EVIDENCE-BASED RECOMMENDATIONS FOR THE MANAGEMENT OF PREMATURE LOSS OF DECIDUOUS MOLARS IN THE NORTH YORK DENTAL PROGRAM

An Evidence-based Report

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Evidence-based Recommendations

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in the North York Dental Program

1.0 The context for evidence-based recommendations

The North York area of the new City of Toronto is a multi-cultural area of over 540,000 people. Thirty-eight per cent (38%) of children in the North York area report they were born outside Canada. In Ontario, the children born outside Canada are 2.5 times more likely to have experienced dental decay and 2.2 times more likely to have urgent need for care. High levels of dental decay and unmet urgent needs also are common to families living in poverty who often seek care from the public health department. Dental diseases are concentrated in a minority of the population. For example, at age 13, 78% of caries is found in 25% of the North York child population.

The Toronto Public Health, North York Office (formerly North York Public Health Department) has provided dental treatment to children since 1939. Since then, clinical and community-based preventive services, such as fluorides and education, have been added.

Each year the program is allocated a fixed budget from which all program costs must be met. The program operates with core values of:

- Population health - doing the greatest good for the greatest number so as to make a measurable difference to the target population's health
- Prevention - health promotion and primary prevention strategies are favoured over treatment and rehabilitation
- Evidence-based care - scientific evidence of need and the effects of intervention will guide the provision of care; where evidence is lacking, studies may be mounted to develop that evidence
- Equity - care will be allocated directly in proportion to need with urgent and basic needs having priority
- Ethics - the program will adhere to ethical principles of autonomy, non-maleficence, beneficence, justice and collegiality and will be open it its resolution where these principles conflict

Program guidelines have been developed to assist clinicians in making decisions on the management of patient care. The guidelines and the underlying evidence-based report, also assist managers to allocate resources to achieve maximum impact and to assure the quality of patient care. These guidelines assist staff in decision-making for quality care. They also assist the managers in their decisions on allocation of resources to best fit the needs and to maximize the impact of the services provided.

2.0 The need to examine space maintenance

Based on evidence available until 1991, the Community Dental Health Services Research Unit evaluated North York Public Health Department Guidelines on the use of space maintainers. The report, the Use of Space Maintainers in the North York Public Dental Program, QA Report No. 4, was published in 1993 (Woodward & Leake 1993). The authors identified gaps in the evidence on the efficacy of the appliance and the appropriate indications for its use. The 1993 report was, therefore, prepared under the assumption that space maintainers were indeed efficacious. It evaluated each of the factors affecting the effectiveness of the appliance listed in North York Guidelines, parent; patient; clinical; dental; and technical factors. The authors concluded the 1993 report with a flow chart that integrated these factors to facilitate clinical decision making.

In 1996, a review was deemed necessary to identify additional evidence available from the literature. The purpose of the review is to examine whether and when the appliance should be used and which type of space maintainer should be used under different clinical situations.

3.0 Structure of this report

The findings of the current review are presented in this evidence-based report. The structure of this report is based on the template proposed at the RCDSO/CDHSRU Workshop (Leake et al. 1996). The template covers the following areas:

1. Target population
2. Clinical problem
3. Clinical flexibility
4. Search strategy
5. Inclusion criteria
6. Summary of evidence
7. Comparison of costs
8. Relative importance of the potential outcomes
9. Evidence-based recommendations and any minority views
10. Comments or suggestions for further research

4.0 Target Population

The recommendations made in this review apply to children with primary or mixed dentitions who receive dental care from the North York Dental Program.

5.0 Clinical Problem

The premature loss of primary teeth may reduce the arch length required for the succeeding tooth hence predisposes crowding, rotation, and impaction of the permanent teeth (Popovich &

Thompson 1988). Appropriate use of space maintainers is advocated to hold the space until the eruption of the permanent tooth. This report seeks to address the following questions:

- What are the consequences of early loss of primary teeth?
- Are space maintainers efficacious?
- Are space maintainers effective?
- What are the appropriate indications for space maintainers?
- Which type of space maintainer should be used under different clinical situations?

Most authors have discussed space maintenance in the context of premature loss of primary molars (MacGregor 1964; Olsen 1959, 1953; Kronfeld 1964; Ryan 1964). It is generally agreed that the premature loss of primary teeth in the anterior segment does not require space maintenance except for aesthetic reasons (Ryan 1964).

5.1 Prevalence of the Problem

We analyzed the Ontario Dental Index database to determine the prevalence of premature loss of primary teeth among children aged 5, 7 and 9 years of North York in 1994. Table 1 displays the number of the deciduous canines and molars, which were lost prematurely due to caries, or were so badly decayed that extraction was deemed necessary. As expected, the percentage of children with one or more teeth lost increased with age. Among 5-year-olds, 4.6% had lost one or more teeth. The corresponding percentages for the 7- and 9-year-olds were 9.0% and 10.6%, respectively. While most had just one tooth lost prematurely, the maximum number of teeth lost or to be lost, again increased with age, were 7, 8 and 10 for the groups aged 5, 7 and 9, respectively. Those aged 9 had

the highest mean count, 0.235 compared to 0.093 and 0.194 for the 5- and 7-year-olds, respectively.

5.2 Effects of Premature Loss of Primary Molars

The 1993 Report

The 1993 report referred to seven publications pertinent to the effect of premature loss of primary teeth (Bayardo 1986; Eckles & Shulman 1990; Popovich & Thompson 1988, 1974; Ronnerman & Thilander 1978; Johnsen 1980 and Seipel 1949). The authors of four of these papers, two review articles and two case studies, supported the notion that premature loss of primary teeth might result in the reduction of arch length, which in turn, might cause crowding, rotation and impaction in the permanent dentition (Bayardo 1986;

Eckles & Shulman 1990 and Popovich & Thompson 1988, 1974). Scientific evidence was available from three clinical studies (Johnsen 1980; Ronnerman & Thilander 1978 and Seipel 1949). Johnsen (1980) studied 10 children, eight of whom had bilateral and two had unilateral premature primary first molar loss. All of the 10 children had a normal occlusion and all but one had favourable space predictions. Johnsen (1980) observed space loss at the extraction sites in five of the bilateral cases. The maximum total space loss per child was 4.7mm (2.4mm for one site; 2.3mm for the other). Ronnerman & Thilander (1978) with a sample of 104 children, observed that children with early loss of primary molars showed significantly less relative space in both jaws. Seipel (1949) compared the loss in space on the extraction to the non-extraction side of 50 cases. The mean difference between the two sides was 1.9±0.3mm, with the majority of cases, approximately 70%, under 3mm (estimated from a graph in the paper).

This Review

This review identified four additional longitudinal studies on the association between premature loss of primary molars and crowding in the permanent dentition (Kronfeld 1953; Ronnerman 1977; Pedersen et al. 1978; Harvold et al. 1970). Kronfeld (1953) found that 51% of the prematurely lost first primary molars and 70% of prematurely lost second primary molars resulted in a loss of space and a consequent malposition of a permanent tooth in that quadrant. Ronnerman (1977) studied the effect of loss of primary first and second molars in 186 children study casts. He compared the relative space in each of the four quadrants between Group A and B for the four comparison pairs shown in Table 2.

For primary second molars, the upper limit for the age studied was 10 1/2 years instead of the 9 1/2 years for primary first molars. After examining a series of three study casts made in each child at the age of 9, 11 and 13 years (sample size = 186), Ronnerman found that there were significant differences in relative space between group A and group B in pair #3 and there was no difference between the groups in pair #2. In other words, children with loss of primary molars before 7 1/2 years of age developed more crowding than children with no loss, but losses after 7 1/2 years had little impact on the relative space.

Pedersen et al. (1978) conducted a longitudinal study on 723 third-grade children, 324 of whom experienced early loss of primary teeth. As shown in the Table 3, early loss of primary teeth was found to result in a statistically significant increase in frequency of malocclusion and a statistically significantly increase in treatment need.

Using materials collected at the Burlington Orthodontic Research Centre, Ontario, collected between 1952 and 1970, Harvold examined the lateral- and oblique cephalometric headfilms of 76 children taken when they were at age 6, 9, 12, 14 and 16. The subjects were divided into two groups,

one group (n = 27) consisted of subjects with premature loss of deciduous molars and the other group (n = 49) consisted of subjects without premature loss prior to age 9. Analyses of the asymmetry measures showed that:

> *"...premature loss of deciduous molars did not seem to have a constant effect on the permanent dentition. A standard F-ratio test indicated some significant differences in variances at age 6, 9, 12 and 14 but none at age 16. According to these analyses, it seems reasonable to conclude that interceptive orthodontic treatment, in order to maintain space after premature loss of deciduous molars, is not always indicated."*

5.2.1 Factors Affecting Amount of Space Loss after Premature Loss of Primary Molars

The 1993 Report

The 1993 report identified eight publications that discussed factors affecting the amount of space reduction resulting from premature loss of primary teeth (Ghafari 1986; Northway et al. 1984; Owen 1971; Popovich & Thompson 1988; Beierl & Hune 1974; Eckles & Shulman 1990; Stratford 1976 and Wright & Kennedy 1981). Popovich & Thompson (1988) provided a comprehensive list of these factors, some of which were also discussed by other authors: tooth specificity (Ghafari 1986; Northway et al. 1984 and Owen 1971); chronological age; dental age; crowding potential; malocclusion type; eruption sequence; oral musculature; habits; post-extraction interval (Beierl & Hune 1974; Eckles & Shulman 1990; Ghafari 1986; Owen 1971; Stratford 1976 and Wright & Kennedy 1981); alveolar bone and anomalies.

Of the eight references from the 1993 report, only one reported findings from a clinical study. Northway et al. (1984) studied the effects of premature loss of primary teeth in 107 children. These children were followed from the age of six for an average of 5.9 years. Among its findings, the study demonstrated that in the mandible, the most severe reduction in space, 3.7mm in excess of the control

side, was observed in association with the loss of the primary second molar. In the maxilla, loss of the primary first and/or second molar resulted in similar reduction in space, 3mm to 4mm in excess of the control side. Northway et al. (1984) also studied the impact of the age of exfoliation on the amount of arch reduction. The authors found that the amount of space loss in the maxilla was age-related. The space reduction four years after loss of primary upper molars were 4.1mm, 2.1mm and 1.5mm, for extractions at age 6, 7 and the over-7 group, respectively. In the mandible, there was no relation between age at extraction and the amount of space loss which ranged from 2.6 to 3.4mm in 4 years.

This Review

This review identified two additional longitudinal studies that examined the same issue. Kronfeld (1953) found that 51% of the 68 cases of prematurely lost primary first molars and 70% of the 52 cases of prematurely lost primary second molars would result in a loss of space and a consequent malposition of a permanent tooth in that quadrant. Ronnerman (1977) studied the dental casts of 186 children and found that children who lost their primary molars before the 7 1/2 years of age had more crowding than those without premature tooth loss. Children who lost their primary molars after the age of 7 1/2 years suffered little loss in relative space.

Conclusion

There is scientific evidence to support the claim that the amount of space reduction resulting from premature loss of primary molars is affected by the specific tooth lost and the age at which exfoliation occurs. While no scientific evidence has been identified to support the significance of other factors that were mentioned, their clinical significance is supported by experts opinion (Ghafari 1986; Owen 1971; Popovich & Thompson 1988; Beierl & Hune 1974; Eckles & Shulman 1990; Stratford 1976 and Wright & Kennedy 1981). However, the study by Harvold shows that the effects were

transient and were not noticeable by the age of 16.

6.0 Clinical Flexibility

The 1993 report and this review focus on the use of space maintainers in the premature loss of primary molars. The recommendations do not apply to premature loss of other primary teeth nor do they apply to the loss of permanent teeth.

This report does not apply to children undergoing active orthodontic care nor to children who may warrant orthodontic care for tooth loss and or other reasons.

Parents of children with premature loss of deciduous teeth may ignore the recommendations, if the children are uncooperative in accepting care or unable to maintain a low level of caries incidence since the placement of a space maintainer may increase the amount the plaque and the risk of caries.

7.0 Summary of the Evidence for Efficacy

7.1 Search Strategy

Since this was an update of the 1993 report, computerized literature searches were conducted on Medline <1991 to November 1996> using the three strategies listed below. 1991, which was covered in the literature review for the 1993 report, was included in the current search to identify relevant articles published during the year but had not been entered into the Medline database at the time the previous review was conducted.

1. Subject heading = space maintenance

   (Note: There are no such subject headings as space maintainers or space maintainer).

   Yield = 24 articles

2. Subject heading = orthodontics, preventive

Yield = 15 articles

3. (Subject headings = tooth loss OR tooth eruption OR tooth migration)

AND (Textword = premature)

Yield = 15 articles

The abstracts of the 54 articles were screened by the authors. Eleven articles were identified as potentially relevant to the research questions by at least one author. Of these, seven were retrieved from the Faculty of Dentistry Library at the University of Toronto. (Of the four articles that were not available, two were in missing issues and two in journals to which the library does not subscribe.) The reference listed in the seven articles were reviewed to gather additional relevant publications. The results of the various stages of the literature search are summarized below:

Medline search yielded:	54	
Potentially relevant based on screening of abstract:		11
Available from Faculty Library:	7	
Relevant articles from reference lists:		14
Available from Faculty Library:	11	
All relevant articles (7+11=18):	18	

In addition, we included one report of an examination of the data from the Burlington Orthodontic Research Centre conducted by Harvold et al. (1970).

7.2 Inclusion Criteria

The literature search for the 1993 report adopted three inclusion criteria, "written in English",

"review articles" and "human subjects involved". This review does not restrict the searches using these criteria as we hope to identify all potentially relevant articles.

7.3 Evidence of the effectiveness of space maintainers

To address the clinical problem of premature loss of primary molars and answer the questions listed in section 2.0, we summarize scientific evidence in the following areas:

A. Causal relationship between premature loss of primary teeth, reduction in arch length and crowding, rotation and impaction in the permanent dentition

B. Amount of space loss is determined by the following factors:

* the tooth lost
* dental age of the patient
* eruption of adjacent permanent teeth
* amount of crowding and spacing in the remaining dentition
* occlusion
* intercuspation
* eruption sequence
* duration for which the spaces are present

C. Space maintainers will prevent space loss:

under ideal conditions, i.e. efficacy

under normal conditions, i.e. effectiveness & durability

D. Factors affecting effectiveness of space maintainers:

* parent factors

* patient factors

* dental factors

E. Technical issues:

* duration of space maintenance

* effectiveness of different type of appliances under different clinical situations

7.3.1 Evidence on the Effect of Premature Loss of Primary Molars

The findings of the clinical studies relevant to the above areas are summarized in Table 4. As shown in the Table, different authors used different outcomes measures, such as change in arch length; change in relative space and prevalence of malocclusion. As well, assessment of outcomes was made at different patient ages in different studies. The outcome measure used and the age at which the assessment was made determine the clinical significance of study findings. Intermediate outcomes, e.g. space reduction and crowding which may eventually resolve without orthodontic intervention, are of less interest than final outcomes such as the prevalence of malocclusion in the permanent dentition when the patients reach their late teens.

The clinical studies from the 1993 report and this review provide evidence to support the relation between premature loss of primary molars and the transient loss of arch length and malposition of succeeding permanent teeth. There are two longitudinal studies with comparison groups on the dentitions at age 15 and 16 and they have opposite findings. Ronnerman & Thilander (1978) found significant differences in arch length (1mm) and relative space (2.3-4.0mm) between those with and without premature loss of primary molars. On the other hand, Harvold et al. (1970) found significant differences in some asymmetry measures between the extraction and non-extraction groups at ages 6,

12 and 14 but none at age 16.

Thus, while there is evidence to suggest premature loss of primary molars may lead to loss in arch length and relative space, Harvold's study showed such loss may well be transient. Where this is the case, the long-term impact of premature loss of primary molars in terms of malocclusion in the permanent dentition would be negligible. This observation should at the minimum highlight the importance of case selection for space maintenance if not cast doubt on the need for space maintenance in the first instance.

7.3.2 Efficacy of Space Maintainers

The 1993 Report

The 1993 report identified two controlled trials (Kisling & Hoffding 1979 and Artun & Marstrander 1983); one longitudinal study with controls (Seipel 1949); two longitudinal studies without controls (Hill et al. 1975 and Swaine & Wright 1976) and one case study (Thornton 1982). These studies yielded conflicting findings.

Kisling & Hoffding (1979) demonstrated the effectiveness of Sannerud's space maintainer on 88 children who had both maxillary first primary molars or both mandibular first primary molars extracted. In 55 children, a space maintainer was inserted on one extraction side. In the other 33, space maintainers were inserted on both extraction sides. For the 55 children who had a treated and a control side, the amount of space loss averaged 0.9mm and 3.3mm, respectively. For the 33 children who had a space maintainer in both sides, the average space loss for both side together was 0.7mm. Hence, the authors showed that space maintainers reduced space loss. It was also noted that during the observation period replacement of the space maintainer was required in 30 of the 55 children. It is,

however, worth noting that the natural dentition has a "leeway" space as a result of the primary premolars being longer mesio-distally than their permanent successors. Normally this space averages 1.0-1.5mm in each quadrant so any loss of space within this range should have no harm and would still qualify as a clinical success. The findings from examining the data available from the paper against this standard are shown in Table 5.

The data in the paper do not allow for paired comparison in the 55 cases where space maintainers were only inserted on one side, nor do they allow the use of 1.5mm of space loss as a cut-off. Therefore, a group comparison is presented above using 1mm and 2mm as cut-off points. Table 5 shows that a smaller proportion of the treated than the control sides experienced space loss greater than 1mm (42% versus 91%) or 2mm (11% versus 76%).

Seipel (1949) followed 72 cases in which a space maintainer had been inserted after early loss of primary molars. He found that in 18% of the cases crowding was prevented as a result of the space maintainers, i.e. there was crowding on the control side but none on the treated side. In 50% of cases, the effectiveness of space maintainers was questionable, as such malocclusion occurred in both the treated and the control side or there was no malocclusion in either side. Negative effects such as undesirable migration or blockage of normal development, were noted in 15% of cases. Thus a net of 3% (18%-15%) of patients had benefits.

Swaine & Wright (1976) studied the effectiveness of direct bonded space maintainers in 42 children who had lost at least one primary molar prematurely. After six months, 38 (70%) of the 44 appliances inserted were in position. Of these 38, 34 appliances maintained the space, i.e. no space change. The change in space was less than 0.1mm in the other four appliances.

Artun & Marstrander (1983) studied the failure rate of space maintainers. The failure rates, in

terms of dislodged appliances, for direct bonded space maintainers, fabricated with 0.032" round, plain wire and 0.32" multi-stranded wire, were 25% and 11%, respectively. Hill et al. (1975) reported the problems encountered with 95 of the 226 appliances (43%) inserted. The most common problem was lost appliances. Thornton (1982) reported on seven cases of misuse and failures of space maintainers. The problems include blockage of the eruption of permanent teeth, irritation to soft tissue and displacement of abutments. The author suggested that these problems could potentially be avoided with improvement in diagnosis, appliance design and construction and follow-up.

This Review

This review identified two additional longitudinal studies, one with controls and one without controls. Kronfeld (1953) examined the study casts of 400 children to study, among other things, the effect of the use of space maintainers on the incidence of malocclusion. Sixty-eight primary first molars and 52 primary second molars had been lost prematurely among these children. The following two-by-two tables, Tables 6 and 7, are constructed using data abstracted from the paper.

The odds ratio for the protection from space loss with the use of space maintainers for premature loss of primary first and second molars were 0.54 (95% CI 0.15-1.89) and 0.29 (95% CI 0.32-1.05), respectively. While Kronfeld claimed a protective effect of space maintainers against space loss, our calculations showed that the effect was not statistically significant.

Santos et al. (1993) studied the effectiveness of direct-bonded space maintainers. Sixty appliances were inserted into 36 children (without controls). Of the 60, five were classified as failure as the appliances were debonded. Of the 55 which remained intact, three displayed a space reduction of 0.5mm or greater. Among the remaining 52 appliances, there were no statistically significant difference in the mean space between the start and the end of the study.

Conclusion

The findings from the clinical studies cited above appear to support the protective effect of space maintainers against space loss as a result of premature loss of primary molars. However, the effectiveness of the appliance is dependent upon its ability to impact on the relevant outcome, i.e. the prevention of crowding. Seipel (1949) found that a net gain occurred in 3% of the 72 cases as a result of space maintenance and in 50% (37) of cases the effectiveness of space maintenance was questionable. From the information provided in the paper we cannot determine the proportion of the 37 cases that had malocclusion on both sides and the proportion of the cases that had malocclusion on neither side. Therefore odds ratios for the protective effect of space maintenance cannot be computed. However, these findings support our conclusion in section 2.1.2 that malocclusion does not always follow premature loss of primary molars. As well, they highlight that space maintenance is not proven to be beneficial. Careful diagnosis and treatment planning; well-designed and well-constructed appliance; and meticulous follow-up may be key success factors. These factors are discussed in detail below.

7.3.3 Effectiveness of Space Maintainers

The 1993 Report

As mentioned, the 1993 report evaluated the North York Guidelines for Use of Space Maintainers. The Guidelines derived in the report, specify that following the premature loss of primary molars, space maintenance should be performed if parent, patient and clinical factors are considered favourable, i.e.

Parent factors:

- Parents have a positive attitude towards the child's treatment.

- Parents understand the need for regular monitoring of the appliance and are willing to see that the appliance is checked as required.

Patient factors:

- Patient has good oral hygiene.
- Patient obtains maintainer within three weeks of extraction.

Clinical factors:

- Cuspal interferences are absent which might otherwise prevent movement of teeth.
- Leeway space is adequate for erupting permanent teeth.
- Wide spacing of deciduous teeth is absent.
- Succeeding permanent tooth is present and is unlikely to emerge within one year.

The 1993 report identified five publications, reviews of literature and documentation of expert opinion, that highlighted the importance of favourable parent, patient and clinical factors in achieving space maintenance (Beierl & Hune 1974; Daly & Walker 1990; Popovich & Thompson 1988; Stratford 1976; Wright & Kennedy 1981). As well, two relevant clinical studies were cited (Hill et al. 1975; Kisling & Hoffding 1979). On the importance of parent involvement, in terms of frequent checking of the appliance and regular attendance of follow-up appointments, Hill et al. (1975) conducted a four-year longitudinal study and found that there were problems with 43% of 196 appliances inserted. Among the problems were lost appliances; breakage and failure to attend follow-up appointments. Kisling & Hoffding (1979) inserted 121 space maintainers in 88 children and found that replacement of the appliances were required in 30 children. These studies highlighted the crucial role of parental involvement for space maintainers to achieve their therapeutic goals.

With regards to patient factors, the importance of good oral hygiene was pointed out by a number of authors (Beierl & Hune 1974; Stratford 1976; Popovich & Thompson 1988; Daly & Walker 1990). It was widely accepted that the insertion of an appliance might cause soft tissue irritation and damage if the child did not have good oral hygiene and the appliance had not been well-designed and well-maintained. Another patient factor the 1993 report identified was the timing of space maintenance. The greatest amount of space loss was observed in within six months of tooth loss (Beierl and Hune 1974; Stratford 1976; Wright & Kennedy 1981). The need to initiate space maintenance soon after the extraction of the primary molar was therefore widely-recognised. The three-week limit specified in the North York Guidelines appeared arbitrary as there was no mention of it in the literature.

Among clinical factors, favourable space condition, i.e. enough space for permanent teeth eruption while no wide spacing of deciduous teeth, and the absence of cuspal interferences were two criteria advocated by a number of experts (Daly & Walker 1990; Stratford 1976; Popovich & Thompson 1988). As well, it was suggested that space maintenance should be considered if and only if the succeeding tooth was present and was expected not to erupt within six months after the loss of the primary tooth (Beierl & Hune 1974; Daly & Walker 1990; Stratford 1976; Wright & Kennedy 1981). Again, North York Guidelines, which required the succeeding tooth not be erupt within the next year, were more stringent than what was suggested in the literature.

To predict when the succeeding tooth would erupt, the 1993 report cited a number of references. In 874 children, Gron (1962) determined the association with tooth formation and tooth emergence. He found that tooth emergence was more closely associated with the stage of root formation than with the chronological or skeletal age of the child. The majority of teeth studied had 75% of their root formed at the time of emergence. Other studies, on the other hand, demonstrated the

predicting ability of dental age and chronological age. Fanning (1962) selected four boys and four girls who underwent early unilateral extraction of a deciduous molar (aged 4-4.5 and 5.5-6 years for primary first molars; aged 7.5-8 and 9-9.5 years for primary second molars). No change was observed in the rate of root formation in the succeeding premolars. However, there was an immediate spurt in the eruption of the premolars, regardless of their stage of root formation.

Posen (1965) observed premolar eruption in 96 children who underwent unilateral extraction of a deciduous molar. He found that:

1. Eruption of a premolar was delayed when the deciduous molar was lost between the age four and five years.
2. After the age of five, there was a gradual decrease in the delay of premolar eruption.
3. From the age of eight on, till ten, premolar eruption was hastened by the loss of the deciduous molar.

Loevy (1989) studied 33 children with unilateral extraction of primary molars and his findings parallelled those of Posen.

Finally, some authors have found an association between the rate of emergence with the amount of alveolar bone covering the succeeding tooth (Popovich & Thompson 1988; Daly & Walker 1990). Daly & Walker (1990) in their review on space maintenance cited that it took 4-6 months for a tooth to move through 1mm of bone.

This Review

This review did not identify any additional evidence relevant to the evaluation of these factors as criteria for the provision of space maintenance.

Conclusion

While no additional evidence has been identified for this review, there seems to be ample evidence to support the importance of the parent and patient factors as considerations for considering space maintenance. Careful space analysis and prediction are crucial in the assessment of the clinical factors that determines treatment success. The requirement for space maintainers to be inserted within three-weeks of tooth loss, in cases when the succeeding permanent tooth is not likely to emerge within a year, appear more stringent than what would be supported by the literature. These stringent requirements serve to limit provision of space maintenance to cases where the therapy is likely to be effective.

7.3.4 Duration of Space Maintenance

The 1993 Report

Besides parent, patient and clinical factors, North York Guidelines also addressed the issue of durability of space maintainers. As to the length of time they are required, it made the following recommendations that the space be maintained as follows:

- When deciduous first molars are prematurely lost and the parent, patient and clinical factors are favourable, a space maintainer should be inserted and maintained until the first permanent molar emerges; and
- When a deciduous second molar is prematurely lost and the parent, patient and clinical factors are favourable, a space maintainer should be inserted and maintained until the succeeding permanent tooth begins to emerge.

As to which type of material should be used the report recommended:

- For single tooth spaces, band and loop, or crown and loop should be used.
- For multiple tooth spaces, lingual or palatal arch should be used.

The 1993 report did not identify any evidence to support the points at which space maintenance should be withdrawn specified in North York Guidelines. However, it cited Popovich & Thompson (1988) review which stated:

- Following premature loss of deciduous first molars, if both the permanent first molar and the permanent lateral incisor had erupted, space maintenance was not required.
- Following premature loss of deciduous second or both deciduous first and second molars, if both first and second permanent molars were present, space maintenance was not required.

With regards to the choice of specific type of appliance for single space, multiple maxillary space and multiple mandibular space, the recommendations of North York Guidelines were in line with opinion of many authors (Beierl & Hune 1974; Daly & Walker 1990; Ghafari 1986; Popovich & Thompson 1975; Tang & Wei 1990; Wright & Kennedy 1981). The 1993 report also identified two clinical studies on direct bonded space maintainers (Artun & Marstrander 1983; Swaine & Wright 1976). Both studies were designed to establish the failure rates of space maintainers. Swaine & Wright (1976), classifying appliances that remained intact six months after insertion as successful, found the success rate to be 77% and 65% in the maxilla and mandible, respectively. The difference in success rate between the arches was not statistically significant. Artun & Marstrander (1983) using a parallel definition for failure, found that failure rates to be the same for the two arches, 11%. The authors attributed the difference in findings between their study and that of Swaine & Wright (1976) to the improvement in appliance design.

This Review

This review identified six articles that discussed the use of different types of space maintainers. (Croll et al 1979; White 1977; Ryan 1964; MacGregor 1964; Olsen 1953, 1959). Croll et al. (1979) suggested the following indications for the use of crown and loop space maintainers:

1. Premature loss of primary first molar with caries affecting the primary second molar in the same quadrant;
2. Premature loss of a primary second molar with insufficient eruption of the permanent first molar to facilitate banding for a holding arch, or band and loop space maintainers; and
3. Very early loss of a primary first molar with many years before anticipated eruption of the first premolar.

White (1977) suggested different types of space management for different types of occlusion in the primary dentition. He presented the following protocol:

1. When the dentition was in a flush terminal plane, typically providing an end-to-end relationship of the first permanent molars:

- if either the upper or lower second primary molar was lost prior to the eruption of the first permanent molar, watchful waiting was recommended;
- when the first permanent molar had erupted, a removable appliance with either a finger spring or "split-saddle" might be used to upright this tooth if necessary. Afterward it could be modified to be a space maintainer.

2. If the dentition was a mesial step and a lower second primary molar was lost prematurely, then an immediate distal shoe space maintainer could be appropriate. The upper situation may be treated by the use of a removable appliance.

3. In the case of a distal step, active orthodontic treatment should be considered.

Conclusion

There is no scientific evidence that support or contradict North York recommendations on which type of space maintainers should be used and for how long. However, the NYPHD recommendations appear to be consistent with expert opinion.

7.4 Summary of Evidence

Based on the literature searches conducted for the 1993 report and this review, we conclude that:

1. Premature loss of primary molars may result in loss of arch length and subsequent crowding of permanent teeth. There is also evidence to support that premature loss of primary molars may lead to malpositioning of the succeeding permanent teeth. However, the prevalence of space reduction and crowding in the permanent dentition may be transient, since by the age of 16 they do not appear to be higher among those who lost primary molars prematurely than those who do not. (Bayardo 1986; Eckles & Shulman 1990; Popovich & Thompson 1988, 1974; Ronnerman & Thilander 1978; Johnsen 1980; Seipel 1949; Kronfeld 1953; Ronnerman 1977; Pedersen et al. 1978 and Harvold et al. 1970. - Quality of evidence: II-2).[1]
2. There is evidence to support that the amount of short-term space reduction resulting from premature loss of primary molars is determined partly by the specific tooth lost and the age at which exfoliation occurs. Loss of primary second molars appears to result in more short-term space reduction than loss of primary first molars. Loss of primary molars before the age of 7 1/2 years results in transient

[1] **Classification of quality of evidence and recommendation is based on the systems presented in: The Canadian Task Force on the Periodic Health Examination. (1994) The Canadian guide to clinical preventive health care. Ottawa, Canada, Health Canada.**

space loss and malposition of permanent teeth while losses after that age has little impact on the relative space (Ghafari 1986; Northway et al. 1984; Owen 1971; Popovich & Thompson 1988; Beierl & Hune 1974; Eckles & Shulman 1990; Stratford 1976; Wright & Kennedy 1981; Kronfeld 1953 and Ronnerman 1977. - Quality of evidence: II-2).

3. There is evidence to support the protective effect of space maintainers against space loss as a result of premature loss of primary molars (Kisling & Hoffding 1979 and Artun & Marstrander 1983; Seipel 1949; Hill et al. 1975; Swaine & Wright 1976; Kronfeld 1953 and Santos 1993. Quality of evidence: II-1). However, the net effectiveness (benefit - harm) of the appliance was a low as 3% in the study by Seipel (1949) - Quality of evidence: II-2) and not statistically significant in others.
4. There is evidence to support the importance of careful maintenance and follow-up of the appliance in clinical success. (Beierl & Hune 1974; Daly & Walker 1990; Popovich & Thompson 1988; Stratford 1976; Wright & Kennedy 1981; Hill et al. 1975 and Kisling & Hoffding 1979. Quality of evidence: II-3). Parents' and patients' attitude and involvement are therefore important considerations prior to performing space maintenance. There is less strong evidence to support the other factors for consideration stated in North York Guidelines. However, there is only consensus, among experts, that space maintenance is beneficial for some but not all children who have lost their primary molars prematurely. The factors suggested in North York Guidelines help to identify this group of children - Quality of evidence: III).
5. North York recommendations on which type of space maintainers should be used and for how long are consistent with expert opinions. (Beierl & Hune 1974; Daly & Walker 1990; Ghafari 1986; Popovich & Thompson 1975; Tang & Wei 1990; Wright & Kennedy 1981; Artun & Marstrander 1983; Swaine & Wright 1976; Croll et al 1979; White 1977; Ryan 1964; MacGregor 1964 and

Olsen 1953, 1959. - Quality of evidence: III).

8.0 Comparison of Costs - space maintainers versus watchful waiting

According to the ODA fee guide, the insertion of a space maintainer, including the design, separation, insertion and where applicable initial cementation and removal, corresponds to 3.0 to 10.5 RVU, depending on the appliance used. Thereafter, maintenance visits are rated as 1.0 to 1.5 RVU. Cost comparison between the provision of space maintenance and watchful waiting is beyond the scope of this report.

9.0 Relative Importance of the Potential Outcomes

Space closure, as a result of watchful waiting or ineffective space maintenance, after premature loss of primary molars, is a reversible outcome since active orthodontic treatment may be prescribed to remedy the situation. The cost of orthodontic care is high.

Space maintenance, when used inappropriately, will not only waste resources but may also cause harms, such as increased risk of caries, loss of abutment teeth and damage to soft tissue.

10.0 Evidence-based Recommendations and Any Minority Views

There is evidence to suggest that premature loss of primary molars may reduce arch length hence may cause malposition of permanent teeth and that space maintainers can be effective in preventing these consequences. However, there is also evidence to support that crowding in the permanent dentition resulting from premature loss of primary molars may be transient and resolves by

age 16. As well, it is generally agreed that space maintainers may cause certain harmful effects, including soft tissue damage, displacement of abutments and caries. Furthermore, the harmful consequences of watchful waiting, as opposed to immediate provision of space maintenance, are reversible. Permanent tooth malposition, should it occur, may be corrected by orthodontic treatment at a later age.

It is therefore recommended that space maintenance should be provided only in cases where the potential for harms is minimal (Classification of recommendation: C). The benefit/harm ratio is maximized when all the following apply:

- The tooth lost is a primary molar.
- The tooth was lost within three weeks.
- The patient is 7 1/2 years or younger.
- The succeeding tooth is present and unlikely to erupt with the next year.
- There are no interferences that will prevent tooth movement, i.e.:
  * no cuspal interferences
  * the first permanent molar and/or the permanent lateral incisor are unerupted
- The space conditions are favourable, i.e. no wide spacing nor crowding in the primary dentition.
- The patient has good oral hygiene.
- The parent(s) understand(s) the treatment, including the need for regular self-monitoring and follow-up visits.

If all of the above criteria are satisfied, space maintenance is indicated.

11.0 Comments or Suggestions for Further Research

As shown by this effort to identify scientific evidence on the use of space maintainers, there are still large gaps in the evidence. It is not clear whether space maintenance has a role to play in preventing space loss and malposition of permanent teeth following premature loss of primary molars. Furthermore, given the need for refining the patient selection process to identify those patients who would benefit most from the procedure, clinical studies should be conducted. Additional evidence so yielded would path the way for economic evaluations which are very much needed for policy and clinical decision making.

12.0 Tables

Table 1- Prevalence of Prematurely Lost Primary Canines and Molars in North York, 1994

	Age		
	5	7	9
Sample size	895	883	950
% of children with one or more teeth lost	4.6	9.0	10.6
Maximum # of teeth lost	7	8	10
Mean # of teeth lost	0.093	0.194	0.235

Source: Special run of the OMH DIS for North York

Table 2- Comparison Pairs for Primary First Molar

Pair	Group A	Group B
#1	No tooth loss	Tooth lost before 9 1/2 years
#2	No tooth loss	Tooth lost between 7 1/2 years and 9 1/2 years
#3	No tooth loss	Tooth lost before 7 1/2 years
#4	Tooth lost before 7 1/2 years	Tooth lost between 7 1/2 years and 9 1/2 years

Table 3 - Effect of Loss of Primary Teeth on Frequency of Malocclusion and Treatment Need

	Non-extraction Group		Extraction Group	
	N	%	N	%
Distal molar occlusion (bilateral)	364	34.9	355	22.8***
Distal molar occlusion (unilateral)	863	12.8	355	22.8***
Maxillary overjet	364	24.2	359	22.8
Deep bite	364	26.3	359	34.5*
Frontal open bite	364	11.5	359	8.1
Midline displacement	364	17.3	359	25.9**
Crossbite right or left	364	9.6	359	24.5**
Need of treatment	364	57.9	358	72.9***
Extraction of permanent teeth	364	11.8	359	31.8***
Major appliance therapy (over 12 months)	364	22.8	359	34.8***

Note: *** = p<0.001; ** = p<0.01.; * = p<0.05.

Table 4 - Summary of the Findings from Studies on the Premature Loss of Primary Molars

Study	Extraction group (n)	Control group (n)	Age range & observation period	Outcome measure	Effect size
Johnsen (1980)	No controls - 8 cases of bilateral premature loss of primary first molars		Initial age ranged from 5 2/12 to 10 10/12 years. Observation period ranged from 1 2/12 to 2 2/12 years.	Total space change (two sides)	4.7mm loss to (gain
Ronnerman & Thilander (1978)	n = 47	n = 57	Mean age when the final cast was taken: Cases:- 15 11/12 years Controls:- 15 8/12 years	Mean differences: U arch length:- U relative space:- L arch length:- L relative space:-	 -1.0mm -4.0mm -1.1mm -2.3mm
Seipel (1949)	Non-extraction sides as controls - 50 unilateral early loss of deciduous molars		Information not available	Space difference between extraction and control sides 10 years after extraction	Mean: -1.9±0.3 Range: -7mm (loss) to (gain)
Kronfeld (1949)	No controls - 50 with loss of deciduous first molars; 29 with loss of deciduous second molars		All cases followed from before 4-years- old for 14 years	% of cases with space loss and consequent malposition of a permanent tooth in that quadrant	Deciduous first 48% Deciduous seco molars: 69%
Ronnerman	146 cases with early loss		Study casts were taken	Relative space	Group with los

(1977)	of primary molars; 46 without		at age 9, 11 and 13 years.	comparison	before 7.5 year smaller relative than that with n
Pedersen et al. (1978)	n = 364	n = 359	Registration and examination at age 9-11	Frequency of malocclusion and perceived need for treatment	Higher frequenc malocclusion ar greater treatme in the cases (se 4)
Harvold et al. (1970)	Loss prior to age 9 (n = 27)	No loss prior to age 9 (n = 49)	Measurements taken age 6, 9, 12, 14 and 16	80 asymmetry measures (16 measures at each age level, 6, 9, 12, 14 and 16)	11 of the 80 m differ in mean v of these differe arise in age 14 mean differenc 1.3mm

Table 5 - Summary of Kisling & Hoffding's Findings

		Space Loss > 1mm	Space Loss > 2mm
Space Maintainer on one side (n=55)	With Space Maintainer (n=55)	n=23 (42%)	n=6 (11%)
	Without Space Maintainer (n=55)	n=50 (91%)	n=42 (76%)
Space Maintainer on both sides (n=33)		n=10 (30%)	n=1 (3%)

Table 6 - Premature Loss of Primary First Molars

	With Space Loss	Without Space Loss	Total
With Space Maintainer	6	12	18
Without Space Maintainers	24	26	50
Total	30	38	68

Table 7 - Premature Loss of Primary Second Molars

	With Space Loss	Without Space Loss	Total
With Space Maintainer	9	14	23
Without Space Maintainers	20	9	29
Total	29	23	52

13.0 References

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