Provision and Timing of Interceptive Orthodontic Treatment by Certified Orthodontists and Pediatric Dentists in Canada

by

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ABSTRACT

Orthodontic Treatment Timing –
A Survey of Orthodontists and Pediatric Dentists in Canada

Introduction: The ideal timing to initiate orthodontic treatment is an important, yet controversial issue. The purpose of this study was to investigate the provision of orthodontic care for 7 types of skeletal dysplasia by paediatric dentists and orthodontists in Canada. Methods: A questionnaire was distributed to randomly selected orthodontists (N=140) and paediatric dentists (N=132) throughout Canada. Surveys returned within 8 weeks were included for c2 statistical analysis. Results: The response rate was 59% for orthodontists and 54% for pediatric dentists. Orthodontists and pediatric dentists differed significantly in the timing of their first orthodontic consultation (p < 0.01). More pediatric dentists used to the dental age to determine the appropriate time to initiate treatment (p < 0.01), whereas more orthodontists relied on the pubertal indicators (p < 0.01). More orthodontists would intervene in the early mixed dentition for moderate mandibular prognathia (p < 0.01); mid-mixed dentition for severe mandibular retrognathia (p < 0.01), late mixed dentition for moderate mandibular retrognathia (p < 0.01) and permanent dentition for skeletal openbite and severe mandibular prognathia (p < 0.01). Most pediatric dentists would intervene in the early and mid-mixed dentition for the specified cases of skeletal malocclusions (p < 0.05). Conclusions: The results of this investigation indicate both consistencies and variation between orthodontic and paediatric practitioners with regard to preference in treatment timing, and the factors that influence these decisions.
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1. INTRODUCTION

1.1 Background

Archaeological evidence revealed that crooked teeth have been noted since the time of Neanderthal man (about 50,000 B.C.). The first attempts to correct crowded or protruding teeth however, were recorded circa 3000 years ago (Wahl, 2005). As dentistry developed in the eighteenth and nineteenth centuries, a greater emphasis and a more systematic approach on the alignment of teeth and the correction of facial proportions emerged.

Edward H. Angle, whose influence on orthodontics began to be felt around 1890, is credited with the development of the concept of occlusion in the natural dentition. Before his time, the treatment of malocclusions was chaotic, with little understanding of normal occlusion and even less understanding of the development of the dentition. Angle’s classification of occlusion has four classes: normal occlusion, Class I malocclusion, Class II malocclusion and Class III malocclusion (Angle, 1899).

What Angle defined as a normal occlusion with ideal tooth interdigitation arranged along a perfectly regular line of occlusion, is quite rare. Between 1930 and 1965, the prevalence of malocclusion in the United States was estimated to be 35% to 95% (Proffit, 2000). These significant discrepancies were largely due to the investigators’ differing criteria for “normal occlusion.”

Malocclusion can cause various problems for patients: (1) psychosocial handicap, (2) problems
with oral function, and (3) greater susceptibility to trauma, periodontal disease or caries (Proffit, 2000). The perceived need and demand for orthodontic treatment vary with social and cultural influences. It can be speculated that dental access to care, family income and varying concepts of esthetics may be the major determinants of how many children receive treatment.

The optimal time to initiate interceptive orthodontic treatments is an important, yet controversial issue (Proffit, 2000). Although some of the occlusal anomalies can improve on their own during the transition from the mixed dentition to the permanent dentition, orthodontic treatment during the preadolescent years can sometimes provide a long-term benefit to the patients. Types of malocclusion that may require interceptive treatment can be categorized into skeletal and dental problems, which are corrected by growth modification and by tooth movement, respectively. This earlier-than-usual treatment that occurs before the adolescent growth spurt has been described as “interceptive” or “early” treatment (Proffit, 2000).

When a jaw discrepancy exists, the ideal solution is to correct the problem by modifying the child’s facial growth. Moyers suggests that early treatment can take advantage of normal growth, before malocclusions become severe (Moyers, 1988). Compliance may also be greater in younger patients. However, Moyers also warns that early treatment may not guarantee long-term benefits. Current research (O’Brien et al., 2003; Tulloch et al., 2004) shows that some early treatment (mixed dentition, preadolescent) produces no more benefit than later treatment (early permanent dentition, during adolescence), but takes longer and costs more (Bowman, 1998). Improper early treatment can be harmful, and two-phase treatment may lengthen the overall treatment time (Yang, 1998).
While the significance of psychosocial distress, related to skeletal dysplasia, should not be underestimated, a universal application of early treatment to all types of malocclusion is also not supported by the literature. As a general principle, any orthodontic treatment should be provided at the time in a child’s development when it would be most effective (produce the best result) and most efficient (provide the best benefit to cost ratio). Indications for early treatment, therefore, should be selected on a case-by-case basis to maximize the benefit to the patient (Wiltshire and Tsang, 2006).

Many studies in the literature focus on fixed orthodontic appliance therapy that is provided by orthodontists (Yang, 1998; Pietila, 2007). It would be of great interest to explore the type(s) of orthodontic treatment provided by other dental professionals. Moreover, it would be revealing to document the current practice patterns regarding treatment timing, given the controversy and debate in the orthodontic literature.

1.2 Literature review on the management of malocclusion

To better understand the effectiveness of early orthodontic treatment, it is important to briefly review the current literature on the management and timing of intervention for various types of malocclusion.

1.2.1 Early management of Class II malocclusion

1.2.1.1 Evolution of growth modification treatment
Whether the growth of the jaws can be modified by orthodontic treatment has been a controversial issue predating the times of Angle. From early on, orthodontists realized that any skeletal discrepancies could manifest into dental malocclusions or facial disharmony. Therefore, in the late 1800s, American orthodontists implemented the use of an extra-oral force (headgear) in their treatments and achieved favorable results (Wahl2, 2005). Subsequently, Angle and his contemporaries abandoned the use of extra-oral traction, because they believed that intraoral Class II elastics could be as effective in modifying the direction and magnitude of mandibular growth (Wahl2, 2005). It was not until the cephalometric investigations by Broadbent (Broadbent, 1937) and Brodie (Brodie, Downs, Goldstein, & Myer, 1938) that practitioners realized that elastics could only correct malocclusions by dentoalveolar movements while exerting little influence on the original skeletal disproportionate growth patterns.

Although headgear was reintroduced in the 1940s, it was seen primarily as a molar-distalizing device. The first evidence that extra-oral force could produce not only tooth movement but also effect maxillary growth came from the retrospective cephalometric studies of patients wearing a headgear (Moore, 1959; Ricketts, 1960; Weislander, 1963). They found that headgear could inhibit maxillary growth and distalize the maxilla in relation to the anterior cranial base.

In Europe, the efforts were focused on stimulating mandibular growth. After the first prototype of Robin’s monobloc in 1907 and Andresen’s activator in the 1930s, there were an array of functional appliances that developed (Graber & Neumann, 1984). The theory behind a functional appliance was that forcing the patient to protrude the lower jaw forward to an ideal anteroposterior relationship may stimulate mandibular growth, and thereby correct the Class II
malocclusion. The skeletal and dental effects of these functional appliances were documented in numerous retrospective investigations (Korkhaus, 1960; Marschner & Harris, 1966; Demisch, 1972; Pan,cherz, 1979; Weislander, 1984; McNamara, Bookstein, & Shaughnessy, 1985; Hagg & Pancherz, 1988; Baccetti, Franchi, Toth, & McNamara, 2000). In fact, there was a significant surge of over 130 articles reporting on the effects of 14 different functional appliances in treating Class II malocclusions during the period between 1980 and 1990 (Tulloch, Phillips, Koch, & Proffit, 1997). All these studies reported successful correction of Class II malocclusion. It was less clear whether the clinical successes with functional appliances were attributed to a stimulated mandibular growth, a dentoalvolar correction or a combination of the two. Moreover, since the correction was achieved in the mixed dentition, there have been continuous debates about whether the correction was an absolute stimulation (larger than an adult) or a temporal stimulation (“borrowed” growth) (Proffit & Fields, 2000).

In order to truthfully measure and compare outcomes of the different means of interventions, the most powerful tool in clinical research is to allocate patients at random to receive one of several treatments. As long as the numbers of subjects are sufficient, randomization is an effective method for balancing confounding factors between treatment groups.

1.2.1.2 Randomized clinical trials

The clinical evaluative sciences emerged in medicine in the 1980s with the new methodology of clinical trials to compare the efficacy and effectiveness of alternative treatment interventions. In 1988, the National Institute of Dental and Craniofacial Research (NIDCR) funded two randomized clinical trials (RCTs) at the Universities of North Carolina and Florida designed to
evaluate the effectiveness of headgear and bionator treatments in the early management of Class II div 1 malocclusions. The results of these two studies, in addition to two other RCTs conducted at the Universities of Pennsylvania and Manchester, reawakened the controversies regarding the ideal timing of orthodontic interventions to modify skeletal or dental patterns in the mixed dentition.

1.2.1.3 Four Clinical Trials on Early Class II Correction

The purpose of the RCT conducted at the University of Florida was to examine the anteroposterior skeletal and dental effects that occur as a result of early orthopedic treatment (Keeling, Wheeter et al., 1998). A total of 249 subjects, diagnosed to have $\frac{1}{2}$ cusp Class II molars, were divided into three treatment groups: control, bionator and headgear/biteplane (16 ounces of force per side). The results indicated that both the headgear and bionator appliances appeared to enhance mandibular growth and their combined skeletal and dental measures (OJ and molar discrepancy) showed significantly greater Class II correction over the control group. The skeletal changes, largely attributable to enhanced mandibular growth in both headgear and bionator subjects, were stable a year after the end of treatment, but dental movements, namely retraction of maxillary teeth and protraction of mandibular teeth, relapsed. In short, this study suggests that both the headgear and bionator appliances may be effective in inducing a favourable skeletal change and Class II correction.

However, the clinical trial at the University of North Carolina painted a different picture on the effectiveness and efficiencies of *early* Class II correction.
The inclusion criteria of the RCT conducted at the University of North Carolina investigated preadolescent children with an OJ of at least 7mm (Tulloch, Phillips, & Proffit, 1998; Tulloch, Proffit, & Phillips, 2004). Their initial results indicated that early treatment with a headgear or functional appliance can reduce the severity of a Class II skeletal pattern. However, the follow-up study suggested that the skeletal effects of early treatment, on average, were not maintained and the increase in mandibular growth might represent an accelerated growth, rather than an absolute net gain. The authors concluded that early treatment followed by later comprehensive treatment on average does not produce a significant difference in jaw relationship or dental occlusion, compared with later one-stage treatment. Variability in skeletal pattern appeared to be a major contributor to variability in treatment response.

The two clinical trials at the Universities of Pennsylvania and Manchester came to a similar conclusion, namely that early Class II correction, followed by retention and a second phase of treatment, may be as effective as a delayed one-phase treatment.

There are three unique features of the RCT conducted at the University of Pennsylvania, compared to the other three studies. Firstly, there was the additional inclusion criterion that considered the patient’s skeletal relationship (i.e. minimal ANB of 4.5°). Secondly, the treatment groups were either a Frankel functional regulator or a combination headgear. However, an important shortfall of this study was the lack of a control group.

The results indicated that headgear seemed to produce an orthopedic effect transferring throughout the totality of the maxilla, an orthodontic effect on maxillary first molars and a lip-bumper effect on the maxillary canines. The functional appliance, on the other hand, promoted
anterior mandibular position and affected maxillary and mandibular incisors. Treatment in late childhood may be as effective as that in mid-childhood. Yet there were also benefits in early treatments: reduced incidence of trauma, psychosocial impact, and improved periodontal health.

The multicentre RCT conducted at the University of Manchester (O'Brien et al., 2003) aimed to investigate the effectiveness of early orthodontic treatment with the Twin-block appliance for the developing Class II division 1 malocclusion. A total of 174 children, aged 8 to 10 years old, with Class II Division 1 malocclusion were randomly allocated to receive treatment with a Twin-block appliance or to an untreated, control group. Results showed that early treatment with Twin-block appliances resulted in reduction of overjet, correction of molar relationships, and reduction in severity of malocclusion. Most of this correction was due to dentoalveolar change, but the resulting skeletal change may not be clinically insignificant. The subsequent study which investigated the psychosocial effects of early treatment indicated that early treatment resulted in an increase in self-concept and a reduction of negative social experiences (O'Brien et al., 2003).

The randomized clinical trials have concluded that:

1. Early treatment with headgear and functional appliances reduced the severity of the developing Class II malocclusion.

2. Two-phase treatment of Class II problems, on average, did not produce major differences in jaw relationships or dental occlusion, compared with later one-phase treatment.

1.2.1.7 Validity of Randomized Clinical Trials Questioned

While the results from the clinical trials have provided us with new insights and valuable
information on the efficiency of early treatment for Class II malocclusion, it is important for practitioners to remain critical and be mindful of the limitations of all research studies. Darendeliler published a review in 2006 that challenged these generalized concluding statements and the methodologies of the clinical trials (Darendeliler, 2006). Firstly, he believed that the inclusion criteria should have been more stringent. A patient cannot be classified as Class II based solely on an overjet of 7mm or more. A patient could be skeletal Class I with harmonious facial features, and with an increased overjet due to proclination of the upper incisors and/or retroclination of the lower incisors. Similarly, choosing on the basis of molar relationship disregards the various phenotypes of a Class II malocclusion and produces a wide variety of skeletal configurations. Secondly, all malocclusions cannot be treated with one type of appliance. Thirdly, these four RCTs studying the outcome of Class II malocclusion showed the average effect of treatment and overlooked the large individual variations of treatment response for any type of orthopedic appliance. Another weakness of these clinical trials was a lack of assessment of the treatment effects on the profile. The narrow parameters defined by these studies may not truly address the wider multifactorial questions.

1.2.2 Early management of Class III malocclusion

Many research studies and much discussion has been devoted to the management of Class II malocclusion. Although the prevalence of Class III malocclusion is low (<1% of American children and increasing slightly in youths and adults), there has also been a lot of enthusiasm in understanding the aberrant growth pattern and management of patients with Class III malocclusion.
1.2.2.1 Skeletal effects of a protraction face mask on nasomaxillary development.

Several circum-maxillary sutures play an integral role in the development of the nasomaxillary complex. Primate studies indicated that an extraoral forward force caused significant changes in the circum-maxillary sutures and the maxillary tuberosity (Kambara, 1977). However, maxillary protraction can result in more than forward displacement on the maxilla. When Nanda in 1978 repeated a similar animal experiment, he determined that different midfacial bones were displaced in different directions depending on the moments of force generated at the sutures (Nanda, 1978). Again using monkey models, Jackson et al. found that anterior positioning of the maxillary complex was accompanied with a small amount of counter-clockwise rotation during the treatment period (Jackson, Kokich, & Shapiro, 1979). Studies on human skulls by Hata et al. found a similar counter-clockwise rotation of the maxilla unless a downward vector of force was applied (Hata et al., 1987). The centre of resistance of the maxilla was found to be at the distal contacts of the maxillary first molars, with one half the distance between the occlusal plane and the inferior orbital rim. Maxillary protraction below the centre of resistance produces an anticlockwise rotation of the maxilla. Hence, to minimize any bite opening, the protraction elastics are attached near the maxillary canines with a downward and forward pull of 30 degrees to the occlusal plane. Maxillary protraction generally requires 300 to 600 gram of force per side. Tension of the elastics can be determined using a tension stress gauge. Patients are instructed to wear the face mask for 14 hours a day (Bishara, 2001).

1.2.2.2 Timing of intervention for Class III malocclusion

Protraction facemasks have shown to be effective in reducing the severity of Class III malocclusion in children in the primary or mixed dentitions (Ngan & Yiu, 2000). However, in a
few patients, the benefits of early treatment are negated by relapse in OJ, OB and midline corrections during the follow-up period. In general, the optimal time to intervene a Class III malocclusion is at the time of the initial eruption of the maxillary incisors (Ngan, 2005). Turpin developed a list of positive and negative factors used to aid in deciding when to intervene in a developing Class III malocclusion (Turpin, 1981; Ngan, 2005). The positive factors include good facial esthetics, mild skeletal disharmony, no familial prognathism, presence of anteroposterior functional shift, convergent facial type, symmetric condylar growth and a growing patient with good compliance. The negative factors include poor facial esthetics, severe skeletal disharmony, established familial pattern, no anteroposterior shift, divergent facial type, asymmetric condylar growth, growth complete and poor compliance. Turpin recommends that early treatment with growth modification can be a good option for patients with the positive factors. For patients with the negative factors, treatments should be delayed until after growth is complete. However, patients should be advised that surgery may be a possibility even when an early intervention is successful.

While many Class III patients present with a maxillary deficiency in both the sagittal and transverse dimensions, a transverse discrepancy may manifest by itself as a unilateral or bilateral posterior crossbite. It is equally important to address the early intervention in the transverse dimension.

1.2.3 Early management of transverse discrepancy

The incidence of posterior crossbite in the primary and mixed dentitions is estimated to range from 7% to 23% with a greater prevalence of unilateral crossbite coupled with a functional shift
of the mandible (Marshall, Southard, & Southard, 2005). The etiology of a skeletal posterior crossbite includes transverse maxillary skeletal deficiency, asymmetric growth of the maxilla or mandible, asymmetric development of the temporomandibular joints and possibly oral digit. It is recommended to start treatment of posterior crossbite by occlusal adjustment of the deciduous dentition. If there is no effect, an orthodontic appliance, preferably fixed, should be applied in the early mixed dentition (Thilander, Wahlund, & Lennartsson, 1984). However, controlled studies have also indicated a wide range of spontaneous correction of posterior crossbites, ranging between 8% to 45% (Kutin & Hawes, 1969; Thilander et al., 1984; Kurol & Berglund, 1992). Early intervention in the case of a unilateral functional crossbite may be even more important because studies have suggested that a lateral shift of the mandible can promote adaptive remodelling of the temporomandibular joint and a subsequent mandibular asymmetry (O’Byrn, Sadowsky, Schneider, & BeGole, 1995). One study suggests that for patients in the mixed dentition, adaptive remodelling of the temporomandibular joints may have already occurred (Nerder, Bakke, & Solow, 1999). A recent prospective clinical study concluded that while unilateral posterior crossbites produce morphological and positional asymmetries of the mandible in young children, these asymmetries can be largely eliminated with early expansion therapy (Pinto, Buschang, Throckmorton, & Chen, 2001). Two Cochrane reviews concluded that occlusal grinding in the primary dentition, with/without the addition of an upper removable expansion plate, was effective in preventing a posterior crossbite in the primary dentition from being perpetuated to the mixed and permanent dentitions (Harrison & Ashby, 2000; Harrison & Ashby, 2001). There was no evidence of a difference in treatment effect (molar and canine expansion) which compared banded versus bonded and two point versus four point rapid maxillary expansion (Harrison & Ashby, 2001). Similarly, there was no difference in treatment
effect when comparing banded versus bonded slow maxillary expansion, transpalatal arch with/without buccal root torque, or upper removable expansion appliance versus quad-helix (Harrison & Ashby, 2001).

In addition to addressing the management of skeletal dysplasia, in either the sagittal or transverse dimensions, it is important to look into the management of an increased vertical dimension.

### 1.2.4 Early management of increased vertical dimensions

An open bite is defined as a lack of incisor overlap in centric occlusion. Generally it could have either a dental or skeletal etiology. Successful identification of the etiology improves the chances of treatment success. A dental open bite generally has an environmental factor, likely a thumb sucking habit or a retained infantile thrust, which can be corrected by a habit-breaking devise. On the other hand, a skeletal open bite is usually associated with a divergent growth pattern, a steep mandibular plane, a long face and a vertical maxillary excess. The underlying skeletal etiology may be related to excessive vertical growth and is more complicated to manage. In addition, a digit habit that is present for an extended period of time may redirect the development of the mandible and accentuate the vertical aspect of the growth (Moore and McDonald, 1997; Proffit, 2000). Airway obstruction has also been implicated in the development of an open bite (Ngan & Fields, 1997).

Once growth is complete, the more ideal treatment to correct skeletal open bite requires orthognathic surgery. However, if the underlying skeletal etiology is diagnosed early, growth modification may be attempted. In a recent study, Iscan et al., investigated the effectiveness of applying a vertical chincap in managing the progression of skeletal open bite (Iscan, Dincer,
Gultan, Meral, & Taner-Sarisoy, 2002). Thirty-five children, ranging from 8-11 years of age, with Angle Class I or II malocclusions and skeletal and dental open bites were evaluated. They were instructed to wear a vertical chincap, which applies 400 gram on each side from beneath the anterior part of the mandibular corpus in an upward direction, for 16 hours per day over a mean period of 9 months. Favourable skeletal growth and mandibular rotation were obtained compared to the control group. Kuster et al., utilized bite plates with either springs or repelling magnets to modify the facial muscle morphology (Kuster & Ingervall, 1992). They achieved 1.3mm improvement in overbite with the spring bite-block therapy and 3mm with the magnetic bite blocks.

Since vertical growth is the last dimension to be completed, some treatment may be prolonged, if begun early. Moreover, long-term studies are needed to determine any tendency for relapse.

Following the studies on the management of aberrant sagittal, transverse and vertical dimensions, it would be important to review the literature regarding the early management of dental anomalies.

1.2.5 Early management of congenitally missing teeth

1.2.5.1 Maxillary lateral incisors

Maxillary lateral incisors are one of the most common congenitally absent permanent teeth. Clinical managements usually involve either implant replacement, a prosthetic bridge or canine substitution. The latter is generally considered the more ideal option given its better longevity and more tooth conservation. If the congenitally missing lateral incisors were diagnosed in the
mixed dentition and the patient and parents elect future implant restorations to replace the missing teeth, every effort should be made to establish sufficient faciolingual thickness of the alveolus at the future implant sites. One option is to encourage canine eruption next to the central incisors by the extraction of the primary lateral incisors (Biggerstaff, 1992). The eruption of the permanent canines adjacent to the central incisors can develop a large faciolingual width of the alveolar ridge in the edentulous area. The canines can be subsequently distalized orthodontically to their ideal sites, leaving an ideal width of alveolar ridge for future implants (Kinzer & Kokich, 2005).

1.2.5.2 Mandibular second premolars

The mandibular second premolar is another common congenitally missing permanent tooth. Frequently, if the patient has no arch length to tooth size discrepancy, the primary second molars should be retained for as long as possible, in order to maintain the alveolar bone both vertically and buccolingually. Moreover, in order to achieve a more ideal posterior occlusion, an appropriate amount of reduction of the mesiodistal width of the primary molars may be performed, after evaluating root convergence and crown width on a periapical radiograph. Often, an occlusal composite build-up or placement of a stainless steel crown may be necessary to establish an adequate crown height and to avoid submergence of the deciduous tooth and tipping of the adjacent teeth.

Primary tooth ankylosis may occasionally occur. As the adjacent teeth and alveolar bone continue to erupt and develop, the ankylosed primary molar appears to submerge below the occlusal table. The best way to detect ankylosis is to compare the bone level on a bitewing
radiograph. One adverse effect of primary tooth ankylosis is the development of a vertical bone defect. The remaining growth potential and tooth position may determine the management of an ankylosed primary second molar (Kokich, 2005). Because a 14-year-old male may still have significant growth remaining, early extraction of the ankylosed primary molar may be indicated in order to allow the alveolar ridge to develop occlusally as the adjacent teeth continue to erupt (Ostler & Kokich, 1994). However, the management may be different for a 14-year-old female with little growth remaining.

1.2.6 Early management of ectopically erupting maxillary canines

The etiology of tooth impaction include systemic factors (endocrine deficiencies, febrile diseases, irradiation) and local factors (tooth size-arch length discrepancies, prolonged retention or early loss of the deciduous canine, abnormal position of tooth bud, presence of an alveolar cleft, ankylosis, cystic or neoplastic formation, dilaceration of roots). It seems that the presence of the lateral incisor root with the right length, formed at the right time, is an important variable needed to guide the erupting canine in a more favourable distal and incisal direction. Becker et al reported an increase of 2.4 times in the incidence of palatally impacted canines adjacent to the sites of missing lateral incisors compared with the general population (Becker, 2007).

Periodic examination of patients should start at age 8, including intra-oral palpation, clinical inspection of the contours of the bone, mobility of the tooth and the radiographic assessment of the location of the permanent canines. Early extraction of the maxillary primary canine may facilitate the eruption of the potentially impacted permanent canines, especially if the permanent maxillary canine overlaps more than half the lateral root (Ericson & Kurol, 1986).
The timing and nature of the surgical procedure of impacted teeth are determined by the degree of root development and the time of the initial diagnosis. At an early stage, a radiographic assessment of a very young child may reveal pathology, such as a supernumerary tooth or an odontoma which may prevent the normal eruption of a permanent tooth. Removal of the pathologic entity should be the priority, without disturbing the adjacent permanent tooth and their follicular cysts (Becker, 2007). At this stage, it would be inappropriate to surgically expose the crown of an immature tooth until at least one half to two-thirds of the roots has been formed. Moreover, at an early stage, the tooth should not be considered impacted and every effort should be made to encourage its natural eruption. Early exposure may risk damaging the crown and root development.

1.3 Results from published surveys on the provisions of orthodontic treatment

The timing of orthodontic treatment can be closely related to the type of care providers, including the general dental practitioners, orthodontists or pediatric dentists. The different treatment approaches by the various dental practitioners may be due to their differences in geography, experience, educational backgrounds and their perceived urgency of intervention. Survey studies are the most direct method to compare and contrast the orthodontic practice patterns of dental care providers. Five surveys have been conducted to investigate early orthodontic treatment timing.
1.3.1 Finnish Orthodontists’ views on indications for and timing of orthodontic treatment (2007)

In 2007, Pietila et al., published the results of a questionnaire that analyzed the variation in the views of Finnish orthodontists on the indications for orthodontic treatment, timing of assessment and treatment methods used. The questionnaire was sent to all 146 orthodontists and the response rate was 57%. The results indicated that Finnish orthodontists generally favoured early treatment; however, there was a wide variation in the choice of appliances and in the timing of treatment, other than crossbite and Class II malocclusions. A crossbite was the most frequent indication for treatment in the primary and early mixed dentition, and a severe Class II malocclusion as the most frequent indication in the late mixed dentition. A quad-helix, headgear and the eruption guidance appliance were the most frequently used appliances.

In Finland, dental care, including orthodontic treatment, is carried out in municipal health centres, and these services are free of charge for children under 18 years of age. At these facilities, the general dentists usually undertake the screening process and refer anyone with a treatment need to the orthodontist who makes the diagnosis and formulates the treatment plan. Orthodontists working full time in municipal health centres tended to prefer early treatment more often than those working part-time or outside health centres.

1.3.2 Orthodontic treatment timing: a survey of orthodontists (1998)

In 1998, Yang and Kiyak surveyed the orthodontists throughout the United States with the purpose of understanding orthodontists’ perspectives on the best time to initiate treatment (Yang & Kiyak, 1998). Questionnaires were distributed to 335 practicing orthodontists in the United
States and the response rate was 41%. Among the 41 conditions listed, orthodontists would most likely treat 21 conditions in the early mixed dentition, especially anterior crossbites (> 76%); 13 conditions in the late mixed dentition, especially deepbites (> 60%) and mandibular inadequacy (> 59%). Orthodontists would treat 2 conditions (maxillary midline diastema and congenitally missing teeth) in later stages. One third would postpone treating mandibular prognathism until adulthood. Patient variables that precluded treatment were behavior (98%) and compliance problems.

1.3.3 Orthodontic treatment provided by pediatric dentists (2003)

In 2003, Hilgers et al., conducted a study to document orthodontic treatment currently provided by pediatric dentists in United States (Hilgers et al., 2003). A 25-item survey was mailed to 492 diplomats of the American Board of Pediatric Dentistry and the response rate was 73%. The results indicated that most practitioners spent less than 10% of their practice time providing orthodontic treatment and reported that this would not change in the future. Practitioners who were dual trained in pediatric dentistry and orthodontics spent more time providing orthodontic treatment, although nearly half spent at least 50% of their time providing traditional pediatric dental treatment.

Most pediatric dentists provided orthodontic treatment in the primary or early mixed dentitions. The most common conditions treated were anterior crossbite, ectopic eruption, habits, posterior crossbite, and space maintenance. The most common orthodontic appliances used were fixed rapid palatal expanders and removable Hawley appliances with finger springs.
1.3.4 Orthodontic treatment provided by general dentists (1996 and 2006)

Two survey studies were published in 2006 and 1996 that examined the provision of orthodontic treatment by general dentists.

In 2006, Galbreath et al., published a study that aimed to document orthodontic treatment provided by general dentists in the United States and to ascertain the variables that influence the practitioners’ treatment pattern (Galbreath et al., 2006). A 21-item survey was mailed to 750 general dentists who have achieved master's level in the Academy of General Dentistry and the response rate was 62%. The authors found that most practitioners spent less than 10% of their practice time providing orthodontic treatment and reported that this would not change in the future. Many provided orthodontic treatment in the permanent dentition, and the most common conditions or malocclusions treated were space maintenance, anterior crossbite, rotation, habits, molar uprighting, and posterior crossbite. The most common orthodontic appliances used were removable Hawley appliances with finger springs, straight wire orthodontic therapy, rapid palatal expanders, and functional appliances.

In 1996, Wolsky et al., conducted a study to document the amount of orthodontic services provided by general dentists in the state of Michigan (Wolsky et al., 1996). A survey was mailed to the randomly selected 1020 general dentists in the state of Michigan and the response to the survey was 75%. The data indicated that 23.7% of general dentists provided no orthodontic services, whereas 57.0% provided limited orthodontic treatment and 19.3% provided comprehensive treatment. The percentage of time spent providing orthodontic services varied greatly among general dentists, with only a very few practitioners spending more than 50% of
their time. Only about 2% of the surveyed practitioners had more than 50 patients undergoing active, comprehensive orthodontic treatment.

The authors extrapolated the results from several other similar investigations and led to an estimate of the relative percentage of treatment provided by orthodontic specialists, pediatric dentists, and general practitioners in the state of Michigan. Almost two thirds of orthodontic patients are treated by orthodontic specialists, with pediatric dentists treating less than 4%. Slightly less than one third of all orthodontic patients appear to receive treatment from general practitioners.

de Mûelenaere et al., investigated the scope of orthodontics undertaken by the private practitioner in South Africa (1990). Results from a questionnaire which was completed by 1,012 dental practitioners, indicated that general practitioners were engaged in a wide range of orthodontic treatment modalities. The authors questioned the ability of the continuing education courses to educate the general practitioners to treat the spectrum of dental malocclusions.

It is important to study and document the provision of orthodontic care by the dental professionals in Canada. Although it has been reported that many general dentists are involved in orthodontic treatment, we decided to focus our study on pediatric dentists and orthodontists. For most general dentists, the majority of the structured learning on orthodontic diagnosis and treatment planning occurs during the undergraduate dental curriculum. On the other hand, certified orthodontists and pediatric dentists, in addition to the dental school program, have had 2-3 years of further didactic education on the basic science of growth and development and
clinical training. Therefore, it would be a more standardized and valid comparison if the study was limited to certified pediatric dentists and orthodontists.

In view of the presented literature and controversy on treatment timing and the scope of treatment provided by dental professionals, the existing practice patterns and treatment timing of the orthodontists in Canada remains unknown to the readers. Moreover, no studies have been published regarding the types of orthodontic treatments provided by the dental professionals in Canada. It is important to explore these issues by conducting a nation-wide survey study on the provision of orthodontic care, particularly as the University of Manitoba is at the threshold of starting a pediatric dentistry specialty program in 2010/2011 and the information will assist in curricular development, didactically and clinically.

1.4 Purpose of the study

Optimum treatment timing for orthodontic problems continues to be one of the most controversial topics in orthodontics. Recent randomized clinical trials were designed to determine the efficacy and effectiveness of interceptive orthodontic treatments. Given the debates among orthodontists and the mixed findings of clinical studies, the purpose of the current study was to understand pediatric dentist practitioners’ practice patterns regarding early orthodontic treatment. While there were some recent surveys that investigated orthodontic services provided by the general dentists, our study focuses on the timing and type of orthodontic care provided by pediatric dentists and orthodontists in Canada for 7 specific types of developing skeletal dysplasia and 25 specific types of dental malocclusion. This project also examines the maturity indicators considered by the dental professionals when determining the optimal timing
to initiate growth modification treatment.

No similar study has been published in either Canada or United States. The data collected from this survey will serve as valuable information as pediatric dentists and orthodontists collaborate to provide their young patients with comprehensive treatment to correct malocclusions. Moreover, the results of this survey may provide a glimpse of the practice patterns in our professions and further improve the education curriculum of the two specialties.
2.0 OBJECTIVES AND HYPOTHESES

Objective #1:
To determine the timing when pediatric dentists and orthodontists in Canada most regularly provide the first consultation and initiate treatment for their patients.

Hypothesis #1: There is no significant difference in the timing when orthodontists and pediatric dentists most regularly provide the first consultation and initiate treatment for their patients.

Hypothesis #2: There is a significant difference in the timing when orthodontists and pediatric dentists most regularly provide the first consultation and initiate treatment for their patients.

Objective #2:
To determine the types of interceptive orthodontic treatment provided by orthodontists and pediatric dentists in Canada.

Hypothesis #1: Orthodontists provide more extensive orthodontic services, including growth modification and with a greater armamentarium of appliances.

Hypothesis #2: There is no difference in the types of orthodontic services provided by orthodontists and pediatric dentists in Canada.

Objective #3:
To determine the maturity indicators considered by the orthodontists and pediatric dentists in Canada in determining the optimal timing to initiate growth modification treatment.

Hypothesis #1: Orthodontists and pediatric dentists consider similar maturity indicators in determining the optimal timing to initiate growth modification treatment.

Hypothesis #2: Orthodontists and pediatric dentists consider different maturity indicators in determining the optimal timing to initiate growth modification treatment.
Objective #4:
To determine the timing of interceptive treatment provided by orthodontists in Canada for the 7 specific types of developing skeletal dysplasia.

*Hypothesis #1:* There is a consistent philosophy among the orthodontists in Canada regarding treatment of the 7 specific types developing skeletal dysplasia.

*Hypothesis #2:* There is not a consistent philosophy among the orthodontists in Canada regarding treatment of the 7 specific types developing skeletal dysplasia.

Objective #5:
To determine the timing of interceptive treatment provided by orthodontists in Canada for the 25 specific types of dental malocclusion.

*Hypothesis #1:* There is a consistent philosophy among the orthodontists in Canada regarding treatment of the 25 specific types dental malocclusion.

*Hypothesis #2:* There is not a consistent philosophy among the orthodontists in Canada regarding treatment of the 25 specific types dental malocclusion.
3.0 METHODS & MATERIALS

To address the issues of timing and provision of interceptive orthodontic treatment, we designed a survey study to examine the orthodontic practice patterns of dental practitioners in Canada. The survey study included development of a questionnaire with a list of the common malocclusions obtained from textbooks and literature.

3.1 Questionnaire

The questionnaire was developed with input from faculty members and residents in the Department of Preventive Dental Science at the University of Manitoba Dental School and practising orthodontists in Winnipeg. The purpose of the final version of the questionnaire survey was to identify the Canadian practitioners' current trends of orthodontic practice and the time when interceptive treatment is initiated for common cases of skeletal dysplasia and dental anomalies.

The dental practitioners that were chosen to participate in this study were certified specialist orthodontists and pediatric dentists in Canada. Orthodontists are assumed to provide interceptive treatment for a large number of patients. It is also important to examine the pediatric dentist group because they are the "front line" providers of oral health care to children. In addition to maintaining oral health, they are often the first ones to diagnose and treat any dental anomalies.

Ethics approval to conduct this study was obtained from the Health Research Ethics Board at the
University of Manitoba. (Protocol reference number: H2008:115). All the dental provincial regulatory bodies in Canada received a copy of the questionnaire and a letter that described the purpose of the study and our intention to conduct the survey with the orthodontists and pediatric dentists in their provinces. A sample letter and a sample questionnaire are included in Appendix.

The survey consisted of two sections that collected the demographic and practice information of the dental practitioners. Demographic information included length of time in practice, length of specialty training program completed, age, gender, and type of practice. Practice information focused on the type of orthodontic / orthopedic appliances used and the preferred treatment timing for a list of skeletal and dental anomalies. The questionnaire which was menu-stratified was designed to be anonymous, and took 30 minutes to complete.

3.2 Sample

Questionnaires were distributed to 132 practicing pediatric dentists and 140 practicing orthodontists in Canada. These numbers represent 1/3 of the registered members of the pediatric dentist association and 1/5 of the respective orthodontist association. These disparities in proportion were because of the differing numbers of practising orthodontists and pediatric dentists in Canada. The selection of the survey participants was made by picking every third name and every fifth name of the current directories of the Canadian Academy of Pediatric Dentistry and the Canadian Association of Orthodontists, respectively.

These 272 practitioners received a questionnaire with a letter describing the purpose of the study. They were asked to return the survey in the enclosed postage-paid return envelope. Each
questionnaire survey had an identification number to recognize which practitioner has returned the survey. Once returned, all identifying information was discarded. No patient-specific information were distributed or collected from the participants.

Six weeks after the questionnaire packages were mailed, reminder letters were sent. Surveys returned within 8 weeks of the reminder letter were included for statistical analysis. 115 questionnaires and an additional 39 questionnaires were completed after the reminder letter. This results in a final sample of 154 completed questionnaires. The response rates of orthodontists and pediatric dentists were 59% and 54%, respectively.

3.3 Statistical Method

Data were compiled into a Microsoft® Excel spreadsheet and verified for accuracy. The data files were then converted for use with the Statistical Package for the Social Science software (SPSS for Windows, 12.0 SPSS, Chicago, Ill) to conduct the analyses.

After consultation with a biostatistician*, two statistical methods were utilized for data analysis. Because the primary purpose of this study was to examine variations in treatment timing, the first level of statistics was descriptive statistics. Descriptive statistics were generated to describe the study sample in terms of provider and practice characteristics as well as, orthodontic conditions treated. The prevalence of each specific orthopedic appliance and bracket type was also determined, along with the preferred method of assessing the appropriate timing to correct skeletal dysplasia.

* Dr. Thomas Hassard, Professor of Biostatistics, in the Department of Community Health Sciences, University of Manitoba.
Differences in treatment timing for the various skeletal and dental dysplasias were conducted with a series of chi square test. Because multiple chi-square tests were run for each variable, the level of significance was determined to be $p < 0.01$. 
4.0 RESULTS

4.1 Demographic information of the respondents.

4.1.1 Response Rate

The number of surveys distributed and returned is detailed in Table 1. A total of 71 pediatric dentists and 83 orthodontists agreed to participate in the study and returned their surveys. Five doctors who participated in the study were dual trained in both orthodontics and pediatric dentistry. Their data were excluded in the data collection and analysis.

The response rates of orthodontists and pediatric dentists were 59% and 54%, respectively. There is no statistical difference in the response rates of orthodontists and pediatric dentists (p < 0.05).

Table 1: Response rate of questionnaire

<table>
<thead>
<tr>
<th></th>
<th>Total surveys distributed</th>
<th>Surveys returned</th>
<th>Additional surveys returned after reminder</th>
<th>Total surveys returned</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pediatric dentist</td>
<td>132</td>
<td>54 (41%)</td>
<td>17 (13%)</td>
<td>71 (54%)</td>
</tr>
<tr>
<td>Orthodontist</td>
<td>140</td>
<td>61 (44%)</td>
<td>22 (16%)</td>
<td>83 (59%)</td>
</tr>
</tbody>
</table>

Figure 1 illustrates the response rates of orthodontists and pediatric dentists in Canada. The response rates for both orthodontists and pediatric dentists were highest (93.3% and 80%, respectively) in the prairie provinces (Saskatchewan and Manitoba), and lowest (33.3% and 25%, respectively) in Quebec.
Fig 1. Response rates of orthodontists (solid fill) and pediatric dentists (gradient fill), as illustrated by province. The prairie provinces include Saskatchewan and Manitoba. The maritime provinces include New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador.

4.1.2 Gender, age and the year of training of the respondents.

The 83 Canadian orthodontists who completed this questionnaire included 17 females (20% of respondents), practitioners with a wide age range, and represented 10 provinces and the Northwest Territory. The 71 Canadian pediatric dentists who completed this questionnaire included 22 females (31% of respondents), practitioners with a wide age range, and represented 8 provinces. There was no significant difference in age between orthodontists and pediatric dentists (P <0.05). Collectively, the respondents were representative of the Canadian orthodontists and pediatric dentists.
4.1.3 Length of Specialty Training

53.1% of the orthodontists who participated in the study completed a 3-year residency training, 42.0% received a 2-year training, and the remaining completed a residency program between 2-3 years. On the other hand, the majority of the responding pediatric dentists (70.8%) completed a 2-year residency program and 27.7% of the respondents received a 3-year training.

Figure 3. Length of residency training reported by the orthodontists and pediatric dentists who participated in the study.
4.1.4 Location and Type of Practice

Over 90% of the Canadian orthodontists and over 70% of the Canadian pediatric dentists maintain a private practice. The remaining respondents are in academia or work in hospitals. 70% of the responding orthodontists started over 100 orthodontic cases in 2007. Close to half of the responding pediatric dentists excluded any orthodontic treatment and started zero orthodontic cases in 2007.

4.2. Types of Orthodontic and Orthopedic Appliances Utilized by Orthodontists and Pediatric Dentists.

Orthodontists and pediatric dentists were asked to indicate the type of orthodontic services they regularly offer and their responses are illustrated in Figure 4. 81% of orthodontists and 55% of pediatric dentists use removable appliances. More pediatric dentists (85%) than orthodontists (62%) regularly prescribed a space maintainer. While full arch fixed appliances are regularly utilized by all the responding orthodontists, 17% of pediatric dentists regularly used full-arch fixed appliances. 77% of orthodontists regularly incorporate partial arch appliances in their treatment mechanics; whilst 17% of pediatric dentists utilize partial arch appliances.
Figure 4. Type of treatment modality utilized by orthodontists (solid fill) and pediatric dentists (gradient fill). The respondents were asked to choose all the options that apply.

Figure 5 illustrates the type of orthopedic appliances regularly used by orthodontists and pediatric dentists. 91% of orthodontists and 40% of pediatric dentists use a maxillary expander. For skeletal Class III growth modification, there are significantly more orthodontists who provide protraction facemask than chin-cups ($p < 0.05$). To correct a skeletal Class II malocclusion via growth modification, headgear and functional appliances are similarly popular among orthodontists. Less than 20% of pediatric dentists regularly use orthopedic appliances to correct Class II or Class III malocclusions.
Figure 5. Type of orthopedic appliances regularly utilized by orthodontists (solid fill) and pediatric dentists (gradient fill). The respondents were asked to choose all the options that apply.

Figure 6 illustrates the type of treatment and diagnostic modality utilized by orthodontists and pediatric dentists. Invisalign was integrated in the treatment by 75% of orthodontists; temporary anchorage devices (TADs) were used by 47% of orthodontists. 10% and 11% of orthodontists regularly used iBraces and Cone-beam CT scans, respectively. Significantly less pediatric dentists (less than 2%) utilized the above mentioned orthodontic devices (p < .01).
4.3. Types of Orthodontic brackets utilized by Orthodontists and Pediatric Dentists.

Figure 7 provides an overview of the type of orthodontic brackets used by orthodontists in Canada. The respondents were allowed to choose multiple bracket types, when applicable. 58% of orthodontists used twin brackets with elastic ligatures, while 73% of orthodontists used self-ligating brackets in addition to twin brackets. Among the self-ligating brackets, the most used bracket system was Damon™ (by 32% of orthodontists), followed by Smart-clip™ (17%), In-Ovation™ (16%) and Speed™ (10%). Twin brackets were used by the majority of pediatric dentists who utilized fixed orthodontic appliances. Damon™ was used by a small percentage of pediatric dentists.
4.4. Growth indicators to initiate growth modification

Doctors were asked the following question: How do you determine an appropriate time to initiate growth modification, when needed? For orthodontists, the most used growth indicator is the pubertal indicators, followed by the cervical vertebrae maturational stage (CVMS), chronologic age and then dental age. On the other hand, the dental age was used to determine the appropriate timing for growth modification by 52% of pediatric dentists, followed by pubertal indicators.
Figure 8. Frequency of growth indicators used by orthodontists and pediatric dentists to determine the appropriate timing to initiate growth modification.

4.5 Current Patterns of Treatment Timing for Skeletal Dysplasia.

For the following questions, the respondents were asked to determine their favoured timing to initiate treatment, assuming that the skeletal anomalies were noted, either clinically or radiographically, during the early mixed dentition.

Figures 9 to 15 illustrate the favoured treatment timing for the specified seven types of skeletal dysplasia. Skeletal Class II malocclusions were divided into moderate and severe mandibular retrognathia, based on the ANB measurement. While no statistical significance could be found in the treatment timing of severe mandibular retrognathia (ANB > 5°), significantly more orthodontists (51% of orthodontists) would intervene a moderate mandibular retrognathia (ANB < 5°) in the late mixed dentition (p < 0.001).

Skeletal Class III malocclusions were divided into four subgroups: (1) moderate mandibular
prognathia without a family history, (2) severe mandibular prognathia without a family history mandibular prognathia with a family history, and (4) maxillary deficiency. Significantly more orthodontists ($p < 0.001$) would intervene in the early mixed dentition for two subgroups: moderate mandibular prognathia ($ANB < -5^\circ$) without a family history and maxillary deficiency of $ANB < -5^\circ$. On the other hand, significantly more orthodontists ($p < 0.001$) would intervene in the permanent dentition for the remaining two subgroups: severe mandibular prognathia without a family history ($ANB > -5^\circ$) and mandibular prognathia with a family history.

The last type of skeletal dysplasia in the study was skeletal open bite $>5$mm. Significantly more orthodontists ($p < 0.001$) would intervene in the permanent dentition for this condition.

It was consistently shown that approximately 40% of pediatric dentists do not provide any orthodontic treatment.

Figure 9. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with moderate mandibular retrognathia ($ANB < -5^\circ$) at the various dental stages of development.
Figure 10. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with severe mandibular retrognathia (ANB > 5°) at the various dental stages of development.

Figure 11. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with moderate mandibular prognathia (ANB > -5°) without a family history at the various dental stages of development.
Figure 12. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with severe mandibular prognathia (ANB < -5°) without a family history at the various dental stages of development.

Figure 13. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with mandibular prognathia with a family history at the various dental stages of development.
Figure 14. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with maxillary deficiency (ANB < -5°) at the various dental stages of development.

Figure 15. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with skeletal open bite >5mm at the various dental stages of development.
4.6 Current Patterns of Treatment Timing for Dental Malocclusion.

For the following questions, the respondents were asked to determine their favoured timing to initiate treatment, assuming that the dental malocclusions were noted, either clinically or radiographically, during the *early mixed dentition* (or primary dentition, when applicable).

Figures 16 to 40 illustrate the favoured treatment timing for the specified twenty-five types of dental anomalies. Canadian Orthodontists' preferred treatment timing is the early mixed dentition for the dental manifestations of either a digit habit (77% of orthodontists; p < 0.001) or tongue habit (70%; p < 0.001). Significantly more orthodontists (43%) also preferred to correct a dental openbite without an apparent habit in the early mixed dentition (i.e., as soon as the dental malocclusion was diagnosed) (p < 0.05). For these three types of malocclusion, more than 1/3 of the pediatric dentists would not provide any treatment. For those who would, more of them would also intervene in the early mixed dentition.

The amount of crowding was also a factor in determining treatment timing. Orthodontists' favoured treatment time for crowding <6mm was the permanent dentition (p < 0.05). For crowding >6mm, a similar number of orthodontists would intervene in the four stages of dental development and no statistical significance could be determined in treatment timing. A different pattern emerged for the pediatric dentists. Forty percent of the responding pediatric dentists would not provide any treatment. For those who would, their preferred timing would be earlier than the orthodontists in the early or mid-mixed dentitions.

Significantly more orthodontists (p <.001) would correct an anterior overjet (OJ) of 3-6mm in
the late mixed dentition (49%), while no statistical significance could be found in the treatment timing of an anterior OJ >6mm. This result was consistent with the earlier finding that more orthodontists would correct a moderate mandibular retrognathia in the late mixed dentition, but no consensus was found in timing of a severe mandibular retrognathia. The pediatric dentists’ practise pattern of increased overjet was similar to that of crowding. Forty percent of them would not provide any treatment. For those who would, their preferred timing would be earlier than the orthodontists in the early or mid-mixed dentitions.

Anterior crossbite was categorized into six subgroups: single tooth in crossbite with or without a CR-CO shift; multiple teeth in crossbite with or without a CR-CO shift; anterior crossbite with associated periodontal defects and primary teeth in crossbite. The orthodontists’ favoured treatment timing was the early mixed dentition for all types of anterior crossbite. On the other hand, forty percent of the responding pediatric dentists would not provide any treatment. For those who would, their preferred timing was similar to that of the orthodontists in the early mixed dentitions.

Posterior crossbite was also categorized into four subgroups: primary teeth in crossbite, bilateral posterior crossbite and unilateral posterior crossbite with or without a CR-CO shift. No significant difference in treatment timing could be determined for a unilateral posterior crossbite without a CR-CO shift. For the other three types of posterior crossbite, the favoured treatment was is early mixed dentition. Forty percent of the responding pediatric dentists would not provide any treatment. For those who would, their preferred timing was also similar to that of the orthodontists.
The favoured treatment timing is the permanent dentition for a maxillary midline diastema >2mm (51%) and missing permanent teeth (43%). Significantly more orthodontists (p < .001) would correct an ectopic eruption of incisors, canines and molars in the early mixed (72%), mid-mixed (43%) and early mixed dentition (62%), respectively. In other words, since the time of intervention coincided with their time of development, the orthodontic practitioners preferred to correct any aberrant eruption and development as soon as it was noted. On the other hand, forty percent of the responding pediatric dentists would not provide any treatment. For those who would, their preferred timing was also similar to that of the orthodontists.

It was consistently shown that approximately 40% of pediatric dentists do not provide any orthodontic treatment.
Figure 16. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with dental manifestations of a digit habit at the various dental stages of development.

Figure 17. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with dental manifestations of a tongue thrust at the various dental stages of development.
Figure 18. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with a dental openbite without an apparent habit at the various dental stages of development.

Figure 19. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with 1-3mm crowding at the various dental stages of development.
Figure 20. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with 3-6mm crowding at the various dental stages of development.

Figure 21. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with >6mm crowding at the various dental stages of development.
Figure 22. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior OJ 3-6mm at the various dental stages of development.

Figure 23. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior OJ >6mm at the various dental stages of development.
Figure 24. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior OB >50% at the various dental stages of development.

Figure 25. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior crossbite (single tooth in crossbite with a CR-CO shift) at the various dental stages of development.
Figure 26. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior crossbite (single tooth in crossbite without a CR-CO shift) at the various dental stages of development.

Figure 27. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior crossbite (multiple teeth in crossbite with a CR-CO shift) at the various dental stages of development.
Figure 28. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior crossbite (multiple teeth in crossbite without a CR-CO shift) at the various dental stages of development.

Figure 29. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior crossbite (periodontal defects) at the various dental stages of development.
Figure 30. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with an anterior crossbite (primary teeth in crossbite) at the various dental stages of development.

Figure 31. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with a posterior crossbite (primary teeth in crossbite) at the various dental stages of development.
Figure 32. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with a posterior crossbite (bilateral crossbite) at the various dental stages of development.

Figure 33. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with a posterior crossbite (unilateral crossbite with a CR-CO shift) at the various dental stages of development.
Figure 34. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with a posterior crossbite (unilateral crossbite *without* a CR-CO shift) at the various dental stages of development.

Figure 35. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with a maxillary midline diastema >2mm at the various dental stages of development.
Figure 36. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with incisor ectopic development & eruption at the various dental stages of development.

Figure 37. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with canine ectopic development & eruption at the various dental stages of development.
Figure 38. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with molar ectopic development & eruption at the various dental stages of development.

Figure 39. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with a periodontal defect (e.g. traumatic recession) at the various dental stages of development.
Fig. 40. Percentage of orthodontists (solid fill) and pediatric dentists (gradient fill) who prefer to treat patients with missing permanent teeth at the various dental stages of development.

Tables 2 and 3 present occlusal deviations that the majority of orthodontists would treat in the specified dentition stage. It is an attempt to present the data from Figures 9 to 40 in a different format and we only focused on treatment timing of the orthodontist practitioners.
Table 2. Skeletal dysplasia for which statistically significantly more orthodontists would initiate interceptive treatment at the specified dental stage

<table>
<thead>
<tr>
<th>Condition</th>
<th>Primary and early mixed dentition (P &lt; 0.05)</th>
<th>Mid-mixed dentition (P &lt; 0.05)</th>
<th>Late mixed dentition (P &lt; 0.05)</th>
<th>Permanent dentition (P &lt; 0.05)</th>
<th>No significant difference in timing can be determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moderate mandibular retrognathia (ANB &lt; 5 deg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Severe mandibular retrognathia (ANB &gt; 5 deg)</td>
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<td></td>
<td>X</td>
</tr>
<tr>
<td>Moderate mandibular prognathia ANB &lt; -5 deg (without a family history)</td>
<td>X</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Severe mandibular prognathia ANB &lt; -5 deg (without a family history)</td>
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<td></td>
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<td></td>
<td>X</td>
</tr>
<tr>
<td>Moderate/severe mandibular prognathia ANB &gt; -5 deg (with a family history)</td>
<td></td>
<td></td>
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<td>X</td>
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<tr>
<td>Maxillary deficiency ANB &lt; -5 deg (i.e., malar deficiency)</td>
<td></td>
<td>X</td>
<td></td>
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<td></td>
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<tr>
<td>Skeletal open bite &gt; 5mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>
Table 3. Dental abnormalities for which statistically significantly more orthodontists would initiate interceptive treatment at the specified dental stage

<table>
<thead>
<tr>
<th>Dental manifestations of a digit habit</th>
<th>Primary and early mixed dentition (P &lt; 0.05).</th>
<th>Mid-mixed dentition (P &lt; 0.05).</th>
<th>Late mixed dentition (P &lt; 0.05).</th>
<th>Permanent dentition (P &lt; 0.05).</th>
<th>No significant difference in timing can be determined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental manifestations of a retained infantile tongue thrust</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dental open bite without an apparent habit</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-3mm crowding</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3-6mm crowding</td>
<td>X</td>
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<td></td>
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<tr>
<td>&gt;6mm crowding</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Anterior OJ between 3-6mm</td>
<td>X</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Anterior OJ &gt;6mm</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior OB &gt;50%</td>
<td></td>
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<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Anterior crossbite: Single tooth in crossbite with a CR-CO shift</td>
<td>X</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>Anterior crossbite: Multiple teeth in crossbite with a CR-CO shift</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior crossbite: Multiple teeth in crossbite without a CR-CO shift</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior crossbite: Periodontal defects noted on the tooth/teeth in crossbite</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anterior crossbite: Primary tooth/teeth in crossbite</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Condition</td>
<td>X</td>
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<tr>
<td>Posterior crossbite: Bilateral crossbite</td>
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<tr>
<td>Posterior crossbite: Unilateral crossbite</td>
<td>X</td>
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<td></td>
<td></td>
<td></td>
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<tr>
<td>Posterior crossbite: Unilateral crossbite</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior crossbite: Unilateral crossbite</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Maxillary midline diastema &gt;2mm</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
<td></td>
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<tr>
<td>Incisor ectopic development and eruption</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Canine ectopic development and eruption</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Molar ectopic development and eruption</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Periodontal defects (e.g. traumatic recession)</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Missing permanent teeth</td>
<td></td>
<td></td>
<td>X</td>
<td></td>
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</tr>
</tbody>
</table>
5.0 DISCUSSION

There has been much debate in the literature concerning the ideal time to initiate orthodontic treatment. The findings of clinical studies suggest that early orthodontic treatment may be appropriate for some types of malocclusion, but it could also create potential hazards, such as reduced patient motivation, increased treatment time and cost and lack of data regarding long-term benefits. Nevertheless, the experiences of many practitioners who have published their opinion suggest that there are advantages to the early orthodontic treatment (Carlson, 2002; English 2002; McNamara, 2002; Pietila et al., 2007).

Our survey results revealed that most Canadian pediatric dentists do not provide comprehensive orthodontic treatment, or extensive early orthopedic growth modification. Orthodontists generally initiate orthodontic treatments later in the mixed dentition than pediatric dentists. Moreover, orthodontists provide more extensive orthodontic services, including growth modification and with a greater armamentarium of appliances. Among the thirty types of malocclusion that we tested in our survey, the response from Canadian orthodontists indicated general consensus regarding the preferred treatment timing for twenty-five types of malocclusion. No statistical significance could be determined in the treatment timing of the five types of malocclusion.

This is the first study that has closely examined the types of orthodontic appliances utilized by orthodontists and pediatric dentists in Canada. The results of this survey may have immense educational value as we document the current practice patterns and the degree of collaboration.
between the two specialty groups in providing comprehensive treatment to their young patients. The results will also be an indicator on how the educational curriculum can be further improved. Future studies could explore the possible variables affecting the types and timing of interceptive orthodontic treatment provided by Canadian pediatric dentists and orthodontists.

5.1 Favourable Response Rates Indicate an Interest in the Research Topic

This study’s response rates for both orthodontists and pediatric dentists were comparable with the response rates of other surveys (Yang 1998; Cummings et al., 2001; Hilgers, 2003; Galbreath, 2006). This suggests an interest in the dental community regarding the topics of treatment timing and the types of orthodontic treatment provided by pediatric dentists. Another reason for the favourable response rate could be attributed to the introduction letter that we sent to the provincial dental associations prior to starting our survey study in the respective provinces. If any practitioners who received the survey had concerns about the legitimacy of this survey and decided to contact their provincial dental regulatory bodies, these practitioners could be assured that their regulatory authorities were aware of the research project.

The reproducibility of pediatric dentists’ responses could be confirmed within the survey. The practitioners were questioned about their preferred stage of dental development to initiate orthodontic treatment at two separate parts of the survey. The first part was a direct question to determine the dental stage that the practitioners would most regularly initiate orthodontic/orthopedic treatment. The second part was a series of questions on treatment timing for different types of malocclusion. Approximately 40% of pediatric dentists consistently responded that they provided no orthodontic treatment. The possible reasons for this observation
will be discussed in section 5.3.

Since most of the orthodontic specialists who received the survey in Manitoba either graduated from our training program or are currently holding a teaching position at the university, they may be more supportive of the research conducted at the University of Manitoba. This may explain the near perfect response rate in Manitoba. On the other hand, the lowest response rate in Quebec may possibly be due to the language factor since this study was conducted only in English.

5.2 Occlusal and Oral Health Status of Young Children

Popovich and Thompson (1966) had suggested earlier that it may be possible to screen the child population for developing malocclusions and to apply interceptive orthodontic treatment where appropriate. Interceptive treatment describes those procedures which reduce the severity of a developing malocclusion or eliminate it all together (Popovich and Thompson, 1966). These procedures may include growth modification, control of deleterious habits, disking of deciduous teeth to allow eruption of permanent teeth, space regaining and correction of crossbites, etc. These treatment procedures fall into the category of primary health care and are often carried out by general dental practitioners or pediatric dentists (Coetzee and Wiltshire, 2000).

As we discuss the efficacy of interceptive orthodontics, it is equally important to review studies that have examined and measured the degree of malocclusion in the different communities. Karaiskos et al., used a modified index for preventive and interceptive orthodontic needs to determine the need for interceptive orthodontic treatment in an inner-city group of 395 Canadian children aged 6- and 9-year-old (2005). The common abnormalities include increased
overjet >5.0mm (11.2% for 6 year olds, 17.5% for 9 year olds), early loss of primary teeth (12% for 6 year olds, 29.4% for 9 year olds), anterior crossbite (10.5% for 6 year olds, 12% for 9 year olds), posterior crossbite (3% for 6 year olds, 8% for 9 year olds) and open bites (10% for 6 year olds, 6.7% for 9 year olds).

The studies undertaken by de Mûlenaere & Wiltshire (1995) and Coetzee & Wiltshire (2000) examined the occlusal status of a group of South African black children aged 3-8 years and 8-9 years, respectively. Their results showed that anterior crossbite, increased overjet, posterior crossbite and anterior open bite were the most important abnormalities found in the latter age group of African black children. Moreover, the majority of subjects (66.5%) presented with Class I malocclusions and there was a greater tendency toward Class III malocclusion. In the younger age group (3-8 years), 53.3% of children presented with some form of malocclusion. The common findings included space loss in the primary or mixed dentition, anterior and posterior crossbite, a deep anterior overbite and tongue thrust. Both studies made it clear that there is an urgent need for early orthodontic treatment among the black community in South Africa.

Two studies in Finland (Järvinen, 1981; Heikinheimo and Salmi, 1987) examined the prevalence of malocclusion and the need for interceptive orthodontic treatment in two groups of children aged 3-5 years and 5 years, respectively. These studies found that 25.8% and 20.4% of children were in need of some type of interceptive orthodontic treatment. One study conducted in the United States indicated that 15% of potential patients were judged to be good candidates for interceptive orthodontics (Ackerman and Proffit, 1980).
5.3 Canadian Pediatric Dentists are Providing Limited Orthodontic Treatment

Our results indicate that approximately 40% of the Canadian pediatric dentists were not providing any orthodontic or orthopedic treatment. A comparable study by Hilgers et al. (2003) was conducted by 492 diplomates of the American Board of Pediatric Dentistry and the results were similar. Less than half of the respondents spent more than 50% of their time providing traditional pediatric dental treatment (Hilgers et al., 2003).

Although our study did not survey the Canadian general dentists, it might be of interest to review the literature that documented the amount of orthodontic services provided by general dentists. Wolsky et al., (1996) surveyed the randomly selected 1020 general dentists in the state of Michigan and the data indicated that 23.7% of general dentists provided no orthodontic services, whereas 57.0% provided limited orthodontic treatment and 19.3% provided comprehensive treatment. The percentage of time spent providing orthodontic services varied greatly among general dentists, with only a very few practitioners spending more than 50% of their time. Only about 2% of the surveyed practitioners had more than 50 patients undergoing active, comprehensive orthodontic treatment. The authors extrapolated the results from several other similar investigations and led to an estimate of the relative percentage of treatment provided by orthodontic specialists, pediatric dentists, and general practitioners in the state of Michigan. Almost two thirds of orthodontic patients are treated by orthodontic specialists, with pediatric dentists treating less than 4%. Slightly less than one third of all orthodontic patients appear to receive treatment from general practitioners.

Our finding that 40% of the Canadian pediatric dentists were not providing any orthodontic or
orthopedic treatment may not be surprising given the shortage of pediatric dentists in North America. The American Academy of Pediatric Dentistry noted that there has been a growing shortage of pediatric dentists in North America since the late 1980s (Davis, 2000; Roberts, 2005). The number of trained pediatric dentists in private practice, public and educational institutions had continued to decline from approximately 3,900 in 1990 to 3,600 in 1998. Moreover, thirty percent were currently seeking associates and an additional thirty percent planned to do so within the next five years (Roberts, 2005). The planned retirement dates of these practitioners were the next 10-15 years (Roberts, 2005). Recognizing the acute national shortage of pediatric dentists in the United States, the US Congress in 2007 approved a $5 million dollar budget for pediatric dentistry training.

Given the existence of only two pediatric dentistry specialty training programs in Canada at the time the study was conducted, the number of current pediatric practitioners may not be adequate to meet the needs and demands of the Canadian pediatric population. There has been no published report on the adequacy of the number of pediatric dentist practitioners in Canada. However, given the fact that the number of Canadian pediatric dentists is about 1/10 of the American pediatric dentist practitioners, it is possible that Canadian dental community is facing a similar shortage of pediatric dentists as in the United States.

If this perceived assessment in Canada is accurate and the trend continues, children may face more challenges trying to obtain specialist pediatric dental care in the near future. Moreover, due to the high prevalence of childhood caries, especially in the First Nation populations, it is perceivable that most Canadian pediatric dentists have become too busy managing childhood
caries to provide interceptive orthodontic treatment. Dr. Johnston commented that “the need for pediatric dentists and residents with hospital experience is great in this country. Some provinces have so few hospital-trained dentists that the ratio of patients to dentist is staggering. (2003)” These pediatric practitioners dedicate their limited resources to public education, behaviour modification and dental restorations of their young patients. In short, the acute shortage of pediatric dentists in Canada and the increased demand for restorative procedures could impact the nature and amount of orthodontic treatment they provide.

Moreover, given the great variety of educational backgrounds of pediatric dentists in Canada, the pediatric practitioners’ practice philosophy regarding interceptive treatment may vary. Their choice of treatment methods may reflect their educational tradition and professional preferences. For example, the American Academy of Pediatric Dentistry promotes early orthodontic care. Their informational brochure indicates that while “pediatric dentists can actively intervene to guide the teeth as they emerge in the mouth, orthodontic treatment early can prevent more extensive treatment later” (AAPD, 2002). The authors, however, did not specify their timing of “early orthodontic treatment.”

Moreover, some important doctrines of clinical orthodontics have been in full swing in the past century. For example, tooth extraction is one controversial issue facing orthodontists, who have debated its merits and problems for decades. During the era when premolar extraction was the modus operandus for orthodontic treatment, this treatment philosophy may have perplexed our pediatric dental colleagues, who were disciplined to maintain arch space after the premature loss of any deciduous molars only to witness universal four premolar extractions later during
orthodontic treatment. In the past decade, the orthodontic literature has been going through another philosophical swing regarding the efficacy of interceptive orthodontic treatment. Most discussions focused on the benefits and burdens of early treatment to the patients and orthodontists. While the public has become better educated about the need for interceptive care, clinicians, on the other hand, are starting to realize that some types of malocclusion cannot be fully corrected until all teeth have erupted, or until all growth is complete as in the case of Class III treatment. It would be interesting to observe if a decade of controversy on early orthodontic treatment has also infiltrated the pediatric dentistry literature. The current consensus is that regardless of the treatment approach adopted, the clinician should always strive for achieving optimal tissue health and stability (Bishara et al., 1998).

5.4 Canadian Pediatric Dentists are Starting Orthodontic Treatment at a Younger Age than Orthodontists

For those Canadian pediatric dentists who were providing orthodontic and/or orthopaedic treatment, they tend to start treatment at a younger dental stage of development than their orthodontist colleagues. The discrepancy in treatment timing may be a reflection of the pediatric practitioners’ background education and practice philosophy. This practice pattern may also be due to the younger patient pool in an average pediatric dentist’s office than an orthodontist’s office. When a general dentist refers a patient to their pediatric dentist colleague, it is generally for the reasons of behaviour management or the extensive treatment required, and the referral usually occurs at an early age. Therefore, pediatric dentists are usually the first doctors to diagnose a dental malocclusion and engage themselves in interceptive treatment. Referrals to orthodontists generally occur at a later age during pre-adolescence or adolescence. Our survey
findings also indicated that more Canadian pediatric dentists saw their patients for the first consultation at the early-mixed dentition, whereas orthodontists at the mid- to late-mixed dentitions.

The American Association of Orthodontists recommends the first orthodontic consultation to occur at age 7, which is around the early mixed dentition stage. It is imperative that the orthodontists educate the public about the importance of early diagnosis of a developing malocclusion. It is also essential that we work with our dental colleagues to recognize the early signs of a developing malocclusion and to make the appropriate referral in a timely manner.

5.5 Canadian Orthodontists Use the Orthopedic Appliances at a Greater Frequency than Pediatric Dentists

For pediatric dentists, the most commonly used orthodontic appliances are maxillary expanders and removable Hawley appliances. No distinction was given in the survey between a slow or rapid expansion rate. These results differed from two American surveys on pediatric dentists in 1983 and 2003 (AAPD, 1983; Hilgers, 2003). The use of maxillary expanders by pediatric dentists changed from 67% (1983) to 74% (2002) to 40% (2009); archwire use decreased from 55% (1983) to 43% (2002) to 18% (2009); and headgear use decreased from 52% (1983) to 31% (2002) to 5% (2009). The decrease in headgear use (AAPD, 1983), however, might also reflect its decreased use by orthodontists.

Orthodontists use orthopedic appliances at a greater frequency. While protraction facemask has become more popular than chin-cup as a Class III growth modification appliance, both the Class
II orthopedic appliances, headgear and functional appliance, were equally popular. The practitioners' preferences of the orthopaedic appliances may reflect their understanding of the developing cranium and the potential growth modifying effects of the appliances. The reason that chin cup therapy has fallen out of favour may be the questionable effects on the sagittal and vertical dimensions. To date, there is no consensus in the literature as to whether chin cup therapy may or may not inhibit the growth of the mandible (Sakamoto et al., 1984; Wendell et al. 1985; Mitani and Fukazawa, 1986). Moreover, the backward mandibular rotation induced by chin cup therapy could be difficult to manage in long-face patients.

It is exciting to see that temporary anchorage devices (TADs) are being utilized by close to 50% of the orthodontists in Canada. Given the fairly recent innovation and development of TADs, it is encouraging to see that the Canadian orthodontists have embraced both the traditional and modern treatment modalities.

For orthodontic brackets, 58% of orthodontists use twin brackets and 73% of orthodontists use both twin and self-ligating brackets. In other words, about 15% of orthodontists incorporated both twin brackets and self-ligating brackets in their practice. A similar survey on orthodontic residents in Canada indicated that 63% of the respondents planned to use self-ligating brackets (Noble et al., 2009). Residents were asked from what company they plan to purchase brackets, Smart-Clip™ emerged as the favoured bracket, followed by In-Ovation™. When probed for the reason(s) for their preference, respondents indicated that the most important reasons were that they used the company product as a resident and liked it (28%), and quality of the brackets (22%). In our study, Damon™ brackets were the most popular self-ligating brackets among the
practising Orthodontists, followed by Smart-Clip™ and In-Ovation™. We did not explore the reasons of the practitioners’ preferences.

5.6 Orthodontists’ Treatment Timing for Skeletal and Dental Malocclusion

Since a significant portion of the pediatric dentists do not provide any orthodontic or orthopaedic treatment (the possible reasons for this observation was discussed in section 5.3), we will focus the discussion of treatment timing on orthodontists. When asked to indicate the best stage to initiate orthodontic treatment for each occlusal deviation, the favoured dentition stage varies greatly depending on the type of malocclusion. For moderate skeletal Class II problems, the late mixed dentition was found to be the ideal stage to intervene. Presumably treatment that started in the late mixed dentition could better correspond to the pubertal growth peak and make efficient use of the leeway space. Moreover, orthodontists may favour the late mixed dentition stage because growth modification treatment could be followed directly by a fixed orthodontic appliance, effectively shortening the overall treatment time. In other words, the appropriate interceptive treatment may sometimes be part of a successful comprehensive orthodontic treatment. This finding is consistent with the results of the clinical trials in which one-stage treatment at the late mixed dentition was suggested as the ideal time to correct a Class II malocclusion. It is important to note that the clinical trials did not distinguish the severity of the Class II malocclusion in their inclusion criteria. Our study wanted to determine if the severity of Class II malocclusion was a factor that could influence the practitioners’ treatment timing. Indeed, the results indicated that there was no consensus among the orthodontists regarding the preferred treatment timing for severe skeletal Class II malocclusion. A similar number of practitioners considered the early-mixed, mid-mixed, late-mixed and the permanent dentitions as
the favoured time to initiate treatment. Presumably some practitioners may wish to intervene earlier for a more severe Class II malocclusion, in an attempt to reduce the severity of the skeletal dysplasia to a range that could potentially be managed non-surgically in the future.

On the other hand, there is better consensus regarding the favoured dentition stage to correct a skeletal Class III malocclusion. Orthodontists preferred to intervene either in the early mixed dentition (for moderate mandibular prognathia without a family history or maxillary deficiency) or permanent dentition (for severe mandibular prognathia without a family history or mandibular prognathia with a family history). The objective of early timely treatment of mild/moderate Class III malocclusions is presumably to create an environment in which a more favourable dentofacial development can occur and to prevent progressive irreversible soft tissue or bony changes. Evidence also suggests that treatment of maxillary protraction and/or inhibition of mandibular growth is more successful when it is started in the primary or early mixed dentition (Mitani, 2002). However, the stability of Class III modification remains unclear. Patients should be made aware that surgery may still be needed at a later time. On the other hand, skeletal open bite was also thought to be most appropriately treated in the adult dentitions stage, presumably with a surgical approach.

Of the 22 occlusal deviations, more orthodontists would most likely treat 12 conditions in the early mixed dentition stage, 3 in the mid-mixed and late-mixed dentition stage, and 4 in the permanent dentition stage. There is no consensus for the ideal treatment timing for 3 types of dental malocclusion: >6mm crowding, anterior OJ >6mm and posterior unilateral crossbite without a CR-CO shift. The lack of consensus for the favoured treatment timing of anterior OJ
>6mm is consistent with that of severe skeletal Class II malocclusion. This finding has important clinical implications because over the two decades from 1979 to 1998, more than half (56%) of the patients evaluated by the Dentofacial Program at the University of North Carolina were judged clinically to have a skeletal Class II malocclusion, and about 1/3 (36%) had >6mm OJ (Proffit et al, 2002). At this time, it seems that unanimity of opinion of the treatment of severe Class II malocclusion is nonexistent among the practising orthodontists.

It is noteworthy that all five types of anterior crossbite described (i.e., with or without a functional shift and with or without periodontal sequelae) were the most likely of all malocclusions to be treated in the early mixed dentition stage. Practitioners believed it to be important to maintain a positive OJ during a child’s growth and development. Crowding <6mm and maxillary midline diastema >2mm are the dental conditions that practitioners tend not to intervene early in the mixed dentition.

The survey also asked at what stage various functional problems should be corrected. The majority of respondents reported that they would treat these conditions as soon as they were diagnosed in the early mixed or deciduous dentition. In particular, significantly more orthodontists would treat thumb/finger sucking early. Bilateral posterior crossbite or unilateral posterior crossbite with a functional shift also warrant early intervention. Moreover, more orthodontists would treat incisor and molar ectopic development and periodontal defects (e.g. traumatic recession) as soon as they were diagnosed.

Although the results of our study concur with these previous reports in most cases, the 83
orthodontists who responded to our survey recommended early treatment for more conditions than previously reported. For example, in a study of practitioners’ decisions regarding treatment of actual cases, Pietila et al (1992) found that the conditions most likely to be treated with Phase I orthodontics were Class II malocclusion, lateral crossbite, and crowding. In the current survey, in addition to the above mentioned dental traits, orthodontists generally preferred early intervention for thumb/finger sucking, anterior crossbite, posterior crossbite involving a functional shift, tooth eruption problems, and malocclusions resulting in periodontal defects.

Due to current evidence (Tulloch et al., 1998; O’Brien et al., 2003; Tulloch et al., 2004), specialist orthodontists with mainstream training at accredited orthodontic programs around the world and in North America, in particular, purposefully refrain from commencing treatment in the primary and even very early mixed dentition (6 years of age).

5.7 Cochrane Reviews on the Timing of Interceptive Orthodontic Treatment

Most Cochrane Reviews are based on randomized controlled trials and provide the highest level of evidence to evaluate treatment outcome. Only a few reviews have dealt with interceptive orthodontics.

5.7.1 Extraction of primary (baby) teeth for unerupted palatally displaced permanent canine teeth in children

The permanent maxillary canine sometimes does not erupt into the mouth correctly. In about 1% to 3% of the population these teeth may be impacted palatally. It has been suggested that if the deciduous canine is removed at the right time this palatal eruption might be avoided. However,
Cochrane Review indicated insufficient evidence to support the extraction of the deciduous maxillary canine to facilitate the eruption of the palatally ectopic maxillary permanent canine (Parkin et al., 2009).

Our study did not specifically investigate the treatment timing of palatally impacted maxillary canines. However, it would be useful to include this type of malocclusion in a future study and compare the results with that of the Cochrane Review.

5.7.2 Orthodontic and Orthopaedic Treatment for Anterior Open Bite in Children

Anterior open bite occurs when there is a lack of vertical overlap of the upper and lower incisors. The aetiology is multifactorial and several treatment approaches have been proposed to correct the malocclusion. The authors conducted a review to evaluate orthodontic and orthopaedic treatments to correct anterior open bite in children.

Although twenty-eight trials were potentially eligible, only three randomised controlled trials were included comparing: effects of Frankel's function regulator-4 (FR-4) with lip-seal training versus no treatment; repelling-magnet splints versus bite-blocks; and palatal crib associated with high-pull chincup versus no treatment. The authors found weak evidence that the interventions FR-4 with lip-seal training and palatal crib associated with high-pull chincup are able to correct anterior open bite (Lentini-Oliveira et al., 2008). More studies are needed to elucidate the interventions for treating anterior open bite.

Our survey results indicated that significantly more orthodontists would treat a dental open in the
early mixed dentition or as soon as it was diagnosed. Our study focused on treatment timing and we did not look into treatment modalities. The treatment recommendations from the Cochrane Review (FR-4 with lip-seal training and palatal crib) can definitely help practitioners make evidence-based make decisions regarding the treatment of an anterior open bite in children.

5.7.3 Orthodontic Treatment for Prominent Upper Front Teeth in Children

Prominent upper front teeth can present a potentially harmful type of orthodontic problem. If a child is referred at a young age, the orthodontist is faced with the dilemma of whether to treat the patient early or to wait until the child is older and provide treatment in early adolescence. The search strategy identified 185 titles and abstracts, from which the authors obtained 105 full reports for the review. Eight trials, based on data from 592 patients who presented with Class II Division 1 malocclusion, were included in the review. The authors concluded that providing early orthodontic treatment for children with prominent upper front teeth is no more effective than providing one course of orthodontic treatment when the child is in early adolescence (Harrison et al., 2007).

5.7.4 Orthodontic Treatment for Posterior Crossbites

Crossbite with functional shift is one of the few conditions requiring treatment in the primary dentition (Proffit, 2000). Delaying treatment until the late mixed or permanent dentitions has been advocated (Proffit, 2000) to allow possible spontaneous correction and to avoid multiple phases of treatment. However, such a delay may risk any undesirable adaptation of the temporomandibular joint, asymmetric mandibular growth, and dental abrasion. Crossbite should not be corrected in the presence of a sucking habit, as the crossbite will probably return after
treatment unless habit is eliminated (Noble et al., 2007). However, appliance therapy may simultaneously discourage the sucking habit and correct the crossbite (Noble et al., 2007).

The search strategy identified seven randomised and five controlled clinical trials that examined the effectiveness of early crossbite correction. The Cochrane Review indicated that removal of premature contacts of the baby teeth is effective in preventing a posterior crossbite from being perpetuated to the mixed dentition and adult teeth. When grinding alone is not effective, using an upper removable expansion plate to expand the top teeth will decrease the risk of a posterior crossbite from being perpetuated to the permanent dentition (Harrison and Ashby, 2001).

Similar to the malocclusion of anterior open bite, our survey results indicated that significantly more orthodontists would treat a posterior crossbite in the early mixed dentition or as soon as it was diagnosed. Our study focused on treatment timing and we did not look into the preferred intervention for a posterior crossbite. The treatment recommendations from the Cochrane Review (removal of premature contacts of the deciduous dentition) can definitely help practitioners make evidence-based decisions regarding the treatment of a posterior crossbite in children.

5.8 Purpose of Early Orthodontic Treatment

Our findings are consistent with the main objectives of early treatment as proposed by Ricketts (Ricketts, 2000)

1. Obtaining a skeletal change.

2. Providing the opportunity of a functional change in the environment.
3. Utilization of the individual growth expression toward the correction.

4. Elimination of detrimental habits

5. Taking advantage of the forces of occlusal development toward the correction.

Wick Alexander also believes that multiple goals can be achieved with early intervention (Alexander, 1986), including

1. Control of growth vectors.

2. Reduced propensity for injury in most Class II, Division 1 cases.


4. Increased self-esteem at a young age.

Although many orthodontic conditions may fit under the wide umbrella of necessary therapies during the early and mixed dentitions, there are clearly many exceptions to early orthodontic interventions. The varied experiences of orthodontists in this survey revealed a wide range of acceptable treatment timing. A sound practice approach is to discuss with patients and parents the advantages and disadvantages of single and two-phase orthodontics before imposing one’s own treatment bias on these patients.

While the significance of psychosocial distress, related to skeletal dysplasia, should not be underestimated, a universal application of early treatment to all types of malocclusion is also inappropriate. As a general principle, any orthodontic treatment should be provided at the time in a child’s development when it would be most effective (produce the best result) and most efficient (provide the best benefit to cost ratio). Indications for early treatment, therefore, should be selected on a case-by-case basis to maximize the benefit to the patient (Wiltshire and Tsang,
Moreover, it can sometimes be difficult to ascertain a patient’s growth status, particularly in boys. In girls, the onset of menstruation is an obvious biologic marker that the peak of the adolescent growth spurt has passed. Some girls mature quite late, and the later the maturation, the broader and slower the adolescent growth spurt. Patients with questionable growth potential become a diagnostic dilemma. The best approach to an adolescent with questionable growth potential is to discuss the severity of the problems with the patient and parents, make sure they understand that camouflage or surgery may be necessary, and then attempt growth modification.

5.9 Study Limitations

Clinicians formulate their diagnosis and treatment plans based on dental, skeletal, maturational and radiographic findings. However, because of the survey nature of this study, the questionnaire did not include the details about each clinical condition. Moreover, given the secular trend to earlier pubertal maturation, a child’s dental age may not correlate perfectly with the skeletal maturity. Therefore, the practitioners’ responses represented their “ideal world” situations. The fact that types of malocclusion influenced their timing of intervention suggests that the questionnaire fulfilled its purpose.
5.10 Evaluation of Null Hypotheses

Objective #1:
To determine the timing when pediatric dentists and orthodontists in Canada most regularly provide the first consultation and initiate treatment for their patients.

Hypothesis #1: There is no significant difference in the timing when orthodontists and pediatric dentists most regularly provide the first consultation and initiate treatment for their patients.

Hypothesis #2: There is a significant difference in the timing when orthodontists and pediatric dentists most regularly provide the first consultation and initiate treatment for their patients.

There is sufficient evidence to reject hypothesis #1 and accept hypothesis #2.
A series of chi-square statistical analysis indicate that there is a significant difference in the timing when orthodontists and pediatric dentists most regularly provide the first consultation and initiate treatment for their patients.

Objective #2:
To determine the types of interceptive orthodontic treatment provided by orthodontists and pediatric dentists in Canada.

Hypothesis #1: Orthodontists provide more extensive orthodontic services

Hypothesis #2: There is no difference in the types of orthodontic services provided by orthodontists and pediatric dentists in Canada.

There is sufficient evidence to accept hypothesis #1.
A series of chi-square statistical analysis indicated that Orthodontists provide more extensive orthodontic services, including growth modification and with a greater armamentarium of appliances.
**Objective #3:**

To determine the maturity indicators considered by the orthodontists and pediatric dentists in Canada in determining the optimal timing to initiate growth modification treatment.

*Hypothesis #1:* Orthodontists and pediatric dentists consider similar maturity indicators in determining the optimal timing to initiate growth modification treatment.

*Hypothesis #2:* Orthodontists and pediatric dentists consider different maturity indicators in determining the optimal timing to initiate growth modification treatment.

There is sufficient evidence to reject hypothesis #1 and accept hypothesis #2.

Orthodontists and pediatric dentists focused on different maturity indicators in determining the optimal timing to initiate growth modification treatment.

**Objective #4:**

To determine the timing of interceptive treatment provided by Canadian orthodontists for the 7 specified types of developing skeletal dysplasia.

*Hypothesis #1:* There is a consistent philosophy among the Canadian orthodontists regarding treatment of the 7 specified types developing skeletal dysplasia.

*Hypothesis #2:* There is not a consistent philosophy among the Canadian orthodontists regarding treatment of the 7 specified types developing skeletal dysplasia.

There is sufficient evidence to partially accept hypothesis #1

Canadian orthodontists have a consensus regarding the treatment timing for 6 of the 7 specified types developing skeletal dysplasia. No statistical significance can be found in the favoured timing of intervention for severe mandibular retrognathia (ANB > 5°).
Objective #5:

To determine the timing of interceptive treatment provided by Canadian orthodontists for the 25 specified types of dental malocclusion.

*Hypothesis #1:* There is a consistent philosophy among the Canadian orthodontists regarding treatment of the 25 specified types dental malocclusion.

*Hypothesis #2:* There is not a consistent philosophy among the Canadian orthodontists regarding treatment of the 25 specified types dental malocclusion.

There is sufficient evidence to partially accept hypothesis #1. Canadian orthodontists have a consensus regarding the treatment timing for 22 of the 25 specified types of dental malocclusion. No statistical significance can be found in the favoured timing of intervention for the following types of dental malocclusion: >6mm crowding, anterior OJ >6mm and posterior unilateral crossbite without a CR-CO shift.

5.11 Future Study

We hypothesized and confirmed that there would be more orthodontists than pediatric dentists who are providing early orthodontic treatments in Canada. This practice pattern may be due to the number differential between the two specialty practitioners. Moreover due to the existing high prevalence of caries in the permanent and primary dentitions of children in Canada, we speculate that most pediatric dentists in Canada are involved with behavior management and dental restorations of their young patients. Moreover, this practice pattern may reflect the educational backgrounds of the pediatric dentists in Canada.

For future studies, it would be of great interest to ascertain the possible variables affecting the types and complexity of malocclusions treated by pediatric dentists. Some factors may be:
i. The demographic and socioeconomic make-up of the patient population

ii. Location of the pediatric dentists’ office, urban or rural.

iii. The proximity to the nearest orthodontist.

iv. Perceived adequacy of orthodontic training

Moreover, it would also be important to explore the possible variables that affect the timing of interceptive orthodontic treatments provided by orthodontists. Some factors that are important to look into may include the following,

i. The demographic and socioeconomic make-up of the patient population

ii. The impact of clinical research and the advocacy of evidence-based dentistry on the orthodontists’ practice pattern.

iii. Is the determination of treatment timing a “management decision” or "biological treatment imperative"? (Bowman, 1998)

Lastly, it would be important to determine the extent of collaboration and referral pattern between pediatric dentists and orthodontists in Canada. Practitioners’ referral patterns can have a direct impact on dental workforce issues and access to care.
6.0 CONCLUSIONS
There are consistencies and variations between orthodontic and pediatric practitioners with regard to treatment timing. Most Canadian pediatric dentists do not provide comprehensive orthodontic treatment, or extensive early orthopedic growth modification. Orthodontists initiate orthodontic treatments later in the mixed dentition than pediatric dentists. Moreover, orthodontists provide more extensive orthodontic services, including growth modification and with a greater armamentarium of appliances. Among the thirty types of conditions listed, the response from Canadian orthodontists indicated general consensus regarding the preferred treatment timing for most (twenty-five) types of malocclusion. The results of this survey document the current practice patterns and the degree of collaboration between the two specialty groups in providing comprehensive treatments to their young patients. Future studies could ascertain the variables that could preclude or motivate treatments in order to better correlate the educational curriculum with clinical practice.


May 30, 2008

Manitoba Dental Association
103 - 698 Corydon Avenue
Winnipeg, Manitoba
R3M 0X9

Dear Dr. Pat Kmet,

At the University of Manitoba, we intend to conduct a survey to randomly selected orthodontists and pediatric dentists in your province in June 2008. The objectives of this survey are to gain an insight on current patterns of treatment and the time when interceptive treatment is initiated. To the best of our knowledge, this type of information has never been sought in more than anecdotal knowledge. Data obtained from this survey will be essential in framing graduate education program and continuing education courses.

Our study have been approved by the Health Research Ethics Board at the University of Manitoba. Attached please find a copy of the approval form.

This information is for educational purposes and all answers are anonymous. We will be more than happy to share with you the outcome of our study.

We would welcome any questions or feedback. I may be reached at Graduate Orthodontic Clinic at 204-789-3545 or umlo5@cc.umanitoba.ca.

Sincerely,

Dr. Eileen Lo
B.Sc., M.Sc, D.M.D.
Graduate Resident
Division of Orthodontics

Dr. Charles Lekic
D.D.M., M.Sc., Ph.D., F.R.C.D. (C)
Professor
Division Head of Pediatric Dentistry
CONSENT FORM

1) **Title of Research Study:** The provision of early orthodontic care by certified orthodontists and pediatric dentists in Canada

2) **Investigators:** Drs. Eileen Lo and Charles Lekic

3) **Purpose:** The purpose of this study is to identify the practitioners’ current trends of orthodontic practice for common cases of skeletal dysplasia and dental anomalies.

4) **Procedures:** This survey has been distributed to 135 practicing pediatric dentists and 135 practicing orthodontists in Canada. These practitioners are randomly selected from the current directories of provincial regulatory bodies. Participants are encouraged to complete the survey and return it in a postage-paid returning envelope or by fax. The survey can also be completed on-line. Each questionnaire survey has an identification number to identify which practitioner has returned the survey. Once returned, all identifying information will be discarded. All information gained through this study will remain confidential. No patient-specific information will be distributed or collected from the participants.

5) **Risks:** There are no foreseeable risks.

6) **Benefits:** The purpose of this research is to acquire scientific knowledge about the current patterns of practice for common cases of skeletal dysplasia and dental malocclusions. Data collected from this survey will serve as valuable information as pediatric dentists and orthodontists collaborate to provide to their young patients comprehensive treatments to correct malocclusions. Moreover, data obtained from this survey will be essential in framing graduate education program and continuing education courses.

7) **Data Collection & Storage:** All information provided will be kept confidential. Participants will return the completed survey in a sealed envelope or by fax. All research materials will be assigned a confidential number for coding purposes. Results will not be released or reported in any way that might allow for identification of individual participants. The results of this survey may be analyzed and published in scientific journals and conferences.

8) **Contact Information:** For other questions about the study, you should contact the Principal Investigator, Eileen Lo, at (204) 227-7776 or through email at umlo5@cc.umanitoba.ca.

9) **Consent Statement:** I have read the above comments and agree to participate in this survey. All my questions have been answered to my satisfaction. I understand that I am free to withdraw from the study at any time.
Section 1: Demographic information

1. What is your gender?
   - Male
   - Female

2. What is your age?
   - 25-35
   - 36-45
   - 46-55
   - 56-65
   - >65

3. Which of the following best describes your current practice (please check all that apply)?
   - Private practice
   - Academic
   - Hospital / Community Health

4. Where is your area of practice?
   - Urban
   - Rural
   - Sub-rural

5. Which specialty are you trained in?
   - Pediatric dentistry
   - Orthodontics
   - Dual trained

6. How long was your specialty graduate training?
   - 2 years
   - 3 years

7. In which province/territory are you practicing?

Section 2: Practice information

8. What was the approximate number of orthodontic cases started in 2007?
   - 0
   - 1-50
   - 50-100
   - 100-300
   - >300

   a) What was the number of cases of space maintainers provided?
      - 0
      - 1-20
      - 20-50
      - 50-80
      - >80

   b) What was the number of removable appliances provided?
      - 0
      - 1-20
      - 20-50
      - 50-80
      - >80

   c) What was the number of cases of fixed appliances provided?
      - 0
      - 1-20
      - 20-50
      - 50-80
      - >80

9. How many hours per year do you spend in orthodontic continuing education courses?
   - 0
   - <20 credit hours
   - 20-40 credit hours
   - >40 credit hours

10. How many years have you been a certified orthodontist / pediatric dentist?
    - <5
    - 5-10
    - 11-20
    - 21-30
    - >30

11. What type of orthodontic services do you regularly offer? (Check all that applies)
    - None
    - Removable appliances
    - Space maintenance
    - Full arch fixed appliances.
    - Partial arch fixed appliances (i.e. 2X4)
    - Fixed Class II correctors
    - Twin brackets with elastic ligatures
    - Self-ligating brackets (specify: Damon, In-Ovation, Smart-Clip, Speed, Visions, others__.)
    - Rapid/slow maxillary expander
    - Protraction facemask
    - Chin-cup
    - Headgear
    - Functional appliance
    - Invisalign
    - Temporary anchorage device
    - iBraces
    - CT Scan

12. When do you most regularly see a patient for the FIRST orthodontic consultation?
13. At what dental stage do you most regularly initiate orthodontic/orthopedic treatments?
- Primary dentition (<6 years)
- Early mixed dentition (6-8 years)
- Mid-mixed dentition (8-10 years)
- Late mixed dentition (10-12 years)
- Early permanent dentition (>12 years)
- None provided

14. How do you determine an appropriate time to initiate growth modification, when needed?
- Dental age
- Chronologic age
- Shoe size
- Brother/sister growth pattern
- Pubertal indicators
- Skeletal age based on hand-wrist x-ray.
- Skeletal age based on cervical vertebral maturation stage

15. Please indicate the time in which you would initiate the necessary orthodontic treatments for each of the conditions described below. Please assume that the dental anomalies were noted, either clinically or radiographically, during the early mixed dentition, unless otherwise noted.

1 = Deciduous dentition.
2 = Early mixed dentition (only permanent molars and incisors present).
3 = Mid mixed dentition (after the first premolars have erupted).
4 = Late mixed dentition (between mid-mixed dentition and permanent dentition).
5 = Permanent dentition

**Skeletal dysplasia**

a. Moderate mandibular retrognathia (ANB < 5°) 1 2 3 4 5
b. Severe mandibular retrognathia (ANB > 5°) 1 2 3 4 5
c. Moderate mandibular prognathia ANB < -5° (without a family history) 1 2 3 4 5
d. Severe mandibular prognathia ANB > -5° (without a family history) 1 2 3 4 5
e. Moderate/severe mandibular prognathia (with a family history) 1 2 3 4 5
f. Maxillary deficiency ANB < -5 (i.e. malar deficiency) 1 2 3 4 5
g. Skeletal open bite > 5mm. 1 2 3 4 5

**Dental anomalies**

a. Dental manifestations of a digit habit 1 2 3 4 5
b. Dental manifestations of a retained infantile tongue thrust 1 2 3 4 5
c. Dental open bite without an apparent habit 1 2 3 4 5
d. 1-3mm crowding 1 2 3 4 5
e. 3-6mm crowding 1 2 3 4 5
f. >6mm crowding 1 2 3 4 5
g. Anterior overjet between 3-6mm 1 2 3 4 5
h. Anterior overjet > 6mm 1 2 3 4 5
i. Anterior overbite > 50% 1 2 3 4 5
j. Anterior crossbite
   i. Single tooth in crossbite with a CR-CO shift 1 2 3 4 5
   ii. Single tooth in crossbite without a CR-CO shift 1 2 3 4 5
   iii. Multiple teeth in crossbite with a CR-CO shift 1 2 3 4 5
   iv. Multiple teeth in crossbite without a CR-CO shift 1 2 3 4 5
   v. Periodontal defects noted on the tooth/teeth in crossbite. 1 2 3 4 5
   vi. Primary tooth/teeth in crossbite. 1 2 3 4 5

k. Posterior crossbite
   i. Bilateral crossbite 1 2 3 4 5
   ii. Unilateral crossbite with a CR-CO shift 1 2 3 4 5
   iii. Unilateral crossbite without a CR-CO shift 1 2 3 4 5
   iv. Primary tooth/teeth in crossbite. 1 2 3 4 5

l. Maxillary midline diastema > 2mm. 1 2 3 4 5

m. Incisor ectopic development and eruption 1 2 3 4 5

n. Canine ectopic development and eruption 1 2 3 4 5

o. Molar ectopic development and eruption 1 2 3 4 5

p. Periodontal defects (e.g. traumatic recession) 1 2 3 4 5

q. Missing permanent teeth. 1 2 3 4 5