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TOOTH SIZE AND AGENESIS OF TEETH: A FAMILIAL STUDY

by

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Submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry

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ABSTRACT

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An increased incidence of microdontia has been reported among siblings with congenital hypodontia. Decreased mean tooth size has been documented in family members of individuals affected with oligodontia throughout the literature. However, only a few have studied families with isolated hypodontia. These studies have not identified a clear genetic basis between congenital hypodontia and microdontia. The current study was undertaken to examine the degree of genetic association between dental agenesis and tooth size. Fifty nuclear families where at least one member was affected with dental agenesis and forty unaffected families were evaluated to identify tooth size differences and estimate heritability of tooth size. Dental agenesis was confirmed using radiographs. Dental casts were utilized to measure tooth size. Analyses of tooth size demonstrated that families

affected with dental agenesis presented with smaller teeth in the anterior region, specifically the lateral incisors, and second molars. An independent evaluation of the maxillary and mandibular arches revealed diminished tooth size in families affected with agenesis in total maxillary tooth size, the maxillary anterior regions, maxillary and mandibular lateral incisors, mandibular first and maxillary second molars. Parent-offspring correlations for tooth size ranged between 0.1950 and 0.6807, when teeth in the anterior, middle and posterior regions of the dentition were analyzed. In general, familial correlations within parent-offspring and sib-sib pairs did not demonstrated significant differences between the affected families and control families. Results indicate that dental agenesis and tooth size may be heritable traits, under polygenetic control with a multifactorial etiology. Future work on a larger sample would strengthen the validity of our results.

DEDICATION

This work is dedicated to:

My parents, Ali and Aghdas, who have always believed in me and sacrificed everything to better their children's future. Thanks you for helping me become the man I am today.

My brother, Hamid, whose courage and bravery has guided me in all my decisions.

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INTRODUCTION

Webster's Third New International Dictionary defines the prefix "hypo" as less than normal (1981). Most authors use the term hypodontia to refer to a congenital absence of one or more permanent teeth, the most common developmental dental anomaly in man (Shapiro and Farrington 1983). Other authors have used terms such as hereditarily missing teeth, anodontia (partial or total), oligodontia, ateleodontia, merestic variation of teeth, dental aplasia and agenesis to describe this condition. The congenital absence of teeth, first reported by Thurman in 1851, is of significance to the dental professional. Clinical management typically requires a multi-disciplinary approach and life-long management. For the most part, orthodontists are concerned with malocclusions that arise from missing teeth. For anthropologists, it is a tool for studying the ongoing process of evolution (Bailit 1975), while to geneticists, it poses an unresolved polymorphic trait (Suarez and Spence 1974). It has been argued by Vastardis that the term "congenitally missing teeth," with specific reference to molar teeth, is a misnomer since permanent teeth are not

present at birth. She supports the use of the term "dental agenesis" instead, as it implies an underlying developmental defect (Vastardis 2000). A review of the literature reveals that this anomaly almost always affects the permanent dentition, as opposed to the deciduous dentition, where it occurs at a prevalence of less than one percent (Burzynski *et al.* 1983).

Dental agenesis has been associated with several syndromes, especially those where the etio-pathogenesis is linked to epithelial tissue, including Down syndrome and anhidrotic ectodermal dysplasia. Although these syndromes can vary in their mode of inheritance, most demonstrate an autosomal dominant pattern with variable expressivity (Graber 1978). Other syndromes with hypodontia include Rieger syndrome, characterized by malformation of the anterior chamber of eyes, umbilical anomalies and agenesis of maxillary and mandibular incisors (Schalk-van der Weide Y *et al.* 1994b), and Marshall syndrome which presents with structural alterations of the eyes, deafness, facial characteristics similar to congenital syphilis and missing or malformed teeth (Graber 1978). Hypodontia associated with non-syndromic disorders comprise a small proportion of

the population, with the majority of these being sporadic or familial in nature (Graber 1978).

Dental agenesis has been associated with other dental anomalies, in particular, alteration in tooth size (Sofaer *et al.* 1971; Garn and Lewis 1970; Grahnén 1956). In fact, Townsend and Brown (1978) defined hypodontia as an aberration in number, size, shape and the overall rate of dental development or eruption sequence. The exact causal factors for this trait, and its related dental findings, are not well understood. Furthermore, the extent to which genetics and/or environmental factors contribute to these traits remains poorly understood.

REVIEW OF THE LITERATURE

Etiology of Tooth Agenesis

Butler, an English paleontologist, offered the earliest explanation for dental agenesis in 1939. He divided the dentition into three developmental fields: incisors, canines, premolars and molars. He further defined the "key" tooth within each field to be the most mesial tooth; labeled the most stable and, all other teeth as progressively less stable. Clayton (1956) redefined the regions as incisor, canine and premolar, and molar segments, a stratification system used to date. He observed that the most distal tooth within a series was more likely to be missing than the preceding teeth. He hypothesized that missing teeth were "vestigial organs," that offered little survival advantage to modern man.

Other authors view hypodontia as a variation of the norm. Individual teeth vary in prevalence of agenesis, suggesting that humans are currently at an intermediate stage of dental evolution towards smaller jaw size, which cannot accommodate the full complement of teeth (Burzynski and Escobar 1983). Anthropologists have attributed the

in the number of teeth to a reduction in jaw size. Graber (1978) suggested that congenital hypodontia will eventually result in less than thirty-two teeth forming. Agenesis has also been associated with those areas of the jaws that are sites of embryonic fusion, labeled as "fragile sites", or the last to receive neural innervation (Kjaer 1997). Such fragile sites include the maxillary-premaxillary junction and the mandibular symphysis. Others have theorized nutritional disturbances and endocrine dysfunction during pregnancy could injure the ectodermal structures or even destroy developing tooth germs (Grahnén 1956; Bader 1965; Fearne and Brook 1993). A study of seventy-two low birth-weight children demonstrated a decreased crown size in the mesiodistal dimension of primary molar and canine teeth compared to sixty normal birth weight children (Fearne and Brook 1993). A positive correlation was found between low birth-weight and mesiodistal tooth size. This implicated environmental factors, including a shorter prenatal growth period, poor perinatal and early postnatal environments as determinants of tooth size. In fact, in a study of heritability of molar size in house mice, the maternal or intrauterine environment was the largest source of environmental variation in the dentition, and second only

to genetic factors (Bader 1965).

Prevalence of Tooth Agenesis

Prior to the advent of sophisticated DNA analysis techniques in the 1980's, most studies of hypodontia were descriptive in nature reporting prevalence rates and relative risks within various populations (Table 1). These studies depicted hypodontia as a highly variable phenotype within and between specific populations. Mandibular incisors were most commonly missing in Asians, and maxillary laterals and mandibular second premolars in Caucasians. For all teeth, with the exception of maxillary lateral incisors, there is symmetry in the prevalence of missing teeth within the dental arch. The left maxillary lateral has a higher predilection for agenesis than its right counterpart (Bailit 1975).

Assuming uniformity of data collection, and random sample recruitment, one would expect similar findings in studies within a given geographic region. Disparities in the frequencies reported are likely due to ethnic and racial backgrounds of the populations investigated (Hunstadbraten 1973), different sample sizes, variations in age, and the absence of radiographic verification. Wisth among those seven-year old, and 6.6% at age nine attributed

TABLE 1.--Studies on Prevalence of Hypodontia.

Author	Year	Sample Size	Prevalence of Hypodontia	Tooth Most Commonly Missing	Race	Sex Predilection
Werther *et al.*	1939	1,000	2.3	Max. Lateral Incisor	Caucasian	None
Byrd	1943	2,835	2.8	Mand. 2nd Premolars	Caucasian	Female
Brown	1955	5,200	4.2	Mand. 2nd Premolars	Caucasian	Female
Clayton	1956	3,557	6.01	Mand. 2nd Premolars	Caucasian	N/A
Grahnén	1956	1,006	6.1	Mand. 2nd Premolars	Caucasian	Female
Glenn	1964	777	5.1	Mand. 2nd Premolars	Caucasian	Female
Hunstadbraten	1964	1,295	10.1	Mand. 2nd Premolars	Caucasian	Female
Muller *et al.*	1970	14,940	3.49	Max. Lateral Incisor	Caucasian and Black	Female
Brook	1974	1,856	4.4	N/A	Caucasian	Female
Tsai *et al.*	1998	2233	7.3	Mand. Central Incisor	Asian	N/A

to delayed dental development. A recall bias could play a significant role, as adults often forget early extractions of permanent teeth. Early extraction of deciduous molars with unresorbed roots could also lead to inadvertent removal of the permanent tooth follicle, and consequently apparent hypodontia (Suarez *et al.* 1974). In addition, most studies do not disclose sample characteristics, such as inclusion of siblings, which could affect prevalence value by up to 1% in a sample of 500 (Graber 1978). Most studies, do agree however, that third molars are the most commonly missing teeth with a prevalence ranging from 9 to 36% (Vastardis 2000; Haavikko 1971; Garn *et al.* 1962a; Grahnén 1956), accounting for 74% of all missing teeth according to Haavikko, while the first and second permanent

molars, mandibular canines and maxillary central incisors are rarely affected (Garn *et* al. 1962b; Grahnén 1956; Wisth *et al.* 1974; Schalk-van der Weide *et al.* 1992).

Non-Syndromic Tooth Agenesis and Related Dental Anomalies

Congenital hypodontia is not an isolated trait, but has been associated with other dental anomalies (Table 2), including deviations in normal dental development, atypical eruption sequence, palatally displaced canines and tooth-size reduction, (Peck *et al.* 1996; Garn *et al.* 1962a).

TABLE 2.--Congenital Anomalies Related to Dental Agenesis

Author	Year	Sample Size	Related Anomalies
Garn	1962	100	Variation in second premolar - second molar eruption sequence
Davies	1968	2170	Four-cusped permanent mandibular first molars
Baum *et al.*	1971	N/A	Decreased tooth size in mesiodistal dimension
Symons *et al.*	1993	5127	Agenesis of other teeth, dental impaction, spacing within dentition
Atasu *et al.*	1995	250	Increased number of arches on finger tips
Peck *et al.*	1996	58	Palatally displaced canines
Baccetti	1998	5450	Small maxillary lateral incisor, infraocclusion of primary molars, palatally displaced canines

Symons *et al.* (1993), in a study of 5,127 patients affected with missing second premolars, reported hypodontia and spacing. A study of 5,450 children, ranging from seven to fourteen years old, revealed an association between second premolar agenesis and peg-shaped maxillary lateral incisors (reduction of the mesiodistal diameter with proximal

surfaces converging towards the incisal surface), infra-occlusion of primary molars, enamel hypoplasia and palatal displacement of the maxillary canines, suggesting a common genetic origin (Baccetti 1998). Although radiographs and dental casts were used to confirm the dental anomalies, the investigation was limited to individuals rather than families. Consequently, it would be impossible to ascertain a clear genetic link between these dental anomalies. Third molar agenesis has been associated with a thirteen-fold increase in hypodontia of other teeth, especially the lateral incisors and second premolars (Garn *et al.* 1962b). Familial studies of palatally impacted maxillary canines revealed an association with anomalies of the maxillary lateral incisors (Zilberman *et al.* 1990). Peck *et al.* (1993) reported a prevalence of 37% for hypodontia among patients with maxillary canine-first premolar transpositions. A follow-up study of patients with palatally displaced canines revealed an increased prevalence of missing or peg-shaped maxillary laterals. It was proposed that tooth agenesis, tooth size reduction, and palatally displaced canines were a complex of genetically determined traits that often occur in combination (Peck *et al.* 1996). However, statistical evaluation of thirty-five

pedigrees, published by Pirinen *et al.* (1996), demonstrated negative familial correlations and, hence, no genetic control was detected in the occurrence of palatally displaced canines in this sample (Valiathan *et al.* 2002).

By far, most studies of hypodontia and related dental anomalies report a close relationship between missing teeth and an alteration of tooth size, with variations in tooth form and size often reported in cases of extensive hypodontia. Studies of the prevalence of anomalies in tooth size have indicated the maxillary lateral incisor crown most often affected (Ooshima *et al.* 1996), with a range of 0.5-3.1% prevalence (Brook 1974) and female predilection (Meskin and Gorlin 1963). As prevalence of hypodontia varies for racial groups, so does permanent tooth size (Bailit 1975). A study of 658 subjects from Southwestern Ohio revealed reduced in permanent tooth size associated with the agenesis of third molars. The reduction in mesiodistal tooth size was more severe when other teeth, in addition to third molars, were congenitally missing. In addition, a gradient for size reduction was noted with the incisors most affected, followed by canines, premolars and molars. No inter-arch or gender related data were reported. Although, cases of dental agenesis were

confirmed radiographically, no mention was made of the protocol for measurement performed or investigator reliability (Garn and Lewis 1970).

A study of tooth size in one hundred patients with hypodontia, not only confirmed a direct relationship between hypodontia and crown size, but also a significant variation in canine size, both mesiodistally and buccolingually (Baum and Cohen 1971b); a tooth previously thought as genetically stable (Osborne *et al.* 1958). Davies reported an increased prevalence of four-cusped permanent mandibular first molar among subjects affected with agenesis of one or more teeth other than third molars versus controls (Davies 1968b).

Sofaer *et al.* (1971) found an association between missing teeth and teeth varying in size and shape in a study of 17,000 high school students. They noted a tendency for larger central incisors on the side of the missing lateral incisor, and smaller than normal central incisors in the presence of a peg-lateral. They related this to local environmental factors present during development, as opposed to genetics. Assuming that once initiation is achieved, a tooth germ proceeds to become a tooth, they concluded that the central incisor and canine

buds form prior to the lateral incisor. Consequently, its formation is dependant on remaining local factors, with agenesis occurring where there are insufficient primordia for tooth germ initiation (Sofaer *et al.* 1971). Environmental factors where further examined by Garn *et al.* (1979a). Through a retrospective study of 289 seven to eight year old children, they concluded that variation in various prenatal factors may affect crown dimension in both the deciduous and permanent dentition. They reported that children of mothers affected by hyperthyroidism and diabetes presented with increased crown size, and children of hypertensive mothers, as well as those with low birth-weight and height, displayed diminished tooth size compared to controls. Though Garn *et al.* reiterated the importance of embryonic development in relation to tooth size, this study failed to address post-natal factors that might affect tooth size, as crowns of permanent teeth form throughout infancy and childhood, with their final dimensions dependant on the overall morbidity and general well-being. Results of this study did not demonstrate an association between tooth size and age of mother, maternal health during pregnancy, birth rank of the child, or health of the child during infancy.

Grahnén's study (1956) of hypodontia in the permanent dentition revealed a generalized reduction of tooth size in subjects with multiple missing teeth. Grahnén recorded the frequency of hypodontia as well as the frequency of peg-shaped lateral incisor teeth in 2,070 subjects affected with hypodontia of six or more teeth excluding third molars. He noted that 45% of subjects with unilateral missing maxillary lateral incisors displayed a peg-shaped incisor on the contra-lateral side. Rune and Sarnäs (1974) studied the mesiodistal dimension of the central incisor, canine and first molar in ninety-one children with oligodontia, an absence of six or more permanent teeth, and reported that the mean tooth size was significantly smaller than Seipel's published reference group. Additionally, tooth formation was delayed in eighty-five of ninety-one children.

The most extensive studies regarding correlation of hypodontia and tooth size have been by Schalk-van der Weide and colleagues. A study of 196 patients with oligodontia found a generalized decrease in mesiodistal dimension of all teeth, especially the maxillary incisors and mandibular second premolars, when compared to Moyers' standards of human occlusal development. They stated that the lateral

incisor developed in the 5-6th month of prenatal life, whereas, the second premolar developed at 9th month, and consequently reduced size was more likely influenced by genetic than environmental factors (Schalk-van der Weide *et al.* 1992). A follow-up study of eighty-two individuals with oligodontia, not only reaffirmed the previous finding, but revealed a reduced labiolingual dimension (Schalk-van der Weide *et al.* 1994a). Examination of first and second-degree relatives demonstrated reduced tooth size, even in the presence of a full permanent dentition. Moreover, they found a greater number of teeth with significantly reduced size compared to Moyer's standards in cases with the greatest number of congenitally missing teeth (Schalk-van der Weide and Bosman 1996). Consequently, they concluded that tooth size was an important variable in determining the mode of inheritance for hypodontia. However, these studies did not attempt to verify a genetic mechanism for such observations through an estimation of familial correlation.

A study of tooth dimension in twelve patients with oligodontia and twenty-one relatives revealed decreased tooth dimensions both labiolingually and mesiodistally of the probands and their unaffected relatives compared to a

control group. Specifically, family members demonstrated a reduction of mesiodistal dimension for the central incisors and maxillary first and second premolars, and buccolingually for the maxillary and mandibular first premolars. Unfortunately, the unaffected controls were comprised of random unrelated individuals rather than families. Furthermore, the sample size was small and could not firmly support these conclusions (McKeown *et al.* 2002).

Systemic Disorders Associated with Dental Agenesis

In addition to the plethora of dental anomalies, congenital hypodontia has also been documented in conjunction with systemic diseases. Dermatoglyphic study of twenty-one patients with congenital hypodontia of lateral incisors and second premolars found an increased number on arches of the finger-tips, with the anomaly presenting as an autosomal recessive trait (Atasu and Akyuz 1995). Patients missing lateral incisors also demonstrated more palmar and plantar loops between the digits, while those missing second premolars presented with increased loops at the base of the palm and ball of the foot. The authors suggested that the distinctive pattern of the palmar and plantar ridges would allow for early

identification of affected children without the use of radiographs.

Genetic analysis of a Finnish family with oligodontia recently reported a mutation of the AXIN-2 gene associated with tooth agenesis (Lammi *et al.* 2004), a gene previously identified in tumors derived from colorectal cancer. The non-sense mutation of exon 7 introduces a premature stop codon leading to degradation of mRNA. This suggests that tooth agenesis might be an indicator of cancer susceptibility. Dental agenesis has also been reported in patients with myelomeningocele, who present with Chiari II malformation; a congenital defect where the brainstem and cerebellar tissue are displaced into the cervical spine (Linderström *et al.* 2002). In addition, case reports of patients with monosuperocentroincisivodontic dwarfism, described an association between a single maxillary central incisor and growth hormone deficiency (Yassin and El-Tal 1998).

Heritability of Tooth Agenesis and Tooth Size

Much attention has been given to the genetics of hypodontia and its underlying heritable component. Genetic epidemiology is a young science that has aided our understanding of genetic and environmental factors related

to a specific phenotype. It allows for an estimation of familial aggregation of a given trait, in instances that, at least, one of the following conditions are met:

1. Higher incidence of a specific trait among the proband's relatives, as compared to the general population.

2. Increased proportion of relatives presenting the trait, compared to the general population.

3. Correlation values of the trait significantly higher than zero between pairs of related individuals.

Traits which often cluster in families can be due to biologic inheritance of the trait via a single or multiple gene mechanism, exposure of individuals to a common environment, or culturally inherited increased susceptibility due to life style differences (Valiathan *et al.* 2002). Genetic epidemiology enables us to estimate the contribution of each of these factors for a given phenotype. Genetic and environmental effects on a trait can be analyzed by computing correlation coefficients between relative pairs, as correlations between various relative pairings are due to specific reasons (Harris and Smith 1980). Siblings, for instance, may possess a common trait through inheritance or a common environment.

Heritability of a trait, symbolized h^2, expresses that proportion of the total variance in a phenotype

attributable to additive genetic factors, with values ranging between zero and one (Khoury *et al.* 1993). As a general rule, h^2 approaches zero when all phenotypic variation can be attributed to non-genetic factors, and one when the environment has limited effects on the trait (Valiathan *et al.* 2002). In addition, variations in the environment will reduce h^2, while common environmental factors increase h^2, in the presence of a common genetic mechanism. Thus, caution must be exercised when applying estimates of heritability from one population to another (Khoury *et al.* 1993).

Heritability is actually the sum of several different components including, additive variance of several different genes transmitted from parent to offspring, dominance variance representing the influence of one allele over another at the same locus as seen in relatives who possess identical genome (full siblings and twins), and epistatic variance due to the interaction of genes at different loci (Lynch and Walsh 1998). Environmental variances can be influenced by those factors shared among family members and those unique to each individual.

The literature reveals that dental agenesis and associated anomalies "run in families", and, consequently,

may be under genetic control. The genetic component of the etiology of hypodontia is reinforced by case reports and twin studies (Arte *et al.* 2001; Vastardis 2000; Thesleff 2000; Mossey 1999; Ranta 1985; Rosenberg-Gertzman 1982; Townsend *et al.* 1978; Chosack *et al.* 1975; Suarez *et al.* 1974; Gravely 1971; Boruchov and Green 1971). Comparing the incidence of hypodontia in large samples of siblings affected with the population as a whole can reveal familial tendencies, thereby suggesting a genetic contribution to this phenotype. Boruchov (1971) assessed the relative contribution of heredity and environment through a comparison of monozygotic and dizygotic twins. Monozygous twins have identical genetic make-up so that any variation should be due primarily to environment, while the dizygotic twins are no more genetically similar than siblings and variations are primarily due to genetic differences. A study of hypodontia among 369 pairs of twins, classified as either monozygotic or dizygotic, reported a concordance of hypodontia in four of nine monozygotic, and four of twenty dizygotic twin pairs. It was argued that, if heredity played an important etiologic role in hypodontia, the expected frequency of concordance, that is both twins affected with hypodontia, would have been higher among

monozygotic twins. It was concluded that the environment was the major contributory factor in hypodontia. However, this study was biased as the conclusions were drawn from a limited sample size, with only nine monozygotic and twenty dizygotic twins who presented with dental agenesis. A later study by Markovic (1982) revealed that eight of nine monozygous twin pairs with missing teeth were concordant, while all dizygous twin pairs were discordant, reinforcing the hereditary nature of hypodontia.

Studies evaluating familial trends in hypodontia led to the conclusion that there is genetic control over tooth development. Increased prevalence of hypodontia among parents and siblings of probands with oligodontia was first documented by Grahnén in 1956, and later by Chosack *et al.* (1975), Brook (1984) and Arte *et al.* (2001). Grahnén reported the greater the number of missing teeth among probands, the greater the frequency of hypodontia among siblings. Familial analysis of 1,006 subjects with hypodontia revealed a frequency 26% and 41% among siblings and parents of probands, respectively; a rate significantly higher than 6% prevalence rate in the general population. Chosack *et al.* (1974) studied 305 families, and observed hypodontia in 14.8% of siblings and 9.4% of parents of the

probands, which was significantly higher than the 4.6% population average. This indicated an increased risk for dental agenesis for family members, and subsequently may be genetically determined. Brook observed hypodontia in a greater proportion of relatives of probands and concluded that the risk for the trait varied between families. The risk, he stated, was dependant on the severity of hypodontia in the proband and the number of family members affected; a conclusion consistent with Chosack's findings (1974). Finally, Arte *et al.* (2001) reported a prevalence of 39% and 36% respectively among first and second-degree relatives of the proband respectively. Although these reports document an increased risk for hypodontia for relatives of probands, they fail to outline a direct genetic mechanism and contribution for the trait.

There are differing opinions as to the transmission mechanism of hypodontia between generations. However, no one theory of transmission successfully explains all familial pedigrees reported. Some investigators explain sporadic cases of hypodontia using a single gene theory, where crown size, shape and hypodontia are pleiotropic manifestations of a single gene, with an autosomal dominant transmission mode (Arte *et al.* 2001; Vastardis 2000;

Grahnén 1956). Arte *et al.* (2001) reported sporadic of transmission, with a penetrance of 97%, using familial data from eleven families. However, they included peg-shaped maxillary incisors as missing, and thus, over estimated the number of affected members in each family. Vastardis (2000) reported an autosomal dominant pattern by studying one family affected with hypodontia of second premolar and third molars. Grahnén (1956) argued that a simple dominance pattern should have an expected frequency of 52% and 53% among parents and siblings, respectively. Since his data revealed 41% and 26%, he hypothesized a dominant gene pattern with incomplete penetrance (not everyone with the genotype will manifest the phenotype). Without an investigation of extended family members, Grahnén warned against making definitive conclusions about the mode of inheritance of hypodontia and suggested that multiple genes may be responsible for hypodontia. Yet other modes of transmission, including X-linked dominant, have been reported in the literature (Rosenberg-Gertzman 1982; Dahlberg 1937). Iltis (1948) attributed the absence of the maxillary lateral incisor to a recessive gene trait. He published two pedigrees of four generations, but was unable to examine all individuals within the families. Further

analyses of these data suggest a dominant gene with incomplete penetrance could also be possible.

Other investigators suggest a polygenic mode, where more than one gene, each with a relatively small influence, is involved in the phenotypic expression of hypodontia. Polygenic theory implies several loci in the human genetic code, which when affected either singly or collectively, produces dental agenesis. In such polygenic traits, the familial pedigree does not demonstrate a discrete pattern of inheritance, in contrast to single-gene traits, as they are determined by an interaction of a number of genes, each with a small, but additive, effect in a given environment (Mossey 1999). Familial analyses of eighty-eight Northeast Ohio families, where at least one person was affected with tooth agenesis, revealed that, although family members of the probands had higher risk of exhibiting the trait, a clear pattern of inheritance was undetectable (Spoonhower 2003). Suarez and Spence (1974) used published data from Grahnén's familial study and concluded hypodontia was not a simple Mendelian trait, but a polygenic one, conditioned by a large number of loci, each with small, additive effect. It is difficult to consider the presence or absence of teeth as a polygenic trait, as these traits usually

manifest continuous distribution (Bailit 1975). Brook argued that dental agenesis and crown size should not be considered as isolated phenomenon. He utilized a multi-factorial model in which hypodontia and microdontia were anomalies of a quasi-continuous trait that also included megadontia and supernumerary teeth, with variations in tooth number occurring at the extreme ends of the spectrum (Brook 1984). That is, variable tooth size may be turned into an all-or-none trait via a threshold mechanism, with the condition present only when the liability exceeds a critical threshold (Figure 1). There are separate curves for males and females due to increased prevalence of larger tooth size and supernumerary teeth in males, as opposed to greater frequency of decreased tooth size and hypodontia in females (Brook and Ekanayake 1980).

Genetic trends have also been documented in relation to microdontia. As with tooth agenesis, tooth size is also an inherited trait which is significantly influenced by the environment (Bailit 1975). This is evident in the correlation of crown size between siblings and their parents, with heritability values ranging from 0.4-0.7 (Bailit 1975). Indeed, Bailit stated that not all teeth were equally heritable, with the most distal tooth in each

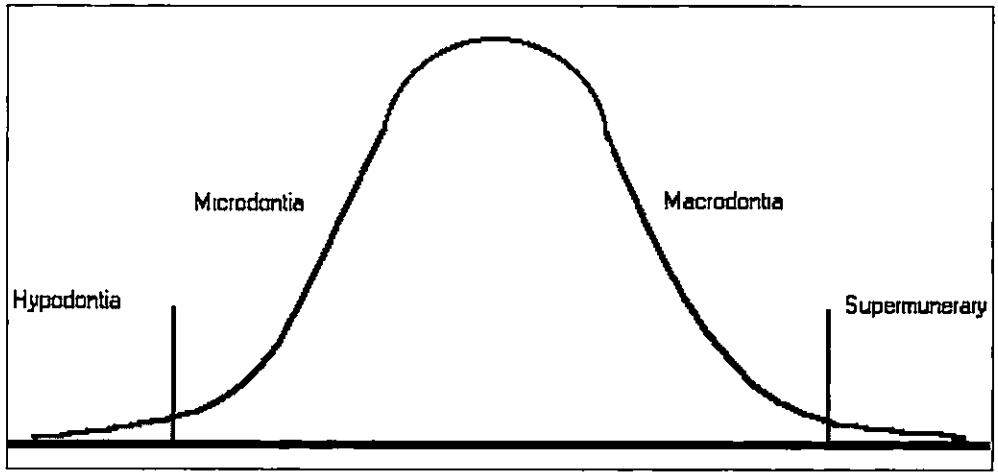


Figure 1. A polygenic model for variation in tooth number and size.

morphological class influenced the most by environment. Grahnén (1956) reported family members of probands possessed a frequency of microdontia of 5.5%, a value significantly higher than the 1.7% for the population as a whole. A study of 103 Mormon families with one member affected by a missing or peg-shaped maxillary lateral incisor revealed a familial nature of these anomalies in first-degree relatives. The parents and siblings demonstrated the trait with a frequency of 17.7% compared to 2.8 for controls (Woolf 1971). Woolf concluded that these traits were not the sequelae of an X-linked mode of inheritance, as affected fathers transmit the condition equally to offsprings of both sexes. He proposed that genetic modifiers accounted for the observed variation in expression (range of the phenotypic expression possible

among affected individuals) of the anomalies among the affected members of the same family, due to mutations at different loci of different alleles. These studies did not attempt to decipher the extent of genetic variance contributing to the overall phenotypic variance.

Molecular Biology

Recent advances in molecular biology and DNA analysis have allowed investigators to study hypodontia at the molecular level and associate numerous genes and gene products with this trait. Homeobox genes are highly conserved genes among invertebrate and vertebrate organisms, in control of patterning, induction, apoptosis, and tissue interactions in the craniofacial complex (Mossey 1999). Of special interest in dental development is the Hox group MSX-1. Vastardis *et al.* (1996) studied an extended family that presented with agenesis of second premolars and third molars in an autosomal dominant pattern and concluded that the phenotype was due to a point mutation of the MSX-1 gene on the short arm of chromosome 4. A study of a family lacking most permanent molars led to the identification of the PAX-9 gene. An insertion of a guanine at nucleotide 219 leads to a frame-shift mutation alters the PAX-9 DNA-binding domain with subsequent

instability of either PAX-9 mRNA or protein (Stockton *et al.* 2000). These genes have been shown to play an essential role in tooth development beyond the bud stage.

Tooth formation is highly conserved among vertebrates, as evident through 460 million years of fossil records (Slavkin 1997). Dental development is regulated by inductive local interactions between epithelial and mesenchymal cells that are related to chemical signals responsible for number, shape, size and site and symmetry of tooth formation within the arches. Mutations in genes that regulate these early interactions could result in agenesis or a modification of size or shape of teeth.

STATEMENT OF THESIS

The aims of the present study are to:

1. Estimate tooth size differences between families identified as having at least one person affected with dental agenesis and unaffected control families.

2. Estimate and compare heritability of tooth size by analyses of familial aggregation of tooth size in families affected with dental agenesis, and unaffected control families.

Specifically, variation in mesio-distal tooth dimension will be analyzed for fifty families where at least one person was affected with tooth agenesis, and forty unaffected control families. Heritability will be calculated and compared using parent-offspring and sibling-sibling pair familial correlations.

MATERIALS AND METHODS

This analytical study sought to estimate familial aggregation of tooth sizes in families previously identified as having at least one member affected with dental agenesis. Fifty probands with tooth agenesis of any permanent tooth excluding third molars, and their families were recruited from the Case Western Reserve University, School of Dental Medicine, Department of Orthodontics and two private practices in Mayfield Heights and Berea, Ohio. Permanent tooth agenesis was confirmed using radiographic examination. Forty subjects without tooth agenesis and their families were randomly selected as controls from the Case Western Reserve University, School of Dental Medicine, Department of Orthodontics. In the event that a family member originally selected as a control was noted to have tooth agenesis, they were recruited to be members of the affected group. Consent was obtained from each participant after informing them about the particulars and nature of the study (Appendix 1). Each subject completed a short questionnaire to document any familial history of tooth agenesis and identify the potential cause for absence of

teeth in both affected and control groups (Appendix 2).

Each family was contacted to arrange an appointment to obtain impressions from consenting family members. In cases where the family could not appear at the orthodontic clinic of Case Western Reserve University, the primary investigator obtained impressions at the family's residence. Impressions were collected using the protocol outlined by Armogan (1998). President™ Putty (Coltene/Whaledent Inc., Mahwah, NJ) impression paste and catalyst material were mixed until they formed a uniform tan color, and placed on both the upper and lower sides of a Polybite™ (Royal Industries, Industry, CA) full-arch impression tray. A tray was inserted into each subject's mouth, with the upper compartment placed against the upper arch. Subjects were then instructed to bite into the lower compartment until their teeth just touched. The tray was removed in approximately a minute, when the material set. Impressions were examined to ensure they were devoid of distortion and captured a complete registration of teeth. The impression trays were labeled using a permanent marker and placed in a ZipLoc™ bag (Dow Brands, Indianapolis, IN), sealed and transported to the orthodontic clinic at Case Western Reserve University, where they were disinfected

using Citrace™ Hospital Germicidal Deodorizer (Caltech Industries, Inc., Midland, MI). Care was taken not to spray the identification numbers on each tray to avoid inadvertent loss of the numbers. Each family was assigned an identification number. Within the family, the proband was coded with the ID number #1, mother #2, father #3, and siblings #4 through #8. Gender information, date of birth and ethnicity were also recorded for each family member.

Impressions were poured with green orthodontic stone, mixed using a Wehmer™ vacuum mixer (Wehmer Company, Benton Harbor, MI) and lightly vibrated to reduce air bubbles in the mix. A two-step procedure was utilized to pour each side of the impression. Once the stone set, the model was separated and identical steps were repeated for the opposing arch. The models were examined for the presence of any voids which could limit the investigators ability to measure the size of each tooth. The upper and lower models were labeled with the patient's identification number, and wrapped to avoid damage. For patients that were in active orthodontic treatment, the initial study models were used in order to avoid dislodgement of the orthodontic appliances and distortion of the putty impression material.

Data Analysis

The mesiodistal dimension of each permanent tooth, excluding 3rd molars, was measured to the 100th of a millimeter using a digital caliper (Electronic Digital Calipers, China) from ideal contact point to ideal contact point, and recorded into the spreadsheet program Microsoft® Excel® (Microsoft, Seattle, WA). The FDI (Fédération Dentaire Internationale) numbering system was used to identify each tooth, where the notation 1 represent the central incisors, 2 the laterals, 3 the canines, 4 and 5 as first and second premolars, and 6 and 7 the first and second molars. The prefix 1 through 4 represent the quadrants, with the upper right as 1, upper left as 2, lower left as 3, and lower right as 4. Hence the maxillary right central incisor was identified as tooth number 11.

Missing teeth were recorded as congenitally absent (m), or not present due to other reasons such as extraction (x). Teeth that had mesial or distal restorations, or were partially erupted, that could have resulted in an inaccurate measure of tooth size, were coded using (RS) and (PE) respectively. Missing measurements due to hypodontia, extraction, restoration and partial eruption, were replaced according to the following protocol:

1. Family specific mean values for the specific tooth.

2. In instances where family members were also missing the tooth, the missing tooth size was replaced with family specific mean of the contra-lateral tooth.

3. In the rare event that the whole family was missing a specific tooth and its contra-lateral counterpart, the missing value was replaced with the mean value of the specific tooth from the entire data set.

Subjects without measurable values of at least half of their permanent dentition were excluded from the sample. This included individuals who, for instance, were fully or partially edentulous at the time of data collection, in addition to those who were missing more than 14 tooth-pairs.

General descriptive statistics, including ethnicity of families, family specific means and variance for tooth size, prevalence of missing measurements either due to agenesis, restorations or partial eruption were determined using pedigree information (PEDINFO) feature of SAGE [2002] (Statistical Analysis for Genetic Epidemiology, Statistical Solutions Ltd, Cork, Ireland).

Data stratification and analyses were performed using the following protocols:

1. Measurements for each tooth type (e.g., central incisors, lateral incisors etc.);

central incisor through second molars, were combined to obtain seven values that represented the mesio-distal dimensions for each tooth type across all four quadrants. Therefore, the computed value for the central incisor represented the mesio-distal dimensions of all four central incisors in the subject's mouth. This was the value used for each tooth type to perform further analyses between the groups affected with dental agenesis and controls outlined below.

2. Total tooth size analysis was performed by adding measurements for teeth 1 thru 7.

3. The arches were analyzed as three segments: anterior (central and lateral incisors), middle (canine, first and second premolars), and posterior (first and second molars).

4. Each tooth was individually analyzed.

5. The data was also stratified to analyze maxillary and mandibular teeth independently. Here, measurements for the tooth and its contra-lateral complement were summed to arrive at the value used for further analysis.

Data were analyzed to determine differences in mean tooth size between affected and control families using segregation analysis (SEGREG) model of SAGE [2002]. A two-tailed, Cochran-Cox two-sample t-test was utilized to assess these differences at $\alpha = 0.05$ significance level. This test allowed for the comparison of means with unequal variance, by the assumptions of a random sample from a normal distribution with means μ_1 and μ_2 and variances σ_1^2 and σ_2^2 respectively, using the following equations:

$$t' = \frac{\overline{y_1} - \overline{y_2}}{s_{(\overline{y1} - \overline{y2})}} \square\, t(df_{1-\alpha/2}), \text{ where } s_{(\overline{y1} - \overline{y2})} = \sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}, \text{ and}$$

$$df_{1-\alpha/2} = \frac{(s_1^2/n_1)t_{1-\alpha/2}(n_1 - 1) + (s_2^2/n_2)t_{1-\alpha/2}(n_2 - 1)}{s_1^2/n_1 + (s_2^2/n_2)}.$$

Estimation of heritability in tooth size was extracted using calculations of familial correlations for

1. Total tooth size,
2. Each of anterior, middle and posterior segments,
3. The first tooth in each segment, namely the central incisor, canine and first molars.

Family correlations (FCOR) values and asymptotic standard errors derived using SAGE [2002] were calculated for parent-offspring and sib-sib pairs in the affected and control groups using the following formula:

$$r_{xy} = \frac{\sum_{i=1}^{N} w_i (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^{N} w_i (x_i - \bar{x})^2 \sum_{i=1}^{N} w_i (y_i - \bar{y})^2}},$$

where x denotes one family member's trait, y the trait on a family member, $\bar{x} = \sum_{i=1}^{N} w_i x_i / \sum_{i=1}^{N} w_i$ and $\bar{y} = \sum_{i=1}^{N} w_i y_i / \sum_{i=1}^{N} w_i$ with a uniform weighting scheme, where each family had the same weights, regardless of the size of the family. The asymptotic standard error was estimated using a second-order Taylor series expansion and replacing all correlation

parameters with their respective estimates. This value is the smallest possible value for standard error, as it implies that the noise in the data is random and not due to systematic error. Spousal correlations were evaluated through hypothesis testing to compare spousal correlation to zero.

Calculated familial correlations were compared to determine any differences in heritability of tooth size between affected and control families. Hypothesis testing to analyze these differences was analyzed using the SEGREG analysis model of SAGE [2002]. This program was used to analyze and compare heritability of tooth size between the two groups for both parent-offspring and sib-sib correlations, making the assumption that the two groups are normally distributed.

Upon completion of data collection, thirty control subjects were randomly selected and measurements were repeated and recorded in a separate spreadsheet program Microsoft® Excel® to evaluate intra-examiner correlation.

RESULTS

General Descriptive Statistics

The families with dental agenesis consisted of 41 Caucasian, 1 African American, 3 Asian, 2 Hispanic, and 3 who identified themselves as other, resulting in a total of fifty families and 199 individuals. The forty control families were comprised of 35 Caucasian, 3 African American, 1 Hispanic, and 1 other, totaling 174 individuals. Non-Caucasian families were subsequently excluded from this study as stratifying data based on race resulted in a very small sample size for the different races. In addition, one individual from the affected group was excluded as there was no report of ethnicity. Another individual was excluded from the control group as they were the identical twin of the proband. Following exclusion of these families, measurements on 150 individuals in the affected and 137 individuals in the control group were analyzed.

Distribution of missing teeth among 41 probands reveal mandibular second premolars most commonly absent, followed by the maxillary lateral incisors and maxillary second premolars (Table 3). Missing measurements due to dental

agenesis, previously extracted teeth, restoration, and partial eruption were replaced as previously outlined under materials and methods section. Of 4,200 measurements for the affected group, a total of 799 were replaced as follows: Seven hundred thirty-three with the family specific mean for the tooth, 48 with the family specific mean for the contra-lateral tooth, and 18 with the mean established from the entire data set, as all family members were missing the specific tooth and its contra-lateral counterpart. Six hundred thirty-two measurements of the 3,836 observations in the control group were replaced, 596 with family mean for the specific tooth, 24 with the contra-lateral, and 12 with mean value for the entire data set.

TABLE 3.--Distribution of Dental Agenesis Among 41 Probands in Affected Group.

Tooth	Frequency of Dental Agenesis in Sample
Lower 5	24
Upper 2	15
Upper 5	10
Lower 1	6
Upper 7	2
Lower 7	1
Upper 6	1
Upper 3	1
Lower 2	1
Lower 3	0
Lower 4	0
Upper 1	0
Lower 6	0
Upper 4	0

Analysis of Tooth size

Means and standard deviations of tooth size for the affected and control groups are outlined in Table 4. Computed values for each tooth, anterior, middle and posterior segments of the arch, and total arch tooth size were compared using the Cochran-Cox two-sample t-test. For each of central incisor through second molars, measurements were combined to obtain seven values which represented the actual sum of the mesio-distal dimension for that tooth across all four quadrants. The critical t-value at the α = 0.05 level, based on sample size, was computed to be 1.977 for the control and 1.976 for families with tooth agenesis. Note that mean values for the anterior region, lateral incisor, and second molar are significantly smaller in families affected with tooth agenesis compared to control families (Table 4).

Maxillary and mandibular teeth were also analyzed independently to ascertain variation between the dental arches. Results of these analyses are summarized in Tables 5 and 6. Analysis of each dental arch individually, demonstrated statistically significant differences in the total size of maxillary teeth, the anterior region, lateral incisors and second molars, and mandibular lateral incisors and first molars. For all teeth analyzed, the mesiodistal

dimension was smaller in families affected with tooth agenesis compared to controls. However, not all teeth displayed statistically significant variation.

TABLE 4.--Mean ± Std. Dev. of Computed Values for Each Tooth, Segment and Total Tooth Size.

	Affected Families	Control Families	Test Statistics
Tooth 1	28.5 ± 1.6	28.6 ± 1.4	0.568
Tooth 2	25.3 ± 1.7	26.0 ± 1.4	3.851 *
Tooth 3	29.6 ± 1.7	29.6 ± 1.5	0.000
Tooth 4	28.4 ± 1.5	28.5 ± 1.5	0.560
Tooth 5	28.3 ± 1.3	28.4 ± 1.5	0.606
Tooth 6	43.4 ± 1.9	43.6 ± 2.0	0.848
Tooth 7	41.0 ± 1.8	41.5 ± 2.0	2.237 *
Anterior Region	53.7 ± 3.0	54.7 ± 2.6	3.039 *
Middle Region	58.0 ± 3.0	58.3 ± 2.6	0.9179
Posterior Region	112.7 ± 4.2	112.6 ± 5.4	0.173
Total Tooth size	224.5 ± 8.8	225.0 ± 8.8	0.480

* Statistically significant at $\alpha = 0.05$.

Heritability of Tooth Size

Heritability of tooth size was determined by using the calculations of familial correlation for total tooth size, each of anterior, middle and posterior segment, and the first tooth in each segment, in both the affected and control families. Since only information from nuclear families was gathered, the familial relationships evaluated included spousal, parent-offspring and sib-sib pairs. Spousal correlations were evaluated through hypothesis

TABLE 5.--Mean ± Std. Dev. of Computed Values for Each Tooth, Segment and Total Tooth Size in the Maxillary Arch.

Maxillary Teeth	Affected Families	Control Families	Test Statistics
Tooth 1	17.5 ± 1.0	17.5 ± 1.0	0.000
Tooth 2	13.3 ± 1.2	13.9 ± 0.9	4.758 *
Tooth 3	15.7 ± 0.9	15.8 ± 0.8	1.015
Tooth 4	14.1 ± 0.8	14.2 ± 0.8	1.048
Tooth 5	13.8 ± 0.8	13.9 ± 0.7	1.143
Tooth 6	21.3 ± 1.0	21.3 ± 1.0	0.000
Tooth 7	20.0 ± 0.9	20.3 ± 1.0	2.533 *
Anterior Region	30.7 ± 1.9	31.4 ± 1.7	3.244 *
Middle Region	29.8 ± 1.5	30.0 ± 1.3	1.185
Posterior Region	55.1 ± 2.1	55.5 ± 2.21	1.560
Total Tooth size	115.6 ± 4.6	116.8 ± 4.4	2.260 *

* Statistically significant at $\alpha = 0.05$.

TABLE 6.--Mean ± Std. Dev. of Computed Values for Each Tooth, Segment and Total Tooth Size in the Mandibular Arch.

Mandibular Teeth	Affected Families	Control Families	Test Statistics
Tooth 1	11.1 ± 0.6	11.1 ± 0.5	0.000
Tooth 2	12.0 ± 0.8	12.2 ± 0.6	2.404 *
Tooth 3	13.9 ± 0.9	14.0 ± 0.8	0.982
Tooth 4	14.2 ± 0.9	14.3 ± 0.8	0.979
Tooth 5	14.6 ± 0.6	14.7 ± 0.9	1.084
Tooth 6	22.1 ± 1.2	22.4 ± 1.3	2.035 *
Tooth 7	21.0 ± 1.0	21.2 ± 1.3	1.423
Anterior Region	23.1 ± 1.3	23.3 ± 1.1	1.386
Middle Region	28.1 ± 1.6	28.3 ± 1.4	1.119
Posterior Region	57.7 ± 2.4	58.2 ± 3.0	1.554
Total Arch	108.9 ± 4.5	109.8 ± 4.8	1.644

* Statistically significant at $\alpha = 0.05$.

testing to compare spousal correlations to zero. No significant difference was detected between spousal

correlations and zero, and consequently was fixed at zero. Parent-offspring correlations ranged between 0.1950 and 0.4636 for the affected families and 0.2498 and 0.6807 in the control families (Table 7). The anterior region; specifically the central incisor, showed the highest familial correlation in the families affected with tooth agenesis, while the posterior region demonstrated the highest correlations in the control families. Sib-sib correlations in affected families ranged from 0.2053 in the anterior region, to 0.4599 for the canines, and from 0.2183 for the central incisors to 0.6350 for the posterior region in the control families as seen in Table 8. All calculated values for familial correlations were positively related, indicating tooth size is a heritable trait.

TABLE 7.--Parent-Offspring Familial Correlations (± Standard Error).

	Affected Families	Control Families	P-Value
Total Arch	0.3394 ± 0.0967	0.5326 ± 0.0921	0.074
Anterior Region	0.4349 ± 0.0847	0.3719 ± 0.1012	0.683
Middle Region	0.2058 ± 0.1023	0.4107 ± 0.0959	0.072
Posterior Region	0.3023 ± 0.0959	0.6807 ± 0.0743	0.001 *
Central Incisor	0.4636 ± 0.0854	0.2643 ± 0.0994	0.936
Canine	0.1950 ± 0.1028	0.2498 ± 0.1007	0.352
First Molar	0.2989 ± 0.0899	0.6097 ± 0.087	0.007 *

* Statistically significant at $\alpha = 0.05$.

TABLE 8.--Sib-Sib Familial Correlations (± Standard Error).

	Affected Families	Control Families	P-Value
Total Arch	0.3828 ± 0.1481	0.5135 ± 0.1305	0.254
Anterior Region	0.2053 ± 0.1475	0.3758 ± 0.1441	0.204
Middle Region	0.4074 ± 0.1467	0.3943 ± 0.1428	0.535
Posterior Region	0.3516 ± 0.1494	0.6350 ± 0.1100	0.063
Central Incisor	0.2854 ± 0.1501	0.2183 ± 0.1472	0.625
Canine	0.4599 ± 0.1425	0.2893 ± 0.1474	0.797
First Molar	0.2568 ± 0.1496	0.5056 ± 0.1315	0.105

* Statistically significant at $\alpha = 0.05$.

Comparisons of heritability in tooth size between the affected and control families generally demonstrated no statistical differences, with the exception of the posterior region in parent-offspring correlations (Tables 7 and 8). In this region, the control families demonstrated a significantly higher correlation compared to the families affected with tooth agenesis. This may, in part, be due to the high proportion of missing values for first and second molars in the two samples.

Intra-examiner reliability was evaluated by repeating measurements for each tooth for thirty randomly selected individuals in the control group. Statistical analysis revealed correlations ranging from 0.958 to 0.999, indicating high intra-operator reliability in measuring tooth sizes (Table 9).

TABLE 9.--Intra-examiner Reliability Correlations.

	Tooth #1	Tooth #2	Tooth #3	Tooth #4	Tooth #5	Tooth #6	Tooth #7
Quadrant #1	0.993	0.993	0.992	0.992	0.990	0.965	0.997
Quadrant #2	0.991	0.993	0.992	0.997	0.988	0.997	0.999
Quadrant #3	0.979	0.990	0.993	0.992	0.992	0.996	0.999
Quadrant# 4	0.981	0.958	0.995	0.993	0.989	0.999	0.995

DISCUSSION

Seasoned clinicians can attest to variation in tooth size and form; specifically, to an increased prevalence of pegged laterals in families of individuals affected with dental agenesis. Several studies confirm a relationship between probands affected with oligodontia and their families (Schalk-van der Weide and Bosman 1996, 1992; Baum and Cohen 1971a, 1971b; Grahnén 1956). However, few have studied families with isolated cases of hypodontia. The current study was undertaken to examine the relationship between dental agenesis and tooth size. Nuclear families were evaluated to identify variation of tooth size and heritability of missing teeth in affected families compared to unaffected controls.

For each tooth type, central incisor through the second molar, the mesiodistal dimensions were summed across all four quadrants. These values were used to analyze each tooth-type, the total size of the dentition, tooth sizes in the anterior (central and lateral incisors), middle (canines, first and second premolars) and posterior (first and second molars) segments of the dentition, following a

stratification system first described by Clayton in 1956. Variation attributed to embryological factors was evaluated through analyses of the maxillary and mandibular arch independently, as well as the three segments, as they differ in their neural innervation and vascular supply.

When complete tooth mass in both arches were assessed, an analysis revealed a generalized reduction in the total tooth size in the maxillary, but not in the mandibular arch. This is perhaps due to variation in vascular and neural innervation (Kjaer 1997) and is contrary to Schalk-van der Weide *et al.* (1996) and Grahnén (1956) who reported a generalized reduction in tooth size throughout the entire dentition. However, it should be noted that these reports studied families of probands affected with oligodontia, who may have presented with diminished tooth size as a manifestation of underlying genetic and/or environmental factors leading to oligodontia.

Comparison of tooth size revealed the incisor region, in particular the lateral incisors, was significantly smaller in the affected families. Some authors have attributed this solely to environmental factors (Garn *et al.* 1979a; Bailit 1975; Sofaer *et al.* 1971). Sofaer *et al.* attributed alteration on lateral incisor morphology to insufficient primordia during tooth formation. Environmental factors may also be implicated in maxillary lateral incisor variability, as these teeth are formed by dental lamina located at the site

of embryonic fusion of the maxillary and medial nasal processes (Kjaer 1997). This viewpoint, however, is not supported by the current study, as heritability of tooth size in the anterior region indicates genetic factors have a significant contribution to tooth size in this region.

Reduced size of mandibular first molars in the current study can be explained by variation in morphology of this tooth. Davies (1968b) first reported an increased prevalence of four-cusped permanent mandibular first molar associated with decreased mesio-distal dimension amongst subjects affected with agenesis compared to unaffected controls. Davies also found smaller maxillary second molars in affected families. This variability may be attributable to increased contribution of environmental factors, as evident by decreased heritability values for the posterior region among affected families. However, these results must be accepted with caution, as these teeth presented with the highest proportion of missing values due to extractions, restorations, and partial eruptions, hence leading to potential error.

The present study also examined heritability of tooth size and dental agenesis through estimation of familial correlation. Familial correlations for each segment and the first tooth in each segment were calculated. These teeth were selected as they have historically demonstrated to be least affected by environmental factors (Butler 1939). Analysis of

results from the current investigation suggests that tooth size is a heritable trait in the Caucasian sample population. Heritability of tooth size can be estimated by doubling parent-offspring correlation (Elston 2000), leading to estimated h^2 values of 0.390 to 0.928 and 0.498 to over one for affected and control families respectively. The theoretical upper limit of heritability for first-degree relatives is 0.5. However, due to sampling fluctuation and environmental covariation (variation in phenotype due environmental or non-genetic factors), it may exceed 0.5, with upper boundaries approaching 1.0. Heritability of tooth size in the study sample was greater than those values of 0.445 and 0.652 for the maxillary and mandibular arch reported by Harris (1980). Harris and Johnson (1991) reported high heritability estimates for skeletal-based craniofacial components, while dental-based traits maintained estimates approaching zero. They attributed dental relations and occlusal similarities within families to common environmental factors rather than to heredity. The current study revealed a total arch length heritability estimate of 0.679 in affected families and over one in control families. Thus, it supports tooth size as a heritable trait under a genetic control mechanism.

Most studies of dental agenesis have attributed this trait to a polygenic model (Spoonhower 2003; Mossey 1999; Brook 1984), where the simultaneous segregation of many genes,

each with a small, but additive affect, contribute to the phenotype (Lynch and Walsh 1998). This model assumes that both genetic and environmental factors are combined into a single continuous variable, of normal distribution, where a large number of loci along with environmental factors contribute to the trait. A polygenic model, therefore, relies on a summary statistic of frequency alleles to quantify the degree of genetic control (Figure 2). Here agenesis occurs in those below a threshold level on the normal distribution.

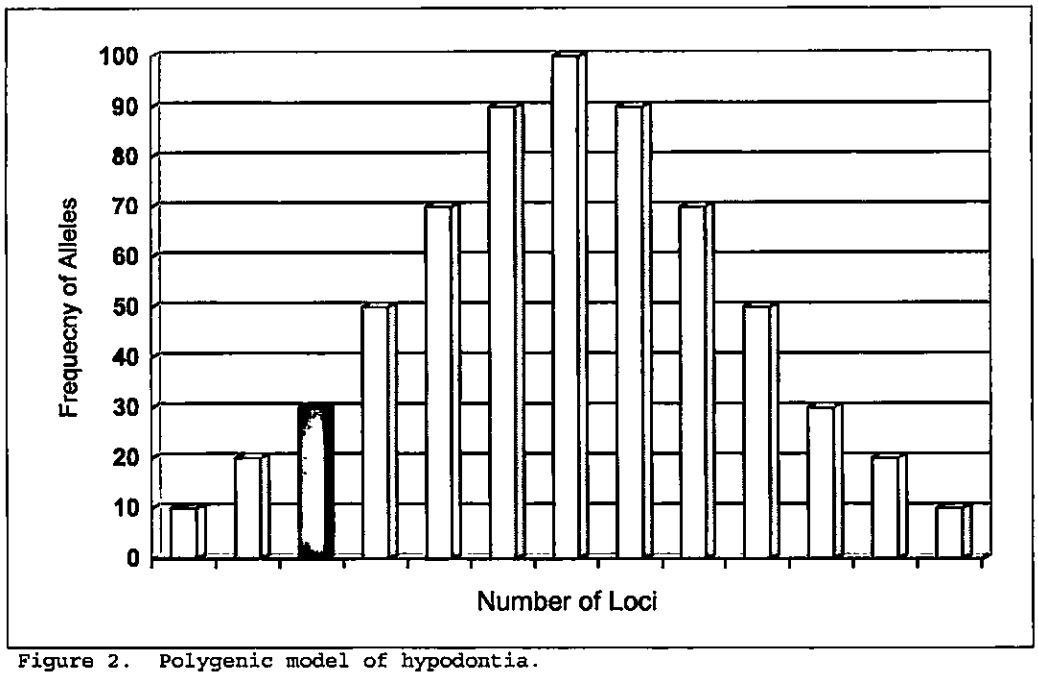


Figure 2. Polygenic model of hypodontia.

Comparisons of heritability in tooth size between affected and control families generally demonstrate no statistical differences, with the exception of the posterior region in parent-offspring correlations, where estimates of

0.6807 in control families, and 0.3023 in affected families were reported. It may be argued that, since genetic factors account for twice the variation in the control families versus affected families, the environment exerts an accentuated contribution to tooth size in the posterior segment. The posterior segment contains the non-succedaneous teeth in the dentition. This might predispose these teeth to alternative genetic and environmental controls during development. These results, however, could have been affected by the high proportion of missing values for first and second molars in the two samples, leading to potential bias during data replacement.

In genetic studies, twins, siblings and parents are the most common participants. Siblings resemble each other not only because they share on average one-half of their genes, but because they experience similar environments. Our study found sib-sib correlations that ranged from 0.205 to 0.460 for affected families and 0.218 to 0.635 for control families. These values are not consistent with the increased parent-offspring correlations calculated. Sibling correlations usually overestimate the genetic contributions, as they incorporate all acquired similarities which arise from inhabiting a common environment, a phenomenon termed "cohabitational effect" (Garn *et al.* 1979b). Therefore,

familial resemblance could be due to either a common genetic predisposition or common environmental factors.

The current study excluded third molars in both the selection criteria for agenesis and tooth size measurements. This was done since these teeth possess the highest prevalence of dental agenesis (Vastardis 2000; Haavikko 1971; Garn *et al.* 1962a; Grahnén 1956), and their frequent impaction makes mesio-distal measurement impossible. If third molars had been included in the selection criterion for dental agenesis, it might have revealed further differences in tooth size between the two groups. In the current study, individuals only missing third molars may have been included in the control group, contributing to misclassification bias. The inclusion of these teeth is a logical next step, as most studies which have reported decreased tooth size in those with dental agenesis accounted for the absence of this tooth (Garn and Lewis 1970; Davies 1968b). Furthermore, the identification of MSX-1 gene came from a forward genetic evaluation of a family with a pattern of agenesis that included third molars and second premolars, reinforcing the importance of this tooth in the characterization of this phenotype (Vastardis *et al.* 1996).

The current study suggests significant variability in tooth size from a multiplicity of genes and environmental factors leading to this phenotype. The development of the

dentition can be altered through many different genetic factors. Genetic modifiers, different alleles and mutations at different loci, may all account for the familial variability in patterns of dental agenesis and tooth size among affected members of the same family and in different families. Predisposing genotypes, once coupled with proper temporal and appropriate prenatal and postnatal environments, may lead to phenotypic variations in tooth morphology. Other diseases attributed to polygenic modes of inheritance include type I insulin dependant diabetes mellitus (CV = 0.525) (Alper *et al.* 2000), and Graves disease (CV = 0.2-0.4) (Stenszky *et al.* 1985).

The probability of the next patient in a dental chair possessing a polygenic trait, including dental agenesis, is a sigmoid function of the number of alleles summed over all loci. The nature of such variations suggests that strategies used in the current study will be well supplemented in the identification of such complex traits, by characterization of meaningful sub-phenotypes.

Tooth presence, position and shape are determined by multiple morphoregulatory and environmental factors. It is perhaps of no surprise there exists a wide variation in tooth morphology. The question remains whether genetics or the environment exert a greater influence on malocclusion?

SUMMARY AND CONCLUSIONS

In the present study, data on fifty nuclear families were collected, where at least one person in each family was affected with tooth agenesis of a permanent tooth, other than a third molar. Forty unaffected families served as the control group in order to estimate tooth size differences and heritability of tooth size between these groups. Analyses of the data led to the following conclusions:

1. Families affected with dental agenesis presented with smaller teeth in the anterior region, specifically the lateral incisors and second molars.

2. Diminished tooth size in families affected with agenesis in the anterior regions, specifically lateral incisors in the maxillary arch. In addition, maxillary second molars were smaller in these families. Furthermore, total tooth size in this arch was smaller in this group compared to controls.

3. Mandibular lateral incisors and first molars also presented with smaller mesio-distal dimensions in the families affected with tooth agenesis, compared to control families.

4. Parent-offspring correlations ranged between 0.195 and 0.681, indicating that tooth size is a heritable trait and under polygenetic control with a multifactorial etiology.

5. Only the posterior region in parent-offspring correlations demonstrated significant variation between the affected families and control families.

Of greatest significance, this study strengthens the frequent observation that occlusal characteristics run in families. This carries great implications for the etiologic basis of malocclusion, a malady for which millions seek treatment every year.

APPENDIX 1

Consent Form

and IRB Approval

Informed Consent:

The form required for voluntary participation in this study is included:

Assent and Parental Permission

Genetic Analysis of Congenital Hypodontia

You are being asked to participate in a research study dealing with the cause for missing teeth and tooth size. You were selected as a possible participant because you or a family member of yours has been identified with missing teeth, or to serve as an unaffected control.
Researchers at Case Western Reserve University are conducting this study.

Background Information:

The purpose of the study is to determine the reasons for missing teeth in family members. The absence of teeth, affects the position and size of the rest of your teeth, your bite, overall oral health and often, facial and dental appearance.

Procedures:

If you consent to participate in this study, we would ask you to do the following things:

- Allow us to count your teeth and assess if any teeth may be missing. Time needed: 1 minute. No instruments will be used.
- Complete a simple and short questionnaire. The questions will gather information about the age, race, teeth that may be missing, medical conditions, and your dental history. The time required will be within 3-4 minutes.
- Have you make a quick impression of your teeth for us by biting into an impression tray with putty like material. Approximate time required 2-3 minutes.

The total time involved will be approximately 7 minutes.

Risks and Benefits to being in the study:

There are no known risks to three procedures you are requested to undergo besides minimal discomfort or increased salivation during the impressions.
Your only benefit will be your contribution to the understanding of a complex and common condition.

Confidentiality:

Access to research records will normally be limited to the researchers. However, the University's Institutional Review Board (IRB) and other regulatory agencies, may review the research records to ensure that the rights of human subjects are being adequately protected. The information gathered via the clinical assessment, questionnaire, impressions, will be kept private. In any sort of report we might publish, we will not include any information possible that will make it possible to identify a participant. Research records will be kept in a locked room and only authorized researchers will have access to the records.

Please check one of the following

- ☐ I give permission for medical record and demographic information to be stored indefinitely
- ☐ I would like my medical record and demographic information destroyed after the stated project is completed

Voluntary nature of the study:

Your participation is voluntary, and your refusal to participate will not affect your current or future relation with the University. If you decide to participate, you are free to withdraw at any time without penalty or loss of benefits to which you are otherwise entitled.

Contacts and Questions:

The researchers conducting this study are Dr. Manish Valiathan and Dr. Mohammad Razavi. You may ask any questions you may have now. If you have questions later, you may contact them at (216) 368-0673 or (216) 368-4649.

If you would like to talk to someone other than the researcher's about (1) concerns regarding the study, (2) research participant rights, (3) research related injuries, or (4) other human subject issues, please contact Case Western Reserve University's Office of Research Administration at (216) 368-4510 or write:

Case Western Reserve University
Office of Research Administration
4 Adelbert Hall
10900 Euclid Avenue
Cleveland, OH 44106-7015

You will be given a copy of this form for your records.

Statement of consent:
I have read the above information. I have received answers to the questions I have asked. I consent to participate in the study.

Signature of the participant: Date

Signature of the Parent or Guardian Date

Signature of the person obtaining consent Date

Case Western Reserve University
Institutional Review Board
NOTICE OF APPROVAL

Responsible Investigator: **Manish Valiathan**
Department: **Dental Clinic Ortho**
IRB Protocol #: **20010605**
Title: ***Genetic Analysis of Congenital Hypoplasia***
Co-Investigator: **Mohammad Razavi**

Approval Date: **July 19, 2003**
Continuing Review Deadline: **July 3, 2004**
Expiration Date: **July 18, 2004**

The Institutional Review Board (IRB) has APPROVED the above new protocol through the full review process.

It has been determined that this study involves minimal risk, and that the following vulnerable populations will be involved: minors.

As an investigator of human subjects, your responsibilities include the following (see full description of responsibilities at our website):

1. Report all adverse events and unanticipated problems involving human subjects to the IRB Office, located in the Office of Research Compliance (ORC), within three (3) business days of your knowledge of the occurrence.
2. Provide the IRB with a complete Continuing Review form (available at the CWRU IRB Web Pages, or from the ORC) by the continuing review deadline noted above, and when the study is terminated.
3. Discontinue all work pertaining to this protocol if a continuing review approval is not finalized by the expiration date noted above.
4. Submit all proposed changes to the protocol to the IRB, and receive approval from the IRB, before implementation of the change.
5. Keep all research data and original consent documents in your possession for at least three (3) years after the study is terminated.

Questions? Please visit our website:
http://ora.ra.cwru.edu/orc_humansubjects_CWRU_IRB.asp

OR
contact our administrative office...

Isabel Sanchez, IRB Administrator
216.368.6993
Maureen Dore-Arshenovitz, IRB Assistant
216.368.6925
Fax: 216.368.3737

CASE Institutional Review Board
Office of Research Compliance
Sears Building 657
Cleveland, OH 44106-7230

APPENDIX 2

Questionnaire

Family Questionnaire to filled out by all Biological relatives

Family Identification Number: *To be filled in by the investigator*
Subject Number: *To be filled in by the investigator*

First Name: Last Name: Gender (circle): M F
Date of birth:
Address
Telephone

Ethnic Background /Race (you may circle more than one if necessary):

White African American/Black

Hispanic Asian

American Indian or Alaska Native

Native Hawaiian or other Pacific Islander

Other

**Please circle your relationship with _____:
Mother Father Brother Sister Other (specify)_____

1. Do you have any permanent teeth that are missing? (Circle) Yes No

2. If yes, why? (Circle) Cavities Gum disease Trauma Orthodontics Never formed

3. Does anyone else in your family, unavailable to fill out this form, have teeth that never formed?
   Yes No

4. If you answered Yes to the above question, is their relationship to you on your mothers or fathers side? How are they related to you? Please be specific.

APPENDIX 3

Tooth-Size in Families Affected with Dental Agenesis

Appendix 3 Tooth-Size in Families Affected with Dental Agenesis

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	Family ID	ID	MID	FID	Sex	DOB	Ethnic Background	11	12	13	14	15	16	17	21	22	23	24	25	26	27	31	32	33	34	35	36	37	41	42	43	44	45	46	47			
2	3	1	2	3	f	8/1/1980	African American	10 70	7 89	8 82	8 18	m	11.29	PE	10 14	7 82	N/E	8 09	m	11 10	PE	6 42	7 02	7 89	7 58	N/E	11 45	N/E	6 39	6 86	7 61	8 09	N/E	12 77	PE			
3	3	2	0	0	f	12/15/1961	African American	10 88	x	x	8 49	7 87	12.62	12.25	10 89	8 41	x	8 62	7 62	RS	12 62	6 16	6 66	RS	8 35	x	12.88	12 12	8 50	8 84	RS	x	RS	12.22	12.10			
4	3	3	0	0	m		African American	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Divorced		
5	3	4	2	3	m	3/25/1981	African American	11 68	9 19	9 53	x	8 08	12.41	11 81	11 89	8 45	x	8.24	8 18	12 42	x	7 07	8.02	8 86	x	RS	13 11	PE	7.00	7 72	8 67	8 04	x	13 48	12.41			
6	4	1	2	3	f	6/22/1985	White	8 75	8 94	7 74	7 01	7 13	10 94	PE	8 58	7 07	7 74	8 92	8 91	10 72	9 36	5 51	6 14	6 86	8.86	7.15	10 78	10 62	5 42	8 07	8.62	7 21	m	10 76	10.58			
7	4	2	0	0	f	1/30/1954	White	8 84	7 05	7 40	6 48	x	RS	9 15	8 82	7 00	7 99	6 85	x	RS	RS	5 48	6.24	8 91	6 75	x	RS	10 18	5 48	6 08	7 11	7 02	x	10 72	RS			
8	4	3	0	0	m	11/14/1951	White	RS	8 53	8 45	x	8 14	RS	RS	9.29	8 44	RS	x	7 86	RS	12.09	5 86	6.90	7 00	7 90	x	RS	11 96	5 86	6 45	7 60	RS	x	RS	12.44			
9	6	1	2	3	f	2/15/1964	other	7 98	m	7.27	6.72	m	9.73	9.45	8.09	m	7.24	6 63	m	10.03	9.28	4 88	5.35	9.27	6 86	7.13	10.85	10 19	4.57	5.20	6 03	6 70	7 11	10 71	10.25			
10	6	2	0	0	f	5/28/1955	other	7 08	5 42	7 61	6 95	6 73	9 90	x	7 98	6 58	7 74	7.24	x	x	x	5 04	5 55	6 73	6 67	7 08	10 98	9 71	4 99	5 64	7 04	6 76	7 03	RS	x			
11	6	3	0	0	m		other	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Where about unknown		
12	9	1	2	3	m	5/2/1988	White	9 18	7.41	8 09	7 48	m	11.06	N/E	8.82	7.26	8 19	7.38	7 41	10 88	N/E	8 96	8 01	7 16	7 48	m	11 65	PE	5 75	5.81	7.09	7 48	m	11 78	N/E			
13	9	2	0	0	f	2/11/1967	White	9 07	7 53	8 01	RS	RS	10 44	10.26	9 02	8 77	7 84	7 56	7 07	10 15	x	5 83	5 63	6 73	7 74	7 91	11 80	11 53	8 96	5 67	8 85	7 15	RS	12.05	10 56			
14	9	3	0	0	m	12/10/1944	White	8 72	7.24	8.23	RS	RS	x	x	8.82	8 66	7 81	x	RS	RS	RS	5 37	x	7 09	8 93	7 59	x	x	5 42	8 08	7.10	RS	RS	RS	11 41			
15	13	1	2	3	m	7/28/1958	White	8 04	8 18	7.96	8 95	N/E	10.43	N/E	8.01	8 04	8.35	PE	N/E	10 69	N/E	5 35	5.87	8 81	7.00	m	10 96	N/E	5.31	8.01	7 03	8 95	m	10 61	PE			
16	13	2	0	0	f	10/5/1961	White	7 33	8 08	8 57	8.42	8 76	10.20	8.62	7 43	8.04	7 71	8 89	8 75	9 47	9 00	4 57	5 83	8 30	8 60	5 90	9 12	8 91	4 78	5 56	6.83	8.24	m	9 12	8 97			
17	13	3	0	0	m		White	RS	8 65	7 72	RS	RS	RS	10 70	8.24	8 69	7 53	8 99	8 30	RS	10 17	5 53	6 11	7 41	8 96	7 72	x	11 02	5.21	8 04	6.87	7.17	7 71	x	RS			
18	13	4	2	3	m	5/18/1980	White	8 09	8 91	N/E	7 38	8 98	10 17	N/E	8.02	7 05	7 87	7 49	RS	RS	N/E	6 07	6 94	8 91	7 51	N/E	10 79	N/E	5.22	6.21	7.02	7 42	N/E	10 82	N/E			
19	13	5	2	3	f	4/8/1985	White	7 93	5 34	7 71	8 94	7 17	10 31	10 09	7 84	8 48	7 45	8.26	7 09	10 96	9 72	5.22	5 63	7.22	8 41	m	10 32	10 30	5 13	5 39	7 12	5 70	m	10 02	9 15			
20	13	6	2	3	m	francis	White	7 89	8 44	7 86	8 46	8.86	10 06	9 58	8 03	8 85	7 85	8 02	8 61	10 48	9 34	4 90	5 92	7 55	8 72	8 85	9 52	8 86	4 98	6 89	7.22	8 64	N/E	9 84	9 48			
21	13	7	2	3	f	3/4/1982	White	7 48	5 65	N/E	N/E	N/E	9.05	N/E	7 40	8 04	N/E	N/E	N/E	9 38	N/E	8 04	5 40	N/E	N/E	N/E	9 40	N/E	5 00	5 31	N/E	N/E	N/E	9 62	N/E			
22	15	1	2	3	f	12/8/1968	Asian	8 31	7 12	8 32	7 58	RS	RS	10.21	8.33	7.09	7.93	7.82	8 72	11.86	10 61	5.36	5.87	8 73	7 92	8.96	RS	PE	m	5 49	7.01	7 93	RS	11 63	PE			
23	15	2	0	0	f		Asian	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Adoptive Parents		
24	15	3	0	0	m		Asian	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Adoptive Parents		
25	15	4	0	0	f	12/8/1966	Asian	8 72	7 84	7 91	7 63	8.82	11 37	11.24	8 78	7 83	7 62	7 39	6 91	11.28	11.21	5 67	6 74	6 66	7 86	7 85	11 84	PE	5 47	5 78	6 94	7 72	7 79	11 86	11.21			
26	16	1	2	3	f	2/8/1986	White	8 32	m	PE	8 71	7 03	RS	PE	8 51	m	8 09	8 96	8.87	RS	PE	5.27	6 18	8 78	7.09	7.57	10 40	PE	5 52	6 15	6.70	7.28	7 62	10 40	PE			
27	16	2	0	0	f	10/8/1967	White	8 66	8 16	7 55	7 14	8 57	9 42	9 07	8 93	8 84	7 31	8 56	8.21	9 70	8 27	6 13	5 66	6 48	8 12	8 87	10 30	9 75	5.22	8 77	8 89	8 74	7 06	10 17	9 53			
28	16	3	0	0	m	8/8/1963	White	9.25	8 87	7 84	RS	RS	x	10 04	9 14	8 66	8 11	7 19	7 16	x	10 04	5 34	6 06	7.27	7.28	RS	RS	x	5 42	8.96	7.23	7 06	8 68	11 89	10 37			
29	16	4	2	3	f	9/27/1991	White	8 76	8.21	N/E	7 38	N/E	10.29	PE	8.86	8 70	N/E	8 41	N/E	10 01	PE	5 36	6 33	N/E	N/E	N/E	10.14	PE	5 37	8 11	8 83	PE	N/E	10.08	PE			
30	20	1	2	3	f	12/18/1980	White	8 53	5 74	8 96	7.20	8 81	10.08	N/E	8.22	m	7 00	7 04	8 66	10.26	N/E	5.27	5 32	6.28	8 62	8.96	10 86	10.31	4 73	5.81	6.09	6.55	N/E	10 79	N/E			
31	20	2	0	0	f	3/18/1980	White	8 31	8 08	7 18	8 89	8 80	9 86	9 47	8 48	8.24	7.20	R	8 73	RS	RS	5 82	5 73	6 30	7 13	7 18	10 79	RS	5 58	5 74	6 40	8.83	7 14	RS	9 96			
32	20	3	0	0	m	1/15/1980	White	RS	8 14	7 86	7 44	8.24	11 15	9 97	8 66	5.27	8 01	8 86	8 85	10 74	9 94	5.29	5 86	8 87	6 84	m	10 41	9 32	x	8.09	7 44	8 08	8 76	RS	9 96			
33	21	1	2	3	f	12/2/1982	White	8.25	m	N/E	N/E	N/E	10 63	N/E	9 10	m	N/E	N/E	N/E	10.42	N/E	5.33	5.75	N/E	N/E	N/E	10.30	N/E	5 72	5 79	N/E	N/E	N/E	10 38	N/E			
34	21	2	0	0	f	5/27/1962	White	8 58	7 15	8.25	x	8 44	RS	9 32	8.51	7 58	8 07	x	8 19	RS	9 31	5 59	6 18	6 74	8 80	7 02	10 49	9 78	5 68	8 02	8 98	7 19	RS	10 61	9 54			
35	21	3	0	0	m	10/8/1967	White	8 63	7.01	7 70	x	8 31	10 61	9 50	8 02	7 14	7 72	8 86	8 33	RS	8 12	5 76	5 93	6 79	8 56	RS	RS	9 77	5 84	5 80	7 14	8.45	8 78	11 13	10.26			
36	21	4	2	3	f	1/16/1987	White	8 96	N/E	N/E	N/E	N/E	10.27	N/E	9 84	N/E	N/E	N/E	N/E	10 33	N/E	5 96	5 80	N/E	N/E	N/E	10 63	N/E	5 71	5 97	N/E	N/E	N/E	10 71	N/E			
37	25	1	2	3	m	5/28/1985	White	9 43	8 53	8 36	7 40	8 81	10 62	9.91	9 09	8 35	8 31	7 87	7 43	10 00	9 34	5.49	5 85	8 76	7.36	m	11 71	10.34	5 44	6.03	8 75	7.23	m	11.59	10 69			
38	25	2	0	0	f	5/26/1958	White	7 51	5 85	7 71	8 94	RS	RS	PE	7 71	6 05	7 38	8 85	7 05	RS	PE	5.25	5.72	8 89	8 18	m	10 89	10 08	5 82	5 48	6 57	8 89	m	RS	9 57			
39	25	3	0	0	m	11/6/1964	White	8 62	8.26	7 47	8.79	RS	10 67	10.24	8 81	8 66	7 47	8 74	8 14	10 60	PE	5 04	5 80	6 56	8 63	8 45	RS	9 96	5 00	5 81	7.27	8.80	8 50	RS	9 96			
40	25	4	2	3	m	9/27/1980	White	8 44	8 42	7 56	8.61	8 06	11 14	9 16	8 65	8 43	7 98	8 84	8 65	11 07	9 74	5.23	5 98	7 48	8 47	8 76	10 83	9.72	5 55	5 58	7 59	8 43	8 72	11 33	9 49			
41	25	5	2	3	m	6/8/1987	White	8 96	8 91	7 96	8 88	8 96	10.29	N/E	8 82	8.20	7.28	8 76	8 96	10 71	N/E	5 45	5 61	8 66	9.57	8 94	11.24	N/E	5 73	5 85	6 87	8 84	7.26	10.85	9 61			
42	27	1	2	3	f	7/8/1969	Other	8 58	m	7 12	7 05	7 12	11 34	10 39	9 53	m	7 12	7 08	8 84	11.24	10 32	6 04	6 15	6 83	7 48	7 59	11 78	PE	5 96	6.24	8 82	7 46	7 87	11 72	PE			
43	27	2	0	0	f	10/8/1968	Other	9 04	8 41	7 35	7 10	8 73	9 51	PE	8 90	8 10	7 32	7 01	8 69	9 96	9 35	5 60	5 99	8 51	8 92	8 93	10 63	10.27	5 49	8 17	8 55	8 71	7 07	10 48	10 37			
44	27	3	0	0	m	8/7/1958	Other	8.81	x	7 89	8.48	7 12	x	9 96	8 84	x	x	8 04	x	x	9 73	5 40	6 03	7 07	7 10	8 97	x	x	5 33	8 17	8.97	8 85	7 43	11.29	x			
45	27	4	2	3	m	10/1/1991	Other	9 30	8.21	7 70	7 05	8 82	10 92	N/E	9.27	8 63	7 67	8 43	7 04	10 84	N/E	5 87	6 91	7 37	8 90	7 78	11.25	N/E	5 84	8.69	7.21	7.24	7 87	11 56	11 00			
46	27	5	2	3	m	5/19/1988	Other	8 41	8 07	8 91	7.05	8 91	10 48	10.21	8.36	8 00	N/E	8 63	8.26	10 57	10.20	5 64	6 39	9 78	8.27	8 84	10 33	10 18	5 75	8.22	8 71	8 89	8 89	10 85	10 13			
47	30	1	2	3	f	8/28/1988	White	8 97	8 48	7.51	8 90	N/E	10.08	N/E	9 04	8.42	7.43	6.85	N/E	10 30	N/E	5 74	6.36	7 16	7.46	m	11.71	N/E	5.75	8.20	8 89	7 31	m	11 61	N/E			
48	30	2	0	0	f	12/5/1955	White	7 86	8 42	7 62	8 61	x	RS	9 48	7 97	8 93	7 58	RS	x	RS	10.25	5 35	5 70	8 63	8 89	x	RS	x	8.23	8 68	8 48	8 83	x	RS	RS			
49	30	3	0	0	m		White	9 32	7.23	7 95	RS	RS	10 16	PE	9 51	8 30	8.22	RS	RS	RS	10 33	5 61	6 58	7 55	7 36	7 84	RS	11 69	5.88	6.35	7 42	7 46	RS	RS	11.21			
50	30	4	2	3	m		White	9 16	8 93	N/E	N/E	N/E	11.21	N/E	9 19	8 57	N/E	7.28	8 98	11 48	N/E	5 79	6 34	N/E	N/E	N/E	11 03	N/E	5 90	6 36	N/E	7 84	N/E	11.25	N/E			
51	36	1	2	3	f	12/4/1990	White	10.09	m	9 13	7 91	7.23	10 98	PE	10.21	8.83	8.14	8.00	7 51	11 04	PE	6 07	8 99	7 72	7.96	x	11.45	PE	6 38	7.08	7 86	8 10	x	11 37	PE			
52	36	2	0	0	f	12/29/1985	White	8 90	8 66	x	7 18	7.28	10 41	10.27	8 91	7 31	7 42	7 36	7 42	10 42	10 04	5 84	5 79	7 12	7.27	7.28	10 82	9 83	5 13	5 86	8 94	7 62	7 57	10 98	10 58			
53	36	3	0	0	m	6/14/1962	White	9 41	7 06	8 16	7 11	7 31	x	11.29	9 51	7.24	8 31	7 12	6 74	11 31	10.21	8.21	8.26	8 89	7 39	7 67	x	x	6 13	8.53	7 48	7.38	7 49	11 31	x			
54	36	4	2	3	m	12/10/1982	White	8 93	7.29	8 32	7 98	7 74	9 88	N/E	8 98	7 34	8 42	7 78	7 69	10.24	N/E	8 08	8 33	7 76	8 32	7 50	11 42	N/E	5 83	6.23	7 42	8 00	7 71	11 08	11 39			
55	37	1	2	3	f	1/8/1970	White	7 95	8.39	7 41	8 31	5 87	9 84	8 78	7 82	5 41	7.50	8.28	8 04	9 75	8 93	5.27	5.21	6 61	6 45	m	10 02	9 38	5.14	5.23	6 70	8 89	m	10 10	9 37			
56	37	2	0	0	f	5/8/1942	White	x	m	x	x	x	x	x	x	m	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Edentulous		
57	37	3	0	0	m		White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Deceased		
58	37	4	2	3	m	12/2/1986	White	9 58	m	8.32	7 48	8 07	11.18	10.26	9 56	m	8 15	7 33	8 80	11 14	10 16	x	8.09	7 78	7 34	7 42	11.23	10 16	5.34	6 05	7 84	7 39	7 33	11 62	10.22			
59	39	1	2	3	m	12/2/1986	White	9 05	m	N/E	7.28	N/E	11 48	PE	8 98	m	N/E	7.48	8 74	11 51	11.17	5.83	6 81	7 57	7 67	N/E	12.17	PE	5 77	6.74	8.91	7 76	7.28	12.36	N/E			
60	39	2	0	0	f	3/28/1965	White	8 05	8 19	7 49	8 81	8 34	9 97	9 58	7 69	8 17	7 13	8 65	8 53	9 86	9 77	8.18	8 67	8 73	7 17	7 12	10.28	10.20	4 96	5 61	6.79	8 83	7 09	10 43	9 86			
61	39	3	0	0	m	7/19/1963	White	RS	m	RS	7 17	7 00	11 37	11 07	RS	m	RS	7 45	8 67	10 80	PE	5 66	6 13	7 17	7 61	7 83	11 94	11 83	5 87	6.68	6.85	7 35	7 66	11 73	11 44			
62	39	4	2	3	m	3/1/1985	White	8 85	8 95	N/E	7 13	8 96	10 48	9 85	9 17	8 79	N/E	7.48	7 03	10.24	9 96	5 62	5 96	8 66	8 48	7 64	11.26	PE	5.85	5 98	8 44	7 08	7.48	11 33	PE			
63	39	5	2	3	m	9/17/1990	White	7 47	4 06	8 37	7 07	6 81	9 80	PE	7 87	4 34	N/E	8 79	8 89	9 45	N/E	8 11	5 67	8 74	8 84	7 04	10.32	N/E	5.19	5.48	8 68	8.82	8 85	10 83	9 97			

Appendix 3 Tooth-Size in Families Affected with Dental Agenesis

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
64	40	1	2	3	f	11/26/1958	White	9.06	6.69	7.84	7.05	6.39	10.06	9.52	7.94	6.18	7.69	6.91	5.53	10.07	9.49	m	5.10	6.18	6.86	6.89	10.36	9.73	m	5.24	6.40	7.05	9.98	10.30	9.68			
65	40	2	0	0	f	11/8/1961	White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	4.05	4.97	5.38	RS	RS	x	x	4.49	5.16	6.23	7.16	x	RS	x			
66	40	3	0	0	m	6/12/1944	White	RS	RS	RS	6.96	x	RS	9.01	RS	6.93	8.27	x	RS	RS	RS	5.32	6.24	7.73	7.30	6.90	9.90	10.04	5.22	6.36	7.43	7.05	RS	RS	10.35			
67	40	4	2	3	m	6/20/1963	White	8.16	7.28	8.03	7.61	7.32	RS	10.07	8.08	6.96	8.15	7.42	7.21	RS	PE	5.21	6.12	7.64	7.11	7.82	10.64	10.41	5.45	6.14	7.33	7.26	7.58	10.85	10.58			
68	41	1	2	3	f	3/14/1981	White	8.87	6.36	N/E	7.91	7.07	10.14	N/E	8.96	8.12	8.15	7.90	7.35	10.26	N/E	5.96	5.71	7.36	7.55	N/E	10.51	N/E	5.85	m	7.07	7.77	7.59	10.36	N/E			
69	41	2	0	0	f	4/8/1963	White	9.37	7.17	8.23	x	6.63	x	10.26	9.36	6.96	7.79	x	7.39	x	x	x	6.02	6.41	x	x	x	10.63	x	6.09	6.55	7.01	7.74	x	10.58			
70	41	3	0	0	m	9/3/1962	White	9.49	6.62	7.67	x	x	x	10.14	8.36	6.00	7.34	x	x	x	x	5.62	5.92	6.20	7.43	7.04	x	x	5.40	5.75	6.15	6.99	7.09	x	x			
71	41	4	2	3	m	3/19/1990	White	8.78	6.62	8.37	7.38	7.17	10.82	10.01	8.59	6.61	8.47	7.14	6.98	10.71	10.02	5.71	6.21	7.36	7.70	7.41	11.31	10.81	5.79	6.12	7.32	7.74	7.66	10.82	PE			
72	42	1	2	3	f	1/8/1969	Asian	8.09	6.72	7.63	7.47	7.46	10.79	PE	8.21	5.77	N/E	7.45	7.26	10.98	10.15	m	6.13	6.55	7.03	7.25	11.61	10.05	5.61	5.56	6.43	7.17	7.41	11.64	PE			
73	42	2	0	0	f		Asian	8.82	5.67	7.20	6.78	6.63	x	9.14	8.25	5.78	6.68	6.37	6.59	10.12	9.28	m	5.66	5.83	6.75	6.94	10.68	x	5.39	5.56	6.28	6.86	6.90	11.24	10.10				
74	42	3	0	0	m		Asian	9.24	8.12	8.18	7.78	7.44	10.07	10.62	9.18	8.02	8.28	7.82	RS	RS	RS	6.19	6.92	7.42	7.67	7.31	11.78	11.36	6.25	6.76	7.43	7.61	7.23	11.35	11.44				
75	43	1	2	3	m	11/27/1978	White	8.02	m	7.64	6.44	6.26	10.75	10.39	8.51	m	7.13	6.83	6.18	10.38	10.18	4.48	5.35	6.51	6.23	m	RS	10.21	4.72	5.06	6.32	6.58	6.63	RS	10.65			
76	43	2	0	0	f	7/14/1955	White	8.34	6.19	8.25	RS	RS	RS	x	8.29	7.18	7.72	RS	RS	RS	x	5.46	6.34	6.86	6.82	x	RS	10.31	5.44	6.42	6.89	7.26	x	x	RS			
77	43	3	0	0	m	1/16/1952	White	7.26	m	x	x	7.07	10.16	10.01	7.24	m	x	x	6.28	10.26	10.21	x	x	x	x	m	RS	RS	x	x	x	6.06	m	RS	RS			
78	43	4	2	3	f	5/5/1982	White	7.73	5.92	7.32	7.11	7.00	10.56	9.05	8.07	5.83	7.33	7.21	7.07	10.18	9.15	4.71	5.75	6.13	6.92	m	11.01	9.79	5.35	5.49	6.28	7.14	m	10.69	9.83			
79	46	1	2	3	f	1/16/1966	Other	8.44	7.01	8.47	7.39	7.42	11.04	PE	8.62	7.12	8.06	7.65	7.09	10.77	PE	m	6.22	7.70	7.78	7.71	11.85	PE	m	6.20	7.43	7.96	7.78	12.17	PE			
80	46	2	0	0	f		Other	8.35	7.64	8.19	6.74	6.53	10.12	9.70	8.37	7.70	7.96	6.93	6.06	10.62	9.61	4.66	6.11	7.28	7.25	6.59	x	10.09	4.97	6.22	6.96	6.52	6.63	11.55	x			
81	48	3	0	0	m	10/15/1942	Asian	9.38	7.16	x	x	x	x	x	9.07	6.61	7.85	x	6.60	11.30	x	5.58	5.99	7.14	7.21	7.34	11.84	10.45	5.54	6.11	7.05	6.90	7.34	11.67	11.03			
82	46	4	2	3	m	7/12/1962	Other	8.69	6.95	7.81	7.32	6.15	10.56	9.76	8.97	6.97	7.75	6.96	6.35	10.52	10.07	5.65	6.32	7.13	6.66	6.94	10.89	9.98	5.58	6.31	7.44	6.79	6.89	11.40	10.28			
83	47	1	2	3	f	6/29/1967	White	8.69	7.10	7.63	7.23	m	11.12	10.49	8.51	6.84	7.53	7.29	m	10.96	10.54	5.14	6.81	7.23	7.26	x	11.32	10.93	6.11	6.84	7.11	7.26	m	11.30	10.92			
84	47	2	0	0	f		White	8.73	6.29	7.68	6.70	x	11.41	RS	8.96	6.21	7.73	6.70	x	10.43	RS	5.72	6.11	6.57	6.65	x	10.77	RS	6.16	6.34	6.67	6.72	x	11.18	RS			
85	47	3	0	0	m	5/27/1964	White	9.48	x	RS	7.36	m	RS	RS	9.62	x	8.41	RS	7.34	10.73	10.09	x	6.67	7.09	7.66	7.97	12.48	11.13	x	6.66	7.09	7.69	RS	11.96	11.59			
86	47	4	2	3	f	4/8/1984	White	9.03	6.24	8.15	6.80	m	11.14	11.10	8.96	6.28	7.82	6.69	m	11.28	10.65	6.19	6.82	6.75	6.94	8.17	11.96	11.30	6.09	6.06	7.00	7.34	6.00	12.01	11.44			
87	49	1	2	3	f	2/25/1991	White	8.43	5.53	N/E	7.36	6.86	10.31	PE	8.77	m	N/E	7.19	7.24	11.27	PE	5.31	5.81	6.94	7.27	7.03	11.31	PE	5.32	6.14	7.14	7.66	6.71	11.21	PE			
88	49	2	0	0	f	8/21/1958	White	8.27	4.56	7.19	6.21	5.87	9.96	x	8.20	m	7.10	6.27	6.26	10.08	PE	4.76	5.61	6.22	6.59	7.06	10.65	PE	4.79	5.22	6.33	6.87	6.92	10.63	PE			
89	49	3	0	0	m	3/27/1968	White	9.71	6.25	7.68	6.82	6.86	11.77	10.17	RS	6.23	7.43	6.48	6.62	11.48	10.31	6.25	5.78	7.43	7.30	7.37	11.61	10.28	x	5.46	7.24	7.19	7.23	11.27	9.96			
90	49	4	2	3	f	12/15/1986	White	8.01	6.11	7.64	7.09	6.49	10.49	N/E	8.66	6.13	7.96	6.86	6.57	10.96	10.05	5.14	5.49	6.99	6.83	6.82	10.91	10.53	5.17	5.39	6.83	7.01	7.36	10.81	N/E			
91	49	5	2	3	f	5/5/1969	White	8.10	6.19	7.63	7.03	6.26	11.67	PE	8.35	6.67	7.07	6.86	6.51	11.33	10.41	4.83	5.23	6.32	6.69	6.36	11.65	PE	4.90	5.11	6.41	6.59	6.51	11.67	10.98			
92	50	1	2	3	m	9/27/1967	White	8.50	7.00	N/E	N/E	N/E	10.33	10.28	8.41	6.05	N/E	6.81	N/E	10.25	10.09	5.66	6.12	7.27	7.73	m	10.74	PE	5.58	6.06	6.96	7.69	m	10.79	PE			
93	50	2	0	0	f	5/26/1948	White	8.63	5.87	RS	RS	RS	RS	RS	8.96	6.22	7.37	RS	RS	RS	RS	5.74	5.89	6.01	RS	RS	RS	RS	5.81	6.39	6.67	RS	RS	RS	RS			
94	50	3	0	0	m	2/23/1947	White	9.10	6.62	7.82	x	6.32	x	x	9.06	6.64	8.51	7.39	6.73	x	x	5.34	6.42	7.47	8.05	RS	x	x	5.11	x	6.82	6.84	x	x	10.66			
95	51	1	2	3	f	3/13/1986	White	8.20	m	N/E	N/E	N/E	10.76	N/E	8.27	4.36	N/E	7.27	N/E	10.63	N/E	5.37	6.17	7.01	7.22	N/E	10.99	N/E	5.52	6.11	7.12	7.58	N/E	11.00	N/E			
96	51	2	0	0	f	8/8/1963	White	8.41	6.63	7.73	7.06	6.96	x	RS	8.43	6.19	7.92	6.94	6.96	10.57	7.58	5.64	5.66	6.34	7.14	RS	RS	RS	5.69	6.18	6.71	7.18	RS	RS	10.03			
97	51	3	0	0	m	6/31/84	White	8.29	6.17	8.06	7.28	7.63	11.67	11.72	8.48	4.85	8.79	7.44	7.28	12.05	10.78	5.69	6.29	8.04	7.32	7.84	12.03	10.84	6.06	6.31	8.22	7.58	7.71	11.26	10.56			
98	51	4	2	3	f	6/11/1969	White	9.30	7.01	8.17	7.12	6.77	11.19	9.52	9.07	6.96	8.36	6.77	6.93	11.28	RS	5.77	6.82	7.04	6.95	7.22	11.09	10.11	5.99	6.69	6.92	7.03	7.10	11.10	10.10			
99	51	5	2	3	f	9/16/1984	White	8.92	6.75	7.87	6.63	6.61	10.53	PE	8.57	6.85	7.78	6.76	6.66	10.21	10.58	5.94	6.26	6.96	7.09	7.11	RS	10.29	5.61	6.47	6.71	6.87	7.09	11.48	10.39			
100	51	6	2	3	m	3/25/1962	White	8.77	7.76	8.54	7.87	7.23	10.91	9.76	8.72	7.31	8.41	7.90	7.21	10.97	N/E	5.84	6.29	7.68	8.07	7.96	12.21	11.11	6.60	6.11	7.66	RS	7.78	12.09	11.02			
101	51	7	2	3	f	12/28/1991	White	7.78	6.31	7.62	6.77	N/E	10.06	N/E	7.61	6.44	7.11	6.96	N/E	10.24	N/E	4.97	6.21	6.79	7.10	N/E	11.04	N/E	5.12	6.65	6.59	6.81	N/E	11.05	N/E			
102	51	8	2	3	f	7/1/1986	White	8.24	N/E	N/E	N/E	N/E	10.05	N/E	8.19	N/E	N/E	N/E	N/E	10.45	N/E	5.41	5.65	N/E	N/E	N/E	10.64	N/E	5.54	5.62	N/E	N/E	N/E	10.61	N/E			
103	56	1	2	3	m	11/5/1991	White	8.51	5.67	8.25	N/E	N/E	m	m	8.43	RS	m	N/E	N/E	m	m	5.78	5.70	6.83	N/E	N/E	11.34	m	5.45	5.83	7.48	N/E	N/E	11.35	N/E			
104	58	2	0	0	f	8/14/1960	White	9.53	RS	8.90	7.01	6.55	10.26	m	9.37	RS	8.53	6.83	6.36	10.05	m	6.48	5.43	7.03	6.95	7.28	8.91	x	5.58	5.92	7.36	7.14	7.05	10.32	9.72			
105	58	3	0	0	m		White	8.63	7.72	8.43	x	6.94	9.81	9.67	8.77	6.90	8.19	x	7.22	10.14	9.96	5.90	6.49	7.28	x	7.19	RS	10.43	5.46	6.95	7.64	x	7.42	11.01	10.87			
106	57	1	2	3	f	6/29/1967	White	9.37	m	7.17	6.36	6.74	9.43	8.94	8.38	m	6.69	6.84	6.49	9.54	9.42	5.00	5.54	5.47	6.55	6.56	9.83	9.50	4.89	5.68	6.34	6.62	6.81	9.75	9.64			
107	57	2	0	0	f	8/1/1967	White	8.92	5.74	7.19	7.15	6.75	10.06	10.43	9.36	8.05	7.21	7.27	7.10	10.59	11.04	5.23	5.63	6.59	7.21	7.43	11.78	11.52	5.26	6.05	6.82	7.30	7.27	12.12	11.47			
108	57	3	0	0	m	9/30/1965	White	9.24	7.32	8.07	7.19	7.01	9.94	9.71	9.70	7.14	8.08	6.96	6.36	10.02	PE	5.80	6.48	7.05	7.03	7.12	10.86	9.84	5.62	6.52	6.83	7.02	6.79	RS	10.28			
109	57	4	2	3	f	6/16/1963	White	8.83	6.51	N/E	N/E	N/E	9.94	N/E	9.36	6.63	N/E	N/E	N/E	10.17	N/E	5.97	6.32	6.78	N/E	N/E	11.14	N/E	5.79	6.31	7.14	6.28	N/E	11.12	N/E			
110	57	5	2	3	f	3/2/1996	White	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E	N/E			
111	59	1	2	3	f	10/8/1960	White	8.36	m	N/E	N/E	N/E	10.17	N/E	8.20	m	N/E	N/E	N/E	10.08	N/E	5.19	5.92	N/E	N/E	N/E	10.16	N/E	5.23	5.89	N/E	N/E	N/E	PE	N/E			
112	59	2	0	0	f	10/16/1959	White	8.95	6.84	7.97	6.85	RS	RS	PE	8.61	6.40	7.77	6.95	6.84	RS	PE	5.92	6.46	6.63	7.08	7.41	11.04	10.12	6.02	6.41	6.70	7.70	7.34	RS	10.72			
113	59	3	0	0	m	8/25/1957	White	8.27	5.82	8.07	7.09	6.99	RS	9.37	8.59	5.57	7.99	7.15	7.14	10.82	10.78	5.23	5.39	7.40	7.24	7.63	RS	10.67	5.18	5.52	7.68	7.28	7.65	10.79	10.77			
114	59	4	2	3	m	6/12/1986	White	8.62	6.24	8.23	7.46	7.24	10.48	9.73	8.57	6.15	8.05	7.13	7.28	10.70	10.04	5.65	6.19	6.79	7.43	7.65	10.74	10.69	5.55	6.28	6.96	7.61	7.96	10.33	PE			
115	59	5	2	3	m	9/19/1962	White	8.97	7.14	N/E	N/E	N/E	10.05	N/E	8.42	6.64	N/E	N/E	N/E	10.67	N/E	5.73	6.57	N/E	N/E	N/E	10.77	N/E	5.66	5.61	N/E	N/E	N/E	10.83	N/E			
116	61	1	2	3	f	3/25/1991	Arabic	9.86	7.40	7.90	7.42	N/E	11.64	N/E	9.51	7.51	7.90	7.63	6.94	11.39	N/E	5.87	6.37	7.49	N/E	m	11.67	PE	5.91	6.41	6.63	N/E	m	11.78	N/E			
117	61	2	0	0	f	11/12/1964	Arabic	8.39	7.27	7.84	6.91	RS	11.17	9.80	8.36	7.41	7.73	7.24	6.93	11.08	10.18	5.37	6.25	6.99	7.59	RS	RS	10.98	5.59	5.75	6.28	7.47	7.07	11.65	10.55			
118	61	3	0	0	m	7/25/1957	Arabic	8.48	6.86	8.16	x	7.30	x	x	8.55	4.95	8.16	RS	7.57	x	10.92	5.69	6.65	7.39	7.82	8.04	x	10.84	5.62	6.46	7.51	7.36	7.63	x	x			
119	61	4	2	3	m	9/23/1959	Arabic	9.40	7.42	7.45	7.52	7.10	10.45	9.73	9.19	7.36	7.30	7.58	7.04	10.37	9.76	5.48	6.32	6.77	7.36	7.55	10.94	10.19	5.74	6.23	6.92	7.28	7.45	11.03	10.17			
120	66	1	2	3	f	7/19/1986	White	8.55	6.47	8.19	6.61	N/E	10.58	N/E	8.60	6.22	N/E	6.78	m	10.58	N/E	5.54	6.61	6.50	7.20	7.36	11.66	N/E	5.58	5.79	6.49	6.70	7.30	11.31	N/E			
121	66	2	0	0	f	10/28/1962	White	8.49	5.76	6.97	5.74	m	RS	9.10	8.31	5.66	6.60	6.01	m	RS	RS	5.31	5.48	6.20	6.08	x	11.07	RS	5.26	5.48	6.07	5.87	x	RS	RS			
122	66	3	0	0	m			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Does not live w/ rest of family		
123	66	1	2	3	f	11/16/1966	White	9.05	m	7.51	7.24	7.05	11.33	N/E	8.13	m	7.79	7.21	7.06	11.60	N/E	5.07	5.48	6.66	7.07	7.30	11.51	PE	5.02	5.43	6.66	7.33	7.29	11.18	PE			
124	66	2	0	0	f	8/12/1957	White	RS	RS	7.85	x	x	RS	RS	RS	RS	RS	RS	x	RS	x	5.62	6.08	6.35	x	x	x	x	5.64	6.00	6.63	x	x	x	x			
125	66	3	0	0	m	1/2/1961	White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Where about unknown		
126	66	4	2	3	f	8/30/1977	White	8.63	6.73	7.58	7.35	6.89	9.17	PE	8.55	7.64	7.93	6.97	6.52	9.67	N/E	5.63	6.87	6.32	6.91	7.12	10.58	9.65	5.52	6.91	6.48	7.27	7.00	10.24	9.62			

Appendix 3 Tooth-Size in Families Affected with Dental Agenesis

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
127	66	5	2	3	m	7/23/1976	White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Does not want to participate		
128	66	6	2	3	m	6/10/1979	White	9.38	7.70	8.44	7.26	7.50	11.96	10.36	9.13	8.01	8.64	7.18	7.31	10.56	9.79	8.94	6.16	7.15	7.57	7.91	11.67	11.28	8.96	8.38	8.04	7.29	7.71	11.47	PE			
129	69	1	2	3	f	5/22/1953	White	8.14	m	N/E	N/E	7.14	11.01	10.03	9.14	8.34	N/E	N/E	PE	10.84	PE	9.57	6.67	7.06	7.26	N/E	10.87	N/E	8.26	8.77	N/E	7.21	7.57	10.44	N/E			
130	69	2	0	0	f	4/12/1952	White	8.90	8.96	7.41	RS	RS	RS	RS	8.93	8.66	7.02	RS	RS	RS	x	5.49	5.96	6.56	6.51	RS	RS	RS	5.51	5.81	6.67	8.50	8.68	RS	RS			
131	69	3	0	0	m	11/15/1960	White	8.21	8.45	7.91	x	RS	RS	10.63	9.07	8.19	8.02	x	8.52	RS	RS	5.36	5.40	7.07	x	7.12	RS	RS	x	8.21	7.24	x	7.31	11.38	9.78			
132	69	4	2	3	m	1/9/1980	White	8.59	5.96	8.58	7.07	8.91	10.22	PE	8.57	PE	8.37	7.32	8.56	10.44	PE	5.73	6.38	7.52	7.19	7.36	11.63	11.02	5.79	8.28	7.22	7.16	7.26	11.60	10.74			
133	74	1	2	3	f	2/17/1965	White	RS	7.56	7.62	7.65	8.52	10.85	PE	9.74	7.05	7.97	7.51	7.13	11.07	m	5.39	5.50	6.85	7.50	7.56	11.66	PE	5.48	6.03	7.07	7.42	7.59	11.70	x			
134	74	2	0	0	f		White	8.91	7.48	7.81	x	RS	RS	RS	8.93	7.49	7.41	x	RS	RS	10.81	8.58	6.13	7.16	x	7.59	x	RS	5.54	6.30	7.13	x	7.44	RS	10.96			
135	74	3	0	0	m	9/3/1953	White	9.05	8.99	7.80	6.48	8.17	10.37	10.29	9.29	8.82	7.82	6.45	6.33	10.44	10.27	5.67	5.45	6.85	6.29	6.79	11.60	11.15	5.44	5.85	6.96	8.62	7.02	11.58	11.11			
136	74	4	2	3	m	4/29/1957	White	9.45	7.44	8.28	7.45	7.39	11.40	10.84	9.74	7.11	8.19	7.38	6.96	11.48	10.94	6.21	6.48	7.32	7.11	7.69	11.76	PE	5.92	8.56	7.31	7.20	7.42	11.76	11.18			
137	74	5	2	3	m	11/28/1962	White	9.03	7.08	N/E	7.38	N/E	11.32	N/E	9.06	8.49	N/E	7.41	N/E	11.22	N/E	5.39	5.89	7.53	7.83	N/E	12.08	N/E	5.42	5.96	7.62	7.56	N/E	12.16	N/E			
138	75	1	2	3	m	6/14/1966	White	8.40	8.42	7.56	6.76	7.15	10.82	9.86	8.83	8.40	7.45	6.86	7.10	10.71	10.62	5.39	5.19	6.07	7.09	m	10.90	10.44	5.43	5.37	6.77	7.06	m	11.21	10.42			
139	75	2	0	0	f	4/19/1952	White	8.37	7.39	7.30	7.25	8.84	10.29	9.71	8.14	8.57	7.11	7.44	7.03	11.10	9.97	5.84	5.45	6.34	6.81	7.17	11.27	10.44	5.33	5.47	6.24	7.22	7.33	11.53	10.19			
140	75	3	0	0	m	9/15/1947	White	9.43	7.58	8.21	7.73	7.04	RS	10.63	9.50	7.67	7.76	7.50	RS	11.32	11.47	5.47	6.19	7.48	7.80	8.12	RS	12.17	5.84	5.99	7.58	7.82	RS	x	RS			
141	75	4	2	3	f	11/23/1965	White	8.12	7.31	7.36	7.55	7.24	11.26	10.08	9.18	7.87	7.49	7.03	7.25	11.24	10.21	5.67	5.72	6.52	7.32	7.74	12.26	10.81	5.84	5.96	6.91	7.13	7.43	12.14	10.85			
142	80	1	2	3	f	8/15/1966	White	9.19	8.74	7.05	6.85	m	10.61	9.93	8.03	8.13	7.21	6.67	x	10.55	9.24	6.03	6.16	8.47	7.00	m	10.25	N/E	5.85	6.26	6.82	7.51	7.11	10.58	9.21			
143	80	2	0	0	f	8/14/1948	White	8.19	7.23	7.67	6.48	6.26	RS	PE	8.36	7.04	7.57	6.45	6.62	10.31	8.71	5.44	5.73	6.81	6.73	6.83	10.62	9.51	5.32	5.70	6.90	6.68	6.72	11.27	9.46			
144	80	3	0	0	m	7/19/1956	White	9.43	7.10	7.72	7.19	7.06	10.36	9.52	9.26	8.48	7.83	7.08	PE	PE	9.55	6.00	6.26	7.11	7.42	7.36	RS	10.49	6.06	6.36	7.26	7.49	7.51	10.87	10.64			
145	80	4	2	3	m	2/9/1987	White	9.49	8.87	7.73	7.67	7.79	10.82	10.09	9.06	8.69	7.86	7.44	7.76	10.70	9.97	5.93	6.62	7.29	7.49	8.02	11.34	10.71	5.92	6.70	6.89	7.54	8.14	11.49	11.22			
146	83	1	2	3	m	4/27/1969	White	7.29	m	N/E	6.37	8.19	10.16	10.61	7.24	m	7.15	6.43	8.74	10.11	PE	m	5.05	6.04	8.77	8.90	11.12	10.34	m	5.26	6.64	7.06	8.71	10.85	9.73			
147	83	2	0	0	f	4/17/1950	White	8.82	5.85	7.31	6.77	8.44	RS	10.22	8.35	8.26	8.83	6.78	8.61	x	9.86	5.21	6.08	6.22	6.69	7.14	RS	RS	5.23	8.16	8.45	7.02	RS	RS	10.22			
148	83	3	0	0	m	8/17/1943	White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Where about unknown		
149	83	4	2	3	f	4/7/1982	White	8.95	8.98	7.00	8.55	8.99	10.39	9.83	8.83	8.79	8.54	8.53	8.43	10.58	10.14	5.53	6.11	8.98	8.21	7.09	11.13	9.81	5.87	8.07	8.28	8.77	7.09	11.17	9.79			
150	85	1	2	3	f	3/10/1959	Hispanic	8.48	8.64	N/E	6.83	N/E	10.44	N/E	8.47	8.87	N/E	N/E	N/E	10.21	N/E	5.60	6.16	8.50	8.75	N/E	11.47	N/E	5.72	8.85	N/E	8.86	m	11.84	N/E			
151	85	2	0	0	f	5/11/1960	Hispanic	9.41	7.46	8.28	7.01	7.00	10.74	9.89	9.37	7.37	8.33	7.38	6.94	10.47	9.33	6.06	6.62	7.42	7.23	7.34	RS	11.02	5.87	8.58	7.43	7.00	7.47	x	11.16			
152	85	3	0	0	m	3/26/1959	Hispanic	8.82	8.54	7.40	8.21	8.42	9.87	x	8.83	8.48	7.61	RS	8.37	9.76	9.84	5.18	5.58	6.36	6.34	7.01	RS	10.29	5.16	5.51	6.39	6.39	6.71	RS	10.43			
153	85	4	2	3	f	7/27/1962	Hispanic	9.21	8.78	7.83	N/E	N/E	10.99	N/E	9.22	8.81	7.78	N/E	N/E	10.81	N/E	5.83	6.09	7.06	8.79	7.06	11.22	N/E	5.84	6.09	7.43	6.80	7.22	11.25	N/E			
154	89	1	2	3	m	1/19/1991	White	9.73	m	8.61	7.72	7.17	11.04	10.48	9.71	m	8.65	7.83	7.34	11.12	10.11	6.09	6.52	7.79	8.04	8.12	11.16	N/E	6.12	6.49	7.96	8.02	8.16	11.47	10.87			
155	89	2	0	0	f	8/21/1968	White	8.44	7.67	8.44	7.65	x	11.04	10.25	9.45	7.75	8.36	7.46	x	11.05	10.07	5.82	6.14	7.78	7.93	x	11.44	11.06	5.96	6.34	7.49	8.01	x	11.62	10.57			
156	89	3	0	0	m	10/2/1965	White	8.29	m	x	RS	RS	RS	10.13	RS	m	x	RS	6.96	10.43	9.77	5.41	5.91	6.89	6.78	7.96	RS	RS	5.28	5.94	6.96	6.71	7.63	RS	RS			
157	89	4	2	3	f	1/8/1966	White	9.09	N/E	N/E	N/E	N/E	N/E	10.66	N/E	8.04	7.16	N/E	N/E	N/E	10.67	N/E	5.85	6.03	N/E	N/E	N/E	11.08	N/E	5.75	6.02	N/E	N/E	N/E	PE	N/E			
158	90	1	2	3	m	2/9/1966	White	9.79	8.05	8.90	8.97	7.53	11.97	10.24	9.78	8.22	8.95	8.77	7.33	11.62	10.38	6.04	6.53	8.73	7.27	m	11.50	11.23	5.81	8.19	7.17	8.79	7.93	11.90	11.35			
159	90	2	0	0	f	11/9/1959	White	RS	RS	7.80	7.24	7.34	RS	9.97	RS	m	7.87	7.35	7.37	RS	x	5.68	5.83	6.78	7.10	7.61	RS	10.96	5.68	5.97	6.49	7.05	RS	RS	x			
160	90	3	0	0	m	12/7/1958	White	x	x	8.53	x	RS	RS	10.74	9.09	x	x	x	6.24	RS	10.64	x	6.62	7.67	x	7.41	RS	RS	x	6.71	7.26	x	x	RS	RS			
161	90	4	2	3	m	1/7/1988	White	8.79	7.17	8.87	8.89	8.73	RS	9.44	8.70	7.17	8.96	7.00	6.89	10.47	9.83	5.44	6.36	7.47	7.15	7.31	10.89	11.13	5.75	8.05	7.28	7.12	7.48	RS	10.83			
162	90	5	2	3	f	10/19/1991	White	8.37	7.19	N/E	N/E	N/E	11.90	N/E	8.52	7.09	N/E	N/E	N/E	11.34	N/E	5.80	5.97	7.74	8.67	N/E	9.96	N/E	5.77	8.01	7.36	8.67	N/E	10.06	N/E			
163	90	6	2	3	f	6/30/1964	White	9.43	8.96	8.77	7.42	RS	10.96	10.71	9.32	8.83	8.56	8.98	7.56	11.26	10.18	5.84	6.44	7.46	7.39	7.74	11.41	11.16	5.76	8.78	7.38	7.54	7.55	11.38	11.40			
164	91	1	2	3	m	11/12/1966	White	9.24	8.46	7.86	8.71	m	10.43	N/E	9.54	8.64	8.09	8.39	N/E	10.73	N/E	5.65	5.96	8.71	7.11	m	11.53	N/E	5.77	8.21	7.13	7.11	m	11.58	N/E			
165	91	2	0	0	f	8/3/1962	White	8.89	8.07	7.67	8.92	RS	RS	PE	8.46	8.52	7.97	8.91	RS	RS	RS	5.65	6.27	8.91	8.65	7.17	RS	RS	5.54	8.16	8.79	8.87	RS	RS	RS			
166	91	3	0	0	m	7/9/1960	White	RS	8.38	7.91	8.93	7.12	10.57	9.84	RS	8.58	8.16	7.14	8.95	10.09	9.90	5.25	6.23	7.36	8.91	7.22	11.39	10.81	6.03	8.53	7.22	7.07	7.29	11.06	10.90			
167	91	4	2	3	m	8/27/1986	White	9.20	8.69	8.25	7.37	8.96	11.37	10.61	9.71	7.07	N/E	8.54	8.92	11.29	10.58	6.03	7.00	7.36	7.52	m	11.76	RS	6.28	8.35	7.26	7.17	7.47	11.65	12.72			
168	92	1	2	3	m	5/24/1960	White	8.61	5.92	N/E	N/E	N/E	10.17	N/E	8.06	5.58	N/E	PE	5.82	9.77	N/E	5.06	6.34	N/E	8.77	m	10.46	N/E	5.55	8.04	7.02	8.61	8.77	10.66	N/E			
169	92	2	0	0	f	10/13/1986	White	8.24	5.74	7.87	6.98	6.48	10.24	PE	8.50	6.50	8.05	6.86	6.36	10.17	9.80	5.73	6.00	8.84	6.96	6.75	10.67	x	5.59	8.01	6.45	6.88	6.72	10.57	x			
170	92	3	0	0	m	3/29/1964	White	8.63	8.23	7.47	7.07	5.67	10.05	9.98	8.90	6.68	7.21	6.16	6.18	10.42	9.83	5.67	5.85	8.93	8.47	8.92	9.71	9.93	5.74	8.90	7.18	6.63	8.90	9.12	RS			
171	92	4	2	3	m	4/24/1963	White	8.78	8.10	N/E	N/E	N/E	10.46	N/E	8.63	8.33	N/E	N/E	N/E	PE	N/E	5.68	6.16	N/E	N/E	N/E	11.05	N/E	5.77	8.04	N/E	N/E	N/E	11.24	N/E			
172	92	5	2	3	f	4/30/1987	White	8.16	5.79	8.63	5.98	6.43	9.13	N/E	8.08	5.83	8.54	5.96	6.04	9.06	N/E	5.36	5.45	8.08	6.45	6.48	8.67	N/E	5.18	5.69	6.22	6.24	6.45	8.75	9.12			
173	93	1	2	3	f	11/20/1969	White	9.53	8.87	7.73	8.83	8.34	9.94	9.37	RS	7.01	7.78	6.85	6.31	9.84	9.19	5.71	6.12	7.01	7.16	m	10.32	PE	5.57	5.87	7.00	8.96	m	10.34	9.89			
174	93	2	0	0	f	7/31/1963	White	8.22	6.64	7.47	6.94	6.11	10.81	8.83	8.49	7.14	7.93	6.86	6.12	10.00	PE	5.64	6.01	6.94	8.72	m	RS	10.06	5.41	8.14	8.88	7.03	m	x	RS			
175	93	3	0	0	m	11/16/1962	White	8.78	8.62	8.14	RS	RS	RS	x	RS	RS	RS	RS	RS	10.78	9.18	5.78	6.01	8.09	8.54	7.02	RS	10.33	5.70	8.18	7.42	6.55	8.96	RS	x			
176	94	1	2	3	f	11/20/1962	White	7.76	RS	RS	6.37	m	10.40	9.45	8.16	5.50	7.48	7.06	6.78	10.49	9.44	5.16	5.98	8.58	7.18	7.03	10.92	10.00	5.36	5.72	9.41	8.97	7.02	10.79	9.23			
177	94	2	0	0	f	2/13/1961	White	RS	RS	RS	8.96	8.65	10.69	9.84	RS	8.72	7.96	7.13	6.83	x	9.43	5.23	5.78	6.71	7.62	x	x	11.01	5.49	8.83	8.55	7.80	7.27	11.33	10.59			
178	94	3	0	0	m	5/10/1961	White	8.62	8.06	8.25	RS	RS	RS	RS	8.52	8.09	8.08	7.33	7.18	RS	9.58	5.65	6.18	8.93	7.50	7.35	RS	RS	5.22	8.05	8.59	7.24	RS	RS	RS			
179	94	4	2	3	m	8/15/1965	White	8.82	5.94	7.71	6.90	6.38	10.23	9.48	8.86	6.34	7.41	6.69	6.62	10.33	RS	5.70	5.91	6.63	6.58	6.78	10.18	9.96	5.67	8.06	6.68	7.03	7.14	10.55	10.11			
180	94	5	2	3	f	11/22/1988	White	8.14	6.00	7.96	RS	6.91	RS	8.79	8.31	5.78	7.48	6.97	6.98	10.58	8.75	5.42	5.84	6.58	7.40	7.07	RS	9.66	5.37	8.69	6.63	7.17	7.06	10.83	10.29			
181	95	1	2	3	m	6/6/1987	Asian	8.31	8.10	7.79	7.14	6.76	10.67	10.47	8.58	6.27	7.82	7.22	8.58	10.44	PE	5.13	5.52	7.06	7.17	7.28	11.89	11.09	m	6.04	7.10	7.22	7.30	11.30	10.54			
182	95	2	0	0	f	4/28/1964	White	8.34	6.15	7.43	8.58	RS	RS	RS	8.37	9.37	7.28	RS	RS	RS	8.78	9.26	5.87	8.05	6.82	7.48	RS	RS	5.45	8.89	8.21	8.88	7.36	10.04	RS			
183	95	3	0	0	m	3/10/1963	Asian	8.44	8.58	8.04	7.94	RS	9.96	RS	8.56	8.43	8.00	RS	RS	9.96	9.63	6.63	6.77	8.82	7.43	RS	RS	RS	6.35	8.07	7.21	7.37	RS	RS	RS			
184	95	4	2	3	f	10/14/1966	Asian	9.18	8.50	7.80	7.24	7.13	10.43	10.02	8.14	8.24	8.84	7.41	7.14	10.40	9.72	5.73	5.91	8.44	7.12	7.36	11.04	PE	5.49	8.94	8.39	7.18	7.47	11.03	PE			
185	96	1	2	3	m	1/16/1968	White	9.77	7.13	8.50	7.09	7.77	11.32	11.20	RS	8.95	9.46	7.29	7.35	11.41	11.34	m	6.48	8.31	8.35	m	11.18	PE	m	6.69	8.35	8.03	8.09	11.26	10.99			
186	96	2	0	0	f		White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Divorced		
187	96	3	0	0	m	8/22/1963	White	9.30	7.48	8.20	7.28	8.99	11.28	x	10.21	7.04	8.31	6.94	6.70	11.01	PE	5.74	6.06	7.44	7.01	RS	RS	10.96	5.94	6.38	7.53	7.32	RS	10.63	11.17			
188	96	4	2	3	m	11/22/1969	White	9.84	7.09	8.94	7.79	8.17	11.49	11.59	9.96	7.33	8.96	7.90	7.74	x	11.84	m	6.22	8.58	7.74	7.81	12.22	N/E	6.04	6.32	8.35	8.28	8.31	12.36	N/E			
189	97	1	2	3	f	3/25/1983	Biracial	8.15	8.92	N/E	7.57	N/E	11.12	N/E	8.82	8.96	N/E	7.48	7.09	11.65	N/E	5.49	6.53	8.95	7.75	m	11.68	PE	5.60	8.26	8.99	7.71	N/E	11.62	N/E			

Appendix 3 Tooth-Size in Families Affected with Dental Agenesis

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
190	97	2	0	0	f	2/11/1963	Hispanic	8 87	7 51	8.20	7 85	7 63	10 96	11 01	8 79	7 74	8.26	7 80	7 56	RS	PE	5 66	6 04	7 48	7 92	7 59	RS	11 54	5 48	6.22	7 38	8 11	7 24	RS	RS			
191	97	3	0	0	m	2/7/1964	White	8 39	6 77	7 87	7.23	7 16	11.26	10 36	8 46	6 63	7 90	7 19	7 09	10 87	PE	8 59	5 64	7.23	7 19	8 02	11 75	11 47	5 49	5 47	7.27	7.22	8 13	RS	11 39			
192	97	4	2	3	m	2/19/1991	Biracial	8 06	8 91	8 11	7 56	7 33	11 18	11 02	9 11	6 65	PE	7 63	7 33	11 02	10 96	5 63	6.27	7 53	8 08	7 73	12 17	PE	5 51	6.25	7 00	7 42	7 93	11 86	PE			
193	98	1	2	3	m	12/27/1950	White	9.22	8 60	8 31	N/E	m	12.49	PE	9 48	8.24	8 41	7 62	m	11 93	N/E	5.91	8 09	7.27	7.85	m	12 52	PE	5 94	6 00	7.28	7 86	m	RS	N/E			
194	98	2	0	0	f	12/31/1967	White	8 36	8 18	7 38	7 08	6 42	RS	10 51	8 19	6.20	7 32	6 96	6 77	RS	10 58	5 82	5 59	6 00	6 79	7 23	RS	RS	5 43	5 76	6 17	7 09	7.20	11 19	10.29			
195	98	3	0	0	m		White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Divorced		
196	98	1	2	3	f	11/8/1960	White	7 64	6 34	7 73	6 70	m	9 35	N/E	7 71	6 04	7.75	6 77	m	9.75	N/E	5 06	5.72	6 78	7 15	m	RS	10.27	5.08	5 45	6.78	7 05	m	10 61	PE			
197	98	2	0	0	f	3/25/1962	White	8 06	6 95	7 17	6 74	RS	10 54	RS	8 03	6 78	7 34	6 79	5 92	RS	RS	5 18	6 03	6 49	6 91	6 52	RS	10.23	5 17	6 00	6 65	6 82	RS	RS	RS			
198	98	3	0	0	m		White	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	Divorced		
199	99	4	2	3	f	9/24/1967	White	8 18	7 13	7 92	7.22	7 01	10.34	10.22	8 15	7 32	7 81	7 17	7 04	10 45	10 33	5 31	5 89	6 90	6 86	6 63	10 72	10.27	5.28	5 95	7 08	8 83	6 63	10 69	10 34			
200	100	1	2	3	f	7/8/1969	White	8 86	8 97	7 67	7 77	6 78	10.68	10 58	8 89	8.29	7 78	7 74	6 64	10 76	10 39	5 51	5.95	6 79	7 49	m	10 82	10 67	5 42	5 88	6.87	7.36	7.78	10 92	10 58			
201	100	2	0	0	f	5/1/1964	White	8 61	8 70	7 78	6 94	RS	10 09	9.25	8 96	6.23	7 75	RS	RS	RS	RS	5 35	5 92	6 63	7 39	7 51	RS	RS	5.29	5 86	6 72	7 46	RS	10 67	10 63			
202	100	3	0	0	m	12/27/1947	White	8 93	8 31	7 76	RS	RS	RS	RS	8 84	5 67	7 93	RS	x	RS	11 57	4 99	5 58	7 06	7 15	RS	RS	11 62	5 13	5 72	8 51	RS	RS	RS	11 43			
203	100	4	2	3	f	7/8/1969	White	8 67	5 91	7 88	7 69	7.22	10 86	PE	8 51	5 55	7 91	7 67	7 01	10 47	N/E	5 03	5 89	7 00	7 36	m	10 43	N/E	5 08	5 66	6 73	7 02	7 47	11 38	9 94			
204	100	5	2	3	f	1/30/1961	White	8 79	8 32	7 80	7 91	7 43	11.24	PE	8.78	6 99	7 93	7 97	7 74	11.20	10 84	5 37	5 89	8 44	7 74	7 90	11 89	11 23	5 48	5 98	6 55	7 41	7 70	11 69	11 04			
205	101	1	2	3	m	4/11/1969	White	8 97	8 89	8 43	8 14	8.59	10.25	9 91	8 98	7 02	8 08	8 03	8 98	10 26	9.86	8 54	7 15	7.22	7.88	m	11 15	10.28	5 88	7.07	7 52	8 06	N/E	11 13	PE			
206	101	2	0	0	f	9/18/1967	White	9 51	7.28	8.09	x	7 67	10 67	10.78	9 67	7.21	7 91	x	7 63	10 66	10 84	6 10	6 64	8 94	x	7 82	11 85	10 76	6 15	6.29	7.27	x	7 75	11.23	10 76			
207	101	3	0	0	m	2/16/1967	White	RS	m	RS	7.28	7 11	x	10 92	RS	m	RS	7 06	8 98	x	10 88	5 98	6 65	7 18	7 17	8 76	RS	10 88	6 11	6 50	7 13	7 09	8 74	11 01	x			
208	101	4	2	3	m	3/4/1966	White	8.67	8 53	N/E	N/E	N/E	11 13	N/E	8 98	6 32	N/E	N/E	N/E	11 19	N/E	5 91	8 71	N/E	N/E	N/E	10.91	N/E	6 15	6 67	N/E	N/E	N/E	10 84	N/E			
209	102	1	2	3	f	10/1/1967	White	8 90	7 61	8 40	8.21	7 61	11 48	PE	9 44	7.86	8.27	8 34	7 55	11 43	10 56	5 49	6.82	7.87	8.58	m	11 74	10.82	5 44	6.86	7.34	8.02	8 06	11 81	PE			
210	102	2	0	0	f	8/28/1964	White	8 32	8 47	7 91	8 71	7.20	9 69	9 80	8 35	6 64	7 98	RS	6 63	10 15	x	4 91	5 96	6 35	6 58	7.28	x	11 03	5 34	5 84	6 36	6 49	7 13	RS	x			
211	102	3	0	0	m		White	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Does not live w/ rest of family		
212	102	4	2	3	f	6/7/1965	White	8 12	8 99	8.21	8 95	6 89	10 75	11 06	8 02	6 92	8 12	8 97	7 06	10 77	10 94	5 47	6 03	7 71	7 59	7 32	11 42	11 58	5 31	6 18	7.29	7 66	7 34	11 32	11 45			
213	102	5	2	3	f	1/25/1969	White	9 19	7 87	8 99	8 19	8 12	11 46	N/E	9 18	7 70	8 91	8.20	7 98	11 40	N/E	5 71	6.27	7 69	8 15	8 31	12 66	11 76	5 72	6 37	7 57	7 83	8.22	12.66	11 81			
214	102	6	2	3	f	7/18/1990	White	8 54	7 48	8 09	7 57	7 41	10 69	N/E	8 63	7.26	N/E	7 82	7 35	10 86	N/E	5 18	6 11	7 72	7.29	7 32	11 45	PE	5 32	5 97	7 59	7 18	7 33	11 30	PE			
215																																						
216						N/E. Not Erupted																																		
217						x: Extracted																																		
218						k: Unknown																																		
219						RS Restoration																																		
220						PE. Partially Erupted																																		

APPENDIX 4

Tooth-Size in Control Families

Appendix 4 Tooth-Size in Control Families

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
1	Family ID	ID	MID	FID	Sex	DOB	Ethnic Background	11	12	13	14	15	16	17	21	22	23	24	25	26	27	31	32	33	34	35	36	37	41	42	43	44	45	46	47			
2	1	1	2	3	m	1/5/1978	White	8.67	7.10	8.29	7.45	RS	10.21	9.71	8.45	7.28	8.31	RS	RS	9.97	9.78	5.15	5.99	8.77	7.41	7.33	RS	10.14	5.39	5.99	6.77	7.42	7.25	10.89	10.22			
3	1	2	0	0	f		White	9.44	8.34	7.87	7.37	RS	x	9.35	9.58	7.83	8.06	x	RS	RS	11.67	5.35	5.84	6.54	6.94	7.35	RS	9.31	5.41	5.59	RS	x	RS	9.71	8.90			
4	1	3	0	0	m		White	8.96	8.28	8.12	RS	RS	RS	9.96	8.52	RS	RS	RS	RS	RS	RS	5.23	5.77	7.25	RS	RS	x	RS	5.08	5.77	7.04	6.85	7.22	RS	RS			
5	1	4	2	3	m	2/16/1979	White	8.28	6.69	7.72	7.36	6.74	10.38	9.61	8.37	6.54	7.89	7.20	6.73	10.44	9.79	5.06	5.82	6.65	7.15	7.29	10.32	10.02	4.99	5.49	6.69	6.97	7.14	10.45	10.10			
6	2	1	2	3	f	5/18/1986	White	8.95	7.57	8.11	7.71	7.57	RS	PE	9.11	7.74	8.03	RS	7.32	RS	10.58	5.79	6.19	7.54	8.25	8.20	RS	11.37	5.50	5.99	7.04	7.69	8.06	RS	RS			
7	2	2	0	0	f	2/5/1982	White	8.34	8.22	7.16	x	RS	x	RS	8.45	6.16	7.09	x	RS	RS	10.67	5.20	5.65	6.50	x	RS	RS	RS	5.23	5.96	6.48	7.07	x	RS	RS			
8	2	3	0	0	m	7/16/1980	White	8.05	6.63	7.93	7.03	6.78	RS	x	7.92	7.11	7.96	7.36	6.83	RS	PE	5.43	5.94	7.12	6.83	7.41	RS	RS	5.55	5.96	7.16	7.12	7.48	RS	RS			
9	2	4	2	3	f	5/10/1988	White	8.96	7.15	7.96	7.37	7.22	10.16	N/E	8.58	6.92	N/E	7.30	7.01	RS	PE	5.26	5.81	6.62	7.66	PE	11.43	10.65	5.31	5.76	6.57	7.20	7.53	11.36	10.26			
10	3	1	2	3	m	11/22/1986	White	9.30	7.11	8.49	7.81	7.54	11.02	PE	9.24	7.19	8.45	7.81	7.92	11.13	PE	5.64	6.40	8.17	7.81	8.31	13.06	PE	5.67	6.32	7.96	8.18	8.44	13.07	PE			
11	3	2	0	0	f	12/19/1949	White	8.77	7.16	7.89	7.56	7.12	10.78	9.95	8.67	7.76	7.10	7.86	RS	RS	10.04	5.51	5.75	6.96	x	7.24	RS	RS	5.56	6.13	7.16	7.24	RS	RS	RS			
12	3	3	0	0	m	2/4/1950	White	10.24	7.27	8.24	7.74	6.76	x	PE	9.94	7.41	8.36	7.31	6.64	RS	PE	5.71	6.77	7.90	7.41	RS	12.76	10.29	5.82	6.35	7.68	8.04	7.24	12.63	10.56			
13	3	4	2	3	m	10/7/1983	White	8.83	6.68	PE	7.00	7.33	11.01	10.83	8.28	6.94	8.06	7.08	7.23	10.85	10.58	5.86	6.71	8.06	7.31	7.87	12.12	11.25	5.48	6.34	8.23	7.56	7.89	12.28	PE			
14	4	1	2	3	f	4/14/1969	White	8.52	8.78	PE	7.36	6.92	10.43	PE	8.16	6.74	8.19	7.52	6.95	10.16	9.42	5.22	6.11	7.20	7.14	7.01	10.95	10.78	5.26	5.83	7.33	7.25	7.17	10.85	10.73			
15	4	2	0	0	f	3/26/1964	White	7.89	5.95	7.55	6.90	RS	10.31	9.61	7.63	6.39	7.15	6.80	RS	RS	9.50	5.19	5.78	6.70	6.86	6.92	11.02	10.56	5.25	5.79	7.03	6.33	7.12	RS	10.40			
16	4	3	0	0	m	10/3/1960	White	8.06	6.12	7.32	RS	RS	RS	RS	7.90	6.14	7.07	RS	RS	10.00	9.54	4.97	6.01	6.54	5.99	6.01	RS	RS	5.02	5.37	6.43	6.13	RS	RS	8.73			
17	4	4	2	3	f	1/28/1963	White	7.72	8.04	N/E	N/E	N/E	9.76	N/E	7.84	6.17	N/E	N/E	N/E	9.36	N/E	5.37	5.49	N/E	N/E	N/E	9.49	N/E	4.97	5.61	N/E	N/E	N/E	9.46	N/E			
18	4	5	2	3	f	3/12/1966	White	7.84	5.97	N/E	N/E	N/E	10.25	N/E	8.03	6.12	N/E	N/E	N/E	9.84	N/E	5.53	5.53	N/E	N/E	N/E	10.79	N/E	5.96	5.97	N/E	N/E	N/E	10.28	N/E			
19	5	1	2	3	m	7/12/1985	White	8.96	7.45	8.21	7.61	7.49	10.97	PE	8.62	7.09	8.28	7.58	7.20	10.86	PE	5.58	6.19	7.32	7.51	7.92	11.77	PE	5.42	6.36	7.33	7.56	7.93	11.89	11.73			
20	5	2	0	0	f	3/13/1955	White	7.74	6.31	7.31	6.48	RS	RS	9.67	8.06	6.01	7.35	6.51	RS	RS	9.55	5.19	5.39	6.32	7.07	6.39	12.00	RS	5.11	5.58	6.24	6.96	RS	RS	RS			
21	5	3	0	0	m	12/28/1964	White	9.35	7.00	8.21	7.43	7.76	10.99	PE	8.71	7.31	8.41	8.05	7.06	10.90	PE	5.56	6.15	6.16	7.67	7.58	RS	10.85	5.79	6.22	7.95	7.17	7.53	11.43	11.00			
22	5	4	2	3	f	9/20/1987	White	8.95	7.00	7.99	7.94	7.35	10.53	PE	8.81	7.41	8.98	7.50	7.42	10.53	PE	5.59	6.37	7.11	7.96	7.81	11.94	PE	5.80	6.64	7.06	7.96	8.00	11.85	PE			
23	6	1	2	3	f	5/29/1986	White	8.59	8.85	PE	7.32	6.98	10.84	PE	8.76	7.02	PE	6.94	7.15	10.74	PE	5.44	6.39	RS	7.66	7.02	11.15	10.74	5.49	5.76	6.89	8.99	7.86	10.96	10.53			
24	6	2	0	0	f	6/23/1961	White	8.93	8.66	7.70	8.71	6.96	10.81	9.63	8.83	6.32	8.48	6.51	6.75	10.19	RS	5.35	6.91	7.61	6.49	7.13	10.83	10.22	5.74	6.21	8.91	6.24	7.11	10.03	9.97			
25	6	3	0	0	m	7/16/1964	White	8.76	6.90	8.03	7.48	x	10.42	10.36	8.86	RS	7.79	7.32	x	10.12	10.06	5.51	6.42	7.17	7.05	x	10.72	10.28	5.63	6.36	7.14	7.01	x	10.56	10.04			
26	6	4	2	3	m	10/8/1986	White	8.37	6.83	7.96	7.05	6.62	10.22	RS	8.42	6.60	8.04	6.96	6.63	10.20	9.96	5.64	6.33	7.52	6.93	7.03	10.31	10.12	5.53	6.45	7.62	6.96	7.05	10.14	10.48			
27	6	5	2	3	m	8/23/1982	White	9.22	7.02	N/E	N/E	N/E	10.84	N/E	8.72	7.10	N/E	N/E	N/E	10.06	N/E	5.62	6.46	N/E	N/E	N/E	9.52	N/E	5.74	6.18	N/E	N/E	N/E	9.74	N/E			
28	7	1	2	3	f	7/13/1990	White	8.41	6.96	7.37	6.96	6.96	10.78	PE	8.21	6.80	7.36	6.44	7.05	10.47	N/E	5.22	5.96	6.76	6.64	7.18	11.54	N/E	5.53	5.96	6.66	6.75	7.27	11.22	PE			
29	7	2	0	0	f	9/14/1967	White	RS	9.44	8.14	6.93	6.66	RS	RS	8.42	6.56	8.20	6.51	6.41	10.63	10.57	5.49	5.81	7.26	7.11	7.24	11.67	10.11	5.96	5.81	7.01	6.79	7.32	11.05	10.38			
30	7	3	0	0	m	9/17/1966	White	9.40	7.10	8.93	7.71	7.35	RS	10.56	9.19	7.13	8.78	7.66	RS	10.33	PE	5.96	6.81	7.96	7.64	8.01	12.15	11.24	5.54	6.82	7.96	7.96	7.92	12.28	11.45			
31	7	4	2	3	m	12/20/1966	White	8.62	6.59	8.61	7.34	6.44	10.28	10.51	8.47	6.96	8.01	7.09	6.48	10.07	PE	5.58	5.99	7.31	7.04	7.25	10.79	10.43	5.37	5.74	7.27	RS	7.47	11.06	9.96			
32	8	1	2	3	m	4/21/1991	White	8.35	6.62	7.45	6.96	6.87	9.74	N/E	8.57	6.93	7.48	7.00	PE	9.66	N/E	5.28	5.70	6.51	6.62	PE	10.58	N/E	5.33	5.96	6.46	6.57	PE	10.57	N/E			
33	8	2	0	0	f	12/26/1963	White	8.47	7.11	8.13	6.89	6.92	10.48	9.60	8.42	7.20	7.96	6.10	6.79	9.96	8.96	5.43	5.87	6.57	7.11	6.94	10.96	10.34	5.39	5.84	6.56	6.73	7.29	10.52	10.17			
34	8	3	0	0	m	12/24/1962	White	RS	8.96	8.37	x	8.99	12.71	10.42	9.06	6.61	8.39	x	7.15	12.01	10.54	5.87	6.11	7.87	x	7.95	12.36	10.89	6.04	6.25	7.74	x	7.96	12.11	10.85			
35	8	4	2	3	f	8/26/1989	White	8.50	7.57	7.31	7.33	6.52	10.23	PE	8.99	7.33	7.81	7.26	N/E	10.11	N/E	5.48	5.93	6.63	N/E	N/E	RS	N/E	5.52	5.91	6.92	N/E	N/E	RS	N/E			
36	8	5	2	3	m	4/2/1993	White	8.81	7.10	N/E	N/E	N/E	10.99	N/E	9.02	6.99	N/E	N/E	N/E	10.54	N/E	5.82	6.39	N/E	N/E	N/E	10.67	N/E	5.74	6.29	N/E	N/E	N/E	10.75	N/E			
37	8	6	2	3	m	3/11/1985	White	8.96	8.39	N/E	N/E	N/E	10.51	N/E	8.52	6.86	N/E	N/E	N/E	10.77	N/E	5.52	5.43	N/E	N/E	N/E	11.02	N/E	5.77	5.89	N/E	N/E	N/E	10.93	N/E			
38	9	1	2	3	f	5/6/1987	White	9.51	8.97	8.15	7.25	6.73	10.25	N/E	9.82	7.26	N/E	7.23	6.79	10.70	N/E	5.91	6.42	7.34	7.36	7.80	10.61	N/E	6.18	6.49	7.09	7.36	7.58	PE	N/E			
39	9	2	0	0	f	8/2/1982	White	8.15	7.39	8.01	6.49	6.37	10.96	10.95	8.44	7.40	7.91	6.47	6.34	10.71	10.02	5.24	6.00	6.66	6.47	6.58	11.21	RS	5.96	6.00	6.80	6.39	6.75	10.64	10.16			
40	9	3	0	0	m	3/16/1980	White	9.39	7.07	8.46	RS	RS	11.49	10.58	9.36	7.29	8.03	7.49	RS	11.22	10.28	5.97	6.58	7.11	8.19	8.36	12.04	RS	x	6.90	7.24	7.96	RS	11.95	11.54			
41	9	4	2	3	m	12/27/1989	White	8.63	7.16	8.21	6.96	6.72	10.32	PE	8.99	7.05	N/E	7.23	7.03	10.21	10.75	5.47	5.97	7.09	7.32	7.22	10.72	PE	5.41	5.77	6.99	7.06	7.43	10.65	10.41			
42	10	1	2	3	m	8/4/1988	White	9.28	7.73	N/E	6.83	6.76	11.60	N/E	9.21	7.75	8.28	6.35	6.60	10.84	PE	5.85	6.31	7.13	7.07	7.25	10.83	PE	5.84	6.33	7.31	6.72	7.24	10.86	PE			
43	10	2	0	0	f	4/18/1959	White	8.22	RS	7.03	6.19	6.05	10.72	10.16	8.36	6.93	7.29	6.25	6.09	10.63	PE	5.16	5.58	6.31	6.68	6.97	10.93	11.71	5.99	5.60	6.47	6.38	7.06	10.71	11.93			
44	10	3	0	0	m		White	8.78	7.41	8.50	RS	6.68	11.06	10.44	9.15	7.38	8.25	6.97	RS	10.96	10.36	6.28	6.39	7.25	7.04	7.13	11.64	10.04	6.04	6.42	7.28	7.19	7.20	11.70	10.51			
45	10	4	2	3	f	12/17/1969	White	8.57	8.66	N/E	8.21	N/E	10.82	PE	8.48	6.49	N/E	6.52	N/E	10.05	PE	5.44	5.94	6.44	7.13	6.94	10.39	PE	5.46	5.58	6.46	7.17	6.78	10.41	PE			
46	10	5	2	3	m	1/17/1982	White	8.85	6.29	N/E	N/E	N/E	11.21	N/E	8.76	6.71	N/E	N/E	N/E	10.97	N/E	5.40	5.57	N/E	N/E	N/E	10.71	N/E	5.71	5.96	N/E	N/E	N/E	10.69	N/E			
47	10	6	2	3	m	9/22/1964	White	8.16	6.30	N/E	N/E	N/E	10.97	N/E	8.17	6.35	N/E	N/E	N/E	11.19	N/E	5.69	5.81	N/E	N/E	N/E	10.96	N/E	5.48	5.82	N/E	N/E	N/E	10.77	N/E			
48	11	1	2	3	f	7/2/1969	White	8.25	8.82	7.81	6.73	6.44	10.66	PE	8.29	6.47	7.88	6.71	6.49	10.38	PE	5.28	5.48	6.63	6.87	6.99	11.23	PE	5.23	5.45	6.82	6.70	7.13	11.01	9.19			
49	11	2	0	0	f	4/27/1966	White	8.39	6.12	7.72	6.51	6.38	10.48	9.78	8.34	6.16	7.71	6.31	6.41	10.61	9.89	5.33	5.96	6.73	6.75	6.87	10.57	9.91	5.34	6.02	6.52	6.31	6.86	10.72	9.96			
50	11	3	0	0	m	7/16/1990	White	9.49	7.74	8.22	7.28	6.78	10.42	10.31	9.41	7.96	8.21	6.68	6.86	x	10.47	5.71	6.20	7.27	7.18	7.17	RS	11.03	5.56	6.13	7.41	7.57	6.81	12.33	x			
51	11	4	2	3	m	8/14/1991	White	7.81	8.74	8.05	6.31	N/E	10.16	N/E	7.91	6.86	PE	6.24	N/E	10.06	N/E	5.86	5.70	7.33	7.27	7.34	10.78	N/E	5.65	5.89	7.35	7.28	7.33	10.81	N/E			
52	11	5	2	3	f	12/13/1985	White	7.95	N/E	N/E	N/E	N/E	10.62	N/E	7.93	N/E	N/E	N/E	N/E	10.58	N/E	N/E	N/E	N/E	N/E	N/E	10.28	N/E	N/E	N/E	N/E	N/E	N/E	10.36	N/E			
53	12	1	2	3	f	11/13/1970	White	8.63	7.43	8.02	7.21	7.19	10.26	9.78	8.86	7.55	8.02	6.95	7.15	10.05	9.94	5.65	6.24	6.90	6.83	7.32	11.13	10.61	5.59	6.22	7.01	7.09	7.47	11.01	10.32			
54	12	2	0	0	f		White	9.06	7.10	7.87	RS	RS	RS	RS	8.48	7.20	7.82	RS	RS	RS	x	5.87	6.34	6.86	7.04	7.13	x	x	5.68	6.34	8.94	6.55	6.99	10.98	RS			
55	12	3	0	0	m		White	8.79	7.33	7.13	RS	RS	RS	RS	9.01	6.89	7.32	RS	RS	RS	9.68	5.37	5.71	6.60	6.34	6.61	RS	10.85	5.32	6.65	6.49	6.82	RS	RS	RS			
56	12	4	2	3	m	6/18/1978	White	10.02	8.29	8.26	7.19	7.42	10.71	10.61	10.01	7.34	8.15	7.06	7.20	10.96	10.19	5.68	6.45	6.73	6.97	7.38	11.20	10.89	5.71	6.41	6.96	7.00	7.47	11.11	11.03			
57	13	1	2	3	m	12/2/1985	African American	9.86	8.35	9.52	8.22	7.56	11.61	11.20	10.07	8.23	9.42	8.49	7.41	11.51	11.36	5.96	6.52	8.24	8.37	8.43	12.34	11.59	5.94	6.51	8.23	8.41	8.84	12.58	11.48			
58	13	2	0	0	f	4/16/1958	African American	8.63	7.51	7.78	7.36	7.27	10.23	RS	8.54	7.67	7.74	7.61	6.94	RS	RS	5.17	5.88	6.67	7.73	7.51	11.09	10.79	5.58	6.06	7.01	7.61	RS	RS	10.72			
59	13	3	0	0	m		African American	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Does not live w/ family		
60	14	1	2	3	m	4/25/1966	White	9.26	7.56	8.48	7.67	7.54	10.79	N/E	9.15	7.11	PE	7.79	7.21	11.00	N/E	6.30	6.65	7.22	7.87	7.59	11.63	N/E	6.30	6.58	7.28	7.85	7.42	11.66	N/E			
61	14	2	0	0	f	8/29/1962	White	8.18	6.66	7.50	RS	RS	RS	RS	8.52	6.75	7.35	7.43	RS	RS	RS	5.61	6.19	6.64	7.06	7.38	11.51	11.29	5.66	6.41	6.58	6.83	7.28	RS	11.20			
62	14	3	0	0	m	1/31/1965	White	8.01	6.18	8.27	6.78	RS	RS	9.66	8.09	6.18	8.17	6.74	6.72	RS	9.52	5.28	5.87	6.34	6.35	6.46	RS	9.60	5.35	6.59	6.43	6.20	RS	RS	9.85			
63	14	4	2	3	m	7/3/1991	White	9.06	8.87	7.61	7.59	7.27	11.42	PE	9.18	8.90	7.93	7.82	7.44	10.47	9.83	5.77	6.69	7.17	7.84	7.36	11.20	N/E	5.80	6.51	7.31	7.54	7.64	11.34	N/E			
64	14	5	2	3	f	2/19/1960	White	7.54	5.87	6.59	6.94	6.67	10.61	PE	7.45	6.03	6.96	6.64	6.08	10.48	9.96	5.43	5.93	6.85	6.77	7.28	10.47	9.81	5.50	5.64	6.72	6.63	6.94	10.32	10.00			

Appendix 4 Tooth-Size in Control Families

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
65	15	1	2	3	f	4/25/1990	White	7.27	8.41	7.04	7.47	8.84	10.49	PE	7.34	5.85	7.19	7.42	7.48	10.48	PE	5.21	5.61	8.73	7.49	7.78	10.48	PE	4.88	5.69	8.84	7.56	7.79	10.28	10.42			
66	15	2	0	0	f	2/28/1961	White	8.47	8.34	8.98	RS	RS	RS	RS	8.18	8.02	8.91	RS	RS	RS	RS	8.21	8.06	8.44	RS	RS	RS	RS	8.24	8.04	8.52	RS	RS	RS	RS			
67	15	3	0	0	m	12/5/1951	White	8.28	8.82	RS	RS	RS	RS	x	8.37	8.32	7.77	RS	RS	RS	x	5.04	5.88	8.84	RS	RS	RS	RS	4.96	8.15	8.99	8.89	RS	RS	RS			
68	15	4	2	3	f	12/2/1988	White	8.88	8.82	7.28	7.38	7.13	11.47	10.38	8.89	5.91	7.22	7.14	8.96	11.48	10.49	5.72	8.03	8.84	8.98	7.12	10.34	10.10	5.59	8.14	8.78	7.07	7.23	10.33	10.22			
69	15	5	2	3	f	10/17/1962	White	7.82	8.31	7.21	7.11	8.91	10.24	N/E	7.80	8.25	7.34	8.88	7.56	10.23	N/E	5.57	5.99	8.80	7.49	7.15	10.98	N/E	5.47	8.84	7.05	7.27	7.05	10.87	N/E			
70	15	6	2	3	m	11/30/1903	White	8.93	N/E	N/E	N/E	N/E	10.68	N/E	8.83	N/E	N/E	N/E	N/E	10.63	N/E	5.89	8.03	N/E	N/E	N/E	10.86	N/E	5.79	5.96	N/E	N/E	N/E	10.24	N/E			
71	16	1	2	3	m	10/4/1988	White	RS	8.41	7.55	8.51	8.46	9.90	PE	RS	8.57	7.53	8.58	8.26	10.17	9.49	5.78	8.14	7.20	7.24	8.86	11.09	10.03	5.83	5.96	8.86	7.05	RS	11.22	10.23			
72	16	2	0	0	f	11/21/1958	White	8.48	RS	7.83	8.93	x	11.25	x	8.47	8.77	7.79	RS	x	x	10.54	8.91	8.49	7.14	7.50	8.89	10.49	10.23	5.99	7.01	8.94	RS	RS	x	10.06			
73	16	3	0	0	m	1/24/1952	White	x	x	8.46	RS	x	x	x	9.01	8.85	7.81	RS	x	x	x	5.11	8.23	7.31	7.19	7.57	x	9.36	8.21	8.03	7.29	x	RS	RS	RS			
74	16	4	2	3	f	1/8/1962	White	9.31	7.43	8.56	x	RS	10.68	10.31	9.40	8.95	8.00	x	7.24	10.82	10.34	5.76	8.79	7.27	x	7.66	11.27	RS	5.84	8.65	7.41	x	7.96	10.90	10.78			
75	17	1	2	3	m	3/3/1969	White	9.48	7.44	8.49	7.78	7.32	10.48	PE	9.21	7.54	8.06	7.70	7.37	10.72	N/E	6.16	9.36	7.69	7.77	7.81	11.10	10.87	5.95	8.27	7.44	7.70	7.89	11.14	PE			
76	17	2	0	0	f	7/21/1957	White	9.11	7.20	8.35	RS	RS	RS	RS	9.25	7.21	7.80	x	RS	RS	RS	5.87	8.23	7.32	x	7.91	RS	RS	6.06	8.34	7.24	RS	RS	RS	RS			
77	17	3	0	0	m	11/2/1957	White	8.90	7.85	7.78	7.00	RS	RS	9.68	8.74	7.36	8.01	7.11	RS	RS	9.71	5.63	8.28	7.26	7.03	RS	11.96	x	5.75	8.33	7.14	8.75	RS	10.90	x			
78	17	4	2	3	m	9/13/1985	White	9.52	7.53	7.98	7.37	x	11.00	10.84	9.11	7.54	7.85	7.38	x	10.90	RS	5.74	8.24	7.41	x	7.94	11.69	11.13	5.98	8.37	7.14	x	7.44	11.70	11.08			
79	17	5	2	3	m	8/3/1992	White	9.88	7.47	N/E	7.32	N/E	11.28	N/E	9.48	7.25	N/E	7.16	N/E	11.25	N/E	5.86	8.28	7.86	7.58	N/E	11.01	N/E	5.77	8.15	7.53	7.79	N/E	11.19	N/E			
80	18	1	2	3	m	6/1/1969	Middle East	9.51	8.92	8.82	8.14	8.13	11.91	N/E	9.47	8.81	8.63	8.09	8.08	11.95	PE	6.01	8.96	7.77	9.31	8.08	12.17	PE	6.26	8.90	7.21	8.15	8.32	12.03	N/E			
81	18	2	0	0	f	5/31/1960	Middle East	8.32	RS	8.75	7.25	N/E	RS	x	9.08	8.45	8.30	x	7.21	12.18	11.17	6.36	8.42	8.04	x	7.78	11.64	10.60	6.08	8.51	8.06	7.14	7.69	11.41	x			
82	18	3	0	0	m	9/28/1962	Middle East	8.48	8.37	8.10	x	7.41	11.81	10.32	9.08	8.96	8.29	8.89	x	12.28	x	5.83	8.36	7.93	7.82	7.83	10.79	10.87	5.92	8.31	7.39	7.11	7.73	11.03	10.07			
83	19	1	2	3	f	2/25/1991	White	8.49	8.33	8.08	7.19	7.04	10.26	PE	8.22	8.40	8.15	7.13	8.71	10.90	10.05	5.67	8.93	8.74	7.21	N/E	10.95	10.40	5.83	8.82	8.96	7.24	8.56	11.06	PE			
84	19	2	0	0	f		White	8.55	8.04	RS	RS	RS	RS	10.71	8.58	8.62	7.95	RS	x	RS	10.35	5.56	8.79	7.21	7.02	8.68	11.61	10.58	5.46	8.77	7.02	8.96	RS	x	RS			
85	19	3	0	0	m	9/30/1952	White	7.91	8.65	8.01	8.57	8.89	RS	RS	7.78	8.56	8.04	8.67	RS	RS	10.61	5.48	8.80	8.98	RS	RS	11.65	5.39	8.83	8.89	RS	RS	x	RS			
86	19	4	2	3	f	6/3/1965	White	8.98	7.11	8.13	7.07	7.37	10.82	9.73	8.92	8.73	7.98	7.98	7.25	11.02	10.04	5.53	8.96	8.59	7.59	7.14	11.37	11.09	5.48	8.58	8.82	7.64	7.19	11.63	11.29			
87	19	5	2	3	f	12/2/1992	White	8.45	8.71	N/E	N/E	N/E	11.51	N/E	8.66	8.64	N/E	N/E	N/E	PE	N/E	5.37	8.62	8.75	N/E	N/E	10.58	N/E	5.53	8.64	PE	7.12	N/E	10.49	N/E			
88	20	1	2	3	m	4/9/1986	African American	8.84	7.20	7.98	7.56	7.48	11.18	10.42	8.81	7.03	8.12	7.43	7.20	11.25	10.87	5.67	8.39	7.36	7.45	7.98	11.74	10.84	5.78	8.24	7.44	7.51	7.91	11.85	PE			
89	20	2	0	0	f	8/3/1970	African American	8.87	7.84	7.81	7.72	8.63	10.89	9.99	8.57	7.05	7.24	7.57	6.81	10.90	10.10	5.47	8.51	7.39	7.92	8.32	10.27	10.78	5.39	8.48	8.89	7.89	8.57	10.86	10.21			
90	20	3	0	0	m	6/3/1970	African American	8.63	8.85	8.07	7.28	7.19	11.10	10.83	8.44	8.42	8.13	7.02	8.98	11.08	PE	5.64	8.32	7.96	7.25	7.71	11.56	10.16	5.73	8.25	8.01	8.64	7.78	RS	10.19			
91	21	1	2	3	m	1/23/1992	White	9.02	7.35	7.81	7.57	7.35	11.32	N/E	8.84	7.21	8.19	7.67	7.06	11.63	N/E	5.98	8.34	7.38	8.32	N/E	11.99	N/E	5.78	8.50	7.29	8.02	N/E	PE	N/E			
92	21	2	0	0	f	8/3/1964	White	8.43	7.37	8.28	7.19	7.13	11.22	10.27	8.79	7.05	7.88	7.07	RS	11.30	10.82	5.61	8.48	7.13	7.49	RS	11.36	10.72	5.58	8.50	7.44	7.59	RS	RS	RS			
93	21	3	0	0	m	8/13/1963	White	8.91	7.25	8.46	x	7.21	11.08	10.97	8.85	7.36	8.36	x	7.21	RS	10.59	5.56	8.50	8.82	x	8.04	11.78	11.38	5.18	8.41	7.35	x	7.76	11.94	11.29			
94	21	4	2	3	m	11/4/1989	White	RS	7.33	N/E	7.26	7.35	11.70	N/E	8.94	7.21	N/E	7.37	7.24	11.59	PE	5.47	8.82	7.37	7.53	7.78	11.82	N/E	5.66	8.51	7.29	7.71	7.53	11.68	N/E			
95	21	5	2	3	f	1/13/1985	White	8.80	8.06	N/E	N/E	N/E	11.23	N/E	8.35	7.74	8.01	7.31	N/E	11.27	N/E	5.80	8.13	8.57	7.29	N/E	10.96	N/E	5.60	8.56	7.02	7.19	N/E	10.31	N/E			
96	22	1	2	3	m	3/10/1990	White	9.28	7.21	8.01	7.10	7.52	10.93	N/E	9.11	7.23	N/E	7.17	8.96	10.27	N/E	5.96	8.06	8.96	7.47	7.73	11.51	N/E	5.56	8.09	8.82	7.84	7.61	11.65	10.45			
97	22	2	0	0	f	8/1/1955	White	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Will not consent to study		
98	22	3	0	0	m	11/28/1955	White	8.45	7.08	7.30	8.84	8.54	10.51	10.11	8.49	8.48	7.30	8.85	8.67	10.86	10.05	5.11	8.81	8.37	7.03	7.14	11.27	10.20	5.14	8.96	8.84	7.07	7.09	11.18	10.17			
99	22	4	2	3	f	10/25/1965	White	8.98	8.75	7.83	8.95	7.24	9.50	10.04	8.86	8.93	7.92	8.66	7.17	9.78	8.95	5.58	8.28	7.03	7.29	7.31	10.86	10.45	5.69	8.11	7.11	7.21	7.18	10.81	10.32			
100	22	5	2	3	f	8/22/1998	White	7.89	8.64	7.61	7.07	8.70	9.79	9.49	7.97	8.60	7.57	7.15	8.85	9.73	9.47	5.39	8.56	8.97	8.84	7.06	11.06	N/E	4.83	8.86	8.63	8.95	7.10	11.02	N/E			
101	23	1	2	3	f	11/14/1985	White	9.14	8.22	7.95	7.09	7.02	11.18	10.83	9.21	7.96	7.73	7.11	8.91	10.62	10.37	5.98	8.31	8.98	8.96	7.81	11.93	11.37	5.81	8.54	8.70	7.04	7.18	11.82	11.23			
102	23	2	0	0	f	7/18/1967	White	9.33	8.06	7.58	RS	RS	RS	x	9.04	7.65	RS	7.25	RS	RS	x	5.97	8.41	8.70	7.13	RS	RS	RS	5.62	8.23	7.00	8.71	7.68	RS	11.41			
103	23	3	0	0	m	10/15/1956	White	8.68	8.98	7.08	8.71	x	11.44	x	RS	7.00	7.18	RS	x	RS	9.42	5.69	8.71	8.89	8.61	x	11.90	10.84	5.75	8.61	8.84	8.41	x	11.71	10.87			
104	23	4	2	3	f	7/31/1990	White	8.45	7.03	PE	7.09	PE	10.19	9.44	8.58	7.17	7.74	7.07	7.02	10.15	9.47	5.49	8.03	8.54	8.57	PE	11.03	10.10	5.46	8.95	8.89	8.61	PE	11.28	10.12			
105	24	1	2	3	f	2/21/1993	White	9.02	7.78	N/E	N/E	N/E	10.33	N/E	9.24	7.22	N/E	N/E	N/E	10.42	N/E	5.94	8.08	N/E	N/E	N/E	PE	N/E	5.65	8.03	N/E	N/E	N/E	PE	N/E			
106	24	2	0	0	f	4/11/1961	White	9.18	7.19	7.81	8.64	7.07	10.26	10.49	9.06	7.13	8.08	8.60	7.01	10.82	RS	5.74	8.27	8.50	7.02	7.34	11.64	10.48	5.91	8.30	8.81	8.90	RS	RS	10.87			
107	24	3	0	0	m	12/17/1960	White	9.43	7.23	8.68	8.38	7.76	11.57	11.43	9.51	7.24	8.83	8.18	7.85	11.65	RS	6.06	8.77	7.13	8.28	8.65	11.91	11.82	6.09	8.78	7.57	7.75	8.72	11.66	RS			
108	24	4	2	3	m	7/12/1989	White	9.47	7.44	8.06	7.22	7.08	11.16	10.14	9.38	7.38	8.04	7.15	8.46	10.68	10.34	6.26	7.06	7.19	7.44	8.68	11.65	N/E	6.49	8.35	7.02	7.43	8.33	11.81	N/E			
109	25	1	2	3	f	3/22/1967	White	8.81	8.38	8.19	7.02	8.83	10.50	PE	8.38	8.36	8.03	8.93	8.55	10.58	9.91	5.25	8.99	8.77	7.56	8.87	11.08	10.39	5.17	8.74	8.81	7.20	7.07	RS	9.94			
110	25	2	0	0	f	2/2/1956	White	8.03	8.50	7.50	8.59	8.19	9.96	8.85	RS	8.98	7.37	8.50	8.11	9.47	PE	5.21	8.45	8.45	8.63	8.52	10.09	8.45	5.19	8.42	8.21	8.36	8.22	9.96	8.85			
111	25	3	0	0	m	7/31/1953	White	RS	RS	RS	7.04	RS	RS	10.73	RS	8.59	7.64	7.14	RS	10.71	9.16	5.85	8.27	7.01	8.75	7.88	x	10.54	5.48	8.20	7.08	8.83	7.82	x	RS			
112	25	4	2	3	m	3/13/1989	White	8.80	8.72	8.50	7.83	7.02	10.58	10.51	8.85	7.33	8.06	7.54	7.03	10.41	10.26	5.51	8.59	7.24	7.06	7.25	10.89	10.21	5.59	8.98	8.99	7.04	7.29	11.03	RS			
113	25	5	2	3	f	2/5/1986	White	8.27	8.08	7.28	8.55	8.85	10.45	9.57	8.39	8.72	7.62	7.06	8.98	10.49	9.49	5.53	8.87	8.58	8.56	8.98	10.73	9.69	5.54	8.85	8.56	7.82	8.87	RS	9.84			
114	25	6	2	3	f	1/15/1991	White	7.91	8.31	N/E	7.14	8.34	10.18	9.15	8.20	PE	N/E	8.99	8.98	10.01	9.07	5.17	8.48	8.61	8.91	8.20	9.66	8.97	5.17	8.33	8.98	8.91	8.37	9.82	9.02			
115	26	1	2	3	m	3/16/1950	White	9.71	7.28	PE	7.28	7.11	10.87	N/E	9.52	7.14	N/E	7.25	N/E	10.84	N/E	5.55	8.32	7.14	PE	N/E	11.11	PE	5.83	8.49	7.19	7.21	N/E	11.27	PE			
116	26	2	0	0	f	9/14/1962	White	8.58	8.94	8.14	x	7.27	10.54	9.89	8.57	7.15	8.08	x	8.98	10.57	PE	5.58	8.08	8.77	x	7.31	11.44	10.84	5.48	8.98	8.82	x	7.34	RS	10.69			
117	26	3	0	0	m	10/11/1962	White	9.44	8.55	8.11	x	7.05	11.11	RS	9.54	8.69	7.93	x	7.14	10.88	RS	5.82	8.81	7.82	8.82	x	12.47	10.29	5.74	8.65	7.56	7.04	x	12.05	10.70			
118	26	4	2	3	m	10/13/1983	White	9.09	8.83	N/E	N/E	N/E	10.88	N/E	9.21	8.64	N/E	N/E	N/E	PE	N/E	5.19	8.41	N/E	N/E	N/E	10.86	N/E	5.18	8.43	N/E	N/E	N/E	10.91	N/E			
119	27	1	2	3	f	5/10/1998	White	8.48	8.78	7.85	7.40	8.73	10.53	N/E	9.31	7.08	7.97	7.34	N/E	10.30	10.02	5.93	8.98	7.08	7.25	7.37	10.34	9.81	5.79	8.09	8.98	7.25	7.83	10.32	PE			
120	27	2	0	0	f	8/30/1960	White	9.20	8.32	7.89	x	RS	10.08	10.03	9.06	8.89	7.96	x	7.32	10.35	10.06	5.86	8.13	7.13	x	7.47	RS	10.15	8.08	8.34	7.43	x	7.84	RS	10.36			
121	27	3	0	0	m		White	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Will not consent to study		
122	27	4	2	3	f	5/8/1990	White	9.88	7.63	N/E	N/E	N/E	10.24	N/E	9.79	7.78	N/E	N/E	N/E	10.14	N/E	6.03	8.42	N/E	N/E	N/E	10.71	N/E	8.01	8.36	7.28	N/E	N/E	10.33	N/E			
123	27	5	2	3	m	2/19/1993	White	8.65	8.99	N/E	8.57	PE	10.13	N/E	8.52	8.48	N/E	8.84	N/E	9.87	N/E	5.82	8.49	7.08	7.06	7.48	10.56	N/E	5.45	8.29	7.02	8.78	7.43	10.37	N/E			
124	28	1	2	3	f	4/17/1990	Biracial	7.74	7.10	7.74	7.04	7.05	10.87	PE	7.89	7.11	7.97	7.12	8.94	10.89	8.57	5.37	8.04	8.65	7.09	7.39	11.08	PE	5.33	8.91	8.98	8.99	7.12	11.26	PE			
125	28	2	0	0	f	12/10/1955	White	8.17	8.25	7.48	8.84	8.78	10.03	9.41	8.28	8.67	7.38	8.72	8.80	10.01	9.33	5.72	8.98	8.85	8.81	8.89	11.11	10.13	5.89	8.12	8.68	8.78	7.09	10.70	9.95			
126	28	3	0	0	m	2/15/1954	Hispanic	7.83	8.62	7.91	RS	RS	RS	RS	8.02	8.88	7.98	RS	RS	RS	9.36	5.20	8.92	8.81	7.02	RS	10.47	11.48	5.19	8.87	8.71	8.94	7.15	10.52	11.28			
127	28	4	2	3	f	12/3/1986	Biracial	7.44	8.54	7.78	7.22	8.94	10.03	9.52	7.82	6.38	7.19	7.19	7.12	10.11	9.71	5.23	5.31	8.42	7.02	7.09	10.53	PE	5.19	8.38	8.27	7.13	7.24	10.81	PE			
128	29	1	2	3	f	11/8/1986	White	8.35	7.90	8.15	7.33	8.84	10.98	N/E	9.34	7.31	7.96	7.41	8.73	11.08	N/E	5.81	8.44	7.20	7.82	7.34	11.48	PE	5.94	8.35	7.11	7.47	7.42	11.87	PE			

Appendix 4 Tooth-Size in Control Families

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL
128	29	2	0	0	f	4/3/1980	White	9 18	7 38	7 98	x	RS	RS	RS	9 19	7 53	7 82	x	RS	RS	RS	5 98	6 23	6 43	x	RS	RS	RS	5 81	6 34	7 33	x	RS	RS	RS			
130	29	3	0	0	m	2/24/1980	White	9 38	7 24	7 75	7 32	RS	10.42	RS	9 44	7 19	7 84	7 35	RS	RS	PE	5 52	6 23	7 28	7 48	RS	11 98	11 02	5 56	6 32	7 11	7 28	7 46	11 83	11 07			
131	29	4	2	3	m	9/15/1998	White	9 33	7 43	8 89	8 13	7 72	12.01	11 76	9 06	7 89	8 82	8 04	7 39	12.06	10 98	5 94	6 23	7 93	7 76	8 01	12.26	11 43	5 77	6 44	7 85	7 68	8 05	12 67	11.36			
132	29	5	2	3	f	3/28/1991	White	9.09	7 70	7 81	7 17	7 14	10.83	N/E	9 01	7 35	7 73	7 42	6 77	10 97	N/E	5 95	6 72	7 49	7 23	7 06	11 56	N/E	5 91	6 56	6 69	7 44	6 81	11 59	PE			
133	29	6	2	3	m	12/28/1982	White	9 84	7 06	N/E	7 84	7 51	12.45	N/E	9 35	7 11	N/E	7 70	7 06	12 48	N/E	5 87	6 28	N/E	8.27	7.28	12 13	N/E	5 99	6 19	N/E	8 18	7 73	12 02	N/E			
134	29	7	2	3	m	6/10/1984	White	8.69	7 38	N/E	N/E	N/E	11 15	N/E	8.29	7 05	N/E	N/E	N/E	11 14	N/E	5 74	6 14	N/E	N/E	N/E	10 94	N/E	5 19	6 06	N/E	N/E	N/E	11 16	N/E			
135	29	8	2	3	m	10/8/1995	White	9 68	N/E	N/E	N/E	N/E	PE	N/E	9 14	8 50	N/E	N/E	N/E	11.28	N/E	5 54	6 07	N/E	N/E	N/E	11 14	N/E	5 65	6 19	N/E	N/E	N/E	RS	N/E			
136	30	1	2	3	m	8/4/1991	White	9 44	7 14	8 19	7.23	9 72	9 98	N/E	8.51	7.39	8.27	7 38	8 87	10 06	N/E	8.51	9 02	7.50	7.29	7.08	10 77	8.86	8.34	8.39	7.42	7.75	7.19	10 57	PE			
137	30	2	0	0	f	8/16/1984	White	7 73	7 09	7 78	7 06	6.42	10 16	PE	7 94	6 92	7 61	6 79	6 06	10 06	9 56	4 96	5 79	6 19	6 57	6 81	10 15	9 52	5 03	5 72	6 47	6 46	5 74	10 01	9 47			
138	30	3	0	0	m	12/21/1963	White	9.26	7 37	8.04	7.26	6.84	RS	9 59	9 76	8 62	8 15	7 01	6 98	RS	8 11	8.25	6 77	7 15	7.28	11 61	10 71	x	5 92	6 43	7 71	7 00	7 14	11 56	10 81			
139	30	4	2	3	f	1/24/1988	White	8 54	7 49	7 84	RS	RS	9 76	9 69	8 67	7.33	7 81	7 13	6 89	9 75	9 70	5 41	5 84	6 45	7.47	7.22	10 63	10 44	5 47	5 92	6 96	RS	RS	10 37	10.29			
140	30	5	2	3	m	4/12/1900	White	9 09	7 60	7 98	8 02	7 01	10 17	N/E	9 06	7 35	8 02	7 72	7.28	10.22	10.28	5 76	6 48	6 96	7 13	7 53	11 51	10 61	6 04	6.24	7 03	7 14	7 68	11 31	PE			
141	31	1	2	3	m	8/11/1969	White	8 64	8.74	7 89	7 73	7 16	10 75	N/E	8.23	8 58	7.73	7.42	7 05	10.78	N/E	5 58	6 37	6 95	6.82	7 06	10 56	N/E	5 69	6 03	7 13	7 04	N/E	10.28	N/E			
142	31	2	0	0	f	12/3/1961	White	8 48	8 47	7 58	6 66	6 63	10 94	9 10	8 54	8 81	7 88	6 62	6 87	10 78	8 43	5 61	6.29	6 78	8 78	8 80	10.28	9 75	5 69	6 00	7 34	6.86	6 96	10 14	10 03			
143	31	3	0	0	m	8/21/1961	White	8.21	8 89	7 58	7.28	6 13	10 01	10 44	8 07	8 92	7.28	6 98	6.32	10 41	9 77	5 06	5 72	8 85	8 92	8 98	RS	10 11	5 39	5 73	6 87	7 02	6 81	10 16	9 61			
144	31	4	2	3	m	8/21/1982	White	9 06	8 55	PE	7.37	7.21	10 93	N/E	8 84	8 98	N/E	7 42	7.11	10 83	N/E	5 55	6.21	7.21	7 41	7 57	10 86	N/E	5 33	6 19	7.24	7 36	7 52	10 83	N/E			
145	32	1	2	3	f	8/21/1969	White	9 04	8 74	7.44	8.87	8 74	10.48	10.24	9 07	8.71	7 84	7 11	8 93	10.47	10.32	5.52	5 71	7.06	7 43	7.54	10.87	PE	5 55	5 78	6 91	7.41	7.39	9 59	PE			
146	32	2	0	0	f	8/5/1986	White	8.37	8 84	7 79	7 09	7 31	11 00	10 82	8 33	7 10	7 71	8 85	8 72	9 86	9 52	8.25	5 66	6 52	8 94	7 37	10 86	10 76	5 17	5 62	6 41	7 04	RS	RS	RS			
147	32	3	0	0	m		White	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Deceased		
148	32	4	2	3	m	8/28/1981	White	8.60	8 90	7 84	6 77	6 54	11 14	10.26	8 52	8 08	N/E	6 75	6 48	11 00	9 51	5 42	5 81	6 78	7 07	7.28	11.27	RS	5 38	6 21	6 82	7 16	7 41	11.28	10 32			
149	32	5	2	3	f	3/24/1985	White	8 62	8 73	N/E	N/E	N/E	10 47	N/E	8 53	8 79	N/E	N/E	N/E	10 57	N/E	5 34	5 58	N/E	N/E	N/E	11 56	N/E	5 55	5 71	N/E	N/E	N/E	10 81	N/E			
150	33	1	2	3	m	7/12/1989	White	8 65	8 68	8.25	7 82	8 69	11 01	PE	8 82	8.27	8 01	7 38	8 88	10 35	PE	5.28	5 79	7 11	7 47	7.28	11.27	10 86	5.29	6 16	6 98	7.57	7 31	11.29	10 41			
151	33	2	0	0	f	8/3/1965	White	8 82	8 81	7 68	x	RS	RS	RS	8 68	8 84	7 55	7 00	x	RS	RS	5 29	5 98	7 04	7 12	8 56	11 33	10 48	5 33	5 96	6 64	7 02	RS	RS	10 42			
152	33	3	0	0	m		White	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Divorced		
153	33	4	2	3	m	8/5/1992	White	9 19	7 34	8 30	7 44	8 93	11 70	10.27	9 16	7 33	8 15	7 51	7 86	10 98	PE	5 58	6 31	7 17	7 15	7 79	11 27	PE	5 54	6 19	7.24	7 10	7 41	11.30	PE			
154	34	1	2	3	f	11/22/1991	White	8 58	7.96	8.14	7.63	N/E	11 97	N/E	8.65	7.67	8.27	7.84	7.15	11.72	10 87	5 48	6 39	6 82	7.59	7 96	12.00	N/E	5.50	6 39	6 96	7.53	7 75	11.77	N/E			
155	34	2	0	0	f	10/11/1963	White	8 45	8 73	7 08	x	6.99	10 71	9 41	8 19	8 38	8 79	x	6 35	10 48	9 79	5 47	5 83	7.24	x	8 96	10 94	10 44	5 36	5 77	6 82	x	7 30	10.88	10 33			
156	34	3	0	0	m	8/15/1959	White	8 81	8 63	8 56	7 67	RS	RS	RS	8 97	8 06	8 83	RS	x	11 71	10 75	5 56	6 18	7 60	7 14	7 60	12 06	11.26	5 54	6.24	7 67	7.29	RS	RS	RS			
157	34	4	2	3	m	1/8/1983	White	8 78	8 47	N/E	N/E	N/E	11.26	N/E	8 48	8 92	N/E	N/E	N/E	11 58	N/E	5.24	5 96	N/E	N/E	N/E	11 37	N/E	5 37	6 07	7.29	N/E	N/E	11 07	N/E			
158	34	5	2	3	f	7/19/1986	White	8.60	8 05	8.78	7 61	7 79	11 32	10 99	8 89	8 39	8 41	7 76	8 00	11 58	10 68	5 57	5 96	7 14	7 11	7 97	11 41	PE	5 55	5 94	7.22	7 16	7 94	11 62	PE			
159	35	1	2	3	f	12/4/1969	White	9 15	8 96	7 91	7.27	8 93	11 11	N/E	9 19	8 97	7 89	7 42	7 09	11 52	PE	5 31	5 84	6.73	7.77	7 84	11.42	PE	5 45	5 85	6 87	7.75	7.27	11.42	PE			
160	35	2	0	0	f	8/22/1958	White	8 81	7 19	8 03	x	RS	RS	N/E	8 56	7 30	7 97	x	RS	RS	RS	5 90	6 27	6 96	x	RS	RS	RS	5 74	6 17	7 42	x	RS	RS	N/E			
161	35	3	0	0	m	4/8/1957	White	RS	6 96	8.29	7 43	7.22	11 62	10 37	RS	8 97	8 45	7 57	7.25	11 84	10 36	5 86	6 36	7 08	7 53	7 05	12.27	10 96	5 96	6 43	6 99	7.39	7 08	RS	11 37			
162	36	1	2	3	f	9/15/1996	White	8 95	8.58	7 40	6 86	6.87	10.40	10 02	8 98	8 47	7 37	8 63	8 49	10.69	10.29	5.52	5 72	8 82	8 98	N/E	11 19	PE	5 48	5 96	6 87	8 95	7 03	11.17	11.28			
163	36	2	0	0	f	10/28/1959	White	9 17	7.29	7 69	8 45	8 96	x	RS	9.22	7 01	7 87	8 44	RS	x	x	5 42	5 90	6 34	RS	RS	RS	x	5 41	5 93	6.28	6 72	8 48	x	x			
164	36	3	0	0	m		White	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	k	Deceased		
165	36	4	2	3	m	9/15/1996	White	8.96	8 91	7 69	8 83	8 48	10 09	9 94	8 81	8 98	7 96	8 80	8 46	10 78	10 07	5 82	5 84	6 83	7 18	7.22	11 18	11 47	5 84	5 96	6 90	7 06	7.21	11 16	11.26			
166	37	1	2	3	f	4/8/1980	African American	9.26	7 00	8 39	7 75	N/E	11 52	PE	9 51	8 02	8.46	7 33	7.20	11 57	11.24	5 85	6 43	7 61	7 67	PE	12.22	PE	5 78	6 49	7.59	8.09	7 93	12.25	PE			
167	37	2	0	0	f	10/17/1971	African American	8 96	x	9 30	7 64	7 78	12.41	11.27	8 87	8 18	8 89	7 73	7.35	12.27	PE	6 64	7 18	8 49	8.28	8.37	13.61	x	6.64	7 04	8.67	8.34	x	12.66	x			
168	37	3	0	0	m		African American	8.26	7 44	8 45	7 95	7.25	10 80	10 69	8.27	7 32	8 41	7 90	7.52	10 79	10 69	5 75	7 06	7 79	8.26	8 09	11 97	12.02	5 62	7 00	7 83	8.26	7 96	11 67	11 99			
169	38	1	2	3	m	10/28/1996	White	8 70	7 18	7 93	6 89	7 17	10 53	11 00	8 96	8 94	8 06	7 03	6 96	10 61	10.31	5.77	6.21	7 36	7 13	7 33	11.34	10 90	5.58	6 18	7.23	7.17	7 07	11 55	10.75			
170	38	2	0	0	f	5/15/1996	White	RS	7 41	8.37	x	7.22	11 11	10 64	RS	7 44	8 47	x	7.33	11 04	10 98	5 64	6.20	7 04	x	7 11	12.09	12.05	5 72	6 34	7 03	x	7 80	RS	12.01			
171	38	3	0	0	m	5/1/1958	White	9 10	8 98	8.21	6 80	6 96	12.49	10 66	9 04	8 91	8.14	6 86	6 67	11 51	9.22	5 85	6.21	7 11	7.26	7 42	x	RS	5 82	6.24	7 18	7 14	7 54	RS	RS			
172	38	4	2	3	m	11/2/1991	White	9 45	7 61	7 70	7 68	7 60	11 63	PE	9 43	7 00	7 77	7 48	7.98	11 90	N/E	6.25	7 04	7 84	7 69	7.77	12.05	10 49	6.11	6 84	7 87	7 87	7 86	12.11	10 59			
173	39	1	2	3	m	9/2/1981	White	8 88	7.22	7 99	6.84	6.89	11 06	10.31	8 11	7.21	7 83	6 75	7 05	10.81	10.27	5.22	5 94	6 98	6.88	7 91	12.06	11 36	5 31	5 91	6 98	7 19	7 92	12.02	11 45			
174	39	2	0	0	f	9/27/1962	White	9 13	8 78	7 18	8.84	RS	RS	10 47	9 12	8 92	7.23	8 19	7 10	10.20	10 97	5 75	6 19	6 61	7.21	7.28	11 06	11 59	5 58	6 09	6 61	8 92	RS	11 14	10 92			
175	39	3	0	0	m	12/28/1949	White	8 73	7 61	8 58	7 14	7.29	10.87	10 12	8 74	7 84	8 89	RS	8 91	11 18	10 18	8 07	8 57	7.24	7 06	7 57	RS	12.20	5 95	6.47	7 40	7 18	RS	RS	RS			
176	39	4	2	3	m	2/23/1977	White	9 05	8 95	8 13	x	7 31	11 93	10 63	9 02	8 85	8 31	x	7 47	12.07	11 48	5 76	6.29	7 33	x	7 75	12.62	12.79	5 77	6.20	7 37	x	7 77	12.89	12.73			
177	39	5	2	3	f	12/27/1983	White	8 50	7 03	7.86	6 45	x	10 86	9 81	8 78	8 85	8 00	8 67	x	10 34	10.22	5 46	6 01	6 46	6 76	x	10 82	11 02	5 70	6 02	8 51	8 99	x	10 87	10 94			
178	39	6	2	3	m	10/19/1978	White	9 10	8 03	8.41	7 52	7 78	11.29	10 89	9 15	7 94	8.29	7 53	7 81	11 39	11 18	6 09	6 45	7 03	7 73	7 96	13.22	13 17	5 85	6 37	6 88	7 37	8.07	13 08	13 16			
179	40	1	2	3	m	3/6/1990	White	8.01	8 81	N/E	7 09	8 51	10 02	N/E	7 94	8 84	PE	8 81	8 10	10.09	N/E	5 12	5 84	7 17	7 78	7 42	11 73	N/E	5.27	5 86	PE	7 17	7.26	11.23	10.79			
180	40	2	0	0	f	3/21/1963	White	8.23	8 44	7.20	6 73	8 67	10 01	9 82	8 06	7 08	7 39	8 81	8 93	9 82	PE	5 34	5 88	6 83	6 68	7 31	11.26	10 13	5 33	5 81	6 41	6.84	7.21	RS	10 08			
181	40	3	0	0	m	9/27/1959	White	8.59	7 02	7.86	6 52	RS	9 81	9 68	8 42	8 59	7 70	x	6.59	x	x	5 68	5 79	6 81	6.86	7 08	10 69	10 62	5 52	5 77	6 74	6.34	7 14	x	10 87			
182	40	4	2	3	m	2/8/1969	White	8 78	8 43	7.23	6 98	6 18	10 97	10 06	8 75	8 38	7 47	6 42	6 33	10 65	10 03	5 36	5 87	6 74	7 05	6 83	11 09	9 84	5.28	5 77	6 81	7 18	6 82	10 91	9 93			
183																																						
184						N/E. Not Erupted																																		
185						x. Extracted																																		
186						k. Unknown																																		
187						RS. Restoration																																		
188						PE. Partially Erupted																																		

APPENDIX 5

Family Specific Means for Tooth-Size in Families Affected with Dental Agenesis

Appendix 5: Family Specific Means for Tooth-Size in Families Affected with Dental Agenesis

FamilyID	UR1	UL1	UR2	UL2	UR3	UL3	UR4	UL4	UR5	UL5	UR6	UL6	UR7	UL7	LL1	LR1	LL2	LR2	LL3	LR3	LL4	LR4	LL5	LR5	LL6	LR6	LL7	LR7
FAM04	8 80	8 90	7 51	7 50	7 86	7 87	6.75	6 79	7 64	7.29	10 94	10.72	9 15	10.74	5 62	5 62	6 43	6 19	6 92	7.11	7 18	7 12	7 15	NA	10 78	10 75	10.92	11.51
FAM09	8.99	8 92	7 39	6 90	8.11	7 98	7.48	7 47	NA	7 24	10 75	10.57	10 26	NA	5 62	5.68	5 82	5 92	6.99	7 01	7.38	7.32	7.75	NA	11.78	11 92	11.53	10 99
FAM18	8 76	8 86	6 08	6 41	7 70	7 84	7 07	6 78	6 80	6 68	9 86	9 86	9 56	9 16	5.28	5 38	6.11	6 00	6.84	6.84	6 83	7 02	7.22	7 13	10.28	10 64	9.75	10.00
FAM20	8 42	8 45	5 65	5 76	7.33	7 40	7 17	7.00	6.52	6 75	10.36	10 51	9 72	9 94	5 39	5 16	5.64	5 91	6 48	6.64	6.96	6 79	7.07	6 95	10.69	10.79	9 82	9 66
FAM21	9.11	8 77	7 08	7 36	7.98	7 90	NA	6.66	6 38	6 26	10 61	NA	9 41	9 22	5 68	5 76	6.06	5.96	6 77	7.05	6.68	6 81	7 02	6.79	10 49	10.87	9 78	9 90
FAM25	8 39	8 62	6.39	6 34	7.80	7 62	6.96	6.98	6.80	6 85	10 68	10 60	9 77	9.54	5 29	5 45	5 73	5.75	6 83	7 01	6.64	6.76	6 72	6.83	11 09	11.19	9 95	9 87
FAM30	8 83	8.93	6.51	6 31	7.69	7 73	6 71	6 97	NA	6 98	10 48	10.89	9 48	10 29	5 62	5 66	6.25	6.14	7.11	6 93	7.24	7.36	7 84	NA	11 37	11.43	11 69	11 21
FAM36	9 31	9 40	7 00	6 93	8 54	7.82	7 55	7 57	7 39	7 34	10 46	10 75	10 78	10.13	5 97	5 86	6 34	6.43	7 37	7 42	7 74	7.75	7 48	7.59	11 23	11 19	9.83	10 99
FAM37	8 76	8 69	6 39	5 41	7 87	7 83	6.90	6 81	5.97	6 32	10.41	10 45	9 52	9 55	5 27	5.24	5 65	5.64	7 19	7 17	6.90	7.04	7.42	7 33	10.63	10 86	9.77	9 80
FAM39	8 36	8.35	5 63	5 77	7 93	7 13	7 09	7.17	6 78	6 75	10 58	10 38	10 10	10 30	5 44	5 43	6 05	6 05	6 97	6 71	7.15	7 17	7 41	7 27	11 19	11 34	10 87	10 43
FAM40	8 11	8 01	6 97	6.69	7 94	8 04	7 21	7.17	6 86	6.87	10 06	10 07	9 53	9 49	5.27	5 34	5 82	5.92	7 18	7 05	7.10	7.12	7 20	7 28	10 31	10 58	10 06	10 19
FAM41	8.88	8 80	6 49	6 42	8 09	7 94	7.65	7.37	6 96	7 24	10 48	10 49	10 14	10 02	5 73	5 68	5 97	5 99	6 84	6 77	7 56	7 38	7.23	7 52	10.91	10 60	10 72	10.58
FAM43	8 03	8.29	6 06	6 51	7.74	7 39	6 78	7.02	6 64	6 63	10 66	10 28	9 72	9 67	4 88	5 17	5.81	5 66	6.50	6 50	6 66	6 99	NA	6.63	11.01	10 69	10 10	10 24
FAM47	9 03	8 99	6 54	6 44	7 89	7 87	7 03	6 89	NA	7 34	11 22	10 85	10.80	10 43	6 02	6 12	6 28	6 42	6 91	6 97	7 13	7 26	8 07	8 00	11.63	11.61	11.12	11 31
FAM49	8 50	8.50	5 73	6 34	7 51	7 40	6 90	6.74	6 47	6 62	10 82	11 02	10.17	10 26	5 06	5 05	5 56	5.46	6 77	6 79	6 94	7 03	6 93	6.95	11 19	11.12	10 41	10 48
FAM50	8 80	8 75	6 81	6 45	7 82	8 51	NA	7.10	6 32	6 73	10.33	10 25	10 28	10 09	5 45	5 35	6.27	6 08	7 37	6 89	7 89	7 27	[redacted]		10 74	10 79	NA	10 56
FAM51	8.52	8.52	6 81	6 14	8 15	8 07	7 12	7.11	7 08	7 01	10.89	10 88	10 33	9 64	5 60	5 61	6 22	6 25	7.11	7.13	7 27	7 18	7.51	7.42	11 47	11 33	10 59	10 42
FAM56	9 18	9.07	7 72	6 90	8 52	8 36	7 01	6.83	6 75	6.80	10.04	10.10	9 87	9 96	5 64	5 52	5.96	5 94	7.16	7.45	6.95	7 14	7 24	7.24	9.91	10.67	10 43	10 30
FAM57	8 84	9.20	6.52	6 61	7 48	7.33	6 90	7.06	6 83	6.65	9.84	10 08	9 69	10 23	5 50	5.39	5 96	6 14	6 72	6.76	6.93	6 81	7 04	6.96	10 91	11 00	10 32	10 46
FAM59	8 58	8 69	6.30	6 04	7 96	7 94	7 13	7.08	7 12	7.09	10.48	10.76	9 55	10 41	5 60	5 58	6.01	6.06	6.91	7.08	7 25	7.53	7 63	7 62	10 89	10.56	10.46	10 75
FAM66	8 52	8 46	6.11	5 94	7.58	6.80	6 18	6 40			10 58	10 56	9 10	NA	5 43	5 42	5.65	5 63	6.35	6.28	6 65	6.29	7 38	7.30	11 38	11 31		
FAM68	8 65	8.60	7.22	7 83	7.84	8.12	7 28	7 12	7 15	6 97	10 82	10 61	10.38	9.79	5 55	5 50	5.84	5.90	6.78	6 79	7 18	7.30	7 44	7.33	11 25	10 96	10.47	9 62
FAM69	8 96	9 00	6.46	6.36	7.97	7.80	7.07	7 32	7.03	6.59	10 62	10 64	10 33	NA	5 79	5 86	6 35	6 27	7 05	7 04	7 00	6.96	7.24	7 21	11.25	11 14	11 02	10 26
FAM74	9 11	9 36	7.31	6 99	7.83	7.85	7.24	7 18	6 69	6.81	11 01	11 05	10.57	10 61	5 62	5 56	5.89	6 14	7 15	7 22	7 18	7 20	7.41	7 37	11 78	11.80	11 15	10 98
FAM75	8 83	8.91	7.18	7.10	7.61	7.45	7.40	7 44	7.07	7.13	10 79	11.09	10 07	10 57	5.52	5 56	5 64	5.68	6 60	6 88	7.26	7 24	7.68	7 38	11 48	11 63	10 97	10 49
FAM80	9 08	9 08	6.99	6.58	7.54	7.62	6.99	6 91	7.04	7.14	10.60	10.52	9 85	9 37	5 85	5 79	6 19	6.26	6 92	6.97	7 16	7 31	7.41	7 37	10.74	11.05	10 24	10.13
FAM83	8.35	8 14	6 42	6 52	7 16	6.84	6.56	6 58	6.21	6 59	10 28	10 35	10 22	9 86	5 37	5 45	5 75	5 84	6 28	6 46	6.56	6 95	7.01	6 90	11.13	11.06	9 98	9.90
FAM89	9.15	9 58	7 67	7.75	8 53	8.52	7.69	7 50	7.17	7 11	11 04	10.87	10 28	9 98	5 77	5 78	6 19	6 26	7 49	7 47	7 58	7.58	7.89	7 90	11.30	11.55	11 06	10 72
FAM90	9 10	9 08	6.84	6.83	8.51	8 49	7.13	7.03	7 20	7.24	11 58	11.22	10 09	10.12	5.76	5 71	6 19	6 20	7 24	7.13	7.10	7 01	7 55	7.65	10 94	11 09	11.12	11.19
FAM91	9.11	9.24	6 40	6.70	7 90	8 06	6.98	6 75	7.04	6.94	10 79	10.70	10 23	10 25	5 65	5 91	6 37	6 34	7 09	7 10	7.10	7 06	7 20	7.38	11 56	11 43	10 81	11.66
FAM92	8.41	8 54	5 92	6.09	7 32	7 27	6.68	6 33	6.19	6.12	9 90	9 86	9 98	9 72	5 58	5 52	5.91	5.91	6.52	6 72	6.59	6 54	6 72	6.70	9 88	9.78	9 93	9 12
FAM93	8.51	8 49	6 71	7 08	7 78	7 86	6 89	6.86	6 23	6.22	10 43	10 20	8 60	9 17	5 71	5 56	6 05	6 06	7.35	7.10	6.81	6 75	7 02	6.96	10 32	10.34	10.21	9 89
FAM94	8.32	8 47	6 00	6 09	7 94	7.69	6 72	7 04	6 65	6.92	10 40	10 47	9 39	9.55	5 41	5 40	5 83	5 87	6.67	6.57	7.26	7.22	7 06	7.12	10 54	10 88	10.16	10 06
FAM95	8.34	8.37	6 15	9 37	7.43	7 26	6 58	NA				[redacted]	NA	8 78	5 25	5 45	5.57	5 89	6.05	6.21	6.82	6.86	7 48	7 36	NA	10 04		
FAM96	9.67	10.04	7.23	7 11	8 88	8 92	7.39	7.28	7 64	7.26	11.36	11.21	11 40	11 59	5 74	5.99	6 45	6 46	8 11	8 08	7 70	7.88	7 81	8.20	11.70	11.52	10 86	11.03
FAM97	8 39	8.46	5.77	6.63	7.87	7.90	7.23	7.19	7 16	7 09	11.26	10 87	10 36	NA	5.59	5.49	5.64	5.47	7 23	7.27	7 19	7 22	8.02	8 13	11 75	NA	11 47	11 39
FAM98	8 79	8.83	6.39	6.22	7 85	7.87	7 08	7.29	6 42	6 77	12.49	11.93	10.51	10.58	5.72	5 69	5 84	5.88	6 64	6.73	7.32	7 54	7.23	7.20	12.52	11 16	NA	10.29
FAM99	7 96	7.96	6.81	6 71	7.61	7.63	6 89	6.91	7 01	6 48	10.08	10 10	10.22	10.33	5.18	5 17	5.88	5.80	6 72	6 81	6 98	6.90	6.68	6 63	10.72	10 65	10.26	10 34
FAM100	8 77	8.79	6.44	6 19	7 78	7.86	7 58	7.79	7 14	7.20	10 67	10.81	9.92	10.97	5 25	5 28	5.85	5 72	6 78	6 68	7 43	7 31	7.71	7.65	10 98	11.22	11 17	10 72
FAM101	9 24	9 28	7.09	7 12	8.26	8 00	7 71	7.55	7 12	7 20	10 46	10 46	10.54	10 52	6.21	6.05	6 79	6 62	7 11	7.31	7 43	7.58	7.19	7.25	11 50	11.12	10 63	10 76
FAM102	8 61	8.72	7.28	7.28	8.32	8.32	7.53	7.76	7 45	7.38	10 85	10.93	10 44	10.75	5 35	5 43	6 24	6 24	7 47	7 23	7 60	7.41	7.56	7.62	11 82	11 77	11.30	11 63

APPENDIX 6

Family Specific Means for Tooth-Size in Control Families

Appendix 6: Family Specific Means for Tooth-Size in Control Families

Type	UR1	UL1	UR2	UL2	UR3	UL3	UR4	UL4	UR5	UL5	UR6	UL6	UR7	UL7	LL1	LR1	LL2	LR2	LL3	LR3	LL4	LR4	LL5	LR5	LL6	LR6	LL7	LR7
FAM01	8 84	9.09	7.10	6 79	8.00	8 09	7.39	7.20	6 74	6.73	10 29	10 21	9.56	10 41	5 20	5.22	5.78	5 70	6.80	6.83	7.17	7 08	7.32	7 20	10 32	10 35	9 82	9.74
FAM02	8 50	8 52	6.89	6.98	7.72	7.68	7.37	7.34	7.22	7.05	10 16	[redacted]	[redacted]	10 63	5 42	5 40	5.94	5.91	6.95	6.82	7.58	7.27	7.81	7.69	11.43	11.36	11.03	10 26
FAM03	9.29	9 03	7.06	7.33	8.11	8 00	7.53	7.44	7 19	7.16	10 94	10.99	10.39	10.31	5.73	5.68	6 41	6 29	7 78	7 74	7 51	7 76	7 81	7 79	12 65	12 66	10 77	10 56
FAM04	8.16	7 80	6.28	6 42	7.44	7.47	7.14	7.16	6.92	6.95	10.37	10 08	9.61	9 49	5 13	5.18	5.97	6.00	6 81	6.93	6.66	6.57	6.65	7.15	10.99	10.85	10 67	9 95
FAM05	8.68	8 50	6.94	6 95	7.93	8 18	7.37	7.41	7 53	7.23	10 70	10.70	9.67	9.55	5.49	5.55	6 03	6 20	7 23	7 15	7.48	7 42	7 43	7 82	11 90	11.72	10 85	11.37
FAM06	8.66	8 72	6.82	6 65	7.90	8.10	7.14	6.91	6.83	6.84	10 57	10 31	10.00	9 88	5.49	5 59	6 44	6 20	7.43	7.14	7.03	6.81	7.06	7.27	10 75	10 42	10.34	10 25
FAM07	8.81	8.57	6.75	6 59	8.26	8.09	7.16	6.92	6.86	6.65	10.52	10.38	10 53	10 57	5 56	5 53	6 12	6 09	7.33	7 23	7.11	7.07	7.42	7.50	11.51	11.40	10.59	10.60
FAM08	8.43	8 68	7.10	7.08	7.38	7 65	7.16	7.13	6 70	[redacted]	9 99	9 90	[redacted]	[redacted]	5.37	5.43	5.82	5.80	6.57	6.69	6.82	6 57	[redacted]	[redacted]	10.58	10 57	[redacted]	[redacted]
FAM09	8.92	8.98	7.15	7 26	8.21	7.97	6 91	7.11	6.61	6.71	10.73	10 71	10.77	10 35	5.65	5 75	6 24	6.04	7.06	7 03	7.34	7.20	7.42	7.25	11.20	11 05	[redacted]	10 70
FAM10	8.71	8.81	7.26	7 14	7.77	7 94	6.41	6 52	6.49	6.35	11 01	10.63	10.30	10.36	5 68	5 61	5 98	5 98	6 78	6.88	6.98	6.86	7 07	7.07	10.95	10.92	10.88	11.22
FAM11	8.49	8.49	6.86	6.79	7.88	7 93	6 71	6.49	6.51	6.59	10 43	10 41	10.05	10 18	5 50	5.45	5.84	5 87	6 99	7.05	7.02	6.97	7 09	7.03	10.86	11.22	10.47	9 52
FAM12	9.13	9.09	7.54	7 20	7.82	7.85	7.20	7.04	7 31	7.18	10.49	10.51	10 15	9 94	5 64	5 58	6 19	6 41	6 78	6 85	6.82	6.87	7.08	7.31	11.17	11.04	10.91	10.68
FAM14	8.61	8.48	6 67	6 59	7.69	7.61	7.32	7.28	7 16	7.01	10 94	10.65	9.66	9.80	5.69	5 73	6 23	6.14	6 84	6.86	7 18	7.01	7.21	7 32	11.20	11.12	10.23	10.35
FAM15	8.02	8.01	5 85	6.00	7.18	7.25	7 32	7 15	6.96	7 33	10 73	10.72	10.38	10.49	5.50	5.31	5 88	5 89	6 79	6.89	7 32	7.30	7 35	7.36	10.60	10.49	10 10	10.32
FAM16	8 90	8.96	6.92	6.74	8.10	7.78	6.72	6.58	6.46	6.75	10.61	10 40	10 31	10 12	5 64	5 72	6.41	6.41	7.23	7.13	7.31	7.05	7.24	7.66	10.94	11.06	9 87	10.36
FAM17	9 44	9.14	7 57	7.42	8 09	7.97	7.37	7.34	7.32	7.37	10.92	10.96	10 16	9 71	5.85	5 79	6 29	6 28	7 54	7 31	7 46	7 41	7.88	7.67	11.44	11.23	11.00	11.08
FAM19	8 46	8.43	6 57	6.59	8 07	8.03	6.94	7.23	7.10	6.98	10.86	10 66	10.22	10 26	5 52	5 49	5 76	5 75	6.83	6.92	7 27	7.25	6.91	6.88	11.13	11.06	10 93	11.29
FAM21	8 74	8.71	7 47	7.31	8 18	8.11	7 34	7 36	7.26	7 17	11 31	11.45	10 62	10 71	5 68	5 56	6 45	6 50	7 07	7.28	7 66	7 63	7 91	7 65	11 46	11 31	11 05	11.29
FAM22	8 65	8.61	6.92	6.81	7.69	7.60	6 94	7.03	6.95	6.89	10.18	10.16	9.88	9 82	5.44	5 32	5.93	6.00	6.84	6.83	7.16	7.19	7.31	7.22	11.17	11.17	10.33	10 31
FAM23	8 90	8.94	7 55	7.45	7 45	7.55	6.96	7 14	7.02	6.97	10.93	10 39	10 04	9 75	5 71	5.66	6 37	6 28	6.78	6.81	6.82	6.69	7.51	7 43	11 63	11.64	10 77	10 86
FAM24	9.35	9.32	7.29	7.25	8 18	8.25	7.41	7.31	7.30	7.11	11.00	11.05	10 69	10 34	6 02	6 16	6.70	6.47	6 94	7.07	7.58	7.36	7.56	8 53	11 73	11 85	11 15	10 87
FAM25	8 32	8 46	6.40	6.74	7 86	7.74	7.00	7.03	6.65	6.67	10.34	10.28	9 76	9.57	5 42	5.35	5 77	5 75	6 78	6.61	6 91	7 03	6 97	6 94	10.49	10 27	9.71	9.41
FAM26	9.24	9.21	6.92	6.99	8.13	8.01	7 28	7.25	7.14	7.06	10.77	10.76	9 89	[redacted]	5.58	5 62	6.40	6.37	7.24	7 19	6.82	7.13	7.31	7.34	11 67	11 66	10 57	10 70
FAM27	9.11	8 96	6 70	6.80	7 87	7.98	6 99	7.09	6.73	7.32	10.25	10.21	10 03	10 34	5.77	5 77	6.20	6.24	7.10	7.04	7.16	7.02	7.43	7 53	10 45	10 35	9 98	10 36
FAM28	8.17	8.28	6 25	6.67	7.48	7.36	6 64	6 72	6.79	6 60	10.03	10.01	9.41	9 33	5.72	5 89	5 88	6 12	6 85	6.68	6 81	6.75	6.89	7.09	11.11	10 70	10.13	9.95
FAM29	9.34	9.24	7 47	7.37	8 18	8.04	7 56	7 58	7.33	6 99	11.34	11.64	11.76	10.96	5.82	5.83	6 38	6.37	7 47	7.19	7 71	7 61	7.43	7 49	11 88	12 00	11.23	11 22
FAM30	8.61	8.75	7.34	7 10	7.93	7.97	7.39	7.21	6.75	6.82	10.02	10.03	9 64	8 91	5 58	5 56	6.18	6.14	6.85	7 12	7.15	7.09	8.01	6.93	10 79	10.76	9.91	10 19
FAM31	8.60	8 42	6.66	6.82	7 68	7.56	7 26	7 09	6.78	6 84	10.66	10.70	9 77	9 10	5.46	5 53	6 15	5 99	6 89	7.10	6 98	7 08	7.07	7 10	10.57	10 30	9.93	9.82
FAM32	8.64	8.64	6.73	6.63	7.62	7.63	6.91	6.90	6.86	6.71	10.87	10.45	10 44	9 95	5 40	5 37	5 73	5.87	6.78	6.71	7.15	7.20	7.40	7.40	11.00	10.43	10.78	10 32
FAM33	8.79	8 89	6.90	6 81	8 07	7.90	7.48	7 30	6.81	7 36	11.36	10.67	10 27	[redacted]	5 38	5.39	6 02	6 10	7.11	6 95	7.25	7 23	7.20	7.36	11.29	11.30	10.57	10.42
FAM34	8.59	8 63	6.77	6.60	8 14	8.00	7.64	7 80	7.24	7 17	11.33	11.37	10.20	10.52	5.52	5.49	6.10	6 09	7 20	7.18	7.28	7 33	7.63	7 66	11.60	11.42	10.85	10.33
FAM35	9.15	9.19	6 96	6.97	7.95	8.17	7.35	7.50	7.08	7.17	11.37	11.48	10.37	10 36	5.59	5.71	6.10	6.14	6.91	6.93	7.65	7.57	7.30	7.18	11.85	11.42	10.98	11.37
FAM36	9.06	8 95	6.93	6.74	7.55	7 47	6 66	6 54	6.57	6.49	10.40	10 69	10.02	10 29	5.47	5.45	5.86	5.96	6 43	6.43	6 68	6 84	[redacted]	6.76	11.16	11.17	[redacted]	11.28
FAM38	9.08	9 04	7.30	7 07	8.05	8.12	7.12	7 12	7.24	7 18	11.44	11.21	10 77	10 07	5.88	5.81	6 42	6 35	7 34	7 25	7 36	7 33	7.41	7.57	11.83	11.83	11.15	11.12
FAM39	8 87	8 82	7.25	7.27	7.99	8.05	6 90	6 75	7.32	7.27	11.21	11.00	10.37	10 71	5.73	5.69	6.24	6.18	6 94	6.94	7.13	7.07	7 69	7.92	12.00	11.99	12.03	11 84
FAM40	8 41	8 29	6.68	6.67	7 43	7.52	6.83	6 68	6.52	6 49	10.20	10 25	9.85	10.03	5.38	5.35	5 80	5 71	6.81	6 65	7.11	6.83	7 16	7.11	11.19	11.07	10.13	10 42

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