Survival rate of different fixed posterior space maintainers used in Paediatric Dentistry – A systematic review

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Abstract Purpose: Space Maintainers have long been used for the management of space loss in primary and mixed dentition, but there is a need to have an evidence based approach when selecting the most appropriate space maintainer for space management in children. This systematic review aimed to assess the survival rate of space maintainers in children.

Methods: A systematic literature search was conducted until October 2017 using PubMed, Scopus, and The Cochrane Central Register of Controlled Trials databases to identify peer-reviewed papers published in English. Search keywords and MeSH headings include “primary dentition” and “Fixed Space maintainers”. The inclusion criteria were clinical studies conducted in children less than 12 years of age, who required unilateral or bilateral fixed space maintainer. Retrieved papers were evaluated by four reviewers independently to assess suitability for inclusion in the systematic review and the final decision was made by consensus. Qualities of the included studies were assessed using Quality of Reporting of Observational Longitudinal Research by Oxford Academics and data were extracted for analysis.

Results: The search identified a total of 39 papers for screening after removal of duplicate articles. Among the retrieved studies, 23 papers did not satisfy the study inclusion criteria. Consequently, 16 full text articles were retrieved and reviewed. Finally, those 11 papers which fulfilled all the inclusion criteria were selected and reviewed systematically. Most of the clinical trials were assessed as having moderate and low risk of bias.

Conclusion: There is a wide variation in the survival rate of metal based and resin based space maintainers and also within the metal based space maintainers. There is an inadequate evidence

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One of the greatest challenges in Paediatric dentistry is the management of space loss due to untimely loss of primary teeth. An array of events occur, as the occlusion develops from the primary dentition through the transitional (or mixed) dentition to the permanent dentition stage, these events play an imperative role for a functional, esthetic and stable occlusion. If this continuance is disrupted, it may eventually affect the ultimate occlusal status of the permanent dentition (Dean et al., 2004). These problems can be prevented or their severity can be alleviated if the practitioner employs an adequate planning and space maintenance during initial treatment in the mixed dentition (Choonara, 2005).

Various appliances can be used for space maintenance based on patient’s age, growth and development of dental arches and ability to co-operate. Since removable space maintainers have several disadvantages like poor retention, less tolerance by the child, high chances of appliance dislodgement, the usage of fixed space maintainers would be more appropriate for longer periods of space maintenance. Though, fixed space maintainers are well tolerated and durable; they should be removed once a year to allow inspection, cleaning, and application of fluoride to the teeth.

Resin bonded space maintainers gained popularity due to ease of bondability, ease of fabrication, patient comfort; it eliminates the need of annual inspection as in case of other fixed space maintainers and can be used as a viable alternative to the conventional fixed space maintainers (Kargul et al., 2005). Though resin space maintainers holds several advantages, a study conducted by Saravanakumar et al. (2013) stated that, resin fiber space maintainers can be accepted as a successful space maintainer only for a short period of time.

There are only a few studies on the Survival rate of various fixed space maintainers (metal based and resin based). However, as a Paediatric dentist or as a General Practitioner, it is

to recommend one best fixed space maintainer due to lack of properly designed studies. Hence, clinical trial comparing different types of metal based space maintainer and resin based space maintainer with longer duration of follow-up must be performed to evaluate its survival rate.

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important to have a clear knowledge on the survival rate of different space maintainers. Love and Adams (1971) had reported that a significant amount of space loss occurs due to mesial migration of the posterior teeth. So, it is more important to assess the survival rate of posterior space maintainers, as it preserves arch length and circumference.

The survival rate of space maintainers used in the primary and mixed dentition was not reviewed and reported. There is a need for a systematic review to critically appraise and summarise the results of clinical trials evaluating the survival rate of various fixed posterior (metal based and resin based) space maintainers. This systematic review aimed to assess the survival rate of different types of space maintainers indicated in children.

2. Materials and methods

2.1. Inclusion criteria for considering studies for this review

Inclusion criteria for considering studies for this review were set prior to the search. They were as follows:

2.2. Type of studies

- Randomized controlled trial
- Prospective longitudinal study

2.3. Types of participants

- Children less than 12 years of age
- Children who require space maintainer
- Children with unilateral or bilateral missing primary molars

2.4. Type of intervention

- Fixed posterior space maintainers (metal based and resin based space maintainers)

2.5. Outcome measures

- Survival/longevity of space maintainers
- Success rate of space maintainers
- Failure rate of space maintainers

2.6. Exclusion criteria for considering studies for this review

- Studies on removable space maintainers
- Studies on method of fabrication
- Literature review
- Retrospective studies

2.7. Search Methods for identification of studies

The following search engines were used:

- PubMed (Upto June 2017)
- PubMed Advanced Search
- Cochrane central (Upto June 2017)
- SIGLE (Upto 2017)

Articles in English were only applied during the electronic search to include all the possible clinical trials in the potential relevant article search phase of the systematic review.

2.8. Manual printed copy search

- Journal of Clinical Paediatric Dentistry (JCPD)
- Pediatric Dentistry
- International Journal of Paediatric Dentistry (IJPD)
- Journal of Dentistry for Children
- Journal of Indian Society of Pedodontics and Preventive Dentistry (ISPPD)

2.9. Details of search

2.9.1. PubMed-MeSH terms

((((((((((((((((((((((child) OR children) OR Paediatric) OR Paediatric patients) OR primary dentition) OR deciduous dentition) OR mixed dentition) OR transition dentition) OR child with extracted primary molars) AND ((((space maintainer) OR space maintainers) OR fixed space maintainers) OR fixed posterior space maintainers) OR unilateral space maintainers) OR bilateral space maintainers) space maintainers))AND ((((longevity) OR durability) OR failure rate) OR success rate) OR survival period) OR survival rate).

2.10. Data collection and analysis

2.10.1. Screening and selection

Three review authors (DR), (EMG) and (MR) independently assessed the titles and abstracts of studies resulting from the searches. Full articles of those studies which met the inclusion criteria, or for which there were insufficient data in the title

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Fig. 1 PRISMA flow diagram.
| S. No. | Author and year         | Study design         | Sample size | Follow up duration | Age          | Intervention                                                                 | Variables evaluated                                                                 |
|-------|-------------------------|----------------------|-------------|--------------------|--------------|-------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| 1     | Baroni et al. (1994)    | Prospective clinical trial | 61 patients | 36 Months          | 5–9 years    | Lingual arch -36, Band and loop-33, Nance palatal arch-19                      | Cement loss, Solder failure, Soft tissue lesion, Eruption interference.              |
| 2     | Simsek et al. (2004)    | Prospective clinical trial | 51 patients (Male-32 Female-19) | 18 Months | 7.3 years | Simple fixed space maintainer-64                                               | Broken wire ends, loss of composite resin, angular changes in the abutment tooth. |
| 3     | Kargul et al. (2005)    | Prospective clinical trial | 19 patients (Male-14 Female-5) | 12 Months | 8.4 years | Glass Fiber Reinforced Composite Resin Space maintainer-23                     | Bonding failures                                                                    |
| 4     | Subramaniam et al. (2008) | Prospective clinical trial | 30 patients (Male-23 Female-7) | 12 Months | 6–8 years | Conventional band and loop-30, GFR space maintainer-30                        | Cement loss, Solder failure, Soft tissue lesion, Distortion, Bonding, fracture of fibre frame. |
| 5     | Sasa et al (2009)       | Prospective clinical trial | 40 patients (Male-18 Female-22) | 40 Months | 3.4–7.3 years | Band and loop-40                                                              | Cement loss, Solder failure, Soft tissue lesion                                     |
| 6     | Tunc et al. (2012)      | Randomized clinical trial | 30 patients (Male-13 Female-17) | 12 Months | 6.9 years | Band and loop-10, Direct bonded-10, Fibre-reinforced-10                        | Distortion, cement loss, Loop fracture, Caries or gingival inflammation, broken wire, bond failure, debonding, fracture of fibre frame |
| 7     | Saravanakumar et al. (2013) | Prospective clinical trial | 30 patients (Male-12 Female-18) | 18 Months | 6–9 years | Fibre-reinforced composite resin (FRCR) space maintainer -30                  | Debonding, fracture of fibre frame, gingival inflammation                           |
| 8     | Setia et al. (2014)     | Randomized clinical trial | 30 patients (Male-13 Female-17) | 9 Months | 4–9 years | Conventional band and loop-15, Prefabricated band with custom made loop-15, Ribbond-15, Super splint-15 | Survival rate (successful, failed, loss of follow up, censored at the end of study), caries, gingival health, Debonding, fracture of fibre frame. |
| 9     | Garg et al. (2014)      | Prospective clinical trial | 30 patients | 6 Months | 5–8 years | Conventional band and loop-15, FRCR space maintainer-15                        | Patient acceptance, Debonding, fracture of fibre frame, cement loss, Distortion of band, Slippage of band gingivally, Fracture of loop |
| 10    | Qudeimat and Sasa (2015) | Prospective clinical trial | 36 patients (Male-16 Female-20) | 52 Months | 3.4–6.3 years | Band and loop-18, Crown and loop-18                                          | Decementation, solder breakage, soft tissue lesion                                   |
| 11    | Kirzoglou et al. (2017) | Prospective clinical trial | 44 Patients (Male-11, Female-33) | 24 Months | 6–10 years | Fibre reinforced composite resin space maintainer                            | Debonding and dislodgement of space maintainers, status of abutment teeth, and oral hygiene |
and abstract to make a clear decision, were retrieved. DR, EMG and MR assessed the full text papers independently to establish whether the studies met the inclusion criteria or not. Studies fulfilling the inclusion criteria then underwent quality assessment and data extraction.

2.11. Data extraction

Data were extracted independently and in duplicate by three review authors (DR, EMG and MR). Titles of articles relevant to the review were selected by discussion. Forty titles were identified from the electronic and Seventeen from manual printed copy search. Abstracts and full texts of the articles were reviewed independently. After reviewing the articles independently, eleven articles were selected.

3. Results

A total of 11 studies were identified for inclusion in the review. The search of PubMed and Mesh data bases provided a total of 32 articles. Cochrane library search provided 8 articles. Of these 40 articles, 29 articles were excluded after reading the title and abstracts, as these papers did not meet the inclusion criteria. The full texts of the included 11 articles were reviewed in detail. Fig. 1 depicted the flow chart of complete data collection search process.

There were 4 studies which directly compared Metal and Resin space maintainers (Subramaniam et al., 2008; Tunc et al., 2012; Setia et al., 2014; Garg et al., 2014). All these 4 studies compared only Band and Loop space maintainers with different resin space maintainers. Two studies had compared the survival rate of fixed metal space maintainers, namely, Band and loop, Lingual arch space maintainer, Nance palatal arch space maintainer and crown and loop space maintainer (Baroni et al., 1994; Qudeimat and Sasa, 2015). Two studies reported only the survival rate of a particular fixed metal space maintainer (Simsek et al., 2004; Sasa et al., 2009) and 3 studies had evaluated the survival rate of a solitary resin space maintainer (Kargul et al., 2005; Saravanakumar et al., 2013; Kirzioglu et al., 2017).

Information regarding the study characteristics of the included studies such as study design, setting, population, sample size, interventions, outcome measures, follow-up intervals was depicted in Table 1. Quality assessment of each article with the risk of bias was done based on Quality of Reporting of Observational Longitudinal Research. (Table 2) Risk of bias was considered as low, if 8 or more than 8 criteria were satisfied. Risk of bias was considered as moderate if more than 5 criteria but less than 7 criteria were satisfied and considered as high if 5 or less than 5 criteria were satisfied (Fig. 2).

Among the 11 included studies, all the studies had stated the hypothesis/objective of the study, defined the study population and mentioned the number of participants at the beginning of the clinical trial. Two studies did not account on the eligibility criteria of the participants (Baroni et al., 1994; Kargul et al., 2005) and four studies did not address the number of participants available at each stage of the follow-up (Baroni et al., 1994; Simsek et al., 2004; Qudeimat and Sasa, 2015; Garg et al., 2014). In addition, 2 studies did not specify the reasons for loss of follow-up (Baroni et al., 1994; Kirzioglu et al., 2017). Only 3 studies evaluated the confounding
variables (Tunc et al., 2012; Qudeimat and Sasa, 2015; Kirzioglu et al., 2017), one study did not interpret the type of statistical analysis used (Simsek et al., 2004) and only one study did not account the loss of follow-up in the statistical analysis (Baroni et al., 1994). Moreover, none of the included studies have justified the sample size. The results of each included article according to their survival rate, success and failure rate was presented in Table 3.

4. Discussion

This systematic review was undertaken to evaluate the survival rate of different fixed space maintainers (metal based and resin based) used in Paediatric dentistry. It has shown that there is an inadequate scientific evidence to provide a definitive inference on the survival rate of fixed space maintainers, as there was no direct comparison of all the fixed space maintainers in a solitary study and also due to variation in the follow-up period in each study. Importantly, there were only 4 clinical trials on comparing metal and resin space maintainers and those 4 studies compared only band and loop space maintainers with resin space maintainers. There was no meaningful comparison to arrive at a decision on which space maintainer serves its best. The included studies were all prospective longitudinal clinical trials. This systematic review did not include other type of studies such as fabrication techniques, case reports and reviews in order to maintain the homogeneity with the study design.

Quality assessment of the selected articles was done using Quality of Reporting of Observational Longitudinal Research and the risk of bias was evaluated based on the articles fulfilling these criteria. Out of 11 included studies, providentially, only one study carried a high risk of bias. (Table 2) This systematic review included only clinical trials as there were no randomized clinical trials conducted to evaluate the survival rate of fixed space maintainers due to general problems, such as ensuring equal dental treatment in both study arms, blinding and difficulty to allocate equal number of specific space maintainers for all the treatment groups. Though it is difficult, it is possible to conduct a randomized clinical trial in future by addressing all the drawbacks of the available studies.

4.1. Assessment of individual space maintainers

4.1.1. Band and loop space maintainer

Out of 11 included studies, 7 studies had evaluated the survival rate of band and loop space maintainers. Baroni et al. (1994) had stated that, there was no significant difference in the survival rate of band and loop, Lingual arch and Nance palatal arch space maintainer. Most of the included studies had stated that, band and loop space maintainer exhibited higher survival
rate and the most common reason stated for the failure of the appliance was cement failure and solder breakage (Subramaniam et al., 2008; Sasa et al., 2009; Tunc et al., 2012; Setia et al., 2014; Garg et al., 2014). Based on the above mentioned studies, it can be declared that, band and loop provided satisfactory results in terms of its survival rate. Unfortunately, a study conducted by Qudeimat and Sasa (2015) had disclosed that, band and loop exhibited a lesser survival time of 18.8 months as compared to that of crown and loop space maintainer (40.4 months). So, further clinical trials comparing band and loop and crown and loop with a larger sample size is required to draw a definitive conclusion.

4.1.2. Crown and loop space maintainer;
A study by Qudeimat and Sasa (2015) assessed the survival rate of crown and loop space maintainer and concluded that it had higher survival rate as compared to band and loop space maintainer. Hence, further clinical trials are needed to evaluate the survival rate of crown and loop space maintainer and its comparison with other types of fixed space maintainers.

4.1.3. Nance palatal arch space maintainer
Out of the 11 included studies, only one prospective longitudinal study evaluated the survival rate of Nance palatal arch space maintainer. The author had concluded that, the Nance palatal arch maintained a constant survival rate of 70% at the end of 36 month interval (Baroni et al., 1994). Since Nance palatal arch exhibited a high survival rate, it is imperative to compare its survival rate with other fixed metal and resin space maintainer.

4.1.4. Lower lingual arch space maintainer
Baroni et al. (1994) evaluated the survival rate of lingual arch space maintainer. The author had stated that lingual arch space maintainer had higher number of failures as compared to band and loop space maintainer and Nance palatal arch space maintainer. The possible explanation for the failure of lingual arch space maintainers were tongue interferences, high occlusal load and long span arm (Qudeimat and Fayle, 1998; Moore and Kennedy, 2006).

4.1.5. Resin space maintainers
Few studies have assessed the survival rate of resin space maintainers but none of the studies had proved that it is superior over metal space metal maintainers (Kargul et al., 2005; Saravanakumar et al., 2013; Subramaniam et al., 2008; Tunc et al., 2012; Garg et al., 2014; Kirzioglu et al., 2017). Even though, resin space maintainer has several advantages like ease of fabrication, less bulky, patient compliance, still a well designed clinical trial with adequate follow up period is required to evaluate its longevity.

4.1.6. Simple fixed space maintainer
Simsek et al. (2004) assessed the clinical performance of simple fixed space maintainer and followed up longitudinally for a period of 12–18 months. This is the one of the first study to design and assess the survival rate of simple fixed space maintainer. The author had concluded that there was no loss of abutment space during the follow-up period and can be considered as a successful fixed space maintainer based on clinician experience and selection of patients. Though the author proved it as a successful appliance, no relevant comparison was done with other fixed space maintainers. Hence, clinical trials comparing simple fixed space maintainer with other space maintainers are required to ensure its success rate and survival rate.

4.1.7. Direct bonded space maintainer
Tunc et al. (2012) evaluated the survival rate of Direct bonded space maintainer and compared with Band and loop space maintainer and fibre reinforced space maintainer. The author had stated that the direct bonded space maintainer exhibited a high failure rate of 60% with the survival period of 9.2 months. A study conducted by Swaine and Wright (1976) has stated a 70% success rate for Direct Bonded space maintainer. Debonding and swallowing of the broken wires are considered as risk factors in fabrication of direct bonded space maintainer. Due to these conflicting results, further studies are needed to obtain a better conclusion on its survival period and success rate.

4.1.8. Limitations
Shortcomings of the included studies were, lacking a proper study design and insufficient reporting of data, namely sample selection, allocation, randomization, blinding and follow-up period. Sample size calculation and the power of the study were not mentioned in any of the included study. The conclusion would have been more meaningful if all these confounders were addressed. Though we maintained homogeneity in study selection, Meta analysis interpretation was not possible due to lack of comparison of similar space maintainers in any of the included studies.

The drawback of this systematic review is the effect of confounding factors (age, sex, dental arch, side of jaw) in each study variables which can directly influence the survival rate. Since there is no properly designed clinical trial which compared the different types of space maintainer, no definitive conclusion can be drawn. Hence, a properly designed clinical trial comparing different types of metal based space maintainer and resin based space maintainer with longer duration of follow-up must be performed to evaluate its survival rate.

5. Conclusion
In the light of available evidences, following conclusion can be drawn.

- There is a wide variation in the survival rate of metal based and resin based space maintainers and within the metal based space maintainers.
- There is an insufficiency of evidences to make any recommendation on which fixed space maintainer is appropriate due to lack of properly designed studies.
- Most of the included studies have assessed the survival rate of Band and loop space maintainer and direct comparison of Resin space maintainer was done only with band and loop space maintainer. Meaningful comparison of survival rate of metal and resin based space maintainers cannot be made from these studies, as there was no uniform distribution of types of space maintainers selected in the included studies.
Ethical statement

We further confirm that any aspect of the work covered in this manuscript that has involved either experimental animals or human patients has been conducted with the ethical approval of all relevant bodies and that such approvals are acknowledged within the manuscript.

Conflict of interest

The author declared that there is no conflict of interest.

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