

Survival rate of fixed space maintainers used in Dentistry. Systematic review and Meta-analysis.

Tasa de supervivencia de los mantenedores de espacio fijos utilizados en Odontología. Revisión sistemática y metanálisis.

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Abstract: **Objective:** To determine, through a systematic review and meta-analysis, the survival rate of fixed space maintainers used in Dentistry. **Material and Methods:** A literature search was carried out, following the guidelines of the PRISMA standards, until March 2020, in the biomedical databases: *Pubmed, Embase, Scielo, Science Direct, Scopus, SIGLE, LILACS, Google Scholar* and the *Cochrane Central Registry of Clinical Trials*. The selection criteria of the studies were defined as: clinical trials, without language restriction, up to 10 years old and that report the survival rate of fixed space maintainers used in dentistry. Study risk of bias was analyzed using the *Cochrane Handbook of Systematic Reviews of Interventions*. **Results:** The search strategy resulted in 159 articles, of which 10 were ultimately included for the present study. All included articles reported that the overall survival rate of the fixed space maintainers used in Dentistry was between 20% and 95%; the one with the highest survival rate is the crown and loop with 86.3%. When comparing the fiber-reinforced composite space maintainers with the band and loop it was observed that there is no difference between them; when comparing the crown and loop with the band and loop, a difference was observed, favoring the crown and loop. **Conclusion:** The reviewed literature suggests that the overall survival rate of fixed space maintainers used in dentistry ranges from 20 to 86.3% with a follow-up time of 6 to 18 months.

Keywords: *space maintenance, orthodontic; child; longevity; survival rate; dentistry; meta-analysis.*

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Resumen: **Objetivo:** Determinar, a través de una revisión sistemática y metanálisis, la tasa de supervivencia de los mantenedores de espacio fijos utilizados en Odontología. **Material y Métodos:** Se realizó una búsqueda bibliográfica, siguiendo los lineamientos de los estándares PRISMA, hasta marzo de 2020, en las bases de datos biomédicas: *Pubmed, Embase, Scielo, Science Direct, Scopus, SIGLE, LILACS, Google Scholar* y el *Registro Cochrane Central*. de Ensayos Clínicos. Se definieron los criterios de selección de los estudios que fueron: ensayos

clínicos, sin restricción de idioma, con una antigüedad menor a 10 años y que reporten la tasa de supervivencia de los mantenedores de espacio fijos utilizados en odontología. El riesgo de sesgo del estudio se analizó mediante el Manual Cochrane de Revisiones Sistemáticas de Intervenciones. **Resultados:** La estrategia de búsqueda arrojó 159 artículos, de los cuales 10 finalmente se incluyeron en el presente estudio. Todos los artículos incluidos reportaron que la tasa de supervivencia global de los mantenedores de espacio fijos utilizados en Odontología estuvo entre el 20% y el 95%, dentro de los mantenedores de espacio el que presenta mayor tasa de supervivencia es el de corona

y asa con un 86,3%. Al comparar los mantenedores de espacio compuestos reforzados con fibra con los de banda y bucle se observó que no hay diferencia entre ellos; y al comparar la corona y lazada con la banda y bucle se observó una diferencia a favor de la corona y lazada. **Conclusion:** La literatura revisada sugiere que la tasa de supervivencia general de los mantenedores de espacio fijos utilizados en odontología oscila entre 20 y 86,3 % con un tiempo de seguimiento de 6 a 18 meses.

Palabras Clave: *mantenimiento del espacio en ortodoncia; niño; longevidad; tasa de supervivencia; odontología; meta análisis.*

INTRODUCTION.

Currently, one of the challenges in Dentistry is the loss of space between the teeth caused by the premature loss of primary teeth.¹ Premature loss of primary teeth is commonly caused by poor oral hygiene and tooth decay.²⁻⁵ Recent studies worldwide report that the premature loss of primary teeth ranges between 8.5% and 66.4%.²⁻⁸

The primary or deciduous teeth play an important role in the growth and development of children; because they influence chewing, speech, jaw growth, aesthetics and occlusion. However, most importantly, these teeth serve as natural space maintainers for their permanent successors.^{9,10}

When a primary tooth is lost prematurely, a series of gradual events take place, affecting the occlusion of the permanent dentition causing: crowding of the dental arch, ectopic eruption and impaction of the permanent tooth, inclination of the adjacent teeth, crossbite formation and discrepancies in the dental midline.^{1,9-11} However, these problems can be prevented or reduced if the dentist makes proper planning and uses a space maintainer (SM) during treatment.^{1,9-11}

Currently, various devices can be used for space maintenance, depending on the age of the patient, the growth and development of dental arches and the cooperative capacity of the patient.^{1,10}

The SMs can be fixed or removable, unilateral or

bilateral. Fixed unilateral SMs include the band and loop (BL), crown and loop (CL), direct bonding (DB), fiberglass reinforced composite resin (FRCR), and the distal end shoe or distal shoe (DS). Fixed bilateral SMs include the lingual arch (LA), the Nance arch (NA), and the transpalatal arch (TA).^{9,10-11}

Removable SMs are generally functional and easy to clean, helping to maintain good oral hygiene; however, they have several disadvantages such as: poor retention, less tolerance on the part of the patient and high possibilities of fracture and loss of SM. (1, 9) Fixed SMs are most appropriate for longer periods of space maintenance,¹ however, despite being well tolerated and durable,^{1,9} should be removed once a year to allow inspection, cleaning, and application of fluoride to teeth.¹

There are few studies^{1,11} that deal with the survival rate of SM; however, as specialist or general practice dentists, it is important to have a clear understanding of this topic, since survival of the SM until subsequent tooth eruption is the most important factor in determining the success of the appliance, as it measures its principal function.⁹ In addition, it is known that there is limited evidence in the literature for or against the use of SMs,^{10,12} a recent report by the Canadian Agency for Drugs and Technologies in Health found that the evidence is limited due to poor quality and poor presentation of studies.¹⁰

Thus, there is a need for a systematic review to cri-

tically evaluate and summarize the results of clinical trials (CT) evaluating various SMs (metal and resin based). This systematic review aimed to determine the survival rate of fixed SM used in dentistry.

MATERIALS AND METHODS.

Study design and inclusion/exclusion criteria

The development of the present review was carried out in accordance with a previously prepared research protocol following the guidelines of the PRISMA standards.¹³

PICOS strategy

- Population: Child patients (≤ 10 years) with deciduous or mixed dentition
- Intervention: Fixed space maintainers
- Comparison: Comparator not applicable
- Outcomes: Survival rate
- Studies: Clinical trials

Search

A comprehensive search strategy was performed in the biomedical databases Pubmed, Embase, Scielo,

Science Direct, Scopus, SIGLE (System of Information on Gray Literature in Europe), LILACS, Google Scholar and in the Cochrane Central Register of Clinical Trials until March 2020; through the use of a combination of thematic headings through the following keywords and Boolean connectors: ((space maintainer) OR space maintainers) AND ((((((longevity) OR durability) OR failure rate) OR success rate) OR survival period) OR survival rate). The search in the electronic database was carried out by two authors (JC and RCH) independently, and the final inclusion decision was made according to the following selection criteria:

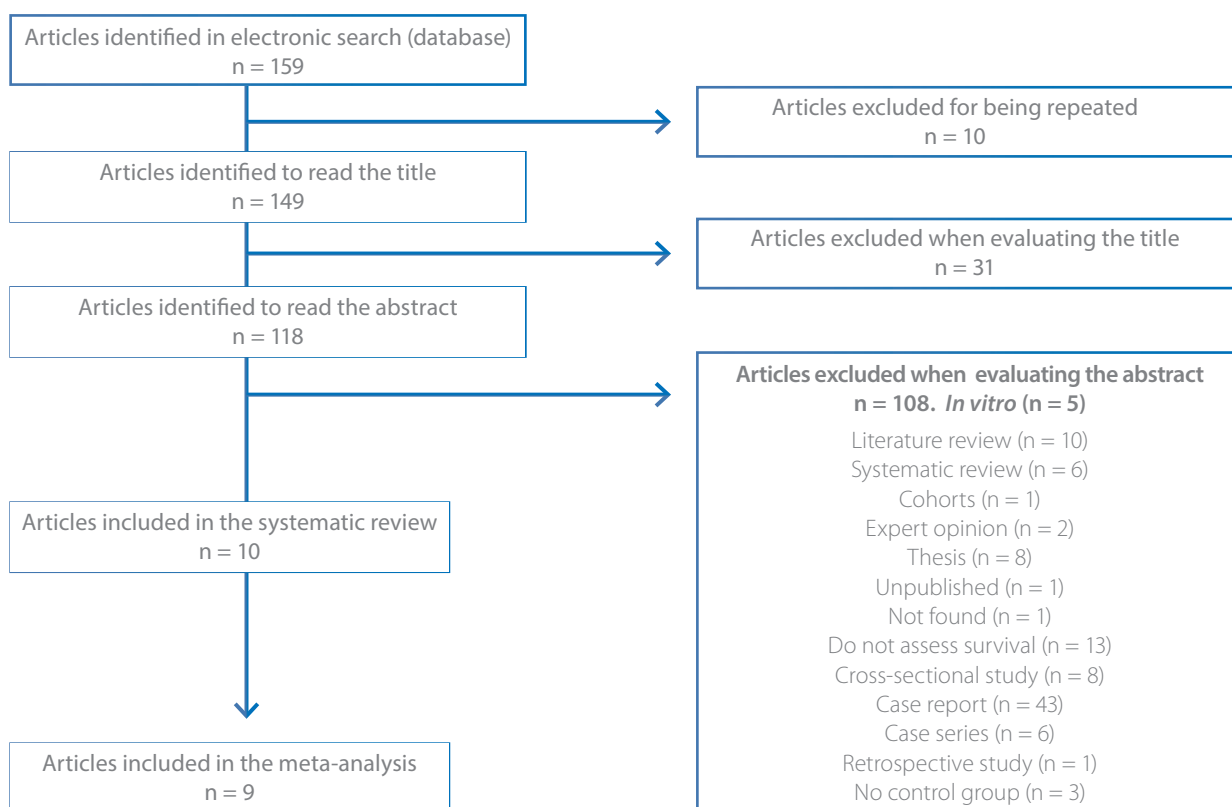
Selection criteria

Inclusion criteria

- Articles that reported the survival rate of SM in children less than or equal to 10 years.
- Articles without language restriction and 10 years old.
- Articles that are clinical trials with a follow-up time greater than or equal to 6 months.

Exclusion criteria

Figure 1. Flow chart of methodology



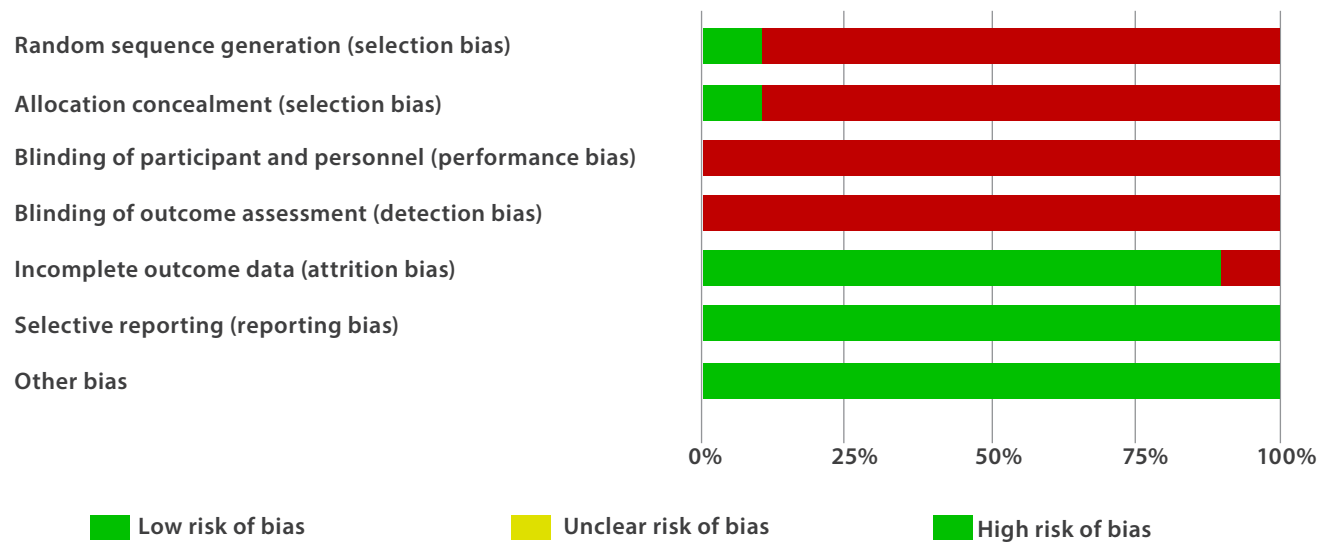
- Articles that are from non-indexed journals.

Data selection and extraction process

The titles and abstracts of each of the studies obtained with the inclusion and exclusion criteria previously described were reviewed; and the full texts of the studies that met these parameters were obtained to determine their risk of bias.

In order to assess the studies, a checklist was made in duplicate, in order to extract the information of interest and switch the data. Three reviewers (JC, RC and JA) independently evaluated the articles regarding name, author, year of publication, type of study, number of patients (pro-portion between men and women), mean age and age range of the

Figure 2. Flow chart of methodology.



Study	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participant and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Abdulhameed <i>et al.</i> , ²⁰ (2014)	+	-	-	-	+	+	+
Eshghi <i>et al.</i> , ¹⁷ (2018)	-	-	-	-	-	+	+
Garg <i>et al.</i> , ²² (2014)	-	-	-	-	+	+	+
Ghoname ²³ (2013)	-	-	-	-	+	+	+
Kamal <i>et al.</i> , ¹⁸ (2017)	-	-	-	-	+	+	+
Mittal <i>et al.</i> , ¹⁶ (2018)	-	-	-	-	+	+	+
Potgieter <i>et al.</i> , ¹⁵ (2018)	-	-	-	-	+	+	+
Qudeimat <i>et al.</i> , ¹⁹ (2018)	-	-	-	-	+	+	+
Setia <i>et al.</i> , ²¹ (2014)	+	+	-	-	+	+	+
Tunc <i>et al.</i> , ²⁴ (2012)	-	-	-	-	+	+	+

patients, follow-up time, country where the study was conducted, study groups, number of patients per study group, inclusion and exclusion criteria, survival rate by group, overall survival rate, failure rate (disunity or decementation, fracture, flexion or distortion, and soft tissue injuries) and risk of bias for each study. For the resolution of any discrepancy

between the reviewers, they met and discussed together with a fourth reviewer (AR) in order to reach an agreement.

Assessment of the risk of bias of the studies

For the assessment of risk of bias, each study was analyzed according to the Cochrane Handbook of Systematic Reviews of Interventions.¹⁴

Table 3. Survival rate and failures according to the type of SM.

Study or Subgroup	Experimental		Control		Weight	Risk Ratio M.H. Ramdom, 95% CI	Risk Ratio M.H. Ramdom, 95% CI	Risk Bias						
	Events	Total	Events	Total				A	B	C	D	E	F	G
2.1.1 MERCRF vs MEBA														
Garg et al., ²² (2014)	19	30	11	30	10.9 %	1.73 [1.00, 2.97]		-	-	-	-	+	+	+
Kamal et al., ¹⁸ (2017)	14	15	13	15	15.8 %	1.08 [0.85, 1.37]		-	-	-	-	+	+	+
Mittal et al., ¹⁶ (2018)	12	15	13	15	14.6 %	0.92 [0.67, 1.27]		-	-	-	-	+	+	+
Potgieter et al., ¹⁵ (2018)	5	10	5	10	6.8 %	1.00 [0.42, 2.40]		-	-	-	-	+	+	+
Setia et al., ²¹ (2014)	5	11	11	15	8.5 %	0.62 [0.30, 1.27]		-	-	-	-	+	+	+
Tunc et al., ²⁴ (2012)	2	10	9	10	4.1%	0.22 [0.06, 0.78]		-	-	-	-	+	+	+
SUBTOTAL (95% CI)		91		95	60.8%	0.95 [0.68, 1.32]		-	-	-	-	+	+	+
TOTAL EVENTS	57		62											
Heterogeneity: Tau²=0.08; Chi²=12.11, df=5(P=0.03); I²=59%														
2.1.2 MECA vs MEBA														
Eshghi et al., ¹⁷ (2018)	19	20	16	20	15.8 %	1.19 [0.93, 1.51]		+	+	-	-	+	+	+
Kamal et al., ¹⁸ (2017)	14	18	3	18	5.3%	4.67 [1.61, 13.50]		-	-	-	-	+	+	+
SUBTOTAL (95% CI)		38		38	21.1%	2.24 [0.32, 15.77]		+	+	-	-	+	+	+
TOTAL EVENTS	33		19											
Heterogeneity: Tau²=1.83; Chi²=12.88, df=1(P=0.0003); I²=92%														
Test for overall effect: Z=0.81 (P=0.42)														
2.1.3 MEUD vs MEBA														
Abdulhameed et al., ²⁰ (2014)	7	15	13	15	10.5%	0.54 [0.30, 0.96]		-	-	-	-	+	+	+
Tunc et al., ²⁴ (2012)	4	10	9	10	7.7%	4.67 [0.20, 0.98]		-	-	-	-	+	+	+
SUBTOTAL (95% CI)		25		25	18.2%	0.50 [0.32, 0.80]		-	-	-	-	+	+	+
TOTAL EVENTS	11		22											
Heterogeneity: Tau²=0.00; Chi²=0.15, df=1(P=0.70); I²=0%														
Test for overall effect: Z=2.86 (P=0.004)														
TOTAL (95% CI)		154		158	100%	0.94 [0.70, 1.26]								
TOTAL EVENTS	101		103											
Heterogeneity: Tau²=0.12; Chi²=30.20, df=g(P=0.0004); I²=70%														
Test for overall effect: Z=0.42(P=0.68)														
Test for subgroup differences: Tau²=5.93; df=2(P=0.05); I²=66.3%														

Risk of bias legend

- A) Random sequence generation (selection bias).
- B) Allocation concealment (selection bias).
- C) Blinding of participants and personnel (performance bias).
- D) Blinding of outcome assessment (detection bias).
- E) Incomplete outcome data (attrition bias).
- F) Selective reporting (reporting bias).
- G) Other bias.

Analysis of results

The data from each study was placed and analyzed in the RevMan 5.3 program (Cochrane Group, UK). The meta-analysis is presented in a forest plot graph, using the relative risk (RR) as a measure of effect, the Mantel-Haenszel statistical method, a random analysis model, and a 95% confidence interval (CI).

RESULTS.

Selection of studies

The initial search in the biomedical databases determined a total of 159 titles, available until March 2020, of which 10 were repeated titles so that only 149 remained.

Then the titles were read excluding 31, then their summaries were read and Those who did not meet the inclusion criteria were discarded. 10 articles were selected for an exhaustive review of their content and methodology, discarding 1 article for subsequent meta-analysis (Figure 1).

Characteristic and results of the studies

In all included studies¹⁵⁻²⁴ the number of patients ranged from 15 to 60 with a follow-up time of 6

months to 18 months. Three studies^{17,23,24} reported that the mean age of the patients ranged from 5 to 6.9 years.

Five studies^{17,19,20,23,24} reported that the total number of patients in relation to their gender (men and women) was 82 and 84 respectively. All studies¹⁵⁻²⁴ specified that the ages of the patients were between 4 and 10 years. The countries where the studies were carried out were:

South Africa,¹⁵ India,^{16,21,22} Iran,¹⁷ Turkey,²⁴ Egypt,^{18,23} United Arab Emirates¹⁹ and Iraq.²⁰ The total number of treated patients was 336. All studies¹⁵⁻²⁴ were randomized clinical trials (RCTs), of which 7^{15-17, 19-21,24} were parallel and 3^{18,22,23} were crossed. Regarding the type of SM, fixed studies were used in all studies,¹⁵⁻²⁴ of which 10,¹⁵⁻²⁴ 2,^{17,19} 2^{20,24} and 6^{15,16,18,21,22,24} studies used BL, CL, DB and FRCR respectively.

In all studies¹⁵⁻²⁴ the survival rate of each of the SM was reported. Within the evaluated failure rates it was observed that 9,^{15-20,22-24} 6,^{15,18,20,22-24} and 5^{16,19,22-24} studies mentioned disunity or decementation and fracture, flexion or distortion, and soft tissue injuries of the SMs respectively

Table 1. Survival rate and failures according to the type of SM.

SM type		FRCR	BL	CL	BL in saddle	Custom BL	FRCR impregnated	DB	FRCR super splint	S	MEAN
		(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
Survival rate	6 months	56.7	34.6	77.5	NR	NR	NR	NR	NR	NR	56.2
	9 months	45.5	73.3	NR	NR	84.6	NR	NR	33.3	NR	59.2
	12 months	64.4	85.7	NR	85.7	NR	73.3	43.4	NR	20	62.1
	18 months	NR	80	95	NR	NR	NR	NR	NR	NR	87.5
	MEAN	55.5	68.4	86.3	85.7	84.6	73.3	43.4	33.3	20.0	61.2
Failures	Disunity or decementation	28.0	21.9	2.8	14.3	NR	20	43.4	NR	0.0	18.6
	Fracture	9.3	4	11	0.0	NR	6.7	0%	NR	26.7	8.2
	Flexion or distortion	0.0	7.2	NR	0.0	NR	NR	13.4	NR	53.3	14.8
	Soft tissue injuries	2.2	2.4	0.0	0.0	NR	0.0	0.0	NR	NR	0.8
	MEAN	9.9	8.9	4.6	3.6	NR	8.9	14.2	NR	26.7	11.0

NR: Not reported. BL: Band and loop space maintainer. FRCR: Fiberglass reinforced composite resin space maintainer. CL: Crown and loop space maintainer; S: Sannrud space maintainer. DB: Direct bonding space maintainer.

Table 1. Characteristics of included studies.

Author Year	Type of study	No. of patients (male/female)	Mean age (range)	Follow-up time	Country	Study groups	No. of patients per group	Disunity or decem-entation (%)	Fracture (%)	Flexion or distortion (%)	Soft tissue injuries (%)	Survival rate per group (%)	Overall survival rate (%)
Potgieter et al. ¹⁵ (2018)	RCT parallel	20	(4-9)	6 months	South Africa	FRCR	10	3/10 (30)	2/10 (20)	0/10 (0)	NR	5/10 (50)	10/20 (50)
Mittal et al. ¹⁶ (2018)	RCT parallel	45	(6-9)	12 months	India	BL	10	0/10 (0)	1/10 (10)	4/10 (40)	NR	5/10 (50)	36/45 (80)
Eshghi et al. ¹⁷ (2018)	RCT parallel	40	5	18 months	Iran	BL	15	1/15 (6.7)	1/15 (6.7)	NR	0/15 (0)	13/15 (86.7)	25/40 (87.5)
Kamal et al. ¹⁸ (2017)	RCT crossover	15	(5-7)	12 months	Egypt	FRCR impregnated	15	2/15 (13.3)	0/15 (0)	NR	0/15 (0)	12/15 (80)	27/30 (90)
Qudeimat et al. ¹⁹ (2015)	RCT parallel	36	(3.4-6.3)	6 months	Arab Emirates	CL	20	3/15 (20)	1/15 (6.7)	NR	0/15 (0)	11/15 (73.3)	17/36 (47.22)
Abdulhameed et al. ²⁰ (2014)	RCT parallel	45	(4-7)	12 months	Iraq	BL	15	0/20 (0)	1/20 (5)	NR	NR	19/20 (95)	23/45 (51.13)
Setia et al. ²¹ (2014)	RCT parallel	60	(4-9)	9 months	India	BL	15	4/20 (20)	0/20 (0)	NR	NR	16/20 (80)	31/51 (60.8)
Garg et al. ²² (2014)	RCT	30	(5-8)	6 months	India	BL	30	1/18 (5.5)	3/18 (17)	NR	0/18 (0)	14/18 (77.5)	30/60 (50)
Ghonomie et al. ²³ (2013)	RCT crossover	15	6.87	12 months	Egypt	BL in saddle	15	13/18 (72)	1/18 (5.5)	NR	1/18 (5.5)	3/18 (17)	23/28 (82.2)
Tunc et al. ²⁴ (2012)	RCT parallel	30	6.9±1.53	12 months	Turkey	BL	10	1/15 (6.7)	1/15 (6.7)	0/15 (0)	NR	13/15 (86.7)	15/30 (50)

NR: Not reported. RCT: Randomized clinical trial. BL: Band and loop space maintainer. FRCR: Fiberglass reinforced composite resin space maintainer. CL: Crown and loop space maintainer. S: Sannrud space main-tainer. DB: Direct bonding space maintainer.

(Table 1).

The average survival rate and failure rate according to the type of SM, (Table 2).

Analysis of study risk of bias

All studies¹⁵⁻²⁴ showed a high risk of bias (Figure 2).

Synthesis of results (Meta-analysis)

Analysis of the survival rate between the different SMs used in Dentistry (Figure 3): The comparison of the survival rate between the different SM used in Dentistry, were determined in 9 studies^{15-22,24} revealing that there was no significant difference between the different types of SM (RR = 0.94, CI 95% = [0.7, 1.26], $I^2 = 70\%$, $p=0.68$). One study²³ was not taken into account as there was no additional study comparing the same SMs.

Subgroup analysis

The comparison of the survival rate between the FRCR and the BL were determined in 6 studies^{15, 16,18,21,22,24} which showed that there was no significant difference (RR = 0.95, CI 95% = [0.68, 1.32], $I^2 = 59\%$, $p= 0.76$). The comparison of the survival rate between the CL and the BL were determined in 2 studies^{17,19} which showed that there was no significant difference (RR = 2.24, CI 95% = [0.32, 15.77], $I^2 = 92\%$, $p= 0.42$).

The comparison of the survival rate between the DB and the BL were determined in 2 studies^{20,24} which showed that there was a significant difference, with a tendency to use the BL (RR = 0.5, CI 95% = [0.32, 0.8], $I^2 = 0\%$, $p = 0.004$).

DISCUSSION.

The objective of this systematic review was to determine the survival rate of SM used in dentistry, based on randomized clinical trials (RCTs).

The results showed that the survival rate of EM varies from 20 to 86.3%, with an average of 61.2%, for a follow-up time of 6 months to 18 months.

This found result could possibly be due to the fact that the studies covered different types of SM where some had a low survival rate and, furthermore, that the majority of studies when comparing only did it between 2 types of SM. When trying to determine the best SM, it depends on its longevity and its

clinical efficacy results (gingival health, plaque accumulation, abutment tooth condition and ease of manufacturing the appliance).

In the present study, it was demonstrated that the failure rates varied between the studies and that the most common cause of failure was disunity or decementation in SM. This common failure may possibly be due to the bond strength of the primary tooth enamel being considerably less than that of the permanent tooth enamel. This can be attributed to the presence of prismfree areas in the enamel of the primary teeth, which tend to have an adverse effect on the strength of the joint, which affects the retention of the resin.² The main reasons for failure of the enamel-resin bond are inadequate surface preparation, moisture contamination, and disturbances during the ad-hesive setting process.² From all of the above, it follows that it is reasonable to expect that SMs may need replacement or repair during treatment.

Therefore, dentists should also take into account the ease of repair, maintenance, and risk of adverse effects when selecting a type of SM. The strength of this systematic review lies in the selection of studies (clinical trials) because an exhaustive search in the most important databases was used and strict selection criteria were used.

However, because the RCTs analyzed did not present a comparison of all the SMs, they presented a high risk of bias (did not present randomization and blinding of participants and personnel) and a high heterogeneity among them ($\text{Tau}_2 = 0.12$, $I^2 = 70\%$), and the majority of these studies are from countries of the Asian continent, which can cause a dilemma since each continent and country has its own culture, ethnicity and type of diet and we believe that these factors can influence future results; it was shown that there is still inadequate scientific evidence to provide a definitive inference about the survival rate of SM.

That is why we recommend performing well-designed RCTs, avoiding heterogeneity between each of the studies, with an adequate sample size and comparing the different types of SM, in order to be able to compare the results and reach a clearer and

more general conclusion.

CONCLUSION.

In general, and based on the results obtained, the survival rate of fixed SMs used in dentistry varies from 20 to 86.3% with a follow-up time of 6 to 18 months.

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Authors' contributions: Arbildo-Vega H: Planned the protocol for the systematic review and meta-analysis, supervised the progress made, is the corresponding author, performed the meta-analysis and revised the final manuscript.

Cantu-Oliva J: searched for information in the databases, extracted the data from the selected articles, collected the data and revised the final manuscript.

Chumpitaz-Durand R: searched for information in the databases, extracted the data from the selected articles, collected the data, assessed the methodological quality of the included studies, and revised the final manuscript.

Agüero-Alva J: Extracted the data from the selected articles, collected the data, assessed the methodological quality of the included studies, and revised the final manuscript.

Rendón-Alvarado A: Collected data, resolved any discrepancy when evaluating the methodological quality of the included studies and revised the final manuscript.

Vásquez-Rodrigo H: Drafted the manuscript and revised the final manuscript.

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