10.0	0	0
Negroid						
American black	Hanihara 1968 [7]	47	83.0	14.9	2.1	0
South African	Grine 1986 [9]	37	83.8	-	-	-
Hybrid						
Japanese-American white	Hanihara 1968 [7]	70	71.4	24.3	2.9	0
Japanese-American black	Hanihara 1968 [7]	42	69.0	31.0	0	0
Others						
Australian Aboriginal	Kuusk 1973 [14]	218	83.5	-	-	-

0+1 = no protostylid trait, 2+3 = groove, 4+5 = triangular shape, 6 = cusp.

protostylid in this study were 13.7% and 0.9% respectively. Therefore, because of their higher prevalences, the distinct and strong types of protostylid may be considered to be features of the primary dentition in southern Chinese children.

Occlusal Groove Pattern

The dryopithecus occlusal groove pattern, a term introduced by Gregory [33], in the primary mandibular second molar is formed by the relationship of the basal contacts of the central ridges of the protoconid, metaconid, hypoconid and the entoconid [6].

The occlusal groove patterns were classified into two types which were referred to by the letter “Y” and by the plus sign “+” [10]. The basic five cusped pattern was the “Y5” type which was referred to as “dryopithecoid”. An additional groove configuration termed the “X” pattern was subsequently added and it was proposed that the cusp number and groove pattern should be considered independently

[11]. Hanihara [6] and Turner [34] adapted the modified classification for their studies.

Hanihara [6] found that the prevalence of the five cusped “Y” type was in the range from 95% to 100% in the primary dentition which was greater than in permanent molars. The trait was, at that time, considered to be an invariable population characteristic [6, 14]. However, in the majority of the previously published studies, the sample sizes were too small to provide statistically representative data. It appears that southern Chinese had a lower prevalence of the “Y” type and a higher prevalence of the “X” type of occlusal groove pattern than for other ethnic groups (Table 7). Nevertheless, more studies are needed to provide higher quality prevalence data for valid comparisons.

Sixth Accessory Cusp

The sixth accessory cusp is one of the extra cusps that is located on the distal aspect of the occlusal surface between

