

CLINICAL PRACTICE GUIDELINES



Oral Health Division
Ministry of Health Malaysia

ORTHODONTIC MANAGEMENT OF DEVELOPMENTALLY MISSING INCISORS

2012

MOH/P/PAK/241.12 (GU)



Oral Health Division
Ministry of Health Malaysia

ORTHODONTIC MANAGEMENT OF DEVELOPMENTALLY MISSING INCISORS

2012

STATEMENT OF INTENT

The clinical practice guidelines are meant to be a guide for clinical practice, based on the best available evidence at the time of development. Adherence to these guidelines may not necessarily ensure the best outcome in every case. Every healthcare provider is responsible for the management of his/her unique patient based on the clinical picture presented by the patient and the management options available locally.

REVIEW OF THE GUIDELINES

These guidelines were first issued in 2005 and revised in 2012. The next review of these guidelines will be in 2016 or sooner if new evidence becomes available.

CPG Secretariat
Health Technology Assessment Section
Medical Development Division
Level 4, Block E1, Parcel E
Precinct 1
62590 Putrajaya, Malaysia

Electronic version available on the following websites:

<http://www.moh.gov.my>
<http://www.ohd.gov.my>
<http://www.acadmed.org.my>

TABLE OF CONTENTS		PAGE
	LEVELS OF EVIDENCE AND GRADES OF RECOMMENDATION	i
	RATIONALE, PROCESS AND OBJECTIVES	ii-iv
	CORE MEMBERS OF CPG DEVELOPMENT GROUP	v
	MEMBERS OF THE REVIEW COMMITTEE	vi
	ALGORITHM FOR ORTHODONTIC MANAGEMENT OF DEVELOPMENTALLY MISSING INCISORS	vii
	GLOSSARY	viii-ix
1	INTRODUCTION	
2	AETIOLOGY	1
2.1	Genetic Factors	1
2.2	Environmental Factors	2
3	PREVALENCE	2
4	DIAGNOSIS	3
4.1	Medical, Dental, Family and Social History	3
4.2	Examination	3-7
5	MANAGEMENT	8
5.1	No Active Treatment	8
5.2	Interceptive Treatment (mixed dentition)	8-9
5.3	Comprehensive Treatment	10-19
6	IMPLEMENTING THE GUIDELINES	19
6.1	Existing Facilitators and Barriers in Applying Recommendations	20-22
7	REFERENCES	23-35
	APENDIX 1	
	SPACE CLOSURE	36
	APENDIX 2	
	SPACE OPENING	37
	SPACE OPENING & INTERIM ORTHODONTIC RETENTION	38
	APENDIX 3	39
	ACKNOWLEDGEMENT	40
	DISCLOSURE STATEMENT	40
	SOURCES OF FUNDING	41

LEVELS OF EVIDENCE

LEVEL	STUDY DESIGN
I	Evidence obtained from at least one properly randomized controlled trial (RCT)
II-1	Evidence obtained from well-designed controlled trials without randomization
II-2	Evidence obtained from well-designed cohort or case-control analytic studies, preferably from more than one center or research group
II-3	Evidence obtained from multiple time series with or without the intervention. Dramatic results in uncontrolled experiments (such as the results of the introduction of penicillin treatment in the 1940s) could also be regarded as this type of evidence
III	Opinions of respected authorities, based on clinical experience; descriptive studies or reports of expert committees.

Source: Adapted from U.S./Canadian Preventive Services Task Force

GRADES OF RECOMMENDATION

A	At least one meta analysis, systematic review, or RCT, or evidence rated as good and directly applicable to the target population
B	Evidence from well conducted clinical trials, directly applicable to the target population, and demonstrating overall consistency of results; or evidence extrapolated from meta analysis, systematic review, or RCT
C	Evidence from expert committee reports, or opinions and /or clinical experiences of respected authorities; indicates absence of directly applicable clinical studies of good quality

Source: Modified from the Scottish Intercollegiate Guidelines Network (SIGN)

Note: The grades of recommendation relates to the strength of the evidence on which the recommendation is based. It does not reflect the clinical importance of the recommendation

RATIONALE AND PROCESS OF GUIDELINES DEVELOPMENT

RATIONALE

Patients presenting with developmentally missing incisors generally suffer from poor dental/facial appearance and function. This condition is often complicated by dental anomalies associated with hypodontia such as impacted teeth, microdontia, hypodontia of posterior teeth, delayed eruption and taurodontism. It is a common problem seen by the general dentist and is usually referred to the orthodontist. Although there are essentially two distinct approaches to managing this problem; that is space closure or opening, these patients often manifest with many underlying skeletal and dental problems, each with their own pros and cons, which oftentimes poses a dilemma for the individual operator. A multi-disciplinary team approach for a holistic management of this condition is therefore recommended and it is important that each member in the team understands his/her role in the overall treatment plan and complement each other in their procedures at each stage for the best treatment outcome.

PROCESS

Evidence was obtained by systematic review of current literature on congenitally/developmentally missing incisors using the usual electronic search engines PubMed/Medline; Cochrane Database of Systematic Reviews; Scopus and Ovid. Local non-indexed journals were hand searched. Literature search was from 1970 to 2011. The term 'congenitally missing teeth' is widely used in literature although the correct terminology currently used is 'developmentally missing teeth' since permanent tooth formation is a developmental process during growth. Relevant key words and terms or MeSH terms were used either singly or in various combinations to retrieve the relevant articles: "hypodontia", "maxillary" "missing teeth", „incisor”, “mandibular”, “management”, “unerupted” “principles”, “orthodontic”, “restorative”, “interceptive”, “congenitally missing teeth”, “developmental missing teeth”, “developmental

absence of teeth”, “developmental formation”, “developmental agenesis”, “congenitally missing incisors”, “agenesis of permanent teeth”, “transplantation”, “hypodontia and restoration”, “hypodontia and bridge”, “autotransplantation”, “implants”, “osseointegrated implants” and “dental implants”.

This CPG was drawn up by a core working committee of orthodontists, a general dental practitioner (GDP) and a dental nurse appointed by the Ministry of Health, Malaysia. The draft was reviewed by a panel of local review members and external reviewers comprising orthodontists, paediatric dental specialists, restorative dental specialists and periodontists and edited by the working committee before being posted on the Ministry of Health, Malaysia website for comments and feedbacks. All statements and recommendations formulated were agreed by the working committee and where evidence was insufficient, recommendations were made based on consensus of the group. These guidelines were presented to the Technical Advisory Committee for CPG for approval.

The levels of evidence and grading of recommendations used in this CPG were adapted from the U.S./Canadian Preventive Services Task Force and the Scottish Intercollegiate Guidelines Network (SIGN).

OBJECTIVES

To assist healthcare professionals in:

1. Interceptive management in children with signs of developing malocclusion and to preserve the alveolar bone for future prostheses
2. Decision to open or close space in the dentition
3. Timely and appropriate management of tooth transplants or prostheses
4. Orthodontic preparation for cases needing or opening.

CLINICAL QUESTIONS

1. What is the etiology and prevalence of developmentally missing incisors?
2. What are the appropriate diagnostic tools to aid treatment planning?
3. What are the interceptive options for developmentally missing incisors?
4. What are the benefits of interventions?
5. What are the treatment options for missing incisors in adolescents and adults?
6. What are the indications and contraindications of space closure and opening?
7. What are the long-term aesthetic and functional outcomes of space-closed orthodontic cases and space-opened restorative cases?

TARGET POPULATION

Inclusion criteria

- Children and adults with developmentally missing permanent incisors

Exclusion criteria

- Cleft lip and palate and craniofacial syndromes
- Developmentally missing permanent teeth other than incisors

TARGET GROUP/USER

These guidelines are applicable to all healthcare professionals involved in the management of oral health and dentition of patients.

CORE MEMBERS OF CPG DEVELOPMENT GROUP

Chairperson

Dr. Loke Shuet Toh

Senior Consultant Orthodontist

Dental Clinic, Jln. Tengku Kelana, Klang, Selangor

Members

Dr. Cheong Wai Sern

Private General Dental

Practitioner

Dental Clinic, Klang, Selangor

Dr. Chia Yang Soon

Orthodontist

Dental Clinic

Shah Alam, Selangor

Dr. Farid Patrick bin Abdullah

Orthodontist

Dental Clinic,

Jalan Perak, Penang

Dr. Fatimah binti Abdullah

Orthodontist

Dental Clinic, Jalan Abdul Samad,

Johor Bahru, Johor

Jeevaretnam A/P K. Sockalingam

Head Dental Nurse

Petaling District Dental Clinic,

Shah Alam, Selangor

Dr. Noorunisa binti Shawal Hamid

Orthodontist

Dental Clinic, Dato' Keramat,

W. P. Kuala Lumpur

Dr. Noraliza binti Amiruddin

Orthodontist

Dental Clinic,

Port Dickson, Negeri Sembilan

Dr. Savithri A/P Vengadasalam

Dental Public Health Specialist

Oral Health Division

Ministry of Health Malaysia

Dr. Siti Adibah binti Othman

Senior Lecturer & Orthodontist

Department of Childrens' Dentistry
and Orthodontics

Faculty of Dentistry

University of Malaya, Kuala Lumpur

Dr. Surguna Devi A/P R. S.**Muniandy**

Orthodontist

Dental Clinic,

Sri Kembangan,

Selangor

Dr. Ummu Aiman binti Yusoff

Orthodontist

Dental Clinic,

Muar, Johor

Zabidah binti Othman

Dental Nurse

Oral Health Division

Ministry of Health Malaysia

MEMBERS OF THE REVIEW COMMITTEE

Dr. Asma Alhusna Abg Abdullah
Lecture & Orthodontist Specialist
Department of Orthodontics
Faculty of Dentistry
Universiti Kebangsaan Malaysia

Lt. Col Dr. Shalene Kereshanan
Orthodontist
Head of Malaysian Armed Forces
Orthodontic Unit
Hospital Angkatan Tentera,
Tuanku Mizan, Kuala Lumpur

President of Malaysian
Association of Orthodontists
(MAO) 2011-2012

Dr. Rohani binti Mahmood
Consultant Restorative Specialist
Head of Restorative Specialty
Putrajaya Dental Clinic, Putrajaya

Dr. Kalaiarasu Periasamy
Senior Consultant Pediatric
Dental Specialist
Sungai Buloh Hospital,
Kuala Lumpur

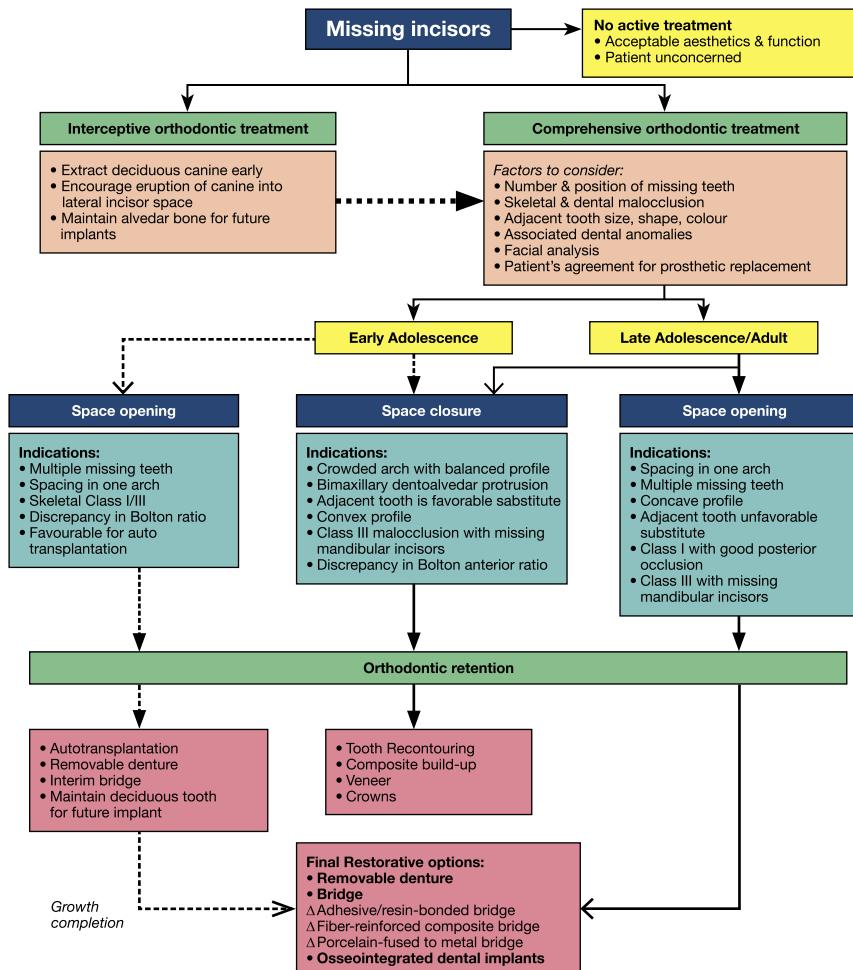
Dr. Mohd. Muzafer Hamirudin
Head of Department
Dept. of Prosthodontics
Faculty of Dentistry
Universiti Kebangsaan Malaysia

And current President of Malaysian
Dental Association (MDA)

Dr. Ian Buchanan
Consultant Orthodontist,
Glasgow Dental Hospital and
School Glasgow
Scotland

Professor Susan Cunningham
Consultant Orthodontist &
Programme Director
UCL Eastman Dental Institute
London, United Kingdom

ALGORITHM FOR ORTHODONTIC MANAGEMENT OF DEVELOPMENTALLY MISSING INCISORS



GLOSSARY

% LAFH	Percentage of Lower Anterior Face Height
Autosomal dominant	Genetic inheritance expressed as a disease
Autotransplantation of tooth	Transplantation of a tooth from one site to another in the same person
Bolton's ratio of anterior teeth	The sum of the mesio-distal widths of the 6 lower anterior teeth over the sum of the mesio-distal widths of the 6 upper anterior teeth. The normal ratio is 0.78
Bonded retainer	A passive wire bonded to the lingual/palatal side of teeth to retain the corrected position of teeth
Bone atrophy	Decrease in bone mass
Bridge	A fixed artificial replacement for a missing tooth or teeth supported by natural teeth or roots adjacent to the space
Contralateral tooth	Tooth of the same series on the opposite side in the same arch
Crown torque	The labio-lingual inclination of the crown
Crown	A type of dental restoration which completely caps or cover a tooth or dental implant
Dental anomalies	Any deviation from normal of the dentition in form, function or position
Ectodermal dysplasia	A syndrome with abnormal development of skin, hair, teeth, nails and sweat glands
Ectopic tooth	Abnormal position of the tooth in the jaw
Golden proportions	Is a two-dimensional measurement of aesthetics and is applied dentally when viewing arrangement of maxillary anterior teeth in a frontal photograph. Each tooth beginning with the central incisor should be 61.8% larger than the tooth distal to it.
Hypodontia	The developmental absence of one or more teeth either in the primary or permanent teeth, excluding third molars
Impacted teeth	Teeth which are prevented from normal eruption

Interceptive orthodontics	Timely management to prevent a developing malocclusion from getting worse
Inter-coronal width	Measurement of the width between adjacent crowns
Inter-radicular width	Measurement of the width between adjacent roots
Lateral cephalogram	Standardised lateral skull radiograph
Microdontia	Teeth which are smaller than the normal series
MMPA	Maxillary-mandibular Plane angle
Oligodontia	Developmental absence of 6 or more teeth
Osseointegrated implants/ Dental implants/ tooth implants	Artificial tooth that is anchored in the jaw bone to replace a missing natural tooth
Prognathism	Abnormal protrusion of the jaw
Removable retainer	A passive removable appliance to maintain the corrected position of teeth
Retrognathism	Abnormal retrusion of the jaw
Sagittal-skeletal	A plane pertaining to an imaginary line extending from the front to the back in the midline of the skull dividing it into right and left parts
Taurodontism	Group of disorders affecting the Temporo-mandibular joint
Tooth Agenesis	Developmental absence of tooth
Tooth Prosthesis	An artificial tooth used to replace a missing natural tooth
Transposition of teeth	Inter-changed position of teeth from its normal position in the series of the normal dentition
Transverse-skeletal	A plane pertaining to an imaginary horizontal line extending from right to left side of the skull and at right angles to the sagittal plane
Veneers	A thin layer of restorative material placed over a tooth surface. It may be made of porcelain or composite.
Vertical-skeletal	Vertical dimensions of the skull in the front and side profile

1. INTRODUCTION

Hypodontia is defined as the developmental absence of one or more teeth either in the primary or permanent dentition, excluding third molars.^{1,level III} Patients with hypodontia especially developmentally missing incisors may present in varying degrees of severity prompting them to seek treatment for improvement in dental/facial aesthetic and functions. Patients commonly complain of 'gaps in their front teeth', non-eruption of permanent incisors following exfoliation of deciduous incisors, disharmony of front tooth size or an unattractive smile. It is quite a common problem often initially seen by the GDP and usually referred to the orthodontist for management.

Missing incisors can have a major impact on dental and facial aesthetics and often may affect the self-esteem and social well being of the individual. Usually this condition can be detected at an early age through early diagnosis by the GDP. Hypodontia is often associated with other dental anomalies and early and/or interceptive management can reduce the development of more severe malocclusion and preserve dental structures necessary for restorative procedures.^{2-3,level III}

These guidelines aim to provide evidence-based recommendations to help healthcare providers in the management of patients with developmentally missing incisors. As with all orthodontic care pathways, patient care should be individually tailored, based on sound clinical judgement, and clinical competency plays an important role in the decision-making process.

2. AETIOLOGY

2.1 Genetic Factors

Hypodontia usually has a genetic basis and often a high proportion of affected individuals have a family history of hypodontia or associated dental anomalies.^{1,level III} Mutation in transcription factors MSX1, PAX9 and AXIN 2 have been identified in families with an autosomal dominant oligodontia.^{2,level III}

Normally, teeth which are ‘end of series’ are more commonly absent i.e. lateral incisors, second premolars and third molars.^{4,level II-2} Hypodontia is also often seen in patients presenting with syndromes such as ectodermal dysplasia, Down’s syndrome and hemifacial microsomia and in non syndromic conditions such as cleft lip and palate. However, familial hypodontia is complex and multifactorial; influenced by a combination of gene function, environmental interaction and developmental timing.^{4,level II-2}

2.2 Environmental Factors

Environmental factors which cause arrested tooth development may include factors that cause failure of tooth bud cell proliferation from the dental lamina. This may be due to infection (eg. rubella, osteomyelitis), trauma in the dental region such as fractures, surgical procedures on the jaw and extraction of the preceding primary tooth, drugs (eg. thalidomide), chemotherapy or radiotherapy at a young age.^{5,level I;2,6,level III}

3. PREVALENCE

The prevalence of hypodontia in the primary dentition is about 0.5% and range from 3.5-6.5% in the permanent dentition in Caucasians, with females outnumbering males by a ratio of 3:2.^{1,3,7,level III} Maxillary lateral incisors are more commonly missing than mandibular incisors in Caucasians.^{1,8,level III} However, mandibular incisors were found to be the most commonly absent teeth in Chinese and Japanese populations and was more prevalent than missing maxillary lateral incisors.^{3,level III} Similar findings have been reported in local Malaysian children where the prevalence of missing mandibular incisors was the highest among developmentally missing teeth (32-49%).^{9,10,11,level III}

KEY MESSAGE

- Aetiology is multifactorial and usually has a genetic basis with familial inheritance
- Mandibular incisors were the most commonly missing teeth in local and Asian populations

4. DIAGNOSIS

4.1 Medical, Dental, Family and Social History

Developmentally missing incisor teeth can be diagnosed early; 3 - 4 years old for missing primary teeth and as early as 6 years old for missing permanent incisors.^{2, level II-2} A diagnostic protocol with meticulous and consistent method of evaluation for patients with hypodontia will assist the clinician in the decision-making process.^{12, level III}

A thorough medical, dental, family and social history should first be taken to confirm the developmental absence of permanent teeth and to determine the possible aetiology. Family history is important as hypodontia usually has a genetic basis with some family members affected, although familial hypodontia is complex. However, aetiology is usually multi-factorial and often influenced by a combination of gene function, environmental interaction and developmental timing.^{4, level II-2}

Surveys have shown that a very high proportion of children with severe hypodontia have reported functional and psychosocial impacts as a result of developmentally missing teeth.^{13-14, level II-3} Excessive spacing and compromised aesthetics becomes a focus for bullying in school and may lead to psychosocial implications in children, such as depression, loneliness, anxiety, low self-esteem and underachievement. Effective counselling will help the victims and the family overcome this and prepare themselves for the complex management of this condition.^{15, level III}

4.2 Examination

4.2.1 Clinical Examination

Most studies investigating dentofacial form in patients with hypodontia have found distinct sagittal-skeletal, vertical-skeletal and dento-alveolar characteristics. These deviations were more apparent in patients with both anterior and posterior teeth missing and increased in severity with increasing number of missing teeth. Anterior hypodontia has a significant effect on the Anterior- Posterior (more retrusive) and vertical skeletal (reduced) relationships as well as the interincisal angle (increased) with

increasing severity of the hypodontia. Therefore, a careful examination of the clinical features must be performed to obtain all information necessary for proper treatment planning.^{16-18,level II-1}

KEY MESSAGE

- Missing primary and permanent incisors can be detected early
- Severe hypodontia may have psychosocial impact on children

4.2.1.1 Extra-oral examination Facial Analysis to:

- Identify adverse skeletal patterns in sagittal, transverse and vertical dimensions

With increasing severity of hypodontia, the sagittal skeletal relationship tends towards a Class III pattern due to a combination of a decrease in maxillary and mandibular prognathism and mandibular length in relation to the anterior cranial base.^{16,level II-1} A significant increase in chin thickness also contributes to the above.^{19, level II-2} The vertical skeletal pattern in severe hypodontia shows a decreased Maxilla-to-Mandibular Plane Angle (MMPA) and reduced % Lower Anterior Face Height (LAFH).^{16,level II-1} In cases where there are missing mandibular incisors, the mandibular symphysis growth and morphology may be affected due to disturbance in tongue-lip pressure and lack of lingual support.^{20,level II-2}

- Identify the soft tissue pattern ^{12, level III}

A convex soft tissue profile is usually an indication for space closure; whereas space opening in the maxillary arch is favoured in patients with a concave profile. When the patient has a high smile line, colour matching and reshaping of the canine replacing the missing incisor as well as labial gingival contours and canine root prominence become more important. If an obtuse nasolabial angle is present, excessive upper incisor retraction during space closure should be avoided.

- Assess and discuss with the patient the dental aesthetics and orthodontic options that may improve the patient's overall aesthetics and self-esteem

Aesthetic values may not be the same between different clinicians and patients.^{21,level II-3} The Bolton ratio of 0.78 between upper and lower anterior teeth and the Golden proportion of 0.618 in the arrangement of the maxillary teeth from the frontal view may be used as a guide when determining the amount of space needed for replacement of maxillary lateral incisors although this may not necessarily produce the best smile aesthetics.^{22,level II-2} A careful aesthetic assessment of the incisors in terms of incisor display, gingival levels and the dental midline as well as contour and shade of the anterior teeth has to be given due consideration prior to planning for orthodontic-restorative treatment.^{23,level II-3}

4.2.1.2 Intra-oral examination to:^{12,level III;23,level II-3;24,level III}

- Assess overall oral health status
- Evaluate current and potential dentition status
- Identify occlusal/dental disharmonies
- Determine the functional status of patient's occlusion i.e. factors associated with malocclusion, deleterious habits and current signs of Temporo-mandibular Joint Dysfunction (TMJD)
- Identify potential periodontal problems such as pocketing
- Examine if sufficient space is available for replacement of missing incisors
- Determine if sufficient tooth structure exists for restoration of microdont incisors

4.2.1.3 Identify associated dental anomalies.^{25,level III}

- Other permanent teeth can be microdont, conical or tapered.^{25,17,level III}
- Delayed formation and eruption of permanent teeth.^{27,level III}
- Maxillary lateral incisors may be microdont or absent.^{28,level 1}
- Maxillary canines may follow an ectopic path Eruption.^{29,level II-2}
- Maxillary canine-first premolar transposition.^{30,level II-2}
- Mandibular lateral incisor-canine transposition.^{31,level II-2}

- Palatally impacted maxillary canines.^{32,level II-2;33,level I}
- Short roots of teeth - tooth agenesis was found in about 46% of individuals with short roots of some permanent teeth especially the maxillary central incisors and premolars.^{34,level III}
- Taurodontism has been reported to be higher in patients with hypodontia.^{35,level II-2; 36,level II-1}
- Rotation of the lateral incisor on the contralateral side have been associated with agenesis of unilateral lateral incisor.^{37,level II-1}
- The lack of teeth is often associated with a developmental failure of alveolar bone with apparent ‘wasting’ of the ridge and lack of posterior support as well as smaller arch dimensions.^{1,level III,38,level II-2}

RECOMMENDATION

- Detailed clinical assessment should be done with focus on skeletal patterns in the sagittal, transverse and skeletal dimensions
- Aesthetic assessment of maxillary incisors should be done at rest and in function
- Use ‘Bolton ratio of anterior teeth’ and ‘Golden Proportions’ measurement as a quantifiable guide to aesthetic values of anterior teeth
- Identify associated dental anomalies and its relation to the presenting malocclusion

Grade B

4.2.2 Radiographic Investigations

The Oral Panoramic Tomograph (OPT) is essential for diagnosis of missing permanent teeth in patients who are 6 years or older. This is generally unsuitable for much younger children because of the length of the exposure and the need for the patient to keep still.^{39,level III} It is also a useful tool for general survey of the dentition and associated dental anomalies.^{41,42,level III} These radiographs can be supplemented with intra-oral radiographs for a closer view of the intended areas.^{43,44,level III;45,level II-2}

- Lateral cephalogram radiographs are taken for analysis of skeletal, dental and soft tissue facial components. A suitable long-term treatment plan requires knowledge of the presenting and developing skeletal pattern and this can be obtained through cephalometric analysis.^{16,level II-1}
- Other diagnostic investigations such as magnetic resonance imaging (MRI) and CT scan for soft and hard tissue imaging are rarely used routinely but may be useful only if indicated by the individual patient's clinical presentation.^{45,level II-2} Cone Beam CT (3-D) may be used for assessment of bone levels/width prior to placement of implants.

4.2.3 Pretreatment diagnostic records

Photographs and study casts are usually needed for proper patient assessment and for documentation purposes.^{45,level II-2} Photos of the patient in relaxed and smiling postures can help the clinician identify critical aspects of their teeth. These procedures are helpful in planning intrusion or extrusion of teeth for more aesthetic gingival margins. Diagnostic orthodontic wax-ups of study models are very useful to evaluate different treatment options and aid treatment planning.^{12,level III}

RECOMMENDATION

Essential pretreatment diagnostic records should include

- Panoramic radiograph
- Study casts
- Photographs

Grade B

Orthodontic wax-up of study casts can be used as a diagnostic aid

Grade C

5. MANAGEMENT

GENERAL PRINCIPLES

KEY MESSAGE

Three main treatment modalities:

- No active treatment
- Interceptive treatment
- Comprehensive treatment

5.1 No Active Treatment

No treatment is necessary if there is no malocclusion associated with a missing incisor and the patient is happy with his/her dentition. Treatment is not recommended if the patient is unwilling to commit to lengthy and costly treatment.^{46,47,level III}

5.2 Interceptive Treatment (mixed dentition)

5.2.1 Role of GDP

• Early detection of missing teeth

The GDP's responsibility in early detection of developmentally missing incisors, associated dental anomalies and developing malocclusion is important for early planning of interceptive and comprehensive treatment with the respective specialists.^{5,44,45,48,level III}

In patients with missing primary incisors, it is recommended that they be monitored until the succeeding permanent incisor is confirmed present by 6 years of age through radiographs.

• Counseling of patient and family

The GDP can prepare the patient and family by outlining the dental, medical, psycho-social, functional, financial and prolonged treatment time implications especially in a severe hypodontia case. Effective counseling can help the family accept multi-disciplinary treatment and improve patient satisfaction.^{45,49,level III}

- Liaison between patient and multi-disciplinary team**

The GDP can provide restorative treatment in straightforward cases, continuing care and maintenance of the treatment outcome following interim or comprehensive treatment. Continuance is important for long term success and patient satisfaction.^{5,47,50,level III}

5.2.2 Extraction of primary canine to prevent/intercept associated impaction of maxillary canine.^{30,32-34,44,level I}

Studies have shown strong association of hypodontia with maxillary canine impaction. Although there is inadequate evidence to support routine extraction of primary maxillary canines to facilitate eruption of impacted permanent canines in children, early extraction of the deciduous canine has been advocated in many studies.^{51,level I}

5.2.3 Early extraction of primary incisor or canine to allow eruption of canine into maxillary lateral incisor position: This may be done:

- To maintain the alveolar bone for future implant placement.**^{5,52-54,level III}

The canine maintains the width and depth of the alveolar bone for insertion of future dental implants. When the canine is then orthodontically moved distally to create space for the implants, the width and depth of the alveolar bone in the lateral incisor region is maintained. This may then negate the need for alveolar bone graft prior to implant insertion.

- For natural space closure**

If space closure is planned, then allowing the canine to erupt and drift into the lateral incisor position will help to reduce the amount of space to be closed orthodontically in the future.^{46,55,56,level III}

5.2.4 Retention of the primary incisor/canine

If the primary incisor and/or canine is functional and there is no interceptive treatment required as explained above, these teeth may be retained to help preserve the alveolar bone for orthodontic treatment and future placement of implants.^{57,level III}

RECOMMENDATION

Interceptive management

- Permanent maxillary canines with potential impaction or transposition should be detected early with radiographs
- Deciduous canines may be extracted early to facilitate eruption of palatally ectopic maxillary canines

Grade A

- Maxillary canines should be allowed to erupt into missing lateral incisor position for natural space closure or preservation of alveolar bone for future prosthesis
- The GDP can play an important role in early detection of missing teeth, counseling of family and liaising with multi-disciplinary team

Grade C

5.3 Comprehensive Treatment

A multi-disciplinary approach involving orthodontist, restorative dental specialist, paediatric dental specialist, periodontist, oral surgeon and GDP is ideal in patients who require inter-disciplinary management.^{5,42,45,53,57-61,level III} Without a team approach, orthodontists tend to manage hypodontia based on their own practice environment and experience.^{62,level II-2} Judging of smile aesthetics in space-closed and space-opened cases vary between and within groups of dentists, orthodontists, dental specialists and layman.^{21,level II-2} Thus, treatment decisions based on perceived finished outcomes may be misleading as both options can produce excellent results.^{47,53,63,level III,64,level I}

KEY MESSAGE

- Multi-disciplinary or inter-disciplinary management is necessary for best treatment outcomes
- Good prosthodontic/restorative work is essential for comprehensive management

5.3.1 Early Adolescence

The decision to open or close space should be made early and restorative procedures for space opening explained to the patient. Spaces may be restored by autotransplantation of premolars, removable dentures or interim bridge until growth completion of the patient when final restorations are done. Space closure may or may not involve fixed appliance treatment.

5.3.1.1 Autotransplantation.^{65,level III; 66,67,level II-2}

This can be recommended if the criteria allows for donor premolars to be donated to the receiver site especially in cases with multiple missing maxillary incisors. In growing children, the transplanted tooth will not only maintain growth and development of the alveolar ridge, but also provide a permanent solution to agenesis of teeth.^{68,level III} Successfully transplanted premolars appear to continue erupting and aesthetics is good when restored with porcelain veneer crowns or full porcelain crowns. Autotransplanted premolars may act as tooth support for bridges in large-span spaces.^{65,level III}

- **Criteria for autotransplantation:** ^{66,67,69,level II-2}

- Timing of root development of the donor premolar is important.
- Roots of the donor premolar should be less than 3/4 formed (Incomplete and complete root formation show 96% and 15 % pulpal healing respectively)
- The diameter of the apical foramen of the graft
- Skill of the surgeon
- Internal cooling of burs and no extra-alveolar storage of the donor tooth prior to transplantation appears to increase the chance for pulpal healing and limit the risk of root resorption.
- Adequate space in the arch.^{65,level III}
- No ‘jiggle’ contacts between donor tooth and opposing teeth during post-surgery.^{66,67,69,level II-2}

RECOMMENDATION

- Autotransplantation of premolars to missing incisors site should be done if
 - Donor premolar roots are less than 3/4 formed
 - Multiple incisors are missing
 - The procedure is handled by skilled surgeons
- The autotransplanted premolars should be restored with veneers or full crowns

Grade B

5.3.1.2 Space opening.

- **Space opening** ^{53,level III}
Is usually not recommended before the age of 13 years so as to prevent relapse and progression of alveolar bone atrophy. If implants are planned as the final restoration, the timing for implantation should be close to the end of orthodontic treatment. ^{70,level II-2} In the meantime the alveolar bone may be preserved by retaining the primary tooth.
- **Restorative options**
 - Conventional porcelain fused to metal bridge.
This is usually not recommended in young patients because of the large amount of tooth reduction required in teeth with young pulps. In young patients, anterior spaces due to missing incisors may be closed and redistributed to the posterior regions for implant placement later.
 - The posterior space may then be restored with interim bridges or bonded retainers while waiting for osseointegrated implants. ^{63,level III,71,level II-2}
 - Orthodontic Retention before implant placement. ^{53,71,level III}
Removable retainers in addition to bonded orthodontic retainers have been recommended after orthodontic opening of space for future implants. Space loss and relapse of the adjacent teeth may result in a second phase of orthodontic treatment prior to implant placement.
 - Interim prosthesis before implant placement. ^{56,63,71,level III}
The interim prosthesis may be a removable or fixed partial denture. Removable partial dentures which are to be worn for a few years

before implant placement may result in relapse of the dentition or loss of space.^{56,63,level III} Bonded orthodontic retainers or fixed resin-bonded or laboratory composite with fibre-reinforcement bridges are recommended for longer interim periods to reduce root approximation.

- Conventional porcelain-fused to metal bridge or tooth implant. This should only be placed after growth completion. Removable partial dentures or bridges may be the final long-term restoration in patients who cannot afford or do not want osseointegrated dental implants in the long term.^{73,74,level II-2;75,level I,44,76,level III}

5.3.1.3 Space closure.

Space closure^{61,level III} may involve grinding or modification of the adjacent teeth, composite build-up or porcelain laminate veneer crown for the long-term.^{44,61,level III} Orthodontic retention is important for maintenance of space closure.

RECOMMENDATION

- Orthodontic tooth positioning should be tailored to the requirements of prosthetic replacement by removable partial dentures, conventional bridges or dental implants
Grade C
- Removable or fixed Interim prosthetic replacements are recommended for space maintenance and stability while waiting for final prostheses
Grade C
- Bonded orthodontic retainers are recommended for longer interim periods before implant placement
Grade C
- Final prostheses like conventional bridges and implants should be done when facial growth is complete
Grade A

5.3.2 Late Adolescence/Adult

The decision to open or close spaces is similar to that in early adolescence and the ultimate goal is excellent aesthetics, periodontal health and function in the long term.^{64,level}

Rationale for space closure

- Most evident advantage is the permanence and biological compatibility of the finished dentition. The patient has his/her own natural dentition with no need for prosthetic replacement.
^{61,level III,77,level II-2}
- There is better contour of the interdental gingival papilla around natural teeth.^{77,level II-2}
- There is natural aging of the dentition and gingival margins as the patient matures and grows.^{77,level II-2}
- Functional occlusion with group-protected function. There is no evidence of temporomandibular dysfunction (TMD) with space closure and group function of teeth.^{61,78,level III,79,level II-2}
- With carefully detailed orthodontic treatment in combination with modern aesthetic dental materials and tooth restorations using bonded ceramics, resin composites and tooth whitening, orthodontic space closure is an attractive option.^{53,61,level III}

Rationale for space opening.^{47,63,78,level III}

- Complete space closure is not possible with multiple missing incisors
- Adjacent teeth not favourable as incisor replacements
- Patient profile and malocclusion does not favor space closure in terms of general periodontal health or aesthetics.^{53,level III}
- With modern prosthetic tooth replacements such as porcelain fused to metal bridges, adhesive or resin-bonded bridges and osseointegrated tooth implants, long-term functional and aesthetic results can be expected. Any of these three options can produce predictable excellent results but the primary consideration is to select the least invasive option that satisfies the aesthetics and functional objectives of the patient.^{61,level III}

5.3.2.1 Indications for space closure or opening

Factors favouring space closure : 47,55,61,78,level III,77,level II-2

I. If missing maxillary incisor

- Missing unilateral incisor
- Tendency towards crowding in a patient with a balanced profile and normal inclination of anterior teeth
- Canines and premolars of similar size and color
- Bimaxillary dentoalveolar protrusion
- Class II malocclusion

II. If missing mandibular incisor

- Class I malocclusion with marked mandibular crowding or protrusion and missing mandibular incisor
- Missing single mandibular incisor
- Class III malocclusion
- Posterior crowding in the mandibular arch
- Discrepancy in Bolton anterior ratio (microdont maxillary lateral incisor)

Factors favouring space opening: 53,63,80,level III

I. If missing maxillary incisor

- Normal intercuspal position of posterior teeth in a well-aligned Class I malocclusion
- Pronounced spacing of the maxillary dentition and normal mandibular dentition
- Class III malocclusion with retrognathic profile
- Large size difference between canine and first premolar.
- Large size difference between canine and contralateral lateral incisor

II. If missing mandibular incisor

- Missing two or more mandibular incisors
- Class II malocclusion with well aligned or spaced mandibular dentition

- Discrepancy in Bolton anterior ratio (large maxillary incisors or small mandibular incisors)
- Normal intercuspaton of posterior teeth in a well-aligned Class I malocclusion

5.3.2.2 Points to consider in orthodontic space closure

Attention to certain key points during tooth movement can produce excellent finishing and function.^{47,56,60,61,78,81,82,level III}

- Marginal level of the relocated canine and first premolar
If the canine is replacing the lateral incisor, then extrusion of the canine and intrusion of the first premolar will result in a more natural marginal gingival contour with the contralateral teeth.
- Crown torque of relocated canine and first premolar
- Monitor centerlines and symmetry during unilateral space closure
- Cosmetic contouring of relocated canine
- Occlusal contact of extruded canine and lower incisors
- Functional occlusion
- Cosmetic reshaping with composite resins and veneers
- Crown lengthening/gingival recontouring
- Retention period

KEY MESSAGE

- Space closure is preferable if aesthetics and function is comparable to predicted treatment outcomes with prosthetic replacement
- Good restorative work is essential for excellent treatment outcomes in space-opening cases

5.3.2.3 Final prosthetic replacements

- **Removable partial denture**

This may be the prosthesis of choice if the patient is unwilling to undergo lengthy and costly treatment.

- **Bridge**

Different options include adhesive or resin-bonded bridge (RBB), fiber-reinforced composite bridge (FRCB) and porcelain-fused to metal bridge (PFB).

- RBBs have a survival rate of about 87.7% after 5 years.^{75,level I} and FRCBs have an overall survival rate of 73.4% at 4.5 years.^{83,level I} Survival time was about 3.9 times higher when RBB was done by senior staff compared with junior staff.^{84,level III} Most frequent complication was due to debonding.^{63,84,level III,75,level I}
- Survival rate of FRCB was 64% after 5 years irrespective of surface or hybrid retained. Most failures were due to fracture of the framework and delamination.^{70,level III,73,level II-2}
- Porcelain-fused-to-gold bridges have favourable long-term survival rate of 68.3% after 20 years. Vital teeth had about three times higher survival rate than root-canal treated teeth. The main reason for these failures was caries (30%).^{85,level II-2}

- **Osseointegrated dental implants**

Currently, single tooth replacement with implants has become one of the most popular treatment alternatives for the replacement of missing teeth for enhanced aesthetics and function. The main benefit is it leaves the adjacent teeth untouched. This is advantageous in younger patients and in sound dentitions. However, it should be placed only after growth completion^{86,level III,87,88,level II-2}

Criteria for placement of implants:

- i. Adequate space

Adequate space for placement of the implant and restoration should be obtained. Generally, a minimum of 6mm space is required at the inter-coronal and inter-radicular regions and 1.5 to 2.0 mm space between the implant head and adjacent teeth, although the space requirement depends on the type and size of implant inserted.^{52,53,89,91,level III,71,level II-2,90,level I}

ii. Root paralleling during orthodontic treatment.^{52,53,89,level III}

Adequate width and depth of bone for the implant is crucial for successful placement. If the adjacent maxillary teeth are too proclined after orthodontic treatment, the space for the future implant may be compromised due to non-root paralleling. Long cone periapical radiographs are essential in assessing adequate space in the root region unless CBCT is available.

- Long-term Stability ^{92,93,level I,94,level II-2}

There is no evidence to support the superiority of different types of implants in their long-term performance.^{95,level I} Three-year and five-year studies of different implants have shown success rates of about 96-100%.^{87,96,97,level II-2}

RECOMMENDATION

Osseointegrated implant placement should be done

- Only after growth completion
- If there is adequate width and depth between adjacent tooth crowns and roots. Generally, a minimum of 6mm space is required at the crown and cervical level

Grade A

- Together with root-paralleling assessment with radiographs

Grade C

KEY MESSAGE

- Survival rate of RBBs after 5 years is 87.7% and the most common complication is due to debonding
- Survival rate of FRCBs after 5 years is 64% and most failures are due to fracture and delamination
- Survival rate of porcelain-fused to gold bridges after 20 years is 68.3% and main reasons for failure are due to root-treated teeth and caries

5.3.2.4 Post-treatment Orthodontic Retention

Retention is advisable for almost all treated malocclusions although there is no standard practice retention regime or protocol and there is variability among orthodontists.^{98,99,level I;100,101,102,103,104,level II-2} There is a universal trend towards vacuum-formed retainers and bonded retainers especially mandibular fixed lingual retainers. Most orthodontists prescribe removable retainers to be worn full-time initially followed by part-time, but lifetime wear and there was no specific time for removal of fixed lingual retainers.^{105,106,107,108,level III} Current orthodontic opinion recommends single or multi-stranded stainless steel wires for bonded retainers.^{98,level I;106,108,level II-2} There was no consistent pattern in the application of retention methodologies and was dependent mainly on personal preferences although permanent retention (lifetime) has been recommended for cases following orthodontic treatment to close generalized spacing or a midline diastema in an otherwise normal occlusion.^{98,109,level I;106,107,108,level II-2}

RECOMMENDATION

- Almost all treated malocclusions need retention to resist the tendency of teeth to return to their pre-treatment positions
Grade A
- Bonded lingual retainers are recommended for long-term retention and stability
Grade A

6. IMPLEMENTING THE GUIDELINES

This section provides advice on the resource implications and strategies associated with implementing the key recommendations for quality management of patients with developmentally missing incisors.

Implementation of this CPG is an essential part of good clinical governance. It is appropriate to the local community, dental outpatients and specialist clinics and is applicable to both public and private sectors.

Mechanisms should be in place to review the current healthcare system to address gaps and weaknesses so as to facilitate the implementation of this CPG recommendations.

Recommended strategies include implementing programmes to:

- Create awareness and training of front-line dental staff
- Train specialist and non-specialist healthcare professionals
- Coordinate the referral system and availability of resources
- Establish multi-disciplinary specialist teams at district level
- Develop and disseminate 'Quick Reference Guides' to healthcare providers and 'Patient information leaflets' to the public.

6.1 Existing facilitators and barriers in applying recommendations

Implementation of the CPG will be facilitated by strengthening the existing referral system and the establishment of multi-disciplinary teams in districts with dental specialists. This CPG should be included in the training module of first-year Dental Officers in orthodontic specialist clinics.

Possible barriers in applying recommendations of the CPG in the local context:

6.1.1 Patient factors:

- Unaware of missing permanent teeth by patients/parents
- Unaware of treatment options
- Lack of awareness resulting in receiving treatment late
- Commitment to possibly lengthy and/or complicated treatment
- Financial implications

Most patients with developmentally missing anterior teeth require comprehensive orthodontic treatment. If the decision is for spaces to be closed, then the patient needs no post-orthodontic restorative dental treatment or perhaps minimum conservative modifications.

By contrast, when spaces are to be subsequently restored, the patient incurs restorative costs for dentures, bridgework or implants. Additional possible costs for crown lengthening, surgical costs for bone grafting and endodontic costs in instances where there is loss of tooth vitality due to repeated tooth preparation may be required. Furthermore, replacement of the restorations may be required more than once during the patient's lifetime.^{98,level II}

6.1.2 Healthcare professional factors:

- Lack of awareness among dental nurses and dental officers (front line staff) especially in districts without dental specialists
- These front-line staff are the primary source of referrals to orthodontists and other dental specialists

6.1.3 Health services factors:

- Lack of dental specialists
- Lack of established multi-disciplinary teams in districts
- Accessibility and financial implications for patients due to logistics of multi-disciplinary teams in rural areas

6.2 To enhance the utilization of this CPG, the following clinical auditindications for quality management using the Peer Assessment Rating (PAR) Index is proposed:-^{111,level II-1,112,level III}

% of patients with missing incisors treated and with good treatment outcomes 2 years after debond	= Number of patients with missing incisors and good treatment outcomes 2 years after debond (>70% reduction in PAR score)	x 100
	Total number of treated patients with developmentally missing incisors	

It is recommended that treatment outcomes be evaluated 2 years after debond instead of the usual time at debond in order to assess stability and relapse of the occlusion. There are different retention regimes and protocols between operators within the country and in other countries.^{105,106,107,108,level III} However, it is the expert group's opinion that the period of 2 years was an adequate time frame for any settling of the occlusion to occur.^{98,level I}

The end of the 2-year review period is also the usual time when the patient is discharged from active care of the orthodontist. Study casts taken at this time can be used for this assessment before the patient is discharged.^{112,level II-1} (Appendix 3) A mean percentage reduction in PAR score should be greater than 70% to be considered a good standard of orthodontic treatment outcome^{113,level II-3}

7. REFERENCES

1. Goodman JR, Jones SP, Hobkirk JA, King PA. Hypodontia:1. Clinical Features and Management of mild to moderate hypodontia. Dental Update 1994;381-384
2. Arte S, Pirinen S. "Hypodontia". Orphanet encyclopedia 2004 May; 1-7
3. Wu CCL, Wong RWK, Hagg U A review of hypodontia: the possible etiologies and orthodontic, surgical and restorative treatment options -conventional and futuristic. Hong Kong Dental J 2007;4(2):113-21
4. Cobourne MT. Familial human hypodontia- is it all in the genes? Br Dent J 2007; 203: 203-8
5. Mattheeuws N, Demaut L, Martens G. Has hypodontia increased in Caucasians during the 20th century. A meta-analysis. Eur J Orthod 2004 Feb;26(1):99-103
6. Nun JH, Carter NE, Gillgrass TJ., Hobson RS, Jepsen NJ, Meechan JG, Nohl FS. The Interdisciplinary management of hypodontia: Background and role of paediatric dentistry. BDJ 2003 vol 194;No 5, March 8:245-251
7. Daugaard- Jensen J, Nodal M, Skovgaard LT, Kjaer I. Comparison of pattern of agenesis in the primary and permanent dentitions in a population characterised by agenesis in the primary dentition. Int J Paediatr Dent 1997 Sep; 7(3): 143-8
8. Larmour CJ, Mossey PA, Thind BS, Forgie AH, Stirrups DR. Hypodontia –A retrospective review of prevalence and etiology. Part 1:Quintessence International 2005 36(4):263-270

9. Nik Hussein NN. Hypodontia in the permanent dentition: a study of its prevalence in Malaysian children. *Aust Orthod J.* 1989 Oct; 11(2):93-5
10. Nik Hussein NN, Majid ZA. Dental anomalies in the permanent dentition. *Dent J Malaysia* 1995;16:33-39
11. Loke ST. Hypodontia in Sabah- What's missing? *Dent J Malaysia* 1999; 20:6-10.
12. Locker D, Jokovic A, PrakashP, Tompson B. Oral health-related quality of life of children with oligodontia.. *Int. J. of Paed. Dent.* 2010;20:8-14.
13. Araújo EA, Oliveira DD, Araújo MT. Diagnostic protocol in cases of congenitally missing maxillary lateral incisors. *World J Orthod* 2006;7(4):376-88
14. Wong ATY, McMillan AS, McGrath C. Oral health-related quality of life and severe hypodontia. *J Oral Rehabil* 2006;33:869-873
15. Gill DS, Hobkirk J, Steven B, Hemmings K, Goodman J. Counselling Patients with hypodontia. *Dental Update June 2008:* pg 2-8
16. Acharya P, Jones SP, Moles D, Gill D, Hunt NP. A cephalometric study to investigate the skeletal relationships in patients with increasing severity of hypodontia. *Angle Orthod* 2010;80:699-706
17. Endo T, Ozoe R, Yoshino S, Shimooka S. Hypodontia patterns and variations in craniofacial morphology in Japanese orthodontic patients. *Angle Orthod*, 2006;76:6
18. Créton M, Cune MS, De Putter C, Ruijter JM, Kuijpers-Jagtman AM. Dentofacial Characteristics of patients with hypodontia. *Clin oral Invest* 2010;14:467-477

19. Chan DWS , Samman N, McMillan AS. Craniofacial profile in Southern Chinese with hypodontia. European Journal of Orthodontics 31 (2009); 300–305
20. Endo T, Ozoe R, Yoshino S, Shimooka S. Congenitally missing mandibular incisors and mandibular symphysis morphology. Angle 2007;77:6
21. Armbruster PC, Gardiner DM, Whitley JB, Flerra J. The congenitally missing maxillary lateral incisor. Part 2: Assessing dentists' preferences for treatment. World J Orthod 2005;6:376-381
22. Bukhary SMN, Gill DS, Tredwin CJ, Moles DR. The influence of varying maxillary lateral incisor dimensions on perceived smile aesthetics. BDJ 2007;203:687-69.
23. Spear FM, Kokich VG, Matthews DP. Interdisciplinary management of anterior dental esthetics. JADA 2006;137:160-169
24. Small BW. Esthetic management of congenitally missing lateral incisors with single-tooth implants: A Case report. Quintessence Int. 1996 Sep;27(9):585-90.
25. Hobkirk J.A. and Brook A.H. The management of patients with severe hypodontia. J of Oral Rehabilitation, 1980;7:289-298.
26. McKeown HF, Robinson DL, Elcock, Al-Sharood M, Brook AH. Tooth dimensions in hypodontia patients, their unaffected relatives and a control group measured by a new image analysis system. Eur J Orthod 2002;24(2):131-141
27. Rune B and Sarnäs KV. Tooth size and tooth formation in children with advanced hypodontia. Angle Orthodont 1974 44:316-321.
28. Baccetti T. A controlled study of associated dental anomalies. Angle Orthod 1998; 68:267-74

29. Brin I, Becker A, Shalhav M. Position of the maxillary canine in relation to anomalous or missing lateral incisors; a population study. *Eur J Orthod* 1986;8:12-16
30. Camillieri S. Maxillary canine anomalies and tooth agenesis. *Eur J Orthod* 2005 Oct;27(5):450-6. Epub 2005 Aug 10.
31. Peck S, Peck L, Kataja M. Mandibular lateral incisor-canine transposition, concomitant dental anomalies, and genetic control. *Angle Orthod* 1998 Oct;68(5):455-66.
32. Pirinen S, Arte S, Apajalahti S. Palatal displacement of canine is genetic and related to congenital absence of teeth. *J Dent Res* 1996 Oct;75(10):1742-6
33. Becker A, Gillis I, Shpack N. The etiology of palatal displacement of maxillary canines. *Clin Orthod Res*. 1999 May;2(2):62-6
34. Apajalahti S, Arte S, Pirinen S. Short root anomaly in families and its association with other dental anomalies. *Eur J Oral Sci* 1999;107:97-101
35. Tóllon-Walton V, Nieminen P, Arte S, Carvalho-Lobato P, Ustell-Torrent JM, Manzanares-Cespedes MC. An epidemiological study of dental agenesis in a primary health area in Spain: Estimated prevalence and associated factors. *Med Oral Patol Oral Cir Bucal*. 2010 July1;15(4):e569-74.
36. Seow WK, Lai PY. Association of taurodontism with hypodontia: a controlled study. *Paed Dent* 1989;11:214-219
37. Baccetti T. Tooth rotation associated with aplasia of nonadjacent teeth. *Angle Orthod* 1998; 68: 471-474.
38. Xianghong Bu, Khaled Khalaf, and Ross S. Hobson. Dental arch dimensions in oligodontia patients. *Am J Orthod Dentofacial Orthop* 2008;134:768-72

39. Whaites E. Essentials of dental radiography and radiology. 2nd Edition 1996. Churchill Livingstone Chapter 15;151-166
40. Whittington BR, Durward CS. Survey of anomalies in primary teeth and their correlation with the permanent dentition. NZ Dental J. 1996 Mar;92(407):4-8
41. Locht S. Panoramnic radiographic examination of 704 Danish children aged 9-10 years. Community Dent Oral Epidemiol. 1980 Oct;8(7):375-80
42. Meechan JG, Carter NE, Gillgrass TJ, Hobson RS, Jepson NJ, Nohl FS dan Nunn JH. Interdisciplinary management of Hypodontia: Oral Surgery. BDJ 2003:423-427
43. White SC, Pharoah MJ. Oral Radiology principles and Interpretation. 5th ed., Philadelphia: Mosby CO; 2004:pg 332.
44. American Academy of Pediatric Dentistry. Guidelines on Management of developing Dentition and Occlusion in Paediatric Dentistry. Reference Manual V 2009: 32/NO6 10/11:213-225
45. Hobson RS, Carter NE, Gillgrass TJ, Jepson NJ, Meechan JG, Nohl F, Nunn JH. The interdisciplinary management of hypodontia: the relationship between an interdisciplinary team and the general dental practitioner. Br Dent J 2003 May 10:194(9):479-82
46. Morgan C, Howe L. The restorative management of hypodontia with implants: 1.overview of alternative treatment options. Dental Update 2003; 30:562-568
47. Kokich Jr VO, Kinzer GA. Managing congenitally missing lateral incisors. Part I:Canine Substitution J Esthet Restor Dent 2005 17:5-10
48. Davies SJ, Gray RJ, Mackie IC. Good occlusal practice in children's dentistry. Br Dent J 2001 Dec 22;191(12):655-9

49. Gill DS, Jones S, Hobkirk J, Bassi S, Hemmings K, Goodman J. Counselling patients with hypodontia. Dent Update 2008 Jun;35(5):344-50, 348-50, 352
50. Gahan MJ, Lewis BR, Moore D, Hodge TM. The orthodontic-restorative interface: 1. Patient assessment . Dent Update 2010 Mar;37(2):74-6
51. Parkin N, Benson PE, Shah A, Thind B, Marshman Z, Glenroy G, Dyer F. Extraction of primary (baby) teeth for unerupted palatally displaced permanent canine teeth in children. Cochrane Database Syst Rev. 2009 Apr 15;(2):CD004621
52. Kinzer GA, Kokich Jr. VO. Managing congenitally missing lateral incisors. Part III: Single-tooth implants. J Esthet Restor Dent 2005;17:202-210
53. Kokich VO, Kinzer GA, Janakiesvski J. Congenitally missing lateral incisors:Restorative replacement. Am J Orthod Dentofacial Orthop 2011 April;Vol 139(4):435-445
54. Kokich VG. Maxillary lateral incisor implants: Planning with the aid of orthodontics. J Oral Maxillofac Surg 2004; 62: 48-56
55. Fekonja A. Hypodontia in orthodontically treated children. Eur J Orthod. 2005 Oct;27(5):457-60. Epub 2005 Jul 25
56. Sabri R. Management of missing maxillary lateral incisors. JADA 1999 Jan;130:80-84.
57. Carter NE, Gillgrass TJ, Hobson RS, Jepson N, Meechan JG, Nohl FS, Nunn JH. The interdisciplinary management of hypodontia: orthodontics. Br Dent J 2003 Apr 12;194(7):361-6
58. Jepson NJ, Nohl FS, Carter NE, Gillgrass TJ, Meechan JG, Hobson RS, Nunn JH. The interdisciplinary management of hypodontia: restorative dentistry. Br Dent J 2003 Mar 22;194(6):299-304

59. Nohl F, Cole B, Hobson R, Jepson N, Meechan J, Wright M. The management of hypodontia: present and future. Dent Update 2008 Mar;35(2):79-90
60. Lewis BR, Gahan MJ, Hodge TM, Moore D. The orthodontic-restorative interface: 2. Compensating for variations in tooth number and shape. Dent Update 2010 Apr;37(3):138-40
61. Zachrisson BU, Rosa M, Toreskog S. Congenitally missing maxillary lateral incisors: Canine substitution. Am J Orthod Dentofacial Orthop 2011 April; vol 139(4):434-445
62. Louw JD, Smith BJ, McDonald F & Palmer RM. The management of developmentally absent maxillary lateral incisors – a survey of orthodontists in the UK. BDJ 2007; 203, E25
63. Kinzer GA, Kokich Jr. VO. Managing congenitally missing lateral incisors. Part II: Tooth-supported restorations. J Esthet Restor Dent 2005;17:76-84
64. Thilander B. Orthodontic space closure versus implant placement in subjects with missing teeth. J Oral Rehabil. 2008 Jan;35 Suppl 1:64-71
65. Zachrisson BU, Stenvik A, Haanaes H. Management of missing maxillary anterior teeth with emphasis on autotransplantation. Am J of Dentofac Orthop 2004; vol 126:3:284-288.
66. Kirsterson L .Autotransplantation of human premolars: A clinical and radiographic study of 100 teeth. Int J of Oral Surgery 1985 Vol 14;2:200-213
67. Paulsen HU, Andreasen JO. Eruption of premolars subsequent to autotransplantation. A longitudinal radiographic study. Eur J of Orthod 1998;2:45-55

68. Aslan BI, Ucuncu N & Dogan A. Long term follow-up of a patient with multiple congenitally missing teeth treated with autotransplantation and orthodontics. *Angle Orthod* 2010; 80(2); 396-404
69. Andreasen JO, Paulsen HU, Yu Z, Bayer T & Schwartz O. A long-term study of 370 autotransplanted premolars. Part II. Tooth survival and pulp healing subsequent to transplantation. *Eur J Orthod* 1990; 12 (1): 14-24
70. Meiers JC, Freilich MA. Chairside prefabricated fiber-reinforced resin composite fixed partial dentures. *Quintessence Int* 2001 Feb;32(2):99-104
71. Olsen TM, Kokich VG Sr. Postorthodontic root approximation after opening space for maxillary lateral incisor implants. *Am J Orthod Dentofacial Orthop* 2010 Feb;137(2):158-9
72. Bishop K, Addy L, Knox J. Modern restorative management of patients with congenitally missing teeth:3. Conventional restorative options and considerations. *Dental update* 2007 Jan-Feb;34:30-38
73. Van Heumen CC, Van Dijken JW, Tanner J, Pikaar R, Lassila LV, Creugers NH, Vallittu PK, Kreulen CM. Five-year survival of 3-unit fiber-reinforced composite fixed partial dentures in the anterior area. *Dent Mater*. 2009 Jun;25(6):820-7
74. Vallittu PK. Survival rates of resin-bonded, glass fiber-reinforced composite fixed partial dentures with a mean follow-up of 42 months: a pilot study. *J Porsthet Dent* 2004 Mar;91(3):241-6
75. Pjetursson BE, Tan WC, Tan K, Bragger U, Zwahlen M, Lang NP. A systematic review of the survival and complication rates of resin-bonded bridges after an observation period of at least 5 years. *Clin Oral Implants Res.* 2008 Feb;19(2):131-41

76. Rada R, Cruz Gonzalez WI. The U-Beam bridge: an advancement in the fiber-reinforced resin-bonded fixed partial denture. *Quintessence Int.* 2009 Jul-Aug;40(7):35-40
77. Robersson S, Mohlin B. The congenitally missing upper lateral incisor. A retrospective study of orthodontic space closure versus restorative treatment. *Eur J Ortho* 2000 Dec;22(6):697-710
78. Rosa M, Zachrisson BU. Integrating esthetic dentistry and space closure in patients with missing maxillary lateral incisors. *J of clinical Orthodontics* 2001 Vol XXXV; No.4:221-234
79. Thordason A, Zachrisson BU., Mjor I A. Remodeling of canines to the shape of lateral incisors by grinding: a long-term clinical and radiographic evaluation. *Am J Orthod Dentofacial Orthop.* 1991; 100(2): 123 – 132.
80. Shafi I, Phillips JM, Dawson MP, Broad RD, Hosey MT. A study of patients attending a multidisciplinary hypodontia clinic. *Br Dent J* 2008 Dec 20;205(12):649-52
81. Newman GV, Newman RA. Report of four familial cases with congenitally missing mandibular incisors. *Am J Orthod Dentofac Orthop.* 1998 Aug;114(2):195-207
82. Argyropoulos E, Payne G. Techniques for improving orthodontic results in the treatment of missing maxillary lateral incisors. A case report with literature review. *Am J Orthod Dentofacial Orthop* 1988 Aug;94(2):150-65
83. Van Heumen CC, Kreulen CM, Creugers NH. Clinical studies of fiber-reinforced resin-bonded fixed partial dentures: a systematic review. *Eur J Oral Sci* 2009 Feb;117(1):1-6
84. Garnett MJ, Wassell RW, Jepson NJ, Nohl FS. Survival of resin-bonded bridgework provided for post-orthodontic hypodontia patients with missing maxillary lateral incisors. *Br Dent J* 2006 Oct 21;201(8):527-34

85. De Backer H, Van Maele G, De Moor N, Van den Berghe L. An up to 20-year retrospective study of 4-unit fixed dental prostheses for the replacement of 2 missing adjacent teeth. *Int J Prosthodont* 2008 May-Jun;21(3):259-66
86. Morgan C, Howe L. The restorative management of hypodontia with Implants: 2. Planning and treatment with Implants. *Dental Update* 2004; 31:22-30
87. Henry PJ, Laney WR, Jemt T, Harris D, Krogh PH, Polizzi G, Zarb GA, Herrmann I. Osseointegrated implants for single-tooth replacement: a prospective 5-year multicenter study. *Int J Oral Maxillofac Implants* 1996 Jul-Aug;11(4):450-455
88. Lundqvist S, Haraldson T. Oral function in patients wearing fixed prosthesis on osseointegrated implants in the maxilla. *Scand J Dent Res.* 1990 Dec;98(6):544-9
89. Kokich VG. Maxillary lateral incisor implants: planning with the aid of orthodontics. *J Oral Maxillofac Surg.* 2004 Sep;62(9 Suppl 2):48-56
90. Esposito M, Grusovin MG, Kwan S, Worthington HV, Coulthard P. Interventions for replacing missing teeth: bone augmentation techniques for dental implant treatment. *Cochrane Database Syst Rev.* 2008 Jul 16;(3):CD003607
91. Richardson G, Russell KA. Congenitally missing maxillary lateral incisors and orthodontic treatment considerations for the single-tooth implant. *J Can Dent Assoc.* 2001;67(1):25-8
92. Esposito M, Grusovin MG, Kakisis I, Coulthard P, Worthington HV. Interventions for replacing missing teeth: treatment of periimplantitis. *Cochrane Database Syst Rev.* 2008 Apr 16;(2): CD004970

93. Esposito M, Grusovin MG, Maghaireh H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: management of soft tissues for dental implants. Cochrane Database Syst Rev. 2007 Jul 18;(3):CD006697
94. *Gibbard LL, Zarb G. A 5-year prospective study of implant-supported single-tooth replacements. J Can Dent Assoc. 2002 Feb;68(2):110-6
95. Esposito M, Murray-Curtis L, Grusovin MG, Coulthard P, Worthington HV. Interventions for replacing missing teeth: different types of dental implants. Cochrane Database Syst Rev 2007 Oct 17;(4):CD003815
96. Cooper L, Felton DA, Kugelberg CF, Ellner S, Chaffee N, Molina AL, Moriarty JD, Paquette D, Palmqvist U. A multicenter 12-month evaluation of single-tooth implants restored 3 weeks after 1-stage surgery. Int J Oral Maxillofac Implants 2001;16:182-192
97. Laney WR, Jemt TH, Henry D, Krogh PJ, Polizzi PH, Zarb G, Hermann GA. Osseointegrated implants for single-tooth replacement: progress report from a multicenter prospective study after 3 years. Int J Oral Maxillofac Implants. 1994;9(1):49-54
98. Johnston C, Burden D, Morris D. Clinical Guidelines: Orthodontic Retention. Revised November 2008
99. Littlewood SJ, Millet DT, Doubleday B, Bearn DR, Worthington HV. Orthodontic Retention: A systematic review. J of Orthod 2006 vol.33:205-212
100. Ormiston JP, Huang GJ, Little RM, Decker JD, Seuk GD. Retrospective analysis of long-term stable and unstable orthodontic treatment outcomes. Am J Orthod Dentofacial Orthop. 2005 Nov;128(5):568-74

101. López-Areal L, Paredes V, Gandia JL. Long-term analysis of upper incisor crowding. A longitudinal study orthodontically treatment patients. *Med Oral Patol Oral Cir Bucal* 2011 Mar 1;16(2):e245-51
102. Artun J, Garol JD, Little RM. Long-term stability of mandibular incisors following successful treatment of Class II, Division 1 malocclusions. *Angle Orthod* 1996;66(3):229-38
103. Andrén A, Naraghi S, Mohlin BO, Kjellberg H. Pattern and amount of change after orthodontic correction of upper front teeth 7 years postretention. *Angle Orthod* 2010 Jul;80(4):432-7.
104. Naraghi S, Andrén A, Kjellberg H, Mohlin BO. Relapse tendency after orthodontic correction of upper front teeth retained with a bonded retainer. *Angle Orthod* 2006 Jul;76(4):570-6
105. Pratt MC, Kluemper GT, Hartsfield JK Jr, Fardo D, Nash DA. Evaluation of retention protocols among members of the American Association of Orthodontists in the United States. *Am J Orthod Dentofacial Orthop* 2011 Oct;140(4):520-6
106. Wong PM, Freer TJ. A comprehensive survey of retention procedures in Australia and New Zealand. *Aust Orthod J* 2004 Nov;20(2):99-106
107. Renkema AM, Sips ET, Bronkhorst E, Kuijpers-Jagtman AM. A survey on orthodontic retention procedures in The Netherlands. *Eur J Orthod* 2009 Aug;31(4):432-7. Epub 2009 Apr 28
108. Singh P, Grammati S, Kirschen R. Orthodontic retention patterns in the United Kingdom. *J Orthod* 2009 Jun;36(2):115-21
109. Edman Tynelius G, Bondemark L, Lilja-Karlander E. Evaluation of orthodontic treatment after 1 year of retention- a randomized controlled trial. *Eur J Orthod* 2010;32:542-547

110. Kennedy DB. Orthodontic management of missing teeth. J Can Dent Assoc 1999;65:548-50
111. Richmond S, Shaw WC, O'Brien KD, Buchanan IB, Jones R, Stephens CD, Roberts CT, Andrews M. The development of the PAR Index (Peer Assessment Rating): reliability and validity. Eur J Orthod 1992 14:125-139
112. Barry G, Kaur G. Guidelines for primary care trusts and local health Boards to assess the treatment outcome of patients treated by specialist orthodontists or dentists using the Peer Assessment Rating (PAR) Index. Clinical Standards Committee of the British Orthodontic Society. 2009 July pg1-9
113. Richmond S. Personal audit in orthodontics. Br J Orthod 1993 20:135-44

Appendix 1 Space Closure

Pre-treatment



Post-treatment



Missing maxillary right lateral incisor
Treatment: early extraction C B/
Canine erupts mesially and
aligned into lateral space

Reshaping of canine

Appendix 2 Space Opening



Panoramic radiograph



Peg-shaped upper right &
Missing left lateral incisor



Space opened & redistributed



Crowned upper right lateral incisor
and bridge to replace left lateral incisor

Space Opening & Interim Orthodontic Retention



Pre-treatment study cast
Missing right and left
maxillary lateral incisor



Space opened orthodontically
for prosthetic replacement
of lateral incisor



Final prosthetic replacement with
Cantilevered bridge



Orthodontic retention with Hawley
Retainers & acrylic pontics

Appendix 3

COMPONENTS

1. Upper and lower anterior segments
2. Left and right buccal occlusion
3. Overjet
4. Overbite
5. Centreline

1) Contact point displacement score

- 0 0–1 mm
- 1 1.1–2 mm
- 2 2.1–4 mm
- 3 4.1–8 mm
- 4 >8 mm
- 5 impacted teeth

2) Buccal occlusal assessment

a) Antero-posterior

- 0 Good interdigitation
- 1 <1/2 unit from full interdigitation
- 2 Half a unit

b) Vertical

- 0 No open bite
- 1 Lateral open bite on at least 2 teeth >2 mm

c) Transverse

- 0 No crossbite
- 1 Crossbite tendency
- 2 Single tooth in crossbite
- 3 >1 tooth in crossbite
- 4 >1 tooth in scissors bite

3) Overjet assessment

a) Overjet

- 0 0–3 mm
- 1 3.1–5 mm
- 2 5.1–7 mm
- 3 7.1–9 mm
- 4 >9 mm

b) Anterior crossbite

- 0 No crossbite
- 1 ≥ 1 teeth edge to edge
- 2 one single tooth in crossbite
- 3 2 teeth in crossbite
- 4 >2 teeth in crossbite

4) Overbite assessment

a) Open bite

- 0 No open bite
- 1 Open bite ≤ 1 mm
- 2 Open bite 1.1–2 mm
- 3 Open bite 2.1–3 mm
- 4 Open bite ≥ 4 mm

b) Overbite

- 0 $\leq 1/3$ coverage of the lower incisor
- 1 $>1/3$ but $<2/3$ coverage of the lower incisor
- 2 $\geq 2/3$ coverage of the lower incisor
- 3 Greater or equal to full tooth coverage

5) Centreline assessment

- 0 Coincident & up to 1/4 lower incisor width
- 1 1/4–1/2 lower incisor width
- 2 $>1/2$ lower incisor width

WEIGHTINGS:

1. Upper and lower incisor segments x1
2. Left and right buccal occlusion x1
3. Overjet x6
4. Overbite x2
5. Centreline x4

ACKNOWLEDGEMENT

The members of the CPG development group would like to express their gratitude and appreciation to the following for their contribution:

- Panel of local and external reviewers
- Ministry of Health Technical Advisory Committee for CPG
- All those who have contributed directly or indirectly to the development of this CPG

DISCLOSURE STATEMENT

The members in the core working committee had completed disclosure forms. None held shares in pharmaceutical firms or act as consultants to such firms. (Details are available upon request from the CPG Secretariat in the Ministry of Health)

SOURCES OF FUNDING

The development of this CPG was supported financially in its entirety by the Ministry of Health Malaysia and was developed without any involvement of the pharmaceutical industry or any outside agency.

