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Morphological and Numerical Characteristics of the Southern Chinese dentitions. Part I: Anomalies in the Permanent Dentition

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Abstract: *Aim:* To investigate the prevalence of eight morphological and numerical anomalies in the southern Chinese permanent dentition and to compare these with studies from different populations.

Materials and Methods: The material used in the study consisted of study models and panoramic radiographs collected from 725 randomly selected 12-year-old children (358 males and 367 females). The anomalies were assessed using diagnostic criteria that have been most often cited in the published literature.

Results: Of the eight dental anomalies studied, the prevalence of hyperdontia (2.6%) was higher than reported for Caucasians, and double tooth (0.8%) and dens evaginatus (4.7%) were the highest amongst all of the populations. Although the prevalence of hypodontia (7.3%) is comparable to that of other populations, mandibular incisors were the most frequently missing teeth in southern Chinese (5.6%) and this finding contradicted those from studies of other ethnic groups.

Conclusion: Higher prevalences of double tooth, dens evaginatus and missing mandibular incisors can be considered to be characteristics of the southern Chinese permanent dentition.

Keywords: Dental anomalies, permanent dentition, southern Chinese.

INTRODUCTION

Developmental variations in the dentition are frequently observed during a routine dental examination. These may include anomalies of number, size and form of the teeth. Such anomalies are of interest in anthropology, genetics, pathology and forensic odontology. Investigators have reported the prevalence of these morphological and numerical variations, in Eskimo [1], Scandinavian [2], Japanese [3], North American Indian [4] and British [5] populations.

If the word anomalous is taken to mean an irregularity of the norm, thus a dental anomaly is a feature of the dentition that can be expected to occur in the minority of a given population. However, the same anomaly may be exhibited by a greater number of people in another population. Therefore, the prevalence of anomalies may be an anthropologic tool, which can be used to identify a particular racial group.

Mongoloid Dentition

The term Mongoloid is considered to refer to a major human racial group who are distinguished by a fold of the eyelid over the inner canthus, prominent cheek bones, straight black hair, small nose, broad face, and yellowish colored skin complexion. Within this group are American Indians, Burmese, Chinese, Eskimos, Japanese, Koreans, Mongols, Manchus, Siamese, Tibetans, and Vietnamese. The Mongoloids of northern Asia may have evolved *in situ* [6], or from Eastern Neanderthals [7], or from southeastern Asia [8].

Interest in the Mongoloid dentition originated from the early archaeological investigations which began with the discovery of *Homo erectus* at Chou Kou Tien in China. Data from this fossil material has led to the hypothesis that there was a genetic continuum through to modern day Mongoloids [6]. Two dental patterns for populations from east Asia have been identified within what has come to be accepted as the original Mongoloid dental complex [9]. This identification is based upon the frequencies of twenty eight traits of the crowns and roots of the teeth [10]. The dental population termed *Sinodonty* originally occurred, and currently lives in north China, while examples of *Sundadonty* live in east Asian and the Sunda continental shelves from Java to northern Japan. The latter group appear not to have had an association with the early people of the Americas; nevertheless, they have been considered to be the most probable source of the ancestral Polynesians [11]. *Sinodonty* is likely to have evolved from *Sundadonty* which is known to have existed in southeast Asia [8]. However, it is not known if *Sundadonty* existed in northeastern Asia prior to the evaluation of *Sinodonty*.

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Published data on traits of the roots of teeth, have described for both *Sinodont* and *Sundadont*, high frequencies of single-rooted maxillary first premolars, three-rooted mandibular canines and three-rooted maxillary second molar teeth [10, 12].

Differences in dental morphology of different racial groups have been known for many years [13, 14]. However, the uniqueness of the Mongoloid dentition was not established until relatively recently [15]. Subsequently, evaluationary studies have been conducted into the micro-evolution of man and population relationships in Asia, the Pacific Basin, and North America [8, 10, 16, 17]. However, minimal research has been published on the frequency of the various characteristics of the Chinese dentition.

The Southern Chinese Dentition

Southern Chinese are defined as those Chinese whose ancestors originated from provinces south of the Yangtze River and speak different dialects from their northern counterparts. Only limited data on the prevalence of morphological and numerical variations of the southern Chinese permanent dentition are available. Hong Kong is located in the southern part of China and 98% of the population originated from south of the Yangtze River. Hence, it would appear to be valuable to gather baseline data on Chinese children who were born and bred in Hong Kong.

The objective of this study was to determine the prevalence of various anomalies of size, form and number such as: hyperdontia, hypodontia, macrodontia, microdontia, double tooth, dens evaginatus, dens ivaginatus and talon cusp. By comparing these data with those of other populations, it was intended to determine if there are any features that maybe considered to characterize the permanent dentition of the southern Chinese.

MATERIALS AND METHODS

This investigation of the southern Chinese permanent dentition was based on a randomly selected sample of 1% of the 12-year-old population living in Hong Kong. The 12 years old cohort was chosen because the dentition is least likely to be effected by occlusal attrition, so any anomalies were unlikely to have been worn away. Furthermore, the number of teeth with caries would be expected to be low due to the recent eruption of the permanent teeth, thus, most teeth would be in the arch and suitable for studying. Also, children of this age are usually manageable in the dental environment.

A sampling frame was constructed which included all the primary and secondary day schools in Hong Kong. Seven primary schools and thirteen secondary schools were then randomly selected according to the percentage of 12 years old children enrolled in these schools. All 1247 participants were transported from their school to the Prince Philip Dental Hospital for the examination. Standardized clinical and radiographic (panoramic radiographs) examinations were performed and alginate impressions were taken and immediately poured in artificial stone. Out of the 1,247 subjects in the selected sample, 1,099 of the subjects were Chinese, of which 98.9% were classified as southern Chinese according to their father's birthplace and the language spoken at home. The subjects who had inadequate quality records were excluded from the present investigation resulting in a final sample consisting of 725 sets of records.

The dental casts were examined by one calibrated examiner using an illuminated magnifying glass (x2), while the radiographs were examined in a darkened room. Ten percent of the record sets were re-examined to test the intra-examiner reproducibility. The following criteria were employed to diagnose eight anomalies

Hyperdontia

Any additional tooth, or tooth like structure formed from a tooth germ, in excess of the usual number for a given region of the dentition.

Hypodontia

One or more congenitally missing teeth. Supported by a dental history to determine if previous extraction had been performed due to caries or as part of orthodontic therapy.

Macrodontia and Microdontia

The diagnostic method was the same as used by Brook [5], and Ooshima and co-workers [18], in which a clinical decision was accompanied by manual measurements of the four maxillary incisors, and when appropriate, the radiographs. The mean size of the incisors in southern Chinese were adapted from Ling [19]. Teeth of a size greater or smaller than 2.0 SD from the mean were considered to be abnormal.

Double Tooth

Notching of the incisal edge and grooving of the labial surface on clinical examination, and radiographic evidence of bifurcation of the pulp system were considered to be a double tooth [18, 20].

Dens Evaginatus

A premolar was diagnosed as exhibiting dens evaginatus when an enamel tubercle on the occlusal surface between the buccal and lingual cusps [21].

Dens Invaginatus

A pulpward projection of enamel from the cingulum was classified according to Hallet [22] and was based on the radiographic appearance.

Talon Cusp

A cusp-like projection from the palatal surface of an anterior tooth that extended at least half the distance from the cemento-enamel junction to the incisal edge [23].

In order to be able to compare the prevalence data with those of studies, literature and data from 1930 to 2009, which were related to dental anomalies in the permanent dentition, were sourced using PubMed and hand searches. The key words used for the PubMed searches were dental anomalies, permanent dentition, hyperdontia, hypodontia, macrodontia, microdontia, double tooth, dens evaginatus, dens invaginatus and talon cusp. Reference lists of articles retrieved from the electronic database were then hand searched to identify additional articles that might provide information relevant to the objectives of this paper. This paper was not proposed to be a systemic review, which was not feasible because the methodology in each of the published studies was different; therefore, statistic analyses were also not performed.

RESULTS

The 725 subjects had a gender distribution of 358 males (49%) and 367 females (51%). The mean chronological ages were 12.55 years and 12.62 years for the males and females respectively. The intra-examiner reproducibility for the diagnosis of each the dental anomalies was calculated using Kappa coefficients and the values ranged from 0.79 to 1.00.

The prevalence of the different types of dental anomalies in the permanent dentition for boys and girls are shown in Table **1**. Since there was no significant differences found between the genders (p=0.11 – 1.00), the data were pooled for comparison with those of other studies, which are displayed in Tables **2** to **8**. Of the eight dental anomalies studied, the prevalence of hyperdontia (2.6%) in this group of children was higher than reported for Caucasians (Table **2**). Although the prevalence of hypodontia (7.3%) was comparable to that of other studies (Table **3**), the mandibular incisors were the most frequently missing teeth in southern Chinese (5.6%), apart from the third molars. This finding contradicted those from studies of other ethnic groups because the second premolars and maxillary lateral incisors were the most frequently reported missing teeth in the literature. Moreover, the prevalence figures of double tooth (0.8%) and dens evaginatus (4.7%) in this study were found to be higher than that has ever been reported for other populations (Tables **4** and **5**).

DISCUSSION

The various anomalies will be discussed by first considering the physical characteristic, followed by the prevalence of that anomaly in the permanent dentitions. The objective is to demonstrate similarities or differences between the Mongoloid and Caucasoid dentitions, and where data are available to identify any distinctive features in the data for the permanent dentition of the southern Chinese.

Hyperdontia

Hyperdontia refers to any normal tooth, or tooth like structure formed from a tooth germ that is in excess of the usual number of teeth for a given region of the dental arch. Hyperdontia often occurs as an associated symptom of a number of syndromes [24].

In the normal healthy individual, there are considered to be four possible aetiologies for hyperdontia. Firstly, the developing tooth germ may split into two separate units. Secondly, the dental lamina, as a result of early histodifferentiation, may undergo further budding, so initiating the development of an additional tooth. Thirdly, the existence of hyperdontia may represent a reversion to a primitive dentition which contained a greater number of teeth than the 32 teeth of the permanent dentition, or the 20 teeth of the primary dentition of modern man. Fourthly, some unknown inherited or environmental factor may have been responsible for causing hyperdontia. Nevertheless, whatever the true aetiology it is interesting to note that males consistently exhibit this trait more frequently than females.

The postulates of atavism, in which there is said to be a reversion to the ancestral forms of teeth, which have subsequently become extinct, is poorly supported because in no known mammalian dentition has there ever been more than four canine teeth. A more favoured hypothesis is that of excessive growth of the dental lamina [25]. Such abnormal proliferations could give rise to a pre-primary type of hyperdontia. If a proliferation of the dental lamina occurs to a normal tooth germ they may become fused together. A post-permanent type of hyperdontia can also occur; as demonstrated by the development of supplemental and/or supernumerary premolars after the normal premolars have erupted [26-30].

Groups of epithelial cells remaining after the break-up of the epithelial cords can, for unknown reasons, develop into extra tooth germs [25]. Yet another theory is that a tooth germ may undergo dichotomy. If the division is equal, the result is a supplemental tooth resembling a tooth of the normal series, while, if unequal in size, the additional tooth is usually malformed or of a conical shape.

Heredity has also been put forward as an explanation for hyperdontia. Stafne [31] stated that: "A sufficient number of persons gave histories of the same anomality having been seen in other members of their families to corroborate the belief that it has a hereditary tendency to occur. The form

Table 1. The Prevalence of the Different Types of Dental Anomalies in the Permanent Dentition of 12 Years Old Southern Chinese Females and Males

Anomaly	Female (N=367)		Male (N=358)	
	no	%	No	%
Hyperdontia	8	2.2	11	3.1
Hypodontia	26	7.0	27	7.5
Macrodontia	11	3.0	15	4.2
Microdontia	31	8.4	19	5.3
Double tooth	3	0.8	3	0.8
Dens evaginatus	16	4.4	18	5.0
Dens invaginatus	2	0.5	1	0.3
Talon cusp	9	2.7	9	2.5

and position of the teeth of various relatives were almost identically the same." This concept has found support from other investigator [32]. Although no clear mode of inheritance has been established, polygenic factors probably need to be combined with environmental factors for hyperdontia to occur.

Hyperdontia in the permanent dentition of the southern Chinese in Hong Kong was found to be 2.7% in a previous study [33], and 2.6% in the present study. These figures are higher than for Caucasians which range from 0.4% to 2.1%; while they are lower than 3.4% for Japanese and 6% for American Blacks (Table **2**). Hyperdontia has consistently been found to affect males more often than females in all racial groups; however, the difference between the gender in this study was statistically insignificant (p=0.49).

Hypodontia

A person is said to exhibit hypodontia when one, or more teeth fail to develop; thus, resulting in the congenital absence of one, or several teeth. It is a condition that is rarely seen in other mammalian species, including other primates.

The congenital absence of teeth may occur because of the adverse effects of local factors; an endocrine disorder; disuse or bone fusion problems. However, more significantly, congenital missing teeth are considered by some investigators to be the expression of an evolutionary trend. A reduction in the number of teeth in the dentition would thus signify an attempt by nature to fit the teeth into a shortened dental arch. In support of this theory, Schultz [34] cited the high frequencies with which the third molars, in the posterior region of the arches, and the maxillary lateral and mandibular central incisors, in the anterior region, are missing. However, he did not extend his hypothesis to include the second premolars. Also, it is now well established that the congenital absence of teeth may result from genetic factors [35-37]; however, the modes of inheritance remain are unclear. Many authors have suggested Mendelian patterns of inheritance [35, 38, 39], whereas others have proposed that hypodontia may result from the interaction of multiple genetic factors [37, 40].

Hypodontia is most common in the permanent dentition where a prevalence of between 2.5% and 11.3%, excluding the third molars has been reported (Table **3**). The prevalence of persons lacking one or more third molars varies from approximately 1% in some African Negroes, and Australian aboriginal samples to an estimated 30% in the Japanese population. While the prevalence in Caucasians varies from 10% to 25%. Pedersen [1] noted a significance difference between east Greenland Eskimos (37%) and mixed natives from southwest Greenland (30%). Hence, he concluded that these population frequencies indicated a genetic basis for third molar agenesis in humans.

With the exception of the third permanent molars, the second premolars have been found, by many investigators, to

Table 2. The Prevalence of Hyperdontia in the Permanent Dentition in Various Published Studies

Ethnic group and location	Author	Number of subjects examined	Prevalence (%)
Southern Chinese			
Hong Kong	Present study	725	2.6
Hong Kong	Davis (1987) [33]	1,093	2.7
Mongoloid			
Japan	Niswander and Sujaku (1963) [84]	4,150	3.4
Caucasian			
Sweden	Thilander and Myberg (1973) [85]	5,459	1.1
British	Brook (1974) [5]	1,115	2.1
Sweden	Bergstrom (1977) [86]	2,589	1.5
Denmark	Locht (1980) [87]	704	1.7
U.S.A.	Buenviaje and Rapp (1984) [88]	2,439	0.5
Sweden	Bäckman and Wahlin (2001) [89]	739	1.9
Spain	Fernández Montenegro *et al.* (2006) [90]	36,057	0.4
Turkey	Altug-Atac and Erdem (2007) [50]	3,403	0.4
U.S.A.	Harris and Clark (2008) [91]	1,100	0.6
Negroid			
U.S.A.	Harris and Clark (2008) [91]	600	6.0
Caucasian and Mongoloid			
Hungary	Gábris *et al.* (2006) [92]	2219	1.5

Table 3. The Prevalence of Hypodontia in the Permanent Dentition in Various Published Studies

Ethnic group and location	Author	Number of subjects Examined	Prevalence (%)
Southern Chinese			
Hong Kong	Present study	725	7.3
Hong Kong	Davis (1987) [33]	1,093	6.9
Mongoloid			
Greenland Eskimos	Pederson (1949) [1]	603	3.0
Japan	Endo *et al.* (2006) [93]	3,358	8.5
Caucasian			
U.S.A.	Werther and Rotheberg (1939) [46]	1,000	2.3
U.S.A.	Byrd (1943) [94]	2,835	2.8
U.K.	Clayton (1956) [95]	3,557	6.0
Sweden	Grahnen (1956) [35]	1,006	6.1
Australia	Davis (1968) [96]	2,179	5.9
Sweden	Thilander and Myrberg (1973) [85]	5,459	6.1
U.K.	Brook (1974) [5]	1,115	4.4
Iceland	Magnússon (1977) [97]	1,641	7.9
Denmark	Rølling (1980) [98]	3,325	7.8
Saudi Arabian	al-Emran (1990) [99]	500	4.0
Ireland	O'Dowling and McNamara (1990) [100]	3,056	11.3
Sweden	Bäckman and Wahlin (2001) [89]	739	7.4
Jordan	Albashaireh and Khader (2006) [101]	1.045	5.5
Turkey	Altug-Atac and Erdem (2007) [50]	3,403	2.6
Negroid			
Kenya	Ng'ang'a and Ng'ang'a (2001) [102]	618	6.3

be the most commonly missing teeth in the permanent dentition [41-45]. However, some reports have shown the maxillary lateral incisors to be the most frequently missing teeth [46, 47], with frequency values within the range 0.8% to 2.5% [48, 49].

It is noteworthy that the mandibular incisor teeth have been observed to be missing in 6.4% [33] and 5.6% (present study) of Hong Kong Chinese children. For all tooth types in the permanent dentition the prevalence is 6.9% [33] and 7.3% (present study) for southern Chinese which are comparable to other racial groups, such as Swedish children (Table **3**). However, the consistently reported gender difference in the literature was not found in the present study (p=0.89).

Macrodontia and Microdontia

The term macrodontia refers to teeth that are larger than normal, that is, their size is outside the usual limits of variation for that tooth type. When only one tooth is affected then it has to be considered to be an anomaly. However, when the characteristic occurs bilaterally it may represent an inheritable trait. Generalised macrodontia may present as a characteristic of a syndrome. Macrodontia is a poorly researched and documented characteristic because very few data are available for analysis. The published prevalence of macrodontia ranges from 0.03% to 1.9% [5, 18, 50] while in this study the prevalence of macrodontia was much higher at 3.6%.

Microdontia is, as the term suggests, a phenomenon in which the teeth are smaller than normal, that is, outside the usual limits of variation for that tooth type. The clinical comparison is usually determined by making comparisons with the affected tooth and the antimere; as well as with the general dimensions of the [35, 39, 51]. The prevalence figures for microdontia in the permanent maxillary lateral incisor teeth in southern Chinese have been found by Ling [19] to be 1.0% which it was 3.3% in the present study, these figures are comparable to those that have been found in Caucasians, such as 3.1% in U.K. [5], and 1.58% in Turkey [50]. Chung and his co-workers [52] also found the prevalence of microdontia to be similar in these two racial groups at 1.9% and 1.7% respectively. Nevertheless, it must be remembered that these figures represent major dimensional differences in individual teeth and not minor variations in the entire dentition. Investigators who have carefully measured teeth have indicated that modern man has permanent teeth that are smaller than those of his ancestors [53]. Furthermore, it has been found that the teeth of Hong Kong children are smaller than those of other populations worldwide [19], and of people from other regions of China [54].

Double Tooth

This anomaly, which is manifested as a structure resembling what appears to be two teeth that have been joined together; is formed of two or more tooth elements; it can be diagnosed clinically by the presence of incisal notching and a groove on the labial surface. Radiographically there is evidence of pulpal bifurcation [55]. The abnormality can be present in the primary or permanent dentition and may be unilaterally or bilaterally distributed within the dental arches.

Reports on the inheritance of double teeth have been published which suggest this characteristic has an aetiology of genetic origins. Whether the condition is autosomal dominant, or recessive is currently unclear; nevertheless, there can be only minor penetrance [20].

Double teeth may occur, firstly, because of fusion of two normal teeth; hence, the dentition is reduced in number; that is, unless a tooth is fused to a supernumerary tooth. Generally, this type of double tooth has two independent pulp chambers. The second possible cause is the apparent partial splitting of a single tooth, which is referred to as gemination, in which case the number of teeth is normal. It is possible that any one, or all of these terms may be appropriate. However, because the aetiology and ontogeny are uncertain the term "double-tooth" is probably the most appropriate term [56, 57].

Although double teeth are less common in the permanent dentition, 0.3% or less, in most of the racial groups, southern Chinese children have been found to exhibit a much higher prevalence of this anomaly than children of other racial groups; for example, 0.1% for British children [5] compared with 0.4% [19] and 0.8% (present study) for southern Chinese children. Additional data about double teeth are displayed in Table **4**.

Dens Evaginatus

Numerous terms have been used to describe dens evaginatus, such as Mongoloid or oriental premolar [21], Leong's premolar [58], tuberculated premolar [59], axial core type odontome [60, 61], occlusal enamel pearl [1], composite dilated odontome [62], cone-shaped supernumerary cusp [63], evaginated odontome [64] and interstitial cusp [65]. Dens evaginatus, which is only found on permanent teeth, is an enamel-covered tubercle which projects from the occlusal surface of a premolar and very occasionally from a canine or molar [60, 61]. Teeth with dens evaginatus usually occur bilaterally [21, 51, 58, 64], and more frequently in the mandibular than the maxilla [58, 61, 64, 66].

Dens evaginatus can be classified according to the location or form of the projection. Based on the location, type one, is the tubercle which arises from the lingual ridge of the buccal cusp, whereas the type two the tubercle is located in the centre of the occlusal surface. On the basis of form, the evagination may be: smooth, grooved, terraced or ridged [61]. The grooved form has a definite groove or fissure surrounding the base. While the smooth form has no groove surrounding the base so it is continuous with the occlusal surface. The other types which are less common have a terraced like base, or minute ridges on the sides.

Table 4. The Prevalence of the Anomaly Double Tooth in the Permanent Dentition in Various Published Studies

Ethnic group and location	Author	Number of subjects examined	Prevalence(%)
Southern Chinese			
Hong Kong	Present study	725	0.8
Hong Kong	Ling (1992) [19]	459	0.4
Mongoloid			
Hawaii (Chinese)	Chung *et al.* (1972) [52]	828	0.1
Hawaii (Japanese)	Chung *et al.* (1972) [52]	6,022	0.2
Caucasian			
U.S.A.	Boyne (1955) [103]	2,000	0.1
U.S.A.	Clayton (1956) [95]	1,688	0.2
Canada	Castaldi et al. (1966) [42]	457	0.2
U.K.	Brook (1974) [5]	1,115	0.1
Sweden	Bäckman and Wahlin (2001) [89]	739	0.3
Croatia	Knezević *et al.* (2002) [104]	3,517	0.2
Turkey	Altug-Atac and Erdem (2007) [50]	3,403	0.3
Filipinos			
Hawaii	Chung *et al.* (1972) [52]	833	0.2

Radiographic examination in one study showed that 42% of evaginations contain pulp tissue [65]. The pulp tissue in the tubercle is normal unless the tubercle has been fractured, or worn down, thereby permitting bacterial invasion, with consequent pulpal necrosis [58]. The necrosis of the pulp tissue, can subsequently, lead to an acute or chronic dento-alveolar abscess [63], or even osteomyelitis [60]. Other patho-radiographic findings include thickening of the periodontal membrane, periapical rarefaction, incomplete root formation, fracture of the root, cyst formation and dilaceration [64].

Although the aetiology of dens evaginatus is not understood there appears to possibly be some association with, racial and genetic factors. Pathogenetically, dens evaginatus has been explained as being an abnormal proliferation of the inner enamel epithelium into the stellate reticulum of the enamel caused by either an outflowing of the enamel epithelium, or by a transient focal hyperplasia of the primitive pulpal mesenchyme. Thus, the resultant tubercle can consist of all three odontogenic tissues; namely enamel, dentine, and pulp.

Although the dens evaginatus trait is usually restricted to Mongoloids; and so most of the reports have involved Chinese, Japanese, Eskimos and to a lesser extent Malays, Aleuts, Filipinos and American Indians, the trait has also been reported in a Greek [67] and a Negro [68]. The reported prevalence among Mongoloid peoples ranges from 0.1% to 4.3% (Table **5**). In two successive surveys of over 1,000 Chinese subjects 1.3% and 1.5%, were affected by dens evaginatus [61, 69]. Keewatin Eskimos, have been found to have dens evaginatus on 3.0% of their premolars [21]. A slightly higher prevalence figure of 4.3% was reported in Alaskan Eskimos and Indians [58]. By contrast no evidence of dens evaginatus was observed in a comparable group of Canadian Caucasians [70]. Although dens evaginatus is more common amongst Mongoloid than Caucasoid people, it is even more common in the southern Chinese as is evident from the prevalence figures of 3.0% to 6.3% for Hong Kong children (Table **5**). The variability in prevalence among subgroups of Mongoloids suggests different gene frequencies within the groups [71].

There have been claims of a sex-linked pattern in the occurrence of dens evaginatus [58, 61, 72]; however, the findings are unequivocal in the literature. In this study, there was no difference between boys and girls in the prevalence of dens evaginatus (p=1.00). An autosomal dominant mode of inheritance with limited degree penetrance is the favoured mode of inheritance [71]. However, only limit data are available from family studies, so the exact mode of inheritance is unclear.

Dens Invaginatus

Dens invaginatus is a developmental malformation which occurs in teeth from an invagination of the enamel organ in the early stages of dental development even before mineralization of the hard tissues.

There are various theories on the cause of this anomaly. The currently accepted theory supports the notion that this particular condition results from an invagination of a single enamel organ [73], which is an extrapolation of the theory

Table 5. The Prevalence of Dens Evaginatus in the Permanent Dentition of Mongoloid Groups in Various Published Studies

Ethnic group	Author	Number of subjects examined	Prevalence (%)
Southern Chinese			
Hong Kong Chinese	Present study	725	4.7
Hong Kong Chinese	Ling (1992) [19]	459	4.5
Hong Kong Chinese	Bedi and Pitts (1988) [105]	442	3.0
Hong Kong Chinese	Cho *et al.* (2006) [106]	7,102	6.3
Other Mongoloid			
Japanese	Kato (1937) [107]	1,467	1.1
Eskimo	Pedersen (1949) [1]	-	0.5
Chinese	Lau (1955) [61]	2,101	1.3
Chinese	Wu (1955) [69]	1,054	1.5
Japanese	Sumiya (1959) [108]	-	1.9
Indian and Eskimo	Merrill (1964) [58]	650	4.3
Keewatin Eskimo	Curzon et al. (1970) [21]	399	3.6
Chinese	Yip (1974) [109]	579	2.2
Thai	Reichart and Tantiniran (1975) [72]	5,694	1.0
Japanese	Goto *et al.* (1979) [110]	42,177	0.1
Chinese (Taiwan)	Lin and Roan (1980) [66]	8,651	3.5
Japanese	Ooshima *et al.* (1996) [18]	745	2.8

suggested by Rushton [74] in which there is a rapid and abnormal growth of cells within the deep surface of the enamel organ which results in invagination of the dental papilla becoming invaginated. He stated that this growth process pressed the incompletely calcified dentine walls and papilla outward so that they become thinned and the deeper part of the bony crypt become enlarged. The already calcified part cannot expand; therefore, as the pressure becomes greater, the tooth widens rapidly from the cusp towards the root. The central pressure must force the crown in a superficial direction and may, thus, be responsible for the conical shape of the root.

The prevalence of dens invaginatus anomaly in Caucasians has been reported to range from 0.25% to 10.0% (Table **6**). Reason for the wide range of figures is probably the lack of universally agreed diagnostic criteria. For example, the prevalence figure of 1.3% from the study by Shafer [31] was much lower than the 5.1% reported by Amos [75] for a similar group of subjects. Although Kong [76] reported a prevalence of 3.6% in a group of Malaysian Chinese children, it seems that this anomalies is less common in southern Chinese. The prevalence of 0.4% in the present study is even lower than a previous report of 1.22% which, however, was based on a smaller sample of 459 southern Chinese children. Nevertheless, no data on other mongoloid populations are available for comparison with the present study.

Talon Cusp

Talon cusp has been loosely used to describe any cusp-like formation, irrespective of size, shape, length, or degree of attachment to the lingual surface of a tooth. The term "palatal accessory cusp" has also been used [18]. A more critical definition was suggested by Davis and Brook [23] that talon cusp is morphologically well delineated, and extends at least half the distance from the cemento-enamel junction to the incisal edge [23]. A large talon cusp may project with connection to the incisal edge of the tooth to give the crown a "T" or "Y" shape. Questions have been asked about this anomaly and its association with dens evaginatus. Both are projections covered by enamel that contain pulp tissue and it is possible that a talon cusp could be the ultimate expression of a dens evaginatus. Therefore, the term "dens evaginatus of the anterior teeth" has also been used instead of the well known "talon cusp" [77].

It has been suggested that this anomalous accessory cusp has a multifactorial aetiology combining both genetics and environmental factors [23]. There is also an increased incidence of talon cusp associated with Mohr and Rubinstein-Taybi syndromes [78] and with anomalies such as complex odontomes and impactions [79]. Permanent maxillary incisors are reported to be the teeth that are most frequently affected by talon cusps [23]. It has also been suggested that talon cusps may occur more frequently in males [80] though this was not evident in the present study.

Talon cusp has been reported to be an extremely rare dental anomaly in Mexican children with prevalence of only 0.06% [81]. Possibly because of different examination criteria for talon cusp, the prevalence figures have varied in different populations (Table **7**); such as 1.0% in Israel [77] and 5.2% in Malaysia [82]. Using a looser definition of talon cusp, that is, a demarcated projection of a millimetre or more

Table 6. The Prevalence of Dens Invaginatus in the Permanent Dentition in Various Published Studies

Ethnic group and location	Author	Number of subjects examined	Prevalence (%)
Southern Chinese			
Hong Kong	Present study	725	0.4
Hong Kong	Ling (1992) [19]	459	0.22
Mongoloid			
Malaysia (Chinese)	Kong (1973) [76]	1,173	3.6
Caucasian			
U.S.A.	Atkinson (1943) [111]	500	10.0
U.S.A.	Shafer (1953) [112]	2,452	1.3
U.S.A.	Amos (1955) [75]	1,000	5.1
Sweden	Grahnén *et al.* (1959) [2]	3,020	3.0
Canada	Poyton and Morgan (1966) [73]	5,000	0.25
U.K.	Brook (1974) [5]	1,115	4.1
Saudi Arabia	Ruprecht *et al.* (1986) [113]	1,500	1.7
Sweden	Bäckman and Wahlin (2001) [89]	739	6.8
Jordan	Hamasha and Al-Omari (2004) [114]	1,660	2.95
Iran	Ezoddini *et al.* (2007) [115]	480	0.8
Malays			
Malaysia	Kong (1973) [76]	703	1.6

Table 7. The Prevalence of Talon Cusp in the Permanent Dentition in Various Published Studies

Ethnic group and location	Author	Number of subjects examined	Prevalence (%)
Southern Chinese			
Hong Kong	Present study	725	2.5
Hong Kong	Ling (1992) [19]	459	1.5
Mongoloid			
Japanese	Ooshima *et al.* (1996) [18]	745	0.9
Caucasian			
North India	Chawla *et al.* (1983) [83]	1,083	7.66
Israel	Dankner *et al.* (1996) [77]	1,350	1.0
Pakistan	Sobhi *et al.* (2004) [116]	450	2.4
Negroid			
Uganda	Barnes (1969) [117]	1,797	2.5
Nigeria	Onyeaso and Oneyeaso (2006) [118]	361	1.9
Others			
Mexico	Sedano *et al.* (1989) [81]	32,022	0.06
Malaysia	Meon (1991) [82]	536	5.2
Hungary	Mavrodisz *et al.* (2003) [119]	600	2.5

Table 8. The Frequency of Various Anomalies in the Permanent Dentition of Southern Chinese People, other Mongoloid Groups and Caucasians

Anomalies	Southern Chinese	Mongoloid (not southern Chinese)	Caucasian
Hyperdontia	moderate	moderate	low to moderate
Hypodontia	high	moderate to high	moderate to high
Macrodontia	moderate	moderate	low to moderate
Microdontia	moderate	moderate	moderate
Double tooth	low	low	low
Dens evaginatus	moderate to high	low to moderate	-
Dens ivaginatus	low	moderate	varied
Talon cusp	moderate	low	moderate to high

Chance of occurrence:
low: <1%
moderate 1% - 5%
high: >5 %

present on the lingual surface of anterior teeth, the prevalence in a sample of children from north India was as high as 7.66% [83]. In Mongoloids, the prevalence has been reported to be 0.9% in Japanese children [18] while higher figures were found in southern Chinese such as 1.5% by Ling [19] and 2.5% in the present study.

Although some of the reported variations may only reflect the use of different diagnostic criteria, or non-representative samples, data from carefully selected ethnically representative populations can provide useful data for at least some of these dental characteristics. From the data gathered during the survey of 12 years old Hong Kong children it is possible to develop part of the specific characteristics of the southern Chinese dental complex (Table **8**).

CONCLUSIONS

The published literature on dental anomalies suggests that variation exists between racial groups and that it seems that variation also exists between sub-racial groups. By comparing data from various populations, the higher prevalence figures for double tooth, dens evaginatus and missing mandibular incisors are suggestive of the fact that these are to be characteristics of the southern Chinese permanent dentition. In part II of this series it is proposed to consider various traits of the permanent dentition of southern Chinese.

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