
DATE: 20 October 2016

CONTEXT AND POLICY ISSUES

Premature loss of primary teeth in children may lead to changes to the permanent dentition including malocclusion and dental arch issues due to drifting teeth. Dental space maintainers (SMs) are commonly used to preserve alignment of the existing dental arch, and to preserve space for unerupted teeth. Broadly, there are two categories of SMs: fixed, which are cemented to one or more teeth, and removable, which are not cemented and can be taken out of the oral cavity. They can be constructed of different materials such as stainless steel wire, or glass fiber-reinforced composite resin (GFRCR). They can be placed on the mandibular or maxillary arch. Examples of SMs include band and loop, lingual arch, palatal arch, and crown-loop.

Given suggestions by dental associations for their use among children for primary teeth loss, it is important to understand the clinical evidence and costs associated with SMs, as well as to look to evidence-based guidelines on appropriate use. Potential benefits include reduction of crowding, ectopic eruption, crossbite, excessive overbite and overjet, and poor molar relationship. However, SMs can increase plaque accumulation, decrease periodontal health, and increase oral microflora.

The purpose of this review is to examine the clinical effectiveness, cost-effectiveness, and guideline recommendations surrounding the types and use of SMs.

RESEARCH QUESTIONS

1. What is the clinical effectiveness of space maintainers in the management of premature loss of deciduous molars (primary teeth)?

2. What is the comparative clinical effectiveness of different types of space maintainers in the management of premature loss of deciduous molars (primary teeth)?
3. What is the comparative effectiveness of space maintainers placed by specialists versus general practitioners?

4. What is the cost-effectiveness of space maintainers for the management of premature loss of deciduous molars (primary teeth)?

5. What are the evidence-based guidelines regarding the use of space maintainers?

**KEY FINDINGS**

One quasi-randomized controlled trial, three controlled clinical trials, and four observational studies were reviewed on the clinical effectiveness of space maintainers (SMs) in the management of premature loss of primary teeth in children. No economic evaluations or evidence-based guidelines were retrieved on the topic.

Comparing patients with and without SMs, studies reported that patients with SMs had more frequent eruption difficulties, but no difference in space loss. Other studies compared different types of SMs including band and loop, lingual holding arch, and glass fiber-reinforced composite resin maintainers. Most types appeared to fare similarly in terms of gingival health and proportion of patients developing caries.

**METHODS**

**Literature Search Methods**

A limited literature search was conducted on key resources including PubMed, The Cochrane Library, University of York Centre for Reviews and Dissemination (CRD) databases, ECRI Institute, Canadian and major international health technology agencies, as well as a focused Internet search. No filters were applied to limit retrieval by publication type. Where possible, retrieval was limited to the human population. The search was also limited to English language documents published between January 1, 2006 and September 21, 2016.

**Selection Criteria and Methods**

One reviewer screened citations and selected studies. In the first level of screening, titles and abstracts were reviewed and potentially relevant articles were retrieved and assessed for inclusion. The final selection of full-text articles was based on the inclusion criteria presented in Table 1.
Table 1: Selection Criteria

<table>
<thead>
<tr>
<th>Population</th>
<th>Pediatric patients (age 0-18) with primary or mixed dentition, with premature loss of deciduous molars (primary teeth)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Dental space maintainers</td>
</tr>
<tr>
<td>Comparator</td>
<td>No space maintainer; different types of space maintainers</td>
</tr>
<tr>
<td>Outcomes</td>
<td>Clinical effectiveness (e.g. prevention of change in the arch length/space, prevention malocclusion (e.g. ectopic eruptions, rotations, crowding, spacing, crossbite, overbite, overjet, impactions, midline shifts), cost-effectiveness, guidelines (including indications, recommendations on type of space maintainer, and type of practitioner)</td>
</tr>
<tr>
<td>Study Designs</td>
<td>HTA/Systematic Reviews/Meta-Analyses</td>
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<tr>
<td></td>
<td>Randomized Controlled Trials</td>
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<td></td>
<td>Economic Evaluations</td>
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<tr>
<td></td>
<td>Non-Randomized Studies</td>
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<tr>
<td></td>
<td>Guidelines</td>
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</tbody>
</table>

Exclusion Criteria

Articles were excluded if they did not meet the selection criteria outlined in Table 1, were duplicate publications, or were published prior to 2011. Guidelines were excluded if they were not evidence-based, or were superseded by more recent publications. Systematic reviews were excluded if only one database was searched, or if only one reviewer selected and assessed the studies.4

Critical Appraisal of Individual Studies

For critical appraisal of the included controlled trials and observational studies, the Downs and Black instrument was used.5 Summary scores were not calculated for the included studies; rather, a review of the strengths and limitations of each included study were described.

SUMMARY OF EVIDENCE

Quantity of Research Available

A total of 250 citations were identified in the literature search. Following screening of titles and abstracts, 229 citations were excluded and 21 potentially relevant reports from the electronic search were retrieved for full-text review. No additional citations were retrieved from the grey literature search. Of these potentially relevant articles, 13 publications were excluded: one enrolled an irrelevant population, three evaluated irrelevant outcomes, six were irrelevant study designs, and three did not include a comparator. Eight publications met the inclusion criteria and were included in this report. Appendix 1 describes the PRISMA flowchart of the study selection.

Additional references of potential interest are provided in Appendix 5.

Summary of Study Characteristics

A detailed description of individual study characteristics is provided in Appendix 2.
Study Design
One study was a quasi-randomized controlled trial (RCT), six were controlled clinical trials (CCT), seven-nine and the remaining four were observational studies. Ten-thirteen No evidence-based guidelines, systematic reviews, or economic evaluations were identified.

Owais et al. was classified as quasi-RCT because the investigators used alternation as a method of SM treatment assignment. Setia et al., seven Subramaniam et al., eight and Nidhi et al. six were classified as CCTs because the investigators “did” not state explicitly that the trial was randomized, but randomization [could] not be ruled out. Four Studies were classified as observational if the investigators did not explicitly report actively introducing a treatment.

Specifically, the observational studies were cohort studies, of which one was retrospective, eleven one was prospective, ten, and two were unspecified. Ten, twelve

Setting
Three studies (38%) were from India, seven-nine one from Jordan (13%), six one from the United States (13%), ten-twelve and three (38%) were unknown. Ten-twelve From the studies that reported settings, all were single centre studies except for Rubin et al., which enrolled participants from three centres. Thirteen The settings varied from an outpatient centre, seven to a teaching hospital, nine to private orthodontic practices. Thirteen None were reported to be from remote settings.

Patient Population
Patients were pediatric patients, with mean ages of 10 years or under, and ranges between two to 12 years of age. Ethnicity was not provided in any study, except one that recruited all Caucasian children. Twelve Inclusion criteria generally required healthy patients with loss of primary teeth during mixed dentition, six-nine and no congenitally missing teeth. Eight-nine Two studies exclusively considered mandibular arches, six, thirteen while others accepted mandibular and maxillary arches. Seven, ten, eleven

Interventions and Comparators
The most common SM examined was band and loop (5 studies, 63%). Seven-nineteen Four studies six, nine examined lingual arch appliances, while three studies two and nine examined glass fiber-reinforced composite resin (GFRCR) maintainers including Ribbond seven and Super splint. Seven

Two studies compared use of SMs versus no dental SM. Eleven, twelve Four studies compared different types of SMs to each other. Seven Ten Two studies compared different types of SMs to each other as well as to no SM. Six, thirteen In terms of the placement of SMs, five studies had comparators placed in separate groups of patients, so that comparisons were made between patients. Six, ten-twelve Three studies had different SM comparators placed either in different quadrants of the mouth, eight, nine or in different extraction sites of the mouth, seven so that comparisons were made within patients.

Outcomes
Several studies examined the presence of caries, seven-nine and gingival health, which was evaluated either as an index score, ten or as the presence of gingival inflammation. Eight, nine One study examined tooth eruption difficulty. Thirteen The remaining studies examined cephalometric measurements from radiographs including sagittal variation in incisors, twelve arch dimensions, six and space loss. Eleven

Summary of Critical Appraisal
A summary of critical appraisal of individual studies can be found in Appendix 3.
The quality of evidence was generally low. Among the clinical trials, one used a quasi-random method of treatment assignment. Three were unclear as to whether a random or non-random method of treatment assignment was used. Not assigning treatments in a random manner introduces selection bias, whereby there may be imbalances in prognostic variables between treatment groups. The quasi-RCT and CCTs did not conceal allocation methods. Given the nature of orthodontic treatments, blinding was not possible. Biases from lack of blinding may have been minimized, however, since outcome measurements were objective. None of the clinical trials provided sample size calculations to ensure they were sufficiently powered to detect treatment effects. It is unclear if statistically non-significant results were due to a lack of power or a true lack of effect.

Among the included studies, three addressed the issue of confounding. Confounding occurs when the outcomes observed may not be a result of SM treatment, but rather a result of other factors such as patient compliance or the child’s cooperativity. Two CCTs applied two different SMs to the same patients, so that patients acted as their own controls. One observational study controlled for known confounders within the statistical model.

Across all studies, the most common follow-up times were 12 months or less, with the longest being 48 months. Other studies followed patients to the end or after SM treatment, or after eruption of permanent teeth, but they did not report the actual follow-up time. Six of the eight studies enrolled fewer than 50 patients or extraction sites per comparator.

Overall, reporting was poor across all studies. Five of the eight studies did not report details of recruitment. Patient populations and settings were also poorly reported. Four studies reported gender. One did not report age. Other patient characteristics such as rurality were not described in any of the studies. In three studies, the country of origin and clinical setting were unknown.

**Summary of Findings**

Detailed findings from each individual study can be found in Appendix 4.

1. **What is the clinical effectiveness of space maintainers in the management of premature loss of deciduous molars (primary teeth)?**

   Four studies examined SM versus no SM as part of their comparisons. There was no description of the care provided for patients who did not receive SMs. In one study, SMs (Schwarz appliance, lingual holding arch, or combination) were associated with greater odds of eruption difficulty after adjusting for confounding (odds ratio not reported; \( P = 0.026 \)). In terms of cephalometric measurements, Letti et al. found the position of the lower incisors changed more in patients with SMs (lingual arch) than patients without. Specifically, patients with SMs had significantly different linear distances between the most prominent portion of the lower incisor crown and the NB line \( (P = 0.002) \), and had significantly different angles between the long axis of lower incisor and the NB line \( (P = 0.000) \). Owais et al. found the inclination of the lower incisors to the mandibular plane was increased in patients with SMs (lingual arch, 0.9 mm or 1.25 mm wire), and the differences were statistically significant compared to patients without SMs \( (P \leq 0.01 \) for 0.9 mm SM, and \( P \leq 0.05 \) for 1.25 mm SM). Alnahwi et al. found no differences in space loss between patients with SM (any type) and without SM (no \( P \)-values reported).
2. **What is the comparative clinical effectiveness of different types of space maintainers in the management of premature loss of deciduous molars?**

Six studies compared different types of SMs.\(^6\)-\(^{10},\(^{13}\) Patients did not develop caries throughout follow-up for most SM types: Setia et al.\(^7\) reported no caries for four types of SMs (band and loop, band and custom loop, Ribbond, and Super splint) over nine months; Subramaniam et al.\(^8\) reported none for two types of SMs (GFRCR, band and loop) over 12 months; and Nidhi et al.\(^8\) reported none for GFRCR over five months, and one case (6.25%) for band and loop. Arikan et al.\(^10\) found plaque deposition was similar across most time points up to nine months for band and loop SM compared to a removable SM (\(P > 0.05\)).

In terms of gingival health, Nidhi et al.\(^8\) reported no inflammation for GFRCR over five months, and Subramaniam et al.\(^9\) reported no inflammation for GFRCR and band and loop over 12 months. Setia et al.\(^7\) noted no statistical differences in the proportion of patients with poor gingival health receiving one of four types of SMs (band and loop, band and custom loop, Ribbond, and Super splint) (\(P = 0.949\)). Arikan et al.\(^10\) found bleeding index scores and changes in pocket depth scores differed between the band and loop SM, and removable SM over the nine months of follow-up (\(P < 0.05\)). However, the data were presented as multiple stratifications, and it was not possible to determine which SM was superior.

In terms of eruption difficulties, in one study, the lingual holding arch had the lowest proportion of patients with problems (4.7%), and the combination of Schwarz appliance and lingual holding arch had the highest (14.7%).\(^{13}\) No statistical comparisons were made.

In terms of cephalometric measurements, Owais et al.\(^6\) found no statistical differences between the lingual holding arch made of 0.9 mm wire and one made of 1.25 mm wire (\(P > 0.05\)).

3. **What is the comparative effectiveness of space maintainers placed by specialists versus general practitioners?**

No comparative data were available. Among included studies, there were no descriptions or summary statistics on whether SMs were placed by specialists or general practitioners.

4. **What is the cost-effectiveness of space maintainers for the management of premature loss of deciduous molars?**

No data were available.

5. **What are the evidence-based guidelines regarding the use of space maintainers?**

No data were available.

**Limitations**

This review identified a substantial literature gap in the management of premature loss of primary teeth in children using SMs. No RCTs, systematic reviews, economic evaluations, or evidence-based guidelines were retrieved. The robustness of the evidence outlined in this review is limited due to the poor quality and poor reporting. Given the variation in the types of SMs, the construction material, the placement of SMs, and the outcomes examined in the included studies, consensus on the potential effects of SMs cannot be drawn.
The extent to which the results could be applied externally is uncertain as a result of inadequate reporting. For one, patient populations were not clearly described and sample sizes were small. Among studies that described their settings, they were from single centres. None appeared to be on Canadian populations.

CONCLUSIONS AND IMPLICATIONS FOR DECISION OR POLICY MAKING

One quasi-RCT, three CCTs and four observational studies were included and reviewed on the use of SMs in children with premature loss of primary teeth. Only clinical effectiveness was examined, including gingival health, presence of caries, plaque formation, eruption difficulties, cephalometric measurements, and space loss. Studies did not examine cost-effectiveness or guideline recommendations.

Overall, several methodological limitations and uncertain generalizability of the studies preclude robust conclusions about the use of SMs.

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REFERENCES


## LIST OF ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>1.NB</td>
<td>Angle between long axis of lower incisor and NB line</td>
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<tr>
<td>1-NB</td>
<td>Linear distance mm between most prominent portion of the lower incisor crown and NB line</td>
</tr>
<tr>
<td>ANOVA</td>
<td>analysis of variance</td>
</tr>
<tr>
<td>CCT</td>
<td>controlled clinical trial</td>
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<tr>
<td>GFRCR</td>
<td>glass fiber-reinforced composite resin</td>
</tr>
<tr>
<td>IMPA</td>
<td>angle between long axis of lower incisor and base of mandible</td>
</tr>
<tr>
<td>LLHA</td>
<td>lower lingual holding arch</td>
</tr>
<tr>
<td>NR</td>
<td>not reported</td>
</tr>
<tr>
<td>RCT</td>
<td>randomized controlled trial</td>
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<tr>
<td>SE</td>
<td>standard error</td>
</tr>
<tr>
<td>SM</td>
<td>space maintainer</td>
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<tr>
<td>vs.</td>
<td>versus</td>
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</table>
APPENDIX 1: SELECTION OF INCLUDED STUDIES

250 citations identified from electronic literature search and screened

229 citations excluded

21 potentially relevant articles retrieved for scrutiny (full text, if available)

0 potentially relevant reports retrieved from other sources (grey literature, hand search)

21 potentially relevant reports

13 reports excluded:
- irrelevant population (1)
- irrelevant outcomes (3)
- irrelevant study design (6)
- no comparator (3)

8 reports included in review
### Table A1: Characteristics of Included Clinical Studies

<table>
<thead>
<tr>
<th>First Author, Publication Year, Setting, Country</th>
<th>Study Design</th>
<th>Patient Characteristics</th>
<th>Type of space maintainer</th>
<th>Comparator(s)</th>
<th>Clinical Outcomes, Statistical Analysis</th>
</tr>
</thead>
</table>
| Setia´ 2014, Outpatient centre, India           | CCT: Extraction site as unit of assignment | 32 children (range: 4 to 9 years; gender NR) who either required extraction of the primary first/second molar or having pre-extracted primary first or second molar in any of the arches; Patients could have single or multiple extraction sites in maxillary or mandibular arch (n= 60 samples) | Band and loop (n= 15 samples) | 1. Prefabricated band with custom made loop (n= 15 samples)  
2. Ribbond (n= 15 samples)  
3. Super splint (n= 15 samples) | Caries (Y/N);  
Plaque deposition of the abutment tooth using Silness and Loe index (Good/ Fair/ Poor)  
Chi-square, McNemar's test (paired data for same patients) |
| Nidhi® 2012, Single centre, India              | CCT: Split-mouth trial | 20 normal, healthy, and cooperative children (range: 4 to 9 years; gender NR) who had premature loss of a primary first molar in at least two quadrants | Glass fiber-reinforced composite resin (GFRCR) in one quadrant of mouth | Band-and-loop in the other quadrant of mouth | Caries or gingival inflammation  
Chi square test; Fisher's exact test |
| Owais® 2011, Single centre, Jordan             | Quasi-RCT: Alternation used as method of treatment assignment; Parallel arms | 67 children (mean age approximately 10 years; gender NR) with late mixed dentition; One or both mandibular primary second molars indicated for extraction | Lower lingual holding arch (LLHA) made with 0.9 mm stainless steel wire (n= 20) | 1. LLHA made with 1.25 mm stainless steel wire (n= 24)  
2. No treatment (n= 23) | Arch dimensions  
Analysis of variance with Bonferroni correction |
| Subramaniam® 2008,                             | CCT: Split-mouth trial | 30 normal, healthy, and cooperative children (range: 6 to 8 years; 23% girls) who | Glass fiber-reinforced composite resin | Band and loop in the other quadrant of mouth (n= 30) | Caries or gingival inflammation |
### Table A1: Characteristics of Included Clinical Studies

<table>
<thead>
<tr>
<th>First Author, Publication Year, Setting, Country</th>
<th>Study Design</th>
<th>Patient Characteristics</th>
<th>Type of space maintainer</th>
<th>Comparator(s)</th>
<th>Clinical Outcomes, Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teaching hospital, India</td>
<td></td>
<td>had premature loss of a primary first molar in at least two quadrants</td>
<td>(GFRCR) in one quadrant of mouth (n= 30)</td>
<td></td>
<td>Chi square test; Fisher’s exact test</td>
</tr>
</tbody>
</table>

GFRCR = glass fiber-reinforced composite resin; LLHA = lower lingual holding arch; RCT = randomized controlled trial
### Table A2: Characteristics of Included Observational Studies

<table>
<thead>
<tr>
<th>First Author, Publication Year, Setting, Country</th>
<th>Study Design</th>
<th>Patient Characteristics</th>
<th>Type of space maintainer</th>
<th>Comparator(s)</th>
<th>Clinical Outcomes, Statistical Analysis</th>
</tr>
</thead>
</table>
| Alnahwi¹² 2015, NR | Cohort, retrospective | 87 healthy children (range 2 to 12 years; gender NR) in the primary or mixed dentition with no congenitally missing or supernumerary teeth; Patients could have maxillary or mandibular prematurely extracted primary second molars (n= 100 samples) | Space maintainer after primary second molar extraction (n= 36 samples)  
Note: Mix of appliances were used (band and loop, lower lingual holding arch, transpalatal arch, and Nance holding appliance)  
Note: Most appliances were placed in the first two months of extraction; 10 samples were placed one to two years after extraction | No space maintainer following the extraction of a primary second molar (n= 64 samples) | Space loss measured by bitewing and periapical radiographs: measurements were made from the mesial surface of the permanent first molar (or the distal surface of the primary second molar if the permanent first molar had not erupted) to the distal surface of the primary canine  
Student's t-test |
| Letti¹² 2013, NR | Cohort, unspecified | 44 Caucasian children with mixed dentition (age NR; 59% girls) | Lingual arch appliance made with 0.9 mm stainless steel wire (n= 30) | No orthodontic/orthopedic treatment (n= 14) | Sagittal variation on the lower incisors:  
1. Angle between long axis of lower incisor and base of mandible (IMPA); |
**Table A2: Characteristics of Included Observational Studies**

<table>
<thead>
<tr>
<th>First Author, Publication Year, Setting, Country</th>
<th>Study Design</th>
<th>Patient Characteristics</th>
<th>Type of space maintainer</th>
<th>Comparator(s)</th>
<th>Clinical Outcomes, Statistical Analysis</th>
</tr>
</thead>
</table>
| Rubin™ 2012, Three private orthodontic practices, United States | Cohort, prospective | Consecutively treated children (mean age about 9 years; 54% girls); Comparators were matched on age, but matching methods were NR | Schwarz appliance (n= 58) | 1. Mandibular lingual holding arch (n= 85)  
2. Combination of both appliances (Schwarz appliance used first then removed; mandibular lingual holding arch used near end of mixed dentition) (n=58)  
3. Controls from another study (n= 100) | 2. Angle between long axis of lower incisor and line NB (1.NB)  
3. Linear distance mm between most prominent portion of the lower incisor crown and line NB (1-NB)  
Student's t-test |

Eruption difficulty: root of the mandibular second molar was at least 75% formed, but the tooth remained unerupted  
Descriptive statistics; Logistic regression for predictors of eruption difficulty (controlling for age, angulation, retromolar space)
<table>
<thead>
<tr>
<th>First Author, Publication Year, Setting, Country</th>
<th>Study Design</th>
<th>Patient Characteristics</th>
<th>Type of space maintainer</th>
<th>Comparator(s)</th>
<th>Clinical Outcomes, Statistical Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arikan NR 2007</td>
<td>Cohort, unspecified</td>
<td>56 healthy children (mean age 8.2 years; range: 7 to 10 years; 43% girls) who had early loss of primary molars (maxillary or mandibular)</td>
<td>Band and loop (n=26)</td>
<td>Removable appliance (n=26)</td>
<td>Gingival index (Lobone); Plaque index (Silness and Loe index; Turesky)(^{14,15}); Bleeding index scores; Pocket depths</td>
</tr>
</tbody>
</table>

1. NB = angle between long axis of lower incisor and line NB; 1-NB = linear distance mm between most prominent portion of the lower incisor crown and line NB; ANOVA = analysis of variance; GFRCR = glass fiber-reinforced composite resin; IMPA = angle between long axis of lower incisor and base of mandible; NR = not reported
### Table A3: Strengths and Limitations of Controlled Trials and Observational Studies using Downs and Black\textsuperscript{5}

<table>
<thead>
<tr>
<th>First Author, Publication Year, Study Design, Comparators</th>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Space maintainer (SM) vs. none:</strong></td>
<td></td>
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<tr>
<td>Alnahwi\textsuperscript{11} 2015</td>
<td></td>
<td></td>
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<tr>
<td>Observational</td>
<td></td>
<td></td>
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</tbody>
</table>
| SM (mix of band and loop, lower lingual holding arch, transpalatal arch, and Nance holding appliance) vs. No SM | • Long follow-up period (up to 48 months)  
• Defined inclusion/exclusion criteria  
• Defined outcomes | • Did not describe recruitment  
• Did not account for confounding  
• Grouped different appliances, which may have different treatment effects into one comparator; did not report the proportion of each SM type used  
• Included patients who had SM applied years after primary second molar extraction  
• Small sample size  
• Single centre |
| Letti\textsuperscript{12} 2013                             |           |             |
| Observational                                            |           |             |
| Lingual arch appliance vs. No SM                         |           |             |
| • Used commonly accepted cephalometric analyses to measure outcomes | • Did not describe recruitment  
• Did not account for confounding  
• Reported a study error in the outcome measurements; measurements were taken again and no significant differences were found (Student’s t test, \( p > 0.05 \))  
• Results did not support conclusions  
• Poor reporting overall  
• Single centre |
| **Comparisons of different types of SM to each other:**   |           |             |
| Setia\textsuperscript{7} 2014                             |           |             |
| CCT                                                       |           |             |
| Band and loop vs. Band and custom loop vs. Ribbond vs. Super splint | • Technique of each SM application described  
• Used commonly accepted index for measuring plaque deposition as an outcome | • Method of randomization not described although there was mention of SM “randomly placed” in extraction sites  
• No information on concealment of allocation  
• No power calculation  
• Small sample size  
• Single centre |
### Table A3: Strengths and Limitations of Controlled Trials and Observational Studies using Downs and Black\(^5\)

<table>
<thead>
<tr>
<th>First Author, Publication Year, Study Design, Comparators</th>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
</table>
| Nidhi\(^8\) 2012 CCT GFRCR vs. Band and loop (in different quadrants of mouth) | • Both SM appliances applied to each patient so that each patient acted as own control to address potential confounding  
• Procedure for SM application clearly described | • Did not describe recruitment  
• No indication that randomization occurred  
• Statistical analysis may not be appropriate (used Chi-square instead of McNemar’s test); did not account for correlation  
• No power calculation  
• Small sample size  
• Single centre |
| Subramaniam\(^9\) 2008 CCT GFRCR vs. Band and loop | • Both SM appliances applied to each patient so that each patient acted as own control to address potential confounding  
• Defined inclusion/exclusion criteria  
• Defined outcomes | • No indication that randomization occurred  
• Did not describe recruitment  
• No information on concealment of allocation  
• No power calculation  
• Small sample size  
• Single centre |
| Arikan\(^10\) 2007 Observational Fixed appliance (band and loop) vs. removable appliance | • Used commonly accepted indices for measuring plaque deposition and gingival health as outcomes  
• Defined most inclusion criteria | • Did not describe recruitment  
• Did not account for confounding  
• Small sample size; further stratified into smaller groups (verbal vs. written health education; test vs. control teeth); made statistical comparisons even with such small sample sizes  
• Single centre |
| Rubin\(^13\) 2012 Observational Schwarz appliance vs. Lingual holding arch vs. Combination of two appliances vs. Control | • Prospective study  
• Defined inclusion/exclusion criteria  
• Defined outcomes  
• Matched comparators based on age (although methods not described)  
• Provided power calculation  
• Statistical analysis controlled for some known confounders (i.e., age) | • Consecutively recruited patients, which may not provide a representative sample  
• Potential for residual confounding  
• Did not describe losses to follow-up  
• Final time point for outcome measurement and statistical analysis varied among patients (“after treatment would be desirable”)  
• Consecutively recruited patients, which may not provide a representative sample |

Comparisons of different types of SM to each other as well as to No SM:
Table A3: Strengths and Limitations of Controlled Trials and Observational Studies using Downs and Black\textsuperscript{5}

<table>
<thead>
<tr>
<th>First Author, Publication Year, Study Design, Comparators</th>
<th>Strengths</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owais\textsuperscript{6} 2011 Quasi-RCT LLHA 0.9 mm wire vs. LLHA 1.25 mm wire vs. No SM</td>
<td>- Defined inclusion/exclusion criteria&lt;br&gt;- Defined outcomes&lt;br&gt;- Assessed information bias: same examiner reassessed outcome measurements of 10 randomly chosen patients; coefficient of reliability was &gt; 90%&lt;br&gt;- Provided numbers lost to follow-up&lt;br&gt;- Statistical analysis was appropriate; Bonferroni correction used for multiple comparison tests</td>
<td>- No information on recruitment&lt;br&gt;- Quasi-random method of treatment assignment (alternation using odd and even numbers)&lt;br&gt;- No information on concealment of allocation&lt;br&gt;- No power calculation&lt;br&gt;- Small sample size&lt;br&gt;- Single centre</td>
</tr>
</tbody>
</table>

CCT = controlled clinical trial; GFRCR = glass fiber-reinforced composite resin; LLHA = lower lingual holding arch; RCT = randomized controlled trial; SM = space maintainer; vs. = versus
### APPENDIX 4: MAIN STUDY FINDINGS AND AUTHOR’S CONCLUSIONS

<table>
<thead>
<tr>
<th>Table A4: Summary of Findings of Included Studies</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>First Author, Publication Year, Study Design, Comparators</td>
<td>Main Study Findings</td>
</tr>
<tr>
<td>Space maintainer (SM) vs. none:</td>
<td>Space loss at 12 months</td>
</tr>
<tr>
<td>Alnahwi¹¹ 2015, Observational</td>
<td>• &gt; 3 mm space loss for both groups</td>
</tr>
<tr>
<td>SM (mix of band and loop, lower lingual holding arch, transpalatal arch, and Nance holding appliance) vs. No SM</td>
<td>• At 6 months and 12 months: No difference in space loss between SM group and No SM group (No P value provided)</td>
</tr>
<tr>
<td>Note: No statistical comparisons at 48 months</td>
<td></td>
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<tr>
<td>Letti¹² 2013, Observational</td>
<td>Change in IMPA from baseline after eruption of permanent canines and premolars</td>
</tr>
<tr>
<td>Lingual arch appliance vs. No SM</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Lingual arch: 1.9°</td>
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<tr>
<td></td>
<td>• No SM: -0.6°</td>
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<tr>
<td></td>
<td>• P = 0.083</td>
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<tr>
<td></td>
<td>Change in 1.NB from baseline</td>
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<tr>
<td></td>
<td>• Lingual arch: 2.7°</td>
</tr>
<tr>
<td></td>
<td>• No SM: -0.8°</td>
</tr>
<tr>
<td></td>
<td>• P = 0.002</td>
</tr>
<tr>
<td></td>
<td>Change in 1-NB from baseline</td>
</tr>
<tr>
<td></td>
<td>• Lingual arch: 0.2 mm</td>
</tr>
</tbody>
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Dental Space Maintainers
<table>
<thead>
<tr>
<th>First Author, Publication Year, Study Design, Comparators</th>
<th>Main Study Findings</th>
<th>Author's Conclusions</th>
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</table>
| Setia, 2014 | No SM: 1.6 mm  
\(P = 0.000\) | perimeter, that is, preventing the molar movement to mesial and the linguoversion of the incisors. [This may lead] to the reduction of mandibular crowding. (p.32) |
| CCT  
Band and loop vs. Band and custom loop vs. Ribbond vs. Super splint | Proportion with poor gingival health at 9 months  
- Band and loop 36%,  
- Band and custom loop 27%,  
- Ribbond 40%,  
- Super splint 50%  
- All comparisons: \(P = 0.949\) | "Prefabricated band with custom made loop may be a viable alternative to conventional band and loop since it has somewhat more success rate and less plaque deposition." (p. 103)  
Ribbond and Super splint “observed higher proportions of patients with poor gingival health as compared to [band and loop] and [band and custom loop], this might be attributed to plaque retentive sites along the fiber framework.” (p. 103) |
| Nidhi, 2012 | Caries  
None developed in the four groups over 9 months of follow-up | "None of the failures because of caries or gingival inflammation were seen in GFRCR space maintainers. It may be because the fibers were coated with flowable composite and finished adequately to allow maintenance of oral hygiene." (p. 28)  
"GFRCR space maintainers can be used as an alternative method to conventional band and loop space maintainers for short term space maintenance required due to premature primary tooth loss." (p. 29) |

Comparisons of different types of SM to each other:

| Setia, 2014 | CCT  
Band and loop vs. Band and custom loop vs. Ribbond vs. Super splint | Proportion with poor gingival health at 9 months  
- Band and loop 36%,  
- Band and custom loop 27%,  
- Ribbond 40%,  
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Ribbond and Super splint “observed higher proportions of patients with poor gingival health as compared to [band and loop] and [band and custom loop], this might be attributed to plaque retentive sites along the fiber framework.” (p. 103) |
| Nidhi, 2012 | CCT  
GFRCR vs. Band and loop (in different quadrants of mouth) | Caries or gingival inflammation  
- At 3 months: None developed in either group in first and third months  
- At 5 months: None developed in GFRCR vs. 6.25% (n = 1 out of 16) in Band and loop | "None of the failures because of caries or gingival inflammation were seen in GFRCR space maintainers. It may be because the fibers were coated with flowable composite and finished adequately to allow maintenance of oral hygiene.” (p. 28)  
"GFRCR space maintainers can be used as an alternative method to conventional band and loop space maintainers for short term space maintenance required due to premature primary tooth loss.” (p. 29) |
### Table A4: Summary of Findings of Included Studies

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| Subramaniam® 2008 | Caries or gingival inflammation  
| | • None in either group over 12 months of follow-up | • “The GFRCR space maintainer seems to be a suitable alternative to the conventional fixed space maintainer.” (p. S103) |
| CCT  
| | Plaque index score  
| | • At baseline, 6 months and 9 months: no difference between groups ($P > 0.05$)  
| | | • At 3 months: groups differed ($P < 0.05$)  
| | Bleeding index score  
| | • At baseline: no difference between groups ($P < 0.05$)  
| | | • At 3 months, 6 months and 9 months: groups differed ($P < 0.05$)  
| | Difference in pocket depth scores since baseline  
| | • At 3 months, 6 months and 9 months: groups differed ($P < 0.05$) | |
| Arikan™ 2007  
| | Plaque index score  
| | • At baseline, 6 months and 9 months: no difference between groups ($P > 0.05$)  
| | | • At 3 months: groups differed ($P < 0.05$)  
| | | Both fixed and removable SM cause an increase in plaque accumulation...Special concern should be given on oral and dental health of children who use fixed SM since they were found to cause an increase in bleeding index and pocket depth compared to the removable appliances.” (p. 233) |
| Observational  
| | Fixed appliance (band and loop) vs. removable appliance |
| | Proportion of patients with eruption difficulty  
| | • Schwarz appliance: 7.8%  
| | | • Lingual holding arch: 4.7%  
| | | • Combination: 14.7%  
| | | • Control: 1%  
| | | Logistic regression (odds ratios NR)  
| | • Schwarz vs. control: $P = 0.04$  
| | | • Lingual holding arch vs. control: $P = 0.42$  
| | | All treatment groups had a higher percentage of mandibular second molar eruption difficulty when compared with the control group.” (p. 150)  
| | | “Schwartz appliance or the combined Schwarz and lingual holding arch in the mixed dentition was associated significantly with mandibular second molar eruption difficulty.” (p. 151) |
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| Owais® 2011 Quasi-RCT LLHA 0.9 mm wire vs. LLHA 1.25 mm wire vs. No SM | Change in lower incisor inclination to the mandibular plane (Li-Mand) at end of treatment since baseline  
- LLHA 0.9 mm wire: 4.50° ± SE 0.77  
- LLHA 1.25 mm wire: 3.36° ± SE 1.07  
- No SM: -0.24° ± SE 0.82  
- Difference between LLHA 0.9 mm wire vs. No SM: 4.74° (P ≤ 0.01)  
- Difference between LLHA 1.25 mm wire vs. No SM: 3.60° (P ≤ 0.05)  
- Difference between LLHA 0.9 mm wire vs. LLHA 1.25 mm wire: 1.14° (p> 0.05)  
Change in distance of the lower incisor edge to the A-Pogonion (Li-A-Pog); Lower molar angulation to mandibular plane (LM1-Mand); Arch length; Arch depth; Inter canine width; Intermolar width; Primary second premolar extraction space  
- No statistically significant difference between groups (Table 3, p.40) | “Lower incisor inclination to the mandibular plane was increased in [LLHA 0.9 mm wire] and [LLHA 1.25 mm wire]… Significant differences were found when…compared with the controls.” (p. 40)  
- “The LLHA used in both treatment groups tended to cause proclination of Li-Mand and forward movement of the lower incisors relative to the A-Pog line (Li-A-Pog).” (p. 41)  
- “The LLHA used in both treatment groups preserved arch length throughout the study duration. There was arch length gain of 0.53 mm in [LLHA 0.9 mm wire] and arch length loss of 0.98 mm in [LLHA 1.25 mm wire].” (p. 41) |

1. NB = angle between long axis of lower incisor and line NB; 1-NB = linear distance mm between most prominent portion of the lower incisor crown and line NB; CCT = controlled clinical trial; GFRCR = glass fiber-reinforced composite resin; IMPA = angle between long axis of lower incisor and base of mandible; NR = not reported; RCT = randomized controlled trial; SE = standard error; SM = space maintainer; vs. = versus
APPENDIX 5: ADDITIONAL REFERENCES OF POTENTIAL INTEREST

Cost-effectiveness analysis (not specific to pediatrics):