A Treatment Planning Classification for Oligodontia

Steven L. Singer, BDS, MSc[a]/Patrick J. Henry, BDSc, MSD, DDSchc[b]/Ian D. Lander, BDSc, MDSc[c]

Purpose: The aim of this research was to provide a classification for patients with oligodontia that could act as an aid in treatment planning. ***Materials and Methods:*** Panoramic radiograph records of 70 patients with oligodontia were used to categorize the extent of the disability and treatment modality. Patients were classified into types 1 through 3 depending on the number of missing primary and permanent teeth, as well as in relation to their prosthodontic requirements. The radiographs were then assessed independently on two separate occasions by three experienced clinicians to validate the classification. ***Results:*** There was a high level of intrarater consistency in allocating patients into the three different types with a Kappa (κ) score of 0.77 for clinician 1, 0.87 for clinician 2, and 0.94 for clinician 3. There was also a strong interrater agreement (overall κ score: 0.88). A κ score greater then 0.6 is regarded as being good and greater than 0.8 as being very good. ***Conclusions:*** Oligodontia is a heterogenous condition. Patients with oligodontia can be classified as having three different types according to the extent of their disability and the complexity of their prosthodontic requirements. This classification is a reliable diagnostic tool based on the positive outcome of the inter- and intrarater consistency. *Int J Prosthodont 2010;23:99–106.*

Tooth absence is the most common congenital dental anomaly, having a reported incidence of between 2% and 10% of the population.[1,2] It is classified according to the number of absent permanent teeth not including third molars. Hypodontia refers to patients with one to five missing teeth. Patients with six or more missing teeth are classified as having oligodontia; anodontia is the term given to the complete absence of teeth.[3]

The incidence of oligodontia is reported to be from 0.08%[1] to 0.16%.[4] In Australia, 19.6% of the population is under 15 years of age.[5] This represents an occurrence of 156 to 311 individuals under the age of 15 per 1,000,000 people. Oligodontia may occur as a feature of a specific disease, such as anhidrotic ectodermal dysplasia, incontinentia pigmenti (an X-linked genetic disorder that affects the ectodermal structures and is associated with congenital tooth absence and abnormal tooth form), or Down syndrome.[6] It can also present as an isolated condition and has been linked to mutations of the MSX1[7–9] and PAX9[10–13] genes with an autosomal dominant inheritance pattern and incomplete penetrance.

The pattern of tooth absence is influenced by the gene affected, as well as the type of mutation within that specific gene.[7–13] The teeth most commonly absent are the permanent second premolars and the maxillary lateral incisors. The permanent first molars and the maxillary central incisors are the least likely to be absent.[2] Molar absence, however, is a prominent feature of some forms of isolated oligodontia.[10–12,14]

Because of its variable genetic etiology, the presentation and subsequent clinical effect on the dentofacial structures of patients diagnosed with oligodontia may vary greatly. As a result, such patients can have very different treatment requirements depending on the degree and site of the dental and alveolar deficiency. The Dental Department at Princess Margaret Hospital, Perth, Australia, has classified patients with oligodontia as having three different types for the past 20 years,

[a]*Consultant Orthodontist, Princess Margaret Hospital for Children, Perth, Australia; Private Practice, Perth, Australia.*
[b]*Emeritus Consultant Prosthodontist, Princess Margaret Hospital for Children, Perth, Australia; Director, The Brånemark Centre, Perth, Australia.*
[c]*Consultant Prosthodontist, Princess Margaret Hospital for Children, Perth, Australia; Private Practice, Perth, Australia.*

Correspondence to: *Dr Steven L. Singer, Consultant Orthodontist, Princess Margaret Hospital for Children, Roberts Road, Subiaco, WA 6008. Fax: +61 8 9340 8135. Email: ssin9420@iinet.net.au*

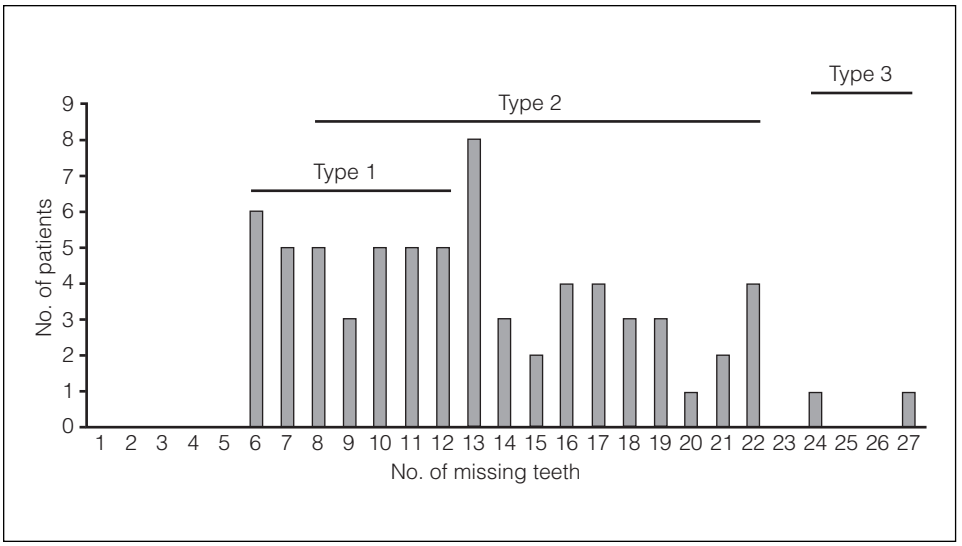

Fig 1 Patient distribution according to the number of missing teeth and oligodontia type.

based on clinical presentation and projected prosthodontic requirements, as an aid in determining the treatment required to achieve a functional occlusion. The aim of this article is to describe this classification and assess the reliability of clinicians to allocate patients with oligodontia into each type.

Materials and Methods

The Dental Department at Princess Margaret Hospital is responsible for the treatment of children born with dental and dentofacial defects within the state of Western Australia. For this study, all patients with 6 or more missing permanent teeth, not including the permanent third molars, registered within the clinic were identified. This study was approved by the hospital ethics committee. Seventy patients (42 males, 38 females) met the classification for oligodontia, with the number of missing teeth ranging from 6 to 27 (Fig 1). Twenty-four patients had an associated syndrome: 19 had ectodermal dysplasia, 2 had incontinentia pigmenti, 2 had Rieger syndrome (a rare autosomal dominant syndrome characterized by ocular and mild cranio - facial anomalies and congenital tooth absence), and 1 suffered from Stickler syndrome (a connective tissue genetic disorder in which dental anomalies are an incidental finding).

Panoramic radiographs were available for all patients. The average age when the radiographs were taken was 11 years 9 months (range: 8 years 9 months to 17 years 7 months). The stage of dental development ranged from the early mixed dentition to permanent dentition.

The occlusal features regarded as being clinically relevant in determining the complexity of future prosthodontic needs for a patient with oligodontia and the preprosthetic treatment required to achieve these goals were as follows:

- The number, location, and type of missing permanent teeth and retained primary teeth.
- The presence and span of current or potential edentulous spaces. The latter referred to retained primary teeth with no permanent successors. At this evaluation, an assessment was made as to whether the spans could be orthodontically reduced in size or eliminated.
- The presence or absence of occlusal contact involving a permanent tooth in the molar region on at least one side and the presence or absence of permanent teeth distal to the canine in at least one quadrant.
- The diagnostic criteria used to differentiate the treatment for oligodontia patients are summarized in Table 1.

Subtypes of Oligodontia

Analysis of patients with oligodontia using these guidelines resulted in the following subtypes.

Type 1. The dental arch is often intact and well developed due to the presence of permanent teeth, and when absent, the retention of their primary predecessors (Figs 2a and 2b). There is always bilateral molar support. The large number of permanent and primary teeth means that there is generally ample alveolar bone with few areas of localized bone deficiency. These are

Table 1 Morphologic Features and Oligodontia Type

	Type 1	Type 2	Type 3
Molar status			
No bilateral molar support	NA	V	A
No posterior teeth in one arch	NA	A	A
Alveolar bone volume			
Ample alveolar bone	A	A	NA
Ample alveolar bone with localized deficiency	A	A	NA
Significant generalized alveolar bone deficiency	NA	A	A
Orthodontic requirements			
No orthodontics	NA	V	A
Limited objective orthodontics	A	V	NA
Complex orthodontics	A	V	NA
Adjunctive implant-assisted anchorage	A	V	NA
Implant-supported archwire	NA	V	NA
Residual spaces			
Edentulous spans limited to 1–2 teeth wide	A	V	NA
At least 1 span greater than 2 teeth wide	NA	A	A
Prosthodontic requirements			
Postorthodontic interim prosthodontics	A	A	NA
Simple prosthodontics or implant prosthesis	A	NA	NA
Complex prosthodontics or prosthetics	NA	A	A

NA = not applicable; V = variable; A = applicable.

Fig 2a Preoperative panoramic radiograph.

Fig 2b Postoperative panoramic radiograph showing tooth alignment and planned retention of the left primary second molars. A space has been opened for implant placement in the anterior maxilla. An occlusal table has been designed for a six-to-six occlusion.

associated with edentulous areas and the mandibular anterior region, even when primary teeth are retained. If present, edentulous spans are one to two teeth wide (6 to 14 mm). The number of sites that require prosthodontic rehabilitation ranges from zero to seven and depends on the number of congenitally missing teeth (Fig 2b).

Type 2. These cases are characterized by large numbers of missing permanent teeth in localized areas and the retention of variable numbers of primary teeth (Fig 3). There may be a lack of uni- or bilateral posterior molar support and in some cases, the absence of permanent teeth distal to the canine in one or more quadrants. Supraeruption of opposing teeth into these spans may be observed. There is ample alveolar bone where teeth are present. However, significant areas of localized, and in some cases generalized, bone deficiency are associated with the large edentulous spans.

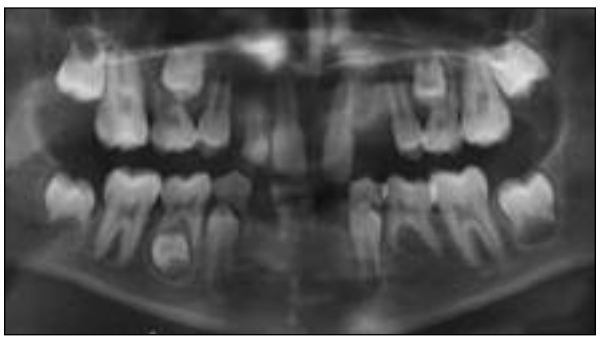

Fig 3 Typical type 2 oligodontia characterized by large numbers of missing permanent teeth in localized areas and the retention of various primary teeth.

Fig 4a Panoramic radiograph illustrating severe oligodontia in a 16-year-old adolescent. Note the eruption of maxillary incisors to the left and the nonfunctional position of the mandibular right second molar.

Fig 4b Panoramic radiograph at age 18. Treatment planning involved implant placement at the site of the right primary first molar to provide adjunctive orthodontic anchorage for maxillary center line correction. Mandibular implants were placed to provide anchorage for the mesial movement of nonfunctional second molars.

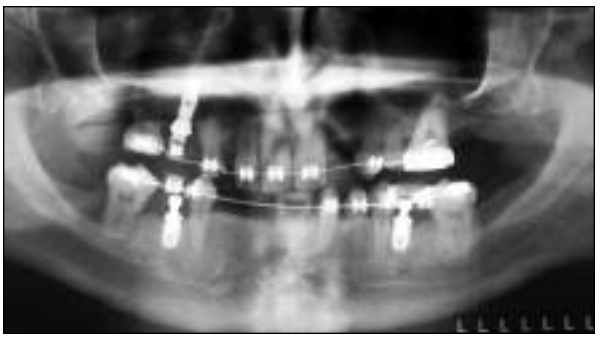

Fig 4c Panoramic radiograph at age 21. Note the correction of the maxillary center line and repositioning of the mandibular molars.

Fig 4d Panoramic radiograph at age 24. Completion of treatment illustrating implant placement and surgical repositioning of the jaws.

In some instances, potentially useful permanent teeth are positioned unfavorably and in poor esthetic and functional locations separated by large interdental spaces (Fig 4a). Several edentulous spaces may be present. However, patients have at least one large potential edentulous span three or more teeth wide. More complex situations may require surgical orthodontic treatment to facilitate long-term occlusal stability (Figs 4b to 4d).

Type 3. There is almost a complete absence of permanent and primary teeth (Fig 5). There is always an absence of bilateral support and a lack of permanent teeth distal to the canines in all quadrants. Consequently, there is a significant deficit in alveolar bone. The basal bone in the maxilla is sparse and represents a significant technical challenge to prosthetic rehabilitation. Figure 6 demonstrates a lack of alveolar development in an extreme case of a single maxillary central incisor present.

The panoramic radiographs were rated by three experienced independent clinicians (one general dentist, one pediatric dentist, and one prosthodontist) to allocate patients into either type 1, 2, or 3 oligodontia. Radiographs were viewed independently on two occasions 1 week apart to assess the intra- and interoperator reliability. On the second occasion, the order of the radiographs was randomized to avoid bias. A chart highlighting the clinical features of importance in identifying the different oligodontia types was available to the clinicians (Table 1). The Kappa (κ) statistic was used to evaluate intra- and interrater reliability for the allocation of patients into type 1, 2, or 3 oligodontia.[15]

Results

The mean number of missing teeth was 13.2 (range: 6 to 27). The median number of missing teeth in the sample was 13 (interquartile range [IQR]: 9 to 17). The allocation by the clinicians of patients into the three types of oligodontia is shown in Table 2. The median number of missing teeth was 7 (IQR: 6 to 11) for type 1, 14 (IQR: 12 to 18) for type 2, and 26 (IQR: 25 to 27)

Fig 5a Panoramic radiograph of a 14-year-old patient illustrating extensive oligodontia and a significant lack of posterior alveolar bone.

Fig 5b Three-dimensional Dentascan at age 15. The treatment plan is for a maxillary tooth-supported overdenture and mandibular implant-supported fixed prosthesis.

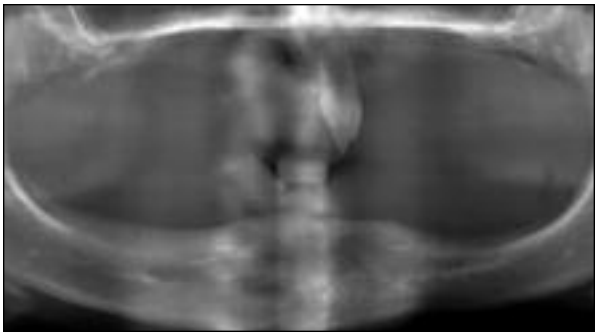

Fig 6a Panoramic radiograph of a patient with 27 missing permanent teeth. This case illustrates a complete lack in development of the alveolar base besides that associated with the single incisor tooth.

Fig 6b *(right)* Lateral cepholmetric radiograph illustrating reduced facial height development related to an absence of the dentoalveolar structures.

for type 3 for clinicians 1 and 2. The median number of missing teeth was 8 (IQR: 6.25 to 11) for type 1, 15 (IQR: 12 to 18) for type 2, and 26 (IQR: 25 to 26) for type 3 for clinician 3. The range of missing teeth was 6 to 13 for type 1, 8 to 22 for type 2, and 24 to 27 for type 3 (Fig 1).

The κ score for intrarater consistency is shown in Table 3. A κ score greater than 0.6 is regarded as being good and greater than 0.8 as very good.[15]

Discussion

In this paper, the panoramic radiographs of 70 patients with oligodontia were analyzed, and depending on their clinical presentation and projected prosthodontic requirements, patients were allocated into one of three types of oligodontia. Panoramic radiographs were chosen to classify the cases because they are the

Table 2 Independent Clinician Allocation of Patients

Allocated oligodontia type	Clinician 1	Clinician 2	Clinician 3
Type 1	21	21	24
Type 2	47	47	44
Type 3	2	2	2

Table 3 Kappa Score for Intrarater Consistency

Intrarater reliability	κ	Confidence limit
Clinician 1	0.77	0.56–0.99
Clinician 2	0.87	0.66–1.00
Clinician 3	0.94	0.73–1.00
Overall interrater agreement	0.88	0.75–1.00

most common radiograph used to assess the state of a patient's dental development. They provide a global view of the dental and alveolar structures of the jaws and if taken after the age of 8 years, will show evidence of all teeth that will develop, excluding permanent third molars.[16] The spectrum of oligodontia was well represented, with the sample of oligodontia ranging from 6 to 27 missing permanent teeth (Fig 1).

The clinical features used to identify the different types of oligodontia proved to be highly effective in allowing the clinicians to allocate patients into one of the three types of oligodontia, as evidenced by the good to very good intrarater κ scores and a very good overall interrater agreement of 0.88 (Table 3). Type 2 was the most common presentation and type 3 the least (Table 2). The severity of oligodontia increased from type 1 to type 3, with the median number of missing teeth also increasing from type 1 to type 3. This was reflected in an increased complexity of prosthodontic treatment required to rehabilitate a patient from type 1 to type 3.

Once a patient is classified, more detailed treatment planning is undertaken for future management, which varies depending on the type. This requires more extensive records such as articulated study casts and diagnostic imaging, including additional radiographic views and computed tomography scans. This classification relates to the treatment required to rehabilitate the absent dentoalveolar structures and does not consider a patient's underlying skeletal pattern. Patients may have a Class III malocclusion due to a tendency towards a skeletal 3 pattern, regardless of type of oligodontia.[17–19] Orthognathic surgery may be required to correct such a discrepancy (Fig 4).

In cases of oligodontia, it is very rare to be able to achieve a 24-tooth occlusion without prosthodontic intervention. A prosthetically driven phase of comprehensive orthodontic treatment is often required to position the permanent teeth present in type 1 and 2 patients into the ideal location for later prosthodontic rehabilitation. For example, if implant placement is planned, precise space distribution and root orientation is necessary to allow for instrumentation and the insertion of implant-supported crowns of sufficient size to achieve a good esthetic and functional outcome. The orthodontic ability to reposition teeth within the arch and the complexity of final prosthodontic treatment to rehabilitate a patient's mouth vary depending on the classification of oligodontia.

In type 1 cases (range: 6 to 13 missing teeth), it is often possible to direct orthodontic treatment towards reducing the number and size of edentulous alveolar sites that will require prosthetic rehabilitation and still achieve a 24-tooth occlusion. If arch length reduction is not possible due to the number of missing permanent teeth, prosthodontic management can be simplified by an orthodontic reduction of the residual edentulous spaces to one or two teeth wide. Generally there are sufficient teeth present to supply the anchorage for controlled tooth movement. Occasionally, however, treatment may be compromised by a lack of anchorage, necessitating the use of temporary anchorage devices. In such cases, if the aim is to reduce or eliminate an edentulous space, it is necessary to choose an implant system that does not impede the desired tooth movement or impact negatively on the edentulous residual alveolar ridge. For example, microimplant systems can be inserted in alveolar bone distant from the area being closed and subsequently connected to the teeth being used as an anchor unit,[20,21] or in the basal bone of the hard palate and subsequently attached to the anchor teeth via a palatal arch.[22]

The large number of missing permanent teeth and the variable number of retained primary teeth that characterize type 2 cases (range: 8 to 22 missing teeth) means that future prosthetic rehabilitation of spans involving at least 3 or more teeth and edentulous free-end removable partial dentures are frequent occurrences. Small residual edentulous spaces of 1 to 2 teeth may also be present. Because of the degree and location of missing teeth, there are often localized, and in some cases generalized, areas of alveolar bone deficiency with supraeruption of teeth overlying the edentulous space. This can limit the ability of orthodontic treatment to reposition teeth within the arch. Therefore, preprosthetic orthodontic treatment is aimed at space consolidation rather than significant space closure to simplify later prosthetic treatment. Some permanent and primary teeth are useful for orthodontic archwire

support. However, they have little strategic value and it is better if they are extracted to facilitate ideal implant placement to allow for the construction of an implant-supported fixed partial denture rather than the alternative of multiple single-tooth implant restorations. Since their removal will result in a loss of alveolar bone volume, this should be delayed until implant placement to stimulate maximum alveolar development during the growth period and to preserve bone volume at the crest of the alveolar ridge for implant insertion.[23,24] Some potentially useful permanent teeth are in nonfunctional locations. If they are to be maintained, the lack of available dental anchorage may mean that implant-supported orthodontics is required to move them into a clinically useful position. The most suitable implant systems are those that can be inserted into alveolar or basal bone so that they can be incorporated directly into the fixed appliance system, not only to provide anchorage but to also support the archwire against occlusal deformation that would otherwise prevent controlled tooth movement. This can be managed using modular transitional implants[20] or standard implants (Figs 4b and 4c).[25,26] The location of residual edentulous spans that will require prosthetic rehabilitation and the permanent and primary teeth that will ultimately be removed should be identified at an early stage of treatment planning to promote efficient orthodontic treatment.

Type 3 was the least common and most severe tissue-deficient presentation of oligodontia. Alveolar bone volume is restricted due to the small number of teeth present. The basal bone in the maxilla is sparse and presents a significant technical challenge to prosthetic rehabilitation; no orthodontic considerations can be made. The situation illustrated in Fig 5 suggests that removable partial dentures may be indicated as an interim stage of treatment when sufficient teeth are available, or conversely, the teeth may be decoronated to serve as transient overdenture support. This type of situation demonstrates vertical discrepancy of the jaws and a lack of bone. The reduced volume in the anterior maxilla may negatively affect denture support.

Anodontia may be regarded as perhaps the most extreme manifestation of oligodontia. This is illustrated in Fig 6, where only one permanent tooth is present. The tissue deficiency observed and the technical issues that have to be overcome to treat the patient prosthetically are very similar in nature to those for a complete absence of teeth, with treatment being only marginally easier due to the presence of alveolar bone around the maxillary incisor.

In types 1 and 2, the relatively large volume of alveolar bone dictates that definitive implant treatment should wait until after the cessation of growth. Therefore, following the orthodontic phase of treatment, the occlusion is retained with removable appliances until the cessation of growth. Augmentation for the subsequent placement of implants for prosthodontic purposes can be delayed until it is convenient and in conjunction with implant installation. Social and functional problems associated with conventional dentures may result in significant pressure to consider early placement of an implant-supported restoration for type 3 oligodontia. The anterior region of the mandible is relatively stable transversely by the age of 6 years,[27] and several case studies have reported on the successful clinical placement of implants in this location when this has been done in the absence of adjacent teeth and hence, alveolar bone.[28–31] If teeth are present, however, implant submergence occurs, which has the potential to affect the clinical outcome.[31,32] The growth completion outcomes of such case reports are not available, so the potential unfavorable affect of growth rotation or the development of a skeletal 3 pattern on an initial favorable implant inclination is impossible to predict.

Oligodontia has been used to classify patients with 6 to 27 congenitally missing permanent teeth, excluding the permanent third molars.[2] This current definition is inadequate since it represents such a heterogenous group of patients requiring vastly different treatment regimes depending on severity. The wide range in number and type of missing permanent teeth and number of retained primary teeth results in a variable degree and location of dental and bone deficiency. As a result, the term "oligodontia" does not provide a useful clinical guide as to the complexity and type of treatment required to treat an individual, particularly in light of the changing paradigms of treatment associated with osseointegrated implants. Historically, oligodontia has been classified as having 6 or more congenitally missing teeth. From a management point of view, it may be more appropriate to consider hypodontia as 1 to 7 missing teeth. This represents 98% of individuals.[2] Eight or more missing teeth represents the remaining population and is the hardest to treat.

The classification guidelines presented here provide a first step in the management of a patient with oligodontia. They can be used as an aid in patient referral and as an objective method for patient screening in dental education. Being able to classify patients into different types according to their clinical presentation, and ultimately prosthodontic requirements, also has the potential to improve intraoperator diagnostic consistency by providing a direction for future treatment in a consistent manner from an early age.

Oligodontia requires careful attention to budgetary considerations because clinical management can extend over many years and having funds depleted prior to the definitive prosthodontic phase is a realistic concern. These guidelines allow for improved budget

assessment, especially for families with several affected children and particularly in the private health care setting. They also assist in the global allocation of fiscal resources in institutional settings and can be applied to enhance insurance reimbursement commensurate with the complexity of care.

Conclusion

Patients with oligodontia can be classified into three different types according to their clinical presentation and complexity of their prosthodontic requirements. This classification is a reliable diagnostic tool based on the positive outcome of the inter- and intrarater consistency.

Acknowledgments

The authors wish to recognize the clinical and administrative staff of the Department of Dentistry at the Princess Margaret Hospital for Children for their contributions in the management and treatment of sick and disabled children. In particular, the efforts of Dr John Winters (pedatric dentist), Dr Glen Liddelow (general dentist), Dr Ian Rosenberg (oral and maxillofacial surgeon), and Dr Elaine Pascoe (statistician) are gratefully appreciated.

References

1. Nordgarden H, Jensen JL, Storhaug K. Reported prevalence of congenitally missing teeth in two Norwegian counties. Community Dent Health 2002;19:258–261.
2. Polder BJ, Van't Hof MA, Van der Linden FPGM, Kuijpers-Jagtman AM. A meta-analysis of the prevalence of dental agenesis of permanent teeth. Community Dent Oral Epidemiol 2004;32:217–226.
3. Hobkirk JA, Brook AH. The management of patients with severe hypodontia. J Oral Rehabil 1980;7:289–298.
4. Rølling S, Poulsen S. Oligodontia in Danish schoolchildren. Acta Odontol Scand 2001;59:111–112.
5. Australian Bureau of Statistics. Population by Age and Sex, Australian States and Territories, June 2005. http://www.abs.gov.au/AUSSTATS/abs@.nsf/mf/3201.0. Accessed 30 July 2009.
6. Koch G, Bergendal T, Kvint S, Johansson UB (eds). Consensus Conference on Oral Implants in Young Patients. Jönköping, Sweden: The Institute for Postgraduate Dental Education, 1996.
7. Kurisu K, Tabata MJ. Review. Human genes for dental anomalies. Oral Diseases 1997;3:223-228.
8. Mostowska A, Biedziak B, Trzeciak WH. A novel c.581C>T transition localized in a highly conserved homeobox sequence of MSX1: Is it responsible for oligodontia? J Appl Genet 2006;47:159–164.
9. Thesleff I. Genetic basis of tooth development and dental defects. Acta Odontol Scand 2000;58:191–194.
10. Kapadia H, Frazier-Bowers S, Ogawa T, D'Souza RN. Molecular charaterization of a novel PAX9 missense mutation causing posterior tooth agenesis. Eur J Hum Genet 2006;14:403–409.
11. Lammi L, Halonen K, Pirinen S, Thesleff I, Arte S, Nieminen P. A missense mutation in PAX9 in a family with distinct phenotype of oligodontia. Eur J Hum Genet 2003;11:866–871.
12. Nieminen P, Arte S, Tanner D, et al. Identification of a nonsense mutation in the PAX9 gene in molar oligodontia. Eur J Hum Genet 2001;9:743–746.
13. Stockton DW, Das P, Goldenberg M, D'Souza RN, Patel PI. Mutation of PAX9 is associated with oligodontia. Nat Genet 2000; 24:18–19.
14. Lindqvist B. Extraction of the deciduous second molar in hypodontia. Eur J Orthod 1980;2:173–181.
15. Altman DG. Practical Statistics for Medical Research. London: Chapman and Hall, 1991:404–408.
16. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–174.
17. Sarnäs KV, Rune B. The facial profile in advanced hypodontia: A mixed longitudinal study of 141 children. Euro J Orthod 1983;5: 133–143.
18. Chung LK, Hobson RS, Nunn JH, Gordon PH, Carter NE. An analysis of the skeletal relationships in a group of young people with hypodontia. J Orthod 2000;27:315–318.
19. Lisson JA, Scholtes S. Investigation of craniofacial morphology in patients with hypo- and oligodontia. J Orofac Orthop 2005;66: 197–207.
20. Gray JB, Smith R. Transitional implants for orthodontic anchorage. J Clin Orthod 2000;34:659–666.
21. Melsen B, Verna C. Miniscrew implants: The Aarhus Anchorage System. Semin Orthod 2005;11:24–31.
22. Wehrbein H, Merz BR, Diedrich P, Glatzmaier J. The use of palatal implants for orthdodontic anchorage: Design and clinical application of the orthosystem. Clin Oral Implants Res 1996;7:410–416.
23. Ostler MS, Kokich VG. Alveolar ridge changes in patients congenitally missing mandibular second premolars. J Prosthet Dent 1994;71:144–149.
24. Lam RV. Contour changes to the alveolar processes following extractions. J Prosthet Dent 1960;10:25–32.
25. Kokich VG. Managing complex orthodontic problems: The use of implants for anchorage. Semin Orthod 1996;2:153–160.
26. Roberts WE, Engen DW, Schneider PM, Hohlt WF. Implant-anchored orthodontics for partially edentulous malocculsions in children and adults. Am J Orthod Dentofacial Orthop 2004;126: 302–304.
27. Oesterle LJ, Cronin RJ Jr, Ranly DM. Maxillary implants and the growing patient. Int J Oral Maxillofac Implants 1993;8:377–387.
28. Alcan T, Basa S, Kargül B. Growth analysis of a patient with ectodermal dysplasia treated with endosseous implants: 6-year follow-up. J Oral Rehabil 2006;33:175–182.
29. Bergendal B, Bergendal T, Hallonsten AL, Koch G, Kurol J, Kvint S. A multidisciplinary approach to oral rehabilitation with osseointegrated implants in children and adolescents with multiple aplasia. Eur J Orthod 1996;18:119–129.
30. Durstberger G, Celar A, Watzek G. Implant-surgical and prosthetic rehabilitation of patients with multiple dental aplasia: A clinical report. Int J Oral Maxillofac Implants 1999;14:417–423.
31. Guckes AD, McCarthy GR, Brahim J. Use of endosseous implants in a 3-year-old child with ectodermal dysplasia: Case report and 5-year follow-up. Pediatr Dent 1997;19:282–285.
32. Thilander B, Odman J, Gröndahl K, Friberg B. Osseointegrated implants in adolescents. An alternative in replacing missing teeth? Eur J Orthod 1994;16:84–95.