PREVALENCE AND PATTERNS OF TOOTH AGENESIS AMONG MALAY CHILDREN

Shani Ann Mani[1], Wan Salmah Yang Mohsin[2] and Jacob John[3]

[1]Department of Paediatric Dentistry and Orthodontics, [3]Department of Diagnostics and Integrated Dental Practice, Faculty of Dentistry, University Malaya, Kuala Lumpur; [2]Jabatan Bedah Mulut, Hospital Melaka, Melaka, Malaysia

Abstract. Tooth agenesis in Malay children, hitherto unreported, was assessed retrospectively from orthopantomograms of 834 healthy children aged 12-16 years who attended the Dental Clinic of Universiti Sains Malaysia. All teeth, including third molars, were assessed for agenesis. On an average, 2.3 teeth were missing per child. Missing third molars were found in 25.7% of children with one or two third molars found to be missing in 18.3% of children. Three point two percent of children had missing teeth other than third molars. After third molars, the upper lateral incisors were found to be the most common missing tooth (1.7%), followed by upper and lower second premolars (1.5%). Eight missing upper canines were also seen (1%). Bilateral agenesis was more common than unilateral agenesis. There were no significant differences between males and females. There was a significant difference between missing teeth between the maxilla and the mandible and right and left side, with more missing teeth in the maxilla and on the right side. The odds of any 3rd molar missing were increased 3.3 times when there was any other missing tooth. In conclusion, the prevalence of tooth agenesis among the studied population was within the normal range, but less than some Asian countries. Unlike other Asian countries, the upper lateral incisor was the most common missing tooth. The prevalence of maxillary canine agenesis was higher than most previous reports. Missing teeth were associated with missing third molars, which is likely due to a genetic abnormality.

Keywords: agenesis, tooth, missing, congenital, hypodontia, third molar, children

INTRODUCTION

Tooth agenesis is a common dental anomaly in humans and occurs when one or more teeth are missing because they were never formed (Tavajohi-Kermani *et al*, 2002; Endo *et al*, 2006; Chung *et al*, 2008; Goya *et al*, 2008; Sanchez *et al*, 2009).

Correspondence: Dr Shani Ann Mani, Department of Children's Dentistry and Orthodontics, Faculty of Dentistry, University Malaya, 50603 Kuala Lumpur, Malaysia.
Tel: +60129655321; Fax: +60379674530
E-mail: shani_jacob@yahoo.co.in

Congenitally Missing Teeth (CMT) is a misnomer, since permanent teeth most frequently found missing, are not present at birth (Vastardis, 2000). The literature describes three patterns of tooth agenesis: 1) missing third molars only (Mok and Ho, 1996; Sanchez *et al*, 2009; Celikoglu and Kamak, 2012), 2) missing teeth excluding third molars (Davis, 1987; Nik-Hussein, 1989; Endo *et al*, 2006; Goya *et al*, 2008; Celikoglu *et al*, 2010; Vahid-Dastjerdi *et al*, 2010), also known as hypodontia, which is defined by most authors as the developmental absence of up to 5 teeth,

excluding third molars, (Kapadia *et al*, 2007; Chung *et al*, 2008; Celikoglu *et al*, 2010; Tunc *et al*, 2011) and 3) tooth agenesis taking all teeth into consideration (Silva Meza, 2003; Chung *et al*, 2008; Harris and Clark, 2008). The other terms related to missing teeth are oligodontia, which is the absence of six or more permanent teeth, and anodontia, the total absence of teeth.

Prevalence rates of tooth agenesis vary by population and are attributed to differences in sampling and examination methods and differences in the age, sex and race of the subjects (Goya *et al*, 2008). The worldwide prevalence of a congenitally missing third molar are much higher than other teeth and ranges from 17% to 28% (Celikoglu and Kamak, 2012). Hypodontia in the permanent dentition occurs in 0.3 to 10.1% of the population (Davis, 1987; Vastardis, 2000; Tavajohi-Kermani *et al*, 2002; Endo *et al*, 2006; Chung *et al*, 2008; Goya *et al*, 2008; Celikoglu *et al*, 2010), while in the primary dentition it occurs in less than 1% (Brabant, 1967; Jarvinen and Lehtinen, 1981; Whittington and Durward, 1996). Hence, interpretation of the literature requires considering whether third molars are included.

The pattern of hypodontia varies by population. Studies among caucasians show lower second premolars and upper lateral incisors are the most common missing teeth after third molars (Mattheeuws *et al*, 2004; Kirkham *et al*, 2005; Harris and Clark, 2008). American blacks have a lower prevalence of congenitally missing teeth than American whites (Harris and Clark, 2008). The second premolars and mandibular lateral incisors are the most common missing teeth after third molars in Asians (Davis, 1987; Endo *et al*, 2006; Goya *et al*, 2008).

The hypothesized etiologies for tooth agenesis include physiological obstruction, disruption of the dental lamina, space limitation, functional abnormalities of the dental epithelium, failure to initiate the underlying mesenchyme, systemic conditions and genetic factors (Chung *et al*, 2008). Besides other genes, mutations of the *MSX1* (Vastardis, 2000) and *PAX9* genes have been associated with tooth agenesis in the premolar and molar regions, respectively (Tavajohi-Kermani *et al*, 2002; Peres *et al*, 2005; Kapadia *et al*, 2007; Pawlowska *et al*, 2009).

A knowledge of the patterns and prevalence of tooth agenesis is important for treatment planning, particularly in the field of orthodontics. Missing teeth result in malocclusion, spacing between teeth and decreased growth of the alveolar process (Nik-Hussein, 1989). It influences skeletal patterns (Tavajohi-Kermani *et al*, 2002; Chung *et al*, 2008; Sanchez *et al*, 2009; Lagana *et al*, 2011; Celikoglu and Kamak, 2012), soft tissue profiles and dental arch width (Ogaard and Krogstad, 1995; Ben-Bassat and Brin, 2009; Sanchez *et al*, 2009; Celikoglu *et al*, 2010). Hypodontia is also associated with other dental anomalies, such as microdontia and palatally positioned maxillary canines. (Peck *et al*, 2002; Garib *et al*, 2009).

There have been no reports of tooth agenesis in the Malay population. Hence, the aim of this study was to determine the prevalence and patterns of tooth agenesis, including third molars, and to determine if there is a higher likelihood of third molar agenesis in Malay children with hypodontia.

MATERIALS AND METHODS

We conducted a retrospective study of all orthopantomograms (OPGs) of

Table 1
Missing teeth by gender.

Tooth no. (FDI notation)	Missing teeth in 360 boys *n* (%)	Missing teeth in 474 girls *n* (%)	Missing teeth in 834 children *n* (%)	Value as a % of missing teeth
12	3 (0.8)	5 (1.1)	8 (1)	1.57
22	2 (0.6)	4 (0.8)	6 (0.7)	1.18
32	0 (0)	2 (0.4)	2 (0.2)	0.39
42	2 (0.6)	3 (0.6)	5 (0.6)	0.98
13	3 (0.8)	1 (0.2)	4 (0.5)	0.79
23	2 (0.6)	2 (0.4)	4 (0.5)	0.79
14	2 (0.6)	2 (0.4)	4 (0.5)	0.79
24	1 (0.3)	1 (0.2)	2 (0.2)	0.39
15	3 (0.8)	3 (0.6)	6 (0.7)	1.18
25	3 (0.8)	4 (0.8)	7 (0.8)	1.38
35	4 (1.1)	2 (0.4)	6 (0.7)	1.18
45	3 (0.8)	4 (0.8)	7 (0.8)	1.38
18	64 (17.8)	79 (16.7)	143 (17.1)	28.15
28	60 (16.7)	76 (16)	136 (6.3)	26.77
38	37 (10.3)	43 (9.1)	80 (9.6)	15.75
48	43 (11.9)	45 (9.5)	88 (10.6)	17.32
Total	232	276	508	99.99

Malay children aged 12 to 16 years, taken between 2004 and 2010, which were available in the radiology department of the dental clinic of the Universiti Sains Malaysia. Ambiguous OPGs of subjects with no proper record of date of birth and poor quality image were excluded.

Older OPGs, available as X-ray films, were viewed on a negatoscope in a dark room, while more recent studies, available in the digital format, were viewed on a computer monitor. The X-rays were examined for the presence of all teeth, including third molars, in each quadrant. The teeth were considered to be present if there was evidence of crypt formation with or without the calcification of the crown and vice versa. Teeth absent due to dental caries or for orthodontic reasons were cross-checked with dental records at the hospital and considered "not missing". In cases of uncertainty, the first two authors examined the OPG together to arrive at a consensus of the tooth most likely to be missing. The operational definition of hypodontia in this study was the developmental absence of one to five teeth, excluding third molars.

Ethical approval for the study was obtained from the Human Ethics Committee of the institution.

Statistical analysis was performed using SPSS software (SPSS, Chicaco, IL). Descriptive statistics were tabulated, and comparisions between groups was done using the chi-square test.

RESULTS

A total of 834 OPGs fulfilling inclusion criteria, from 360 boys and 474 girls, were reviewed. All teeth were present in

Table 2
Distribution of missing teeth by gender, excluding third molars.

No. of missing teeth	Boys, *n* (%)	Girls, *n* (%)	Total, *n* (%)
1	35 (34.3)	47 (37.6)	82 (36.1)
2	39 (38.2)	39 (31.2)	78 (34.4)
3	7 (6.8)	12 (9.6)	19 (8.4)
4	17 (16.7)	22 (17.6)	39 (17.1)
5	2 (2.0)	4 (3.2)	6 (2.6)
6	1 (1.0)	0 (0.0)	1 (0.4)
7	0 (0.0)	1 (0.2)	1 (0.4)
14	1 (1.0)	0 (0.8)	1 (0.4)
Total	102 (100)	125 (100)	227 (100)

Table 3
Distribution of missing third molars by gender.

No. of missing third molars	Boys, *n* (%)	Girls, *n* (%)	Total *n* (%)
1	35 (36.1)	46 (39.3)	81 (37.9)
2	35 (36.1)	37 (31.6)	72 (33.6)
3	9 (9.2)	13 (11.1)	22 (10.2)
4	18 (18.5)	21 (17.9)	39 (18.2)
Total	97 (100)	117 (100)	214 (100)

607 (72.7%). A total of 232 teeth and 276 teeth were missing from 102 boys and 125 girls, respectively (Tables 1 and 2). The average number of teeth missing per child was 2.3. Table 1 shows the distribution of missing teeth by gender. The most common missing tooth was an upper third molar followed by a lower third molar. Other missing teeth in descending order were upper lateral incisors (1.7%) upper and lower second premolars (1.5% each), and upper canines (1.0%) (Table 1). First molars, second molars, mandibular canines, mandibular first premolars and central incisors were not missing in any of the children.

Seventy point five percent had one or two missing teeth (Table 2). Similar findings were found when third molars were considered separately (Table 3). One child was noted to have oligodontia with 14 missing teeth (Table 2). Table 4 shows the number of teeth and children with right/left and unilateral/bilateral hypodontia. Teeth on the right side were missing more frequently than left side and there were more bilaterally missing teeth than unilaterally missing teeth.

There was no significant difference in regard to missing teeth by gender. There was a significant difference by side ($p<0.001$): there were more teeth missing on the right side. A significant difference was seen between the upper and lower arches ($p<0.001$), with more missing teeth in the upper arches. A significant relation-

Table 4
Tooth agenesis by side and if bilateral or not.

Tooth type (FDI notation)	Right side			Left side			Bilateral agenesis			Unilateral agenesis		
	Total absent (*n*)	Children (%)	As a % of missing teeth	Total absent (*n*)	Children (%)	As a % of missing teeth	Total absent (*n*)	Children (%)	As a % of missing teeth	Total absent (*n*)	Children (%)	As a % of missing teeth
18/28	143	17.1	28.15	136	16.3	26.77	210	12.6	41.34	69	8.3	13.58
38/48	88	10.6	17.32	80	9.6	15.75	120	7.2	23.62	48	5.8	9.44
12/22	8	1.0	1.57	6	0.7	1.18	10	0.6	1.97	4	0.5	0.79
32/42	5	0.6	0.98	2	0.2	0.39	4	0.2	0.79	3	0.4	0.59
13/23	4	0.5	0.79	4	0.5	0.79	6	0.4	1.18	2	0.2	0.39
14/24	4	0.5	0.79	2	0.2	0.39	4	0.2	0.79	2	0.2	0.39
15/25	6	0.7	1.18	7	0.8	1.38	12	0.7	2.36	1	0.1	0.19
35/45	7	0.8	1.38	6	0.7	1.18	8	0.5	1.57	5	0.6	0.98

Total absent: Total number of missing teeth.

ship was seen between hypodontia and missing third molars (Table 5). The odds of having a missing third molar with the presence of hypodontia was 3.268.

DISCUSSION

Studies of tooth agenesis in various populations abound in the literature. Generally, extrapolations of studies done in other racial groups are inappropriate (Harris and Clark, 2008). An earlier study of hypodontia in Malaysian children did not state the race of the subjects (Nik-Hussein, 1989). This is relevant since Malaysia is made up of various races, primarily Malay (54.1%), Chinese (25.4%), Indians (7.5%) and other indigenous groups (11.7%) (Oral Health Division, 2005). This study was done in a Malay population since no published data is available in the literature about this population. We chose children aged 12 to 16 years, to exclude cases where development of third molars might be delayed (Vahid-Dastjerdi *et al*, 2010). Generally, third molar crypts develop between ages 8 to 10 years (Liversidge, 2008). While third molars developing as late as 16 years have been reported, the possibility of their appearance after 12 years is low (Richardson, 1980).

Most studies on prevalence of tooth agenesis have been done in orthodontic populations (Endo *et al*, 2006; Varela *et al*, 2009; Vahid-Dastjerdi *et al*, 2010); therefore, the results of this study, done on a pediatric population, should be considered in a separate context. This is pertinent because hypodontia is reportedly higher in an orthodontic population (Vahid-Dastjerdi *et al*, 2010).

Given the majority of studies report missing third molars and hypodontia as

Table 5
Relationship between hypodontia and missing third molars.

Hypodontia *vs* third molar absence	No hypodontia *n* (%)	Hypodontia present *n* (%)	Total *n* (%)
All third molars present	607 (97.9)	13 (2.1)	620 (100)
One to four third molars absent	200 (93.5)	14 (6.5)	214 (100)
Total *n* (%)	807 (96.8)	27 (3.2)	834 (100)

Chi-square test - *p*-value=0.002.

separate entities, we have also discussed our findings separately. As expected, the third molars were the most frequently missing teeth, with one or more molars missing in 25.7% of this population, which is comparable with another study (John *et al*, 2012). Twenty-eight point five percent of Chinese Singaporeans (Mok and Ho, 1996) and 11.5% of Asian- Indian students (Sandhu and Kaur, 2005) were found to have varying degrees of congenitally missing third molars. However, higher incidences were seen in Koreans (Chung *et al*, 2008) and Japanese (Daito *et al*, 1992) with 30% and 51.1% of third molars missing, respectively. The most frequent agenesis pattern in the number of third molars missing in this study was one, two, four and three, similar to some studies (Sandhu and Kaur, 2005; Celikoglu and Kamak, 2012) but different from most studies (Banks, 1934; Nanda, 1954; Mok and Ho, 1996; Celikoglu *et al*, 2010). Usually, third molars are most frequently missing from the maxilla (Mok and Ho, 1996; Sandhu and Kaur, 2005; Celikoglu and Kamak, 2012); this was also seen in our study.

The majority of studies on the prevalence of hypodontia have been done on caucasians, with a reported prevalence range of 4-7% (Polder *et al*, 2004; Kirkham *et al*, 2005; Harris and Clark, 2008). Among African-Americans tooth agenesis was seen in 7.7% of the population (Vastardis, 2000). Studies amongs Asians show widely varying prevalence rates, including 9.4%, 11.2% and 6.9% among Japanese, (Goya *et al*, 2008) Koreans (Chung *et al*, 2008) and Chinese (Davis, 1987), respectively. A previous study of Malaysians found hypodontia among 2.8% of children aged 5-15 years (Nik-Hussein, 1989). Our study was carried out only on Malays and had prevalence rate of 3.2%. Overall, the prevalence, in our study, is comparable to caucasians, but less than other Asian populations.

Most studies show females have a higher incidence of tooth agenesis (Nik-Hussein, 1989; Mok and Ho, 1996; Mattheeuws *et al*, 2004; Polder *et al*, 2004; Harris and Clark, 2008). However, in our study there was no significant difference by gender, similar to some other studies (Endo *et al*, 2006; Chung *et al*, 2008; Goya *et al*, 2008; Celikoglu and Kamak, 2012). Some studies have found a higher prevalence of missing teeth among males (Davis, 1987; Rozkovcova *et al*, 2004; Kirkham *et al*, 2005).

In our study, the most common missing tooth was the upper lateral incisor (1.7%) followed by the lower and upper second premolars (1.5%). Unlike other Asian studies, (Davis, 1987; Endo *et al*, 2006; Chung *et al*, 2008; Goya *et al*, 2008) fewer mandibular lateral incisors were

missing in our study (0.8%). A previous Malaysian study found the upper lateral incisor was the most common missing tooth, followed by mandibular lateral incisors (Nik-Hussein, 1989). Reports of missing permanent canines are rare (Lombardo *et al*, 2007). According to Bolk's theory of terminal reduction, the missing tooth germ will be the most distal of that tooth type, which makes the canines an unlikely candidate for hypodontia (Rozsa *et al*, 2009). Harris and Clark (2008) reported not finding any missing maxillary canines among white Americans. The prevalence of missing maxillary canines among other populations ranges from 0.01% to 2.10% (Fukuta *et al*, 2004; Rozsa *et al*, 2009). There are isolated reports of maxillary canine agenesis in Chinese (Leong and Calache, 1999; Cho *et al*, 2004) and Italian children (Lombardo *et al*, 2007). In this study, upper canines were missing in 1% of the population, which is relatively high compared to other prevalence studies. A much lower prevalence was reported in a previous Malaysian study (0.12%) (Nik-Hussein, 1989). However, the finding that mandibular permanent canine agenesis is rarer (Fukuta *et al*, 2004; Dosumu *et al*, 2009) than maxillary permanent canine agenesis was not observed in this study.

The presence/absence of hypodontia was compared to the presence/absence of third molars in this population; there were more missing third molars, similar to other studies (Chung *et al*, 2008; Harris and Clark, 2008). Pinho *et al* (2009) found a higher incidence of missing third molars among those with missing upper lateral incisors. Garn *et al* (1962) found a 13 fold higher risk of hypodontia when the third molars are missing. One study found no relationship between missing third molars and hypodontia (Shah and Boyd, 1979).

In conclusion, the prevalence of hypodontia among Malays was within the normal range at 3.2%, but considerably lower than other Asian countries. The prevalence of missing third molars was also within the normal reported range of 25.7%. The most common missing tooth besides third molars was the maxillary lateral incisor. The prevalence of missing maxillary canines was 1%. There was an increased chance of a missing third molar when other teeth were missing.

ACKNOWLEDGEMENTS

This study was supported by a USM incentive grant.

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