Scientific Article

# The longevity of space maintainers: a retrospective study

Muawia A. Qudeimat, BDS, MDSc, MRCD(C) Stephen A. Fayle, BDS, MDSc, FDS RCS, MRCD(C)

## Abstract

Methods: *This retrospective study investigated the longevity of 301 space maintainers fitted in 141 patients aged 3.4–22.1 years in the Department of Pediatric Dentistry at Leeds Dental Institute between 1991 and 1995.*

Results: *Failure occurred in 190 space maintainers (63%), of which 36% were due to cement loss, 24% breakage, 10% design problems, and 9% were lost. Using the life table method, the median survival time (MST) for space maintainers was found to be 7 months. Band and loop (B&L) appliances had the highest MST of 13 months, while the lower lingual holding arch (LLHA) had the lowest of 4 months. Unilateral space maintainers survived longer than bilateral space maintainers (MST of 13 months vs. 5 months). Left B&Ls had a MST of 16 months, compared to only 4 months for right B&Ls. Gender, age, arch in which the appliance was placed, the operator planning it, fixed vs. removable, and adequacy of pretreatment assessment did not have a significant effect on survival time. (Pediatr Dent 20:267–72, 1998)*

Various appliances can be used for space maintenance depending on the child's stage of dental development, dental arch involved, primary teeth missing, and which teeth they are.[1–5] Occlusion may also be a factor in determining the type of space maintainer. The patient's age and ability to cooperate and tolerate a removable appliance are also major considerations.[2, 4–6]

The clinical efficacy of space maintainers, and how variables in design and construction affect survival time, have gained little attention from researchers. Some authors have anecdotally attempted to estimate the most common causes of failure of space maintainers and the longevity of these appliances, including a high incidence of breakage in mandibular appliances when compared with other appliances.[3] Others state that fixed space maintainers, if properly designed, are less damaging to the oral tissues than removable space maintainers, and less of a nuisance to the patient, thus more appropriate for longer periods of space maintenance.[4]

In a 4-year prospective study, 226 space maintainers were fitted in 196 children, aged 6–10 years.[7] Problems were encountered in 43% of all the appliances, of which 58% were LLHAs, 31% band and loop and crown and loop appliances, 6% transpalatal arches, and 4% removable appliances. The most common problem was appliance loss. This problem constituted 37% of the total problems, while 27% were due to broken B&Ls, 14% due to failure of cementation, 13% due to patients failing to attend the follow-up appointments, and 11% due to distortion of the arch or loop.[7]

Only one recent study has looked objectively at the longevity of space maintainers, and variables that can affect their survival time in children. Baroni et al.[8] studied the longevity of 88 fixed space maintainers fitted in 61 patients, aged 5–9 years, followed for a maximum of 53 months. Survival was evaluated utilizing the life table method. The overall incidence of failure was 31%. Solder failures accounted for 37% of the total failures, 33% were due to loss of cement, 19% involved soft-tissue lesions, and 11% were caused by interference with eruption of permanent teeth. Nance appliances and B&L space maintainers had a 70% survival rate, while the LLHAs had a 40% survival rate after 36 months of cementation. The differences between the survival time of different designs of space maintainers were not statistically significantly different.[8]

The aim of the present study was to investigate the survival of space-maintenance appliances fitted in the Department of Pediatric Dentistry at a UK dental school over a 5-year period.

## Methods

The study included all patients who had either fixed or removable space maintenance appliances provided in the Department of Pediatric Dentistry at Leeds Dental Institute between January, 1991 and December, 1995. Data concerning the planning, fitting, progress, and fate of each appliance were extracted from patient records. Patients were excluded if they had received dental treatment from another dental service during the study period or if the space-maintenance appliance had an orthodontically active component.

The following information was collected from the patient's record card:

### Pretreatment assessment

1. The date and type of radiographs exposed before the space-maintenance appliance fitting date. In cases

in which a periapical or a bite-wing radiograph was exposed, the quadrant was also recorded.

2. Any preliminary assessment of space needs was recorded, i.e.:
   a. Primary molars relation (Baume's classification)[9]
   b. Presence or absence of crowding or spacing in the primary dentition
3. Whether or not a set of study models was taken
4. Whether or not a mixed dentition analysis was carried out.

#### Adequacy of pretreatment assessment

Patients were deemed to have had adequate pretreatment assessment if all the following pretreatment surveys were recorded as carried out before they were fitted with a space maintainer:

1. For all study group patients
   a. Full radiographic survey showing all the primary and permanent teeth
   b. A set of study models
2. For patients with established mixed dentitions (i.e., all permanent first molars and incisors fully erupted) prior to being fitted with a space maintainer or during the course of treatment (other than those where anterior tooth was lost due to trauma): space analysis results were recorded either on mixed dentition analysis sheet or in the clinical notes
3. For patients with loss of an anterior tooth: clinical records of space measurement.

#### Fate and longevity of space-maintenance appliances

Each appliance could have one of three possible fates: 1) withdrawn, either due to successful space management (i.e., the records demonstrated that the space maintainer was removed because it accomplished the original purpose of its fitting) or lasted until the end of the study period (i.e., the space maintainer survived intact until the study closing date); 2) failed if the patients records demonstrated that the appliance was recorded as lost or removed due to inadequate pretreatment diagnosis, poor design, faulty construction, failure of cementation, failure of a space maintainer due to caries, pulpal/periodontal pathology of an abutment tooth, poor follow-up care, or poor patient cooperation or attendance; or 3) lost to follow-up if the patient failed to attend the follow-up appointment and the fate of the appliance was unknown, or the operator failed to record the presence or absence of the appliance in the clinical narrative and there was no sign of the appliance on subsequent chartings or radiographs.

## Results

The clinical records of 159 patients in whom 326 space maintainers were fitted were originally identified.

**Table 1. Different types of space maintainers included in the study**

| *Design* | *Space Maintainers (%)* |
|---|---|
| Removable partial denture | 82 (31%) |
| Band and loop | 81 (27%) |
| Lower lingual holding arch | 71 (24%) |
| Nance appliance | 30 (10%) |
| Fixed partial denture | 20 (7%) |
| Distal shoe | 6 (2%) |
| Crown and loop | 1 (0.3%) |
| Total | 301 (100%) |

**Table 2. The designation of operator who fitted the space maintainer**

| *Operator* | *Space Maintainers (%)* |
|---|---|
| Postgraduate student | 206 (67%) |
| Undergraduate student | 47 (16%) |
| Hospital and/or University staff | 44 (15%) |
| Not recorded | 4 (1.3%) |
| Total | 301 (100%) |

After applying the exclusion criteria, 18 patients with 25 space maintainers were excluded.

The age range of patients in the study group was 3.4 to 22.1 years (mean 8.8, SD = 13.3). Nineteen patients in the 13–22-year age group had 40 upper, removable space maintainers fitted to keep the space of a traumatically lost anterior tooth or teeth.

Of the 141 patients, 74 were female and 67 were male. In these patients, 301 space maintainers had been fitted (Table 1). Of these, 155 were newly constructed and fitted for the first time and 146 were either a recementation, a repair, or replacement of the original space maintainer. Postgraduate students fitted 69% of the space maintainers (Table 2).

#### Pretreatment assessment

The radiographic assessment carried out before fitting a space maintainer is presented in Table 3. Full radiographic surveys were exposed prior to fitting 87% of the space maintainers. A set of pretreatment diagnostic models were made for 78% of the appliances prior to fitting.

When mixed dentition analysis was considered appropriate, either initially or subsequently during the course of space management, it was carried out and recorded for only 34% of space maintainers (Table 3).

**Table 3. Pretreatment Assessment**

| *Pretreatment Assessment* | *Space Maintainers (%)* | *Patients (%)* |
|---|---|---|
| Radiographs | | |
| Full survey | 261 (87%) | 119 (85%) |
| Some radiographs | 36 (12%) | 20 (14%) |
| No radiographs | 4 (1%) | 2 (1%) |
| Study Models | | |
| Yes | 234 (78%) | 109 (77) |
| No | 67 (22%) | 32 (23%) |
| MDA | | |
| Completed | 67 (34%) | 31 (32) |
| Not Completed | 129 (66%) | 66 (68%) |

**Table 4. Fate of Space Maintainers at the Closing Date**

| *Fate of Space Maintainer* | *N (%)* |
|---|---|
| Failed | 190 (63%) |
| Lost to Follow-up | 64 (21%) |
| Successful | 25 (8%) |
| End of Study | 22 (7%) |
| Total | 301 (100%) |

### Fate of space maintainers

The fate of all study space maintainers is presented in Table 4. One-hundred and ninety were considered failed(141 fixed, 49 removable) and 25 successful.The causes of failure as recorded in the clinical notes are presented in Table 5. The most common cause of failure in this study was failure of cementation (either partial or complete), which was recorded in 36% of all failures.

#### Longevity of space maintainers

The median survival time of space maintainers in this study was 7 months. When both new and all study group space maintainers were considered independently, there was no statistically significant difference between survival time for space maintainers in both groups, suggesting that new space maintainers behaved in a similar fashion to all study group space maintainers.

Variables which might have affected the median survival time for all space maintainers were tested using the log-rank and chi-square tests.[10] The results are presented in Table 6. A statistically significant difference ($P < 0.005$) was found between the median survival times of the four commonly used space maintainers (Fig). The LLHA had the lowest median survival time (4 months), followed by Nance appliance (6 months), then removable partial dentures (9 months), and B&L space maintainers, which showed the highest median survival time of 13 months.

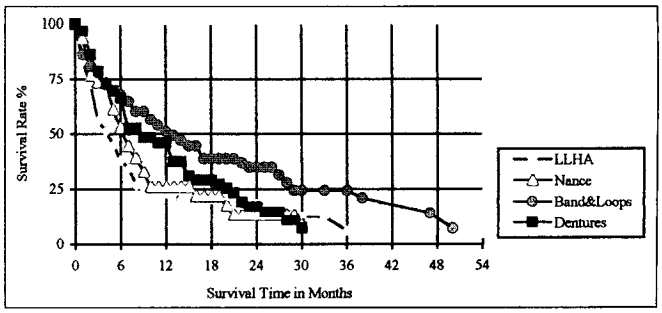


**Fig. Survival rate of four different designs.**

When a space maintainer was considered failed, postfailure action was undertaken in certain instances, and these space maintainers re-entered the study with a new data-capture entry. Of the 190 failed space maintainers, 64 were remade, 60 recemented, 18 repaired, and for 48 space maintainers a decision was made by the operator to discontinue space management. The median survival time for recemented space maintainers was the lowest (4.5 months), followed by newly fitted space maintainers (7 months), then remade space maintainers (10 months), and then repaired space maintainers, in which the highest median survival time was encountered (13.5 months). These differences were statistically significant ($P < 0.0005$).

Twenty-seven patients had more than one space maintainer simultaneously. Of those, 26 had two and only one had three. No statistically significant difference was found between those and patients who had only one space maintainer in terms of median survival time.

Unilateral appliances (i.e., B&Ls, distal shoe, and crown and loop space maintainers) survived more than twice as long as the bilateral appliances (i.e., LLHAs, and Nance appliances) at the 50% level ($P <0.0005$). Left B&L appliances had a median survival time of 16 months, while the right B&L appliances had a median survival time of only 4 months ($P < 0.01$).

When patients who had a similarly situated space maintainer fitted two times or less during the study period were compared with those who had comparable space maintainers fitted more than two times, the first group had a median survival time of 10 months, while the second group had a median survival time of 3.5 months, a statistically significant difference ($P < 0.0005$).

Gender, age, arch in which the appliance was placed, adequacy of pretreatment assessment, and operator who planned or placed the space maintainer had no significant effect on longevity.

## Discussion

### The use of life table method in dental research

In general, the relative gain in utilizing survival information on space maintainer cohorts with partial

**TABLE 5. THE CAUSES OF FAILURE AS RECORDED IN CLINICAL NOTES FOR FAILED SPACE MAINTAINERS**

| *Cause of Failure* | *N of Fixed Appliances* | *N of Removable Appliances* | *N of Space Maintainers* |
|---|---|---|---|
| Failure of cement | 68 | 0 | 68 (36%) |
| Breakage | 15 | 30 | 45 (23%) |
| Design | | | |
| Soft-tissue lesions | 13 | 0 | 13 (7%) |
| Interfering with erupting teeth | 5 | 0 | 5 (3%) |
| Improper selection | 1 | 0 | 1 (0.5%) |
| Lost | 12 | 5 | 17 (9%) |
| Lost tooth from the denture | 2 | 5 | 7 (4%) |
| Inadequate evaluation | 5 | 0 | 5 (3%) |
| Deterioration of fit | 0 | 3 | 3 (2%) |
| Poor patient cooperation | 1 | 1 | 2 (1%) |
| Unacceptable aesthetic | 0 | 2 | 2 (1%) |
| Distorted | 1 | 0 | 1 (0.5%) |
| Combination* | 14 | 3 | 17 (9%) |
| Not recorded | 4 | 0 | 4 (2%) |
| Total | 141 | 49 | 190 (100%) |

* A combination of two or more reasons.

follow-up information will vary directly with 1) the increase in the initial size of the cohort; 2) the completeness of the added survival information; and 3) the magnitude of failure rates during the first few follow-up intervals.[11] Many later texts ignored the potential impact of these factors and merely stated that the life table method is useful in determining survival rates.[12] Factors affecting the reliability of results include: the size of the sample, the length of the study compared with median life, the proportion of data that is censored, and the quality of information on censored data.[12]

Longitudinal studies of dental treatment have usually been carried out retrospectively, and those who have attempted them will agree that lack of record continuity presents a major difficulty.[13]

**Fate of space maintainers**

One-hundred and ninety (63%) space maintainers suffered failure during the study period (Table 4). This was a high failure rate in comparison with previous studies, where failure rates of 43[7] and 31% have been reported. However, in this study the space maintainers were fitted in 141 children with a wider age range of 3.4 to 22.1 years, and the space maintainers were followed for 5 years, in contrast to the only two comparable previous studies where 191 children 6–10 years old were followed for 4 years[7] and 61 children 5–9 years old were followed for a maximum of 53 months.[8]

The most common cause of failure was loss of cement, which represented 36% of the failed space maintainers (Table 5). This paralleled the 33% cement failure rate reported in fixed space maintainers in an earlier study.[8] However, in another prospective study, failure of cement accounted for only 14% of the total causes of failure.[7] Previous authors have reported cement loss due to poorly adapted bands as one of the main causes of fixed space maintainer failure.[6–8] However, failure could also reflect difficulties in keeping a dry field during cementation, especially in the case of bilateral appliances.

Breakage ranked as the second most commonly recorded cause of space-maintainer failure (24%, N = 45) in our study. A similar rate of breakage (27%, N = 26) has been reported by Hill et al.[7] They found that breakage was most commonly encountered in the LLHA followed by B&L space maintainers. In our study, breakage was encountered more in removable partial dentures followed by LLHA space maintainers. However, in the Hill et al. study,[7] there were only four removable partial denture space maintainers (2%) which were all removed by the patients at home and then were lost, while we used 92 removable partial-denture space maintainers. A higher solder failure rate of 37% (N = 10) of total failures in fixed space maintainers has been reported previously,[8] in comparison to 11% (N = 15) of total failures in this study. The former investigators concluded that the relevance of mechanical stress in long-term space maintainers seemed to be more important than appliance design.[8] Others have suggested that most mechanical failures are due to poor construction quality, i.e., incomplete solder joint,[6–14] overheating of the wire during soldering,[6,7,14] wire thinned by polishing,[3] remnants of flux on the wire,[3] and failure to encase the wire in the solder.[3]

It has been anecdotally stated that removable space maintainers are more frequently lost than fixed space maintainers.[15] Although the difference was not clini-

**TABLE 6. SUMMARY OF VARIABLES WHICH MIGHT BE RELATED TO THE MEDIAN SURVIVAL TIME FOR ALL SPACE MAINTAINERS IN THE STUDY GROUP**

| *Variables* | *50% Survival Rate (mo.)* | P |
|---|---|---|
| Lower lingual holding arch | 4 | |
| Nance appliance | 6 | < 0.005 |
| Removable appliances | 9 | |
| Band and loop | 13 | |
| Bilateral fixed space maintainers | 5 | |
| Unilateral fixed space maintainers | 13 | < 0.0005 |
| Recemented | 4.5 | |
| New | 7 | < 0.0005 |
| Replacement | 10 | |
| Repaired | 13.5 | |
| Right band and loops | 4 | |
| Left band and loops | 16 | < 0.01 |
| Fitted more than two times | 3.5 | |
| Fitted two times or fewer | 10 | <0.0005 |

cally or statistically significant, this last point was slightly evident in the present study, where lost appliances represented 10% (N = 5) of recorded causes of failure in removable partial-denture space maintainers and 9% (N = 12) of those in fixed space maintainers.

Soft-tissue pathology resulting from space maintainers is often attributed to impingement.[2,6] In this study, soft-tissue pathology led to the failure of 9% (N = 13) of failed fixed space maintainers in comparison to 19% (N = 5) in fixed appliances in a previous investigation,[8] in which the authors concluded, without statistical analysis, that soft-tissue lesions were mainly related to unilateral space maintainers. In our study, soft-tissue lesions were encountered more in bilateral (7% of total failures recorded for bilateral appliances) than in unilateral space maintainers (6% of total failures recorded for unilateral appliances), but this difference was not statistically significant.

While Baroni et al.[8] found that 10% of the space maintainers in their study failed due to interferences with eruption of the permanent teeth (all were lower permanent incisors), this accounted for only 3% of failed space maintainers in this study (mostly premolars). The difference between the two studies may have arisen from the extensive use of LLHAs in the primary dentition by investigators in the first study.[8] In our study, no LLHAs were fitted in the primary dentition.

#### Survival time of space maintainers

Baroni et al.[8] found no significant difference between different types of space maintainers in terms of survival time. Conversely, the results of the present study indicate that the median survival time may be related to the design of the space maintainer with B&L appliances lasting longer than LLHAs. A possible explanation is that the LLHA and Nance appliances are more subject to occlusal stress than B&L appliances, although this cannot be confirmed from our study.

It has also been anecdotally stated that removable space maintainers may not last as long as fixed space maintainers, and hence fixed space maintainers should be preferred over removable designs.[4] However, when the longevity of fixed space maintainers was compared to removable partial-denture space maintainers in this study, no statistically significant difference between the two groups was found.

In the current study, unilateral space maintainers showed a median survival time more than twice that of the bilateral appliances. Baroni et al.[8] failed to demonstrate such a difference. The reason for this is unknown, but could be related to bilateral appliances being subjected to greater occlusal stress than unilateral space maintainers.

Surprisingly, when median survival times for left- and right-fitted B&L space maintainers were investigated, a statistical and clinical difference was found between the two groups. Again, the reason for this remains obscure, although one possible explanation might be that access and isolation might have been easier to control by a right-handed operator when a B&L was fitted to the left side of the oral cavity. Another possible—but uninvestigated—explanation might be the preference of the right side of the mouth as a chewing side by the children in this study.

No statistically significant difference was found in this study in terms of space maintainer survival time between the different age groups. The seniority of the operator showed no statistical significance in the median survival time of the space maintainer. These findings could suggest that poor design and construction may play a greater role in space maintainer failure than patient cooperation or degree of mental development.

Remade space maintainers survived longer than a newly fitted space maintainer. This could have been due to a more careful assessment in terms of the design selection and other considerations prior to refitting the remade space maintainer. The fact that the recemented space maintainers had a 50% chance of

failing within 4.5 months compared to 10 months for replacement space maintainers strongly suggests the space maintainer's design and construction, rather than the cement itself, could have been the primary cause of failure.

Unexpectedly, space maintainers with adequate pretreatment assessment showed no difference in median survival time when compared with space maintainers with inadequate pretreatment assessment. This possibly reflects that adequate pretreatment assessment may ensure that the use of a space maintainer is appropriate, but does not influence appropriate design selection and construction.

Interestingly, the median survival time for space maintainers that were fitted in similar situations two times or less during the study period was highly significantly longer than the median survival time for space maintainers similarly fitted more than two times. This suggests that in cases where space maintainers have failed in the same situation more than two times, any subsequent replacement is likely to have a poor median survival time.

Two possible explanations for this are that the location may be such that it could be unsuitable in some way for a space maintainer or, alternatively, those patients in whom these appliances were placed may have tolerated them poorly, leading to recurrent failure.

## Conclusions

The following conclusions may be drawn from this study of a dental school population:

1. Overall, failure occurred in 63% of the study space maintainers; 21% were lost to follow-up, and only 8% were considered entirely successful.
2. Loss of cement was the most commonly recorded cause of space maintainer failure, followed by breakage, and then complete loss of the appliance.
3. Median survival time was 7 months.
4. Of the commonly used designs, B&L maintainers had the highest median survival time (13 months) and LLHAs the lowest (4 months).
5. Remade space maintainers had a significantly longer median survival time (10 months) than new (7 months) and recemented space maintainers (4.5 months).
6. Gender, age, arch in which the appliance was placed, adequacy of pretreatment assessment, and operator who placed the space maintainer had no significant effect on longevity.

## Recommendations

1. A band and loop space maintainer design showed a significantly higher median survival time, and should be favored as a space maintainer design whenever possible.
2. When a space maintainer fails twice due to cement loss, careful reassessment is required before further replacement of the appliance is considered.
3. Close supervision and frequent follow-up appointments are necessary for all patients to check the appliance, the integrity of the luting agent, and to clean the abutment tooth as required. In the light of the current study, 2-month follow-up appointments for bilateral fixed appliances and 4-month follow-up appointments for removable and unilateral fixed space maintainers would be advisable.

Dr. Qudeimat was a postgraduate student during the preparation for this study, and is now a clinical demonstrator, Department of Child Dental Health, Leeds University. Dr. Fayle is a Consultant in Pediatric Dentistry, Department of Child Dental Health, Leeds University, UK.

## References

1. Christensen J, Fields H: Treatment planning and treatment of orthodontic problems. In Pediatric Dentistry: Infancy Through Adolescence, JR Pinkham, Ed. Philadelphia: WB Saunders, pp 419–48, 1988.
2. Ghafari J: Early treatment of dental arch problems: I. Space maintenance, space gaining. Quintessence Int 17:423–32, 1986.
3. Wright GZ, Kennedy DB: Space control in the primary and mixed dentitions. Dent Clin North Am 22:579–601, 1978.
4. Foster TD: Dental factors affecting occlusal development. In: A Textbook of Orthodontics, TD Foster, Ed. London: Blackwell, pp 129–46, 1990.
5. McDonald RE, Hennon DK, Avery RH: Managing space problems. In: Dentistry for the Child and Adolescent, RE McDonald, D Avery, Eds. St Louis: Mosby, pp 707–743, 1994.
6. Thornton JB: The space maintainer: case reports of misuse and failures. Gen Dent 30:64–67, 1982.
7. Hill CJ, Sorenson HW, Mink JR: Space maintenance in a child dental care program. J Am Dent Assoc 90:811–15, 1975.
8. Baroni C, Franchini A, Rimondini L: Survival of different types of space maintainers. Pediatr Dent 16:360–61, 1994.
9. Baume LJ: Physiological tooth migration and its significance for the development of occlusion: II. The biogenesis of accessional dentition. J Dent Res 29:331–37, 1950.
10. Brown RA, Swanson Beck J: Survival analysis. In: Medical Statistics on Personal Computers, RA Brown, J Swanson Beck, Ed. London: BMJ Publishing Group, pp 99–118, 1995.
11. Cutler SJ, Ederer F: Maximum utilization of the life table method in analyzing survival. J Chron Dis 8:699–712, 1958.
12. Davies JA: Dental restoration longevity: a critique of the life table method of analysis. Community Dent Oral Epidemiol 15:202–204, 1987.
13. Elderton RJ: Longitudinal study of dental treatment in the general dental service in Scotland. Br Dent J 155:91–96, 1983.
14. Hitchcock HP: Preventive orthodontics. In: Clinical Pedodontics, SB Finn, Ed. Philadelphia: WB Saunders, pp 342–69, 1973.
15. Bayardo RE: Anterior space maintainer and regainer. ASDC J Dent Child 53:452–55, 1986.