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Space changes after early loss of primary 1st molars: A Systematic Review

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ABSTRACT: Background: Opinions vary about the necessity for space maintenance following early removal of first primary molars (D). This review aims to determine the amount of space changes 6 to 12 months after Ds extraction.
Methods: A comprehensive literature search was systematically performed across major biomedical databases to identify relevant studies, such as PUBMED, EMBASE, LILACS, and the Cochrane Library, to identify pertinent studies. Article selection was guided by predetermined eligibility criteria, encompassing both inclusion and exclusion parameters. The principal focus of the analysis was the quantitative assessment of dimensional alterations in the post-extraction space, specifically within the D or D+E regions
Results: Five studies were eligible for inclusion. Results showed that space was lost after premature extraction of primary 1st molars. Upper space loss on control side was less than that of the extraction side, the difference was -0.88 mm (95% CI -1.66 to -0.12; P = 0.004). Lower space loss on the control side was less than the extraction side; the difference was -1.41 mm (95% CI) -1.95 to -0.88; P < 0.001).
Conclusion: The amount of space loss resulting from early extraction is greater than the size difference between the deciduous 1st molar and its successor. It is the clinician's choice to decide whether this amount of space loss is clinically significant enough to place a space maintainer or not.
KEYWORDS: Space maintenance, children, space changes.

I. INTRODUCTION

The natural growth of primary molars is a contributing factor for the development of occlusion. The role they play in preserving the space of their preceding permanent counterparts has made their early loss a valid reason for clinicians to consider space maintenance to avoid loosing the space in the dental arch during development, and its implications in causing or exacerbating a malocclusion thus increasing orthodontic requirements[1].

The premature loss of primary second molars has been widely recognized as having a more significant impact on arch integrity and occlusal development compared to the early extraction of first primary molars. Due to its pivotal role in maintaining dental alignment, the primary second molar is often regarded as a cornerstone of the primary dentition [2]. Current evidence presents conflicting perspectives regarding the clinical significance of premature primary first molar loss and its associated space reduction in developing dentition [1] and since space maintainers may increase risk of decalcification below the bands [3], the benefits of its use must outweigh its potential risk to be indicated in certain situations.

In 2008, In their systematic review, Tunison et al. [4] examined the consequences of primary first molar extraction, ultimately determining that the resulting space reduction lacked clinical significance. Kaklamanos et al. [5] conducted another systematic review in 2016 but he focused on lower space loss and included only 2 studies.in 2024, Zhao et al. investigated the same topic, but he included different types of studies, including cross-sectional studies[6], These studies can negatively affect data analysis either because they lacked baseline information on pre-extraction conditions or because the follow-up period after tooth loss couldnot be precisely determined. Therefore, this systematic review aimed to evaluate current evidence on whether space maintenance is necessary after the premature loss of 1st first molars (Ds).

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II. Materials and Methods

A broad range of electronic databases including PUBMED, EMBASE, Lilacs and Cochrane libraries were solicited for articles through September 2, 2024 (Table 1). Both free-text and controlled terms (MeSH and EMTREE) were used when appropriate The search used combinations of the following key words : Premature or early' 'Deciduous molars', 'Primary molars', 'Temporary molars', , ', 'Loss or extraction or removal', 'Space loss', 'D space', and 'migration and drift' 'Baby molars'. The reference lists and citations of the studies that were included were also reviewed.

Table 1 showing number of hits for different databases searched

	Search terms	PUBMED (to 02/09/24)	COCHRANE LIBRARY (to 02/09/24)	IILACS (to 02/09/24)	EMBASE (to 02/09/24)
1	primary AND molar*	9178	21	2180	9902
2	deciduous AND molar*	4907	6	1551	4967
3	Temporary AND molar*	909	185	278	779
4	Baby AND molar*	1476	7	1291	187
5	Premature OR early	2,291,866	1971	**135927**	3,091,090
6	Extract* OR loss OR remov*	3,150,623	7151	**204117**	4,450,284
7	space AND loss	26,029	49	**1350**	30,760
8	D AND space	42,785	8	**14253**	160,014
9	migration OR drift	469,348	46	**39296**	615,795
10	1 OR 2 OR 3 OR 4	12,978	22	2587	12,822
11	7 OR 8 OR 9	534,723	101	**53675**	792,830
12	5 AND 6 AND 10 AND 11	177	1	42	154

Inclusion Criteria

Only prospective observational studies were included in our analysis, if it has a control group with an intact primary first molar. Study participants were children between the ages of six to nine years with first primary molars of poor prognosis who underwent extraction of primary first molar within one week of the first measurement. The primary outcome measure was the amount of change in extraction space (D or D+E space). Studies should have at least 6 months follow up period and were all reported in English.

Study Selection Process

Two independent evaluators (A.K.E. and M.A.) screened all identified studies against the predetermined inclusion criteria. The screening process involved:

1. Initial triage of search results based on title and abstract review
2. Full-text retrieval for potentially eligible studies or when abstract information proved inconclusive
3. Direct author contact for inaccessible publications
4. Resolution of inter-rater discrepancies through deliberative consensus

Data Extraction

The research team systematically extracted all relevant data in accordance with the STROBE guidelines (Strengthening the Reporting of Observational Studies in Epidemiology), an internationally recognized reporting framework officially supported by the World Health Organization. [7] Information extracted from each article included author information, year of publication, study design, sample size, exclusions and dropouts, follow up duration, eruption stage of first permanent molar, space changes, data sources, statistical methods, and results. Two independent researchers conducted the data extraction process

Table 2: Risk of bias assessment

Evaluation Criteria	"Unmet" Condition	"Met" Condition
- Inclusion/Exclusion Criteria Definition	- Not specified	Clearly specified
Outcome Definition	Not specified	Clearly specified
Comparability of Intervention/Control Groups	High risk of bias or lack of discussion	Groups are adequately comparable, or bias is controlled for
Participant Follow-up	Less than 80% of initial participants included in the final analysis	At least 80% of initial participants included in the final analysis
Rater Reliability	Inter- and intra-rater reliability not reported	Inter- and intra-rater reliability reported with satisfactory agreement
Outcome Assessment Blinding	Not reported	Clearly defined

Assessment for risk of bias

We implemented a customized bias assessment framework incorporating six critical domains derived from STROBE and Cochrane standards [7,8], modified for observational research. The grading system categorized studies as: high-risk (fulfilling ≤2 criteria), moderate-risk (3-4 criteria), or low-risk (≥5 criteria) (Table 2)

Measure of effect size

D or D+E space changes were measured on a continuous scale and were analyzed according to

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differences in mean treatment effects and their standard deviations.

Heterogeneity Evaluation

Visual inspection of forest plots (displaying estimated treatment effects with 95% CIs) complemented quantitative assessment using the I^2 statistic. Following Cochrane guidelines [8], we interpreted I^2 values as: up to 40 percent as minimal heterogenicity, 30 to 60 percent as moderate heterogeneity, 50 to 90 percent as substantial heterogeneity and 75 to 100 percent as considerable heterogeneity

Statistical analysis

We implemented inverse-variance weighted meta-analyses, computing pooled effect estimates through both Fixed-effects models (assuming common true effect) and Random-effects models (accounting for inter-study variance).All computations were executed in R (v2.15.2, The R Foundation for Statistical Computing), with the "meta" package facilitating statistical operations.

III. Results

Two hundred and six studies were identified in the search. There was additional ten articles included via a review of reference lists. After doing the necessary exclusion of irrelevant titles and abstracts, 30 articles were evaluated.Application 0f incision and exclusion criteria resulted in 5 eligible publications (Figure 1), the excluded articles are listed in Table 3 .

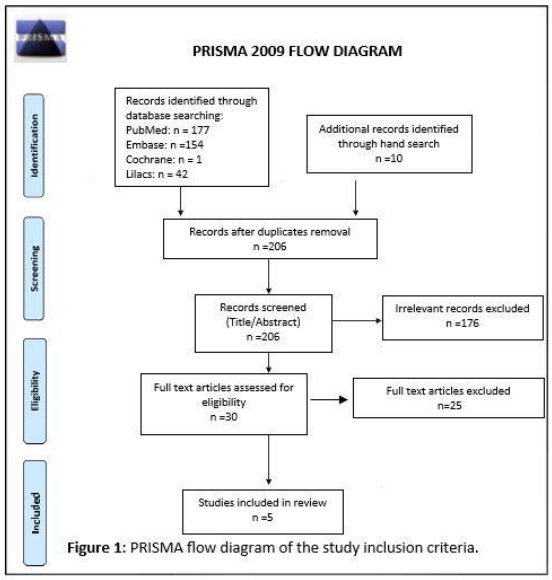

Figure 1: PRISMA flow diagram of the study inclusion criteria.

Table 3: The reasons for exclusion

Excluded articles	Reason
Macena et al. [25]	D or D+E space was not measured in control group
Venkaiah et al.[26]	Follow up less than 6 months
Northway [27], Leighton [28] , Kisling and Høffding [29] , Haavikko and Rahkamo [30], Rönnerman [31], Davey [32], Hoffding and Kisling [33] , Rönnerman and Thilander [34] , Linder-Aronson [35]	Timing of extraction not reported
Rao and Sarker [36], Miyamoto et al. [37], Melsen and Terp [38], Rönnerman and Thilander [39], Rosenzwig and Klein [40], Magnusson [41], Mosharrafian et al. [42], Heidari et al. [43]	Cross sectional study
de Boer [44], Lin and Lin [45], De Souza et al.[46]	Focused on other outcomes
Lin et al. [47]	Same participants enrolled in another study
Clinch [48], Kobylińska et al . [49].	Sample included patients in primary dentition stage

Characteristics of the included studies

All studies (Alexander et al.[13], Lin et al.[9] , Park et al.[12], Kumari and Retnakumari [11], and Lin and Chang [10]) were aimed at following up the extraction space of a prematurely lost primary first molar with measurement of any space changes. This was then compared with the non extraction opposite side in the same patient.All studies were prospective observational studies with a control group. The results showed a wide variation in space changes ranging from no significant loss of primary molar space in the extraction side to a significant loss.

Risk of bias in included studies

All the included studies showed well defined inclusion and exclusion criteria, well defined outcomes toand measure,good exposure and control group comparability, and adequate followup of participants except Kumari et al. [11] who showed that only 75% of participants were retained by the end of the study which his graded as a moderate risk of bias.Only three of the included studies showed adequate examiner reliability and Kappa scores which are graded as a low risk of bias [13][9][10].The remaining two studies did not show adequate examiner reliability which are graded as moderate risk of bias [11] [12]. Although none of the included studies reported blinding, it iswas a impractical for the outcome assessors to the do sothe because of the nature of the study

Results of the meta-analysis

The data from 154 children were included in the pooled meta-analyses for maxillary D or D+E space changes and 178 for mandibular D or D+E space changes. The pooled estimate represents the difference in mean space changes.

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All studies ([10], [11], [12], [9], [13]) did not provide mean space changes, reporting instead baseline and final mean measurements. Four studies showed that the maxillary D space loss on the control side was less than that on the extraction side, the pooled estimate or mean difference was 1.11mm(95%(CI)-1.27 to 0.95;p-value=0.0005)for the fixed effects model and -0.83 mm (95% (CI) -1.65 to -0.11; p-value = 0.004) for the random effects model. The I^2 statistic= 95.1% (p-value < 0.0001) indicating substantial heterogeneity in the results.(Figure 2)

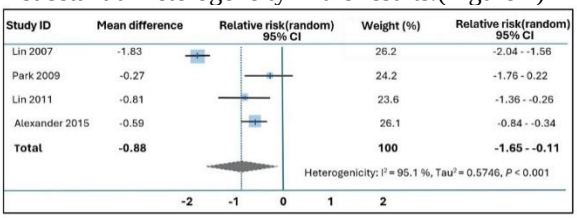

Figure 2: Forest plot of comparison between extraction and control sides regarding maxillary space changes

Three studies showed that the mandibular D space loss in the control side was more than that on the extraction side, the pooled estimate or mean difference was -1.57 mm (95% confidence interval (CI) -1.72 to 1.43; P< 0.001) for the fixed effects model and -1.41 mm (95% confidence interval (CI) -1.94 to -0.89; P < 0.001) for the random effects model.The I^2 statistic= 88.9% (p-value < 0.0001) indicating substantial heterogeneity in the results (Figure 3)

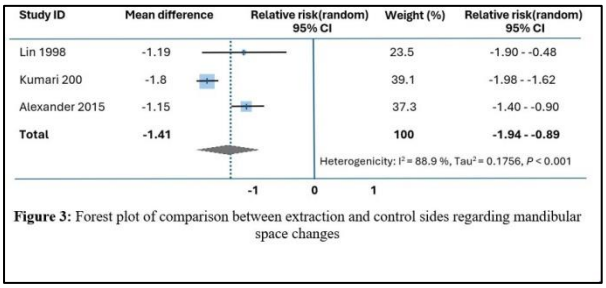

Figure 3: Forest plot of comparison between extraction and control sides regarding mandibular space changes

IV. Discussion

There was a wide variation in the results and conclusions among the included studies. This variation ranged from no significant loss of primary molar space in the extraction side to a significant loss. Furthermore, there were also differences between studies with regard to space loss which ranged from distal migration of primary canines only to mesial migration of the first permanent molars only, and a combination of both. This variation resulted in substantial heterogeneity in the results of the meta-analysis which is easily observed in the forest plots and confirmedusingI-squared statistic (Figure2,3). This high level of heterogeneity could be due to either clinical or methodological variability.

The degree of occlusal interdigitation is reported to be a contributing factor in determining the amount of space loss [14].In the maxilla, it is reported that space loss is more likely to take place[11]. The presence of lip pressure may have some role in space loss particularly in class II div 2 cases [15]. However, there is no solid evidence to support these claims. In addition, it is impossible to determine the degree of relative contribution of these proposed factors, if any. Park et al.[12]showed no statistically significant difference between primary molar space in the extraction side and control side in the maxilla. Three of the analyzed studies agree that the first primary molar space in the extraction side was significantly shorter than in the control side in the mandible [11] and in the maxilla [9, 10] at the end of their follow up period. Moreover, they all attributed this space loss to the distal migration of primary canines; consistent with their finding of increased arch width.

Alexander et al. [13] took into consideration the influence of different facial patterns of children and molar sagittal relationship on space loss. The results showed statistically significant mandibular and maxillary space loss in children with leptoproso pic facial pattern either combined with class I or end on molar relationship. While those with mesoprosopic facial pattern and end on molar relationship showed statistically significant mandibular space loss only. In children exhibiting a mesoprosopic facial structure and Class I molar relationship, neither the upper nor lower jaw experienced substantial space loss. Maxillary space reduction was attributed to the forward movement of teeth located behind the extraction site. Conversely, mandibular space loss resulted from both the backward movement of primary canines and the forward movement of posterior teeth. The research highlighted the role of long facial patterns and their typically weaker musculature in significant space loss.

Meta-analysis was conducted when studies with control groups reported the same outcome. Random

effects model were used since there were more than three included studies. The results showed maxillary D space loss on the extraction side was more than that on the control side with a mean difference of -0.83 mm (95% confidence interval (CI) -1.65 to -0.11; p-value=0.004).In the mandible, D space loss in the extraction side was more than that on the control side with mean difference of -1.41 mm (95% confidence interval (CI) -1.94 to -0.89; p-value < 0.0001). In order to explore the clinical implications of these results, we need to revisit the concept of mixed dentition space analysis that traditionally compares the deciduous unit (C, D, E) and the permanent unit (3, 4, 5) to assess space requirements. This "En masse" way of thinking is not realistic and each tooth has to be considered individually because it measures absolute numerical size differences with no respect to any dynamic physiological events and variables that may compensate for a space deficiency or consume a space surplus.

First, the size of a permanent canine is usually smaller than its predecessor. However, the eruption of a permanent canine in a more labial position and its utilization of the adjacent primate space are usually enough to compensate for this local space deficiency. [16] Second, the size of the second premolars is usually smaller than their predecessors resulting in excess space in the dental archformingthe"Leeway space"[16] or"E-space".[17] Unfortunately,this natural space is commonly misused by most clinicians who blindly consume it to compensate for any space loss occurring in the mixed dentition stage. The philosophy of leaving the space left by a prematurely lost primary first molar unretained, creating future space for the erupting first premolar through extracting primary second molar, and placing holding arches on first permanent molars is unwise. Early extraction of a primary second molar for the purpose of creating sufficient space for eruption of the first premolar will force the child to go through the unpleasant experience of extraction and needle injection. Furthermore, this will cause the child to chew on one functioning side owing to the lack of two deciduous molars on that side for at least one year or until the premolars erupt. This could have potentially negative consequences on oral health.

Moreover, when holding arches are employed, two permanent molars must be banded instead of a single primary molar, thereby increasing the risk of enamel demineralization in the underlying area. The physiological mesial movement of the first molars of the permanent first molar may also be delayed [16], this can negatively affect the occlusion. Due to these unfavorable outcomes, this approach is not recommended.

Whether or not to place a space maintainer is largely contingent on the mean size difference between the first premolar and its predecessor. The primary first molar exceeds its successor in size by less than half mm in the maxilla and 0.6 mm in the mandible [18].These discrepancies are less than the amount of space reduction identified in our meta-analysis. Therefore, to ensure proper eruption of the permanent first premolar, clinicians may consider using a space maintainer to compensate for this anticipated space shortage.

The study is not without limitations.In addition to the heterogeneity of the results,a small number of papers were included for analysis. However, this may be overcomed by the strict inclusion criteria enhancing the data reliability

V: CONCLUSION

The amount of space loss resulting from early extraction is greater than the size difference between the deciduous 1st molar and its successor. It is the clinician's choice to decide whether this amount of space loss is clinically significant enough to place a space maintainer or not..

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