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# Unaccounted clustering assumptions still compromise inferences in cluster randomized trials in orthodontic research

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**Objective:** This meta-epidemiological study aimed to determine whether optimal sample size calculation was applied in orthodontic cluster randomized trials (CRTs). **Methods:** Orthodontic randomized clinical trials with a cluster design, published between January 1, 2017 to December 31, 2023, in leading orthodontic journals were sourced. Study selection was undertaken by two independent authors. The study characteristics and variables required for sample size calculation were also extracted by the authors. The design effect for each trial was calculated using an intra-cluster correlation coefficient of 0.1 and the number of teeth in each cluster to recalculate the sample size. Descriptive statistics for the study characteristics, summary values for the design effect, and sample sizes were provided. **Results:** One-hundred and five CRTs were deemed eligible for inclusion. Of these, 100 reported sample size calculation. Nine CRTs (9.0%) did not report any effect measures for the sample size calculation, and a few did not report any power assumptions or significance levels or thresholds. Regarding the specific variables for the cluster design, only one CRT reported a design effect and adjusted the sample size accordingly. Recalculations indicated that the sample size of orthodontic CRTs should be increased by a median of 50% to maintain the same statistical power and significance level. **Conclusions:** Sample size calculations in orthodontic cluster trials were suboptimal. Greater awareness of the cluster design and variables is required to calculate the sample size adequately, to reduce the practice of underpowered studies.

**Key words:** Cluster, Trials, Orthodontic, Cluster randomized trials

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## INTRODUCTION

Randomized controlled trials (RCTs) are considered the cornerstone of evidence-based practice, serving as the gold standard for evaluating the effectiveness and/or safety of an intervention. A key feature of RCTs is the presence of an untreated control group followed up in parallel with the intervention group. In a simple parallel-arm design, the randomization is implemented at the participant level; the number of analyzed units equals that of the randomized units.<sup>1</sup> However, variations in design may lead to differences between analyzed and randomized units.<sup>2</sup> For example, researchers may randomize a group of individuals rather than one individual to receive an intervention.<sup>2-4</sup> These groups, known as clusters, can include families, schools, villages, or dental practices. Cluster design has gained substantial interest in orthodontics and dentistry, as roughly one-quarter of published orthodontic trials<sup>5</sup> and dental trials<sup>6</sup> structured as cluster designs, where a group of teeth from each participant receives the same intervention as a unit of the cluster.

Sample size calculation is a fundamental step in RCTs to determine the appropriate number of patients during the design stage of a clinical trial. This calculation helps substantiate the importance, significance, and clinical relevance of the identified treatment effect. Large RCTs might unnecessarily expose patients to potentially ineffective or harmful treatments, which may be unethical or resource consuming.<sup>7</sup> Conversely, small RCTs may lack sufficient statistical power to detect clinically meaningful differences between interventions.<sup>7</sup>

Reporting the sample size calculation is required at early stage of the study protocol to support transparency, credibility, and reproducibility of research findings. Key components for calculating sample size include the type I error (typically set at 0.05, or sometimes 0.01), power (usually 80–90%), and the assumptions of the expected difference in estimates for both the control and treatment groups, along with relevant effect sizes that justify a clinically meaningful difference.

Variations in trial design may require specific sample size calculation considerations and assumptions.<sup>8</sup> For instance, in cluster randomized trials (CRTs), observations are correlated, whereas standard parallel-arm RCTs assume these observations are independent. In CRTs, the correlation is generally determined by two parameters: the intra-cluster correlation coefficient (ICC;  $\rho$ ) and the between-cluster coefficient of variation (k). Consequently, each individual in the cluster contributes less than one independent individual, resulting in less unique information per participant and, therefore, reduced power.<sup>9,10</sup> Thus, the sample size calculation for CRTs must be adjusted for clustering by increasing the sample size

using the design effect.

$$D = 1 + (m-1)\rho$$

Where “D” is the design effect, “m” is the number of individuals per cluster, and  $\rho$  is the ICC. In orthodontics, if multiple teeth receive the same intervention and contribute to the outcome, “m” would equal the number of teeth involved from each participant.

For example, consider a trial assessing the white spot lesions formation using two different bracket systems, A and B. To detect a meaningful difference between the two groups based on 80% power and 5% type I error, 200 teeth (10 patients with 20 teeth per patient) are required in each group, while assuming independence between teeth. However, if we consider the number of teeth per patient ( $m = 20$ ) and assume the ICC ( $\rho$ ) of 0.1, the design effect would be  $D = 1 + (20-1) \times 0.1 = 2.9$ , and the required number would be increased to 580 teeth per group, approximately 29 patients per group. However, assuming the ICC ( $\rho$ ) is 0.2, the design effect would be  $D = 1 + (20-1) \times 0.2 = 4.8$ , increasing the required number to 960 teeth per group, approximately 48 patients per group.

Previous studies assessed the adequacy of sample size calculation and found that the sufficiency and correctness of these calculations ranged from 7.3% to 35.6% in dental research<sup>11</sup> and 29.5% in orthodontic trials.<sup>12</sup> Regarding the variations in trial designs, a previous assessment<sup>8</sup> investigated the sample size calculation in longitudinal trials and concluded that most calculations were suboptimal. However, to date, no study has yet assessed the correctness of sample size calculations and their requirements in CRTs specifically. Therefore, the current study aimed to assess the correctness of sample size calculation in orthodontic CRTs and provide a range of miscalculation amount by estimating the expected increase in sample size using the design effect.

## MATERIALS AND METHODS

### Eligibility criteria

Studies were included if they met the following criteria: (1) RCTs of cluster design, multiple teeth or mini-implants within the same patient received an intervention and contributed to outcome measures. (2) Published between January 1, 2017 to December 31, 2023. (3) Published in one of the following six major orthodontic journals (2023): *European Journal of Orthodontics*, *the Angle Orthodontist*, *American Journal of Orthodontics and Dentofacial Orthopedics*, *Progress in Orthodontics*, *Orthodontics & Craniofacial Research*, and *the Korean Journal of Orthodontics*.

Animal and preclinical studies were excluded. Studies

with no clear details regarding cluster design and studies with designs other than clinical trials were also excluded.

### Search and selection of studies

An electronic search of MEDLINE via the PubMed database was undertaken by one author (SM), with the latest update on February 7, 2024, using text words and medical subject headings (Appendix 1). Records irrelevant to the eligible journals were removed, and two authors (SM, HK) performed the initial screening of the studies independently and in duplicate. Trials with interventions involving more than one tooth/mini-implant per patient were included in the full-text review. The same two investigators scrutinized the full texts of potentially eligible articles and evaluated them against the inclusion criteria. In the presence of any disagreement, a consensus was reached after discussion between the two authors.

### Data extraction

Two authors independently extracted the following study characteristics: number of authors, continent of the first author (Europe, Americas, or Asia and others), journal and year of publication, study design (parallel, split-mouth, or crossover), and number of arms. The variables required for the sample size calculation were extracted by a single author (SM) after calibration with another author (MA) and entered into an Excel file (Microsoft, Redmond, WA, USA) equipped with the equation to calculate the design effect for each study based on ICC ( $\rho = 0.1$ ). This value was lower than the reported value (0.2) in previous orthodontic<sup>13</sup> and dental studies,<sup>14,15</sup> and was selected as a more conservative approach because of the lack of a common ICC for different orthodontic outcomes. The value of “*m*” was calculated for each study based on the number of teeth or min-implants contributing to each patient unit. Finally, the required number of patients for CRTs was recalculated by multiplying the design effect with the number calculated by the authors of the original CRT publications, as described previously. For each CRT, the increase in the sample size was divided by the number calculated by the authors of the original publication to provide the percentage of the required increase in the number of participants to maintain the same statistical power.

### Statistical analysis

Descriptive statistics were provided for the included studies using the median and interquartile range (IQR). The associations between calculating the sample size in CRTs (using the appropriate/optimal approach) and study characteristics were planned to be examined using statistical testing. However, this was not feasible, as only one trial reported the design effect and performed

an optimal calculation of the CRT sample size. Five CRTs were excluded from reporting and recalculating the sample size due to the lack of details regarding the sample size. Sensitivity analysis was conducted to isolate the effect of the simple parallel design on the recalculation of the sample size. All statistical analyses were conducted using Stata 15.1 (Stata Corp., College Station, TX, USA) and R statistical package (version 4.3.0; R Foundation for Statistical Computing, Vienna, Austria).

## RESULTS

Following the inclusion of the aforementioned journals, 323 articles were screened. One hundred and fifty-one articles were excluded after reading the title and abstract, and 67 articles were excluded after full-text reading for various reasons (Appendix 2). One hundred and five CRTs were eligible for inclusion and data extraction (Figure 1).

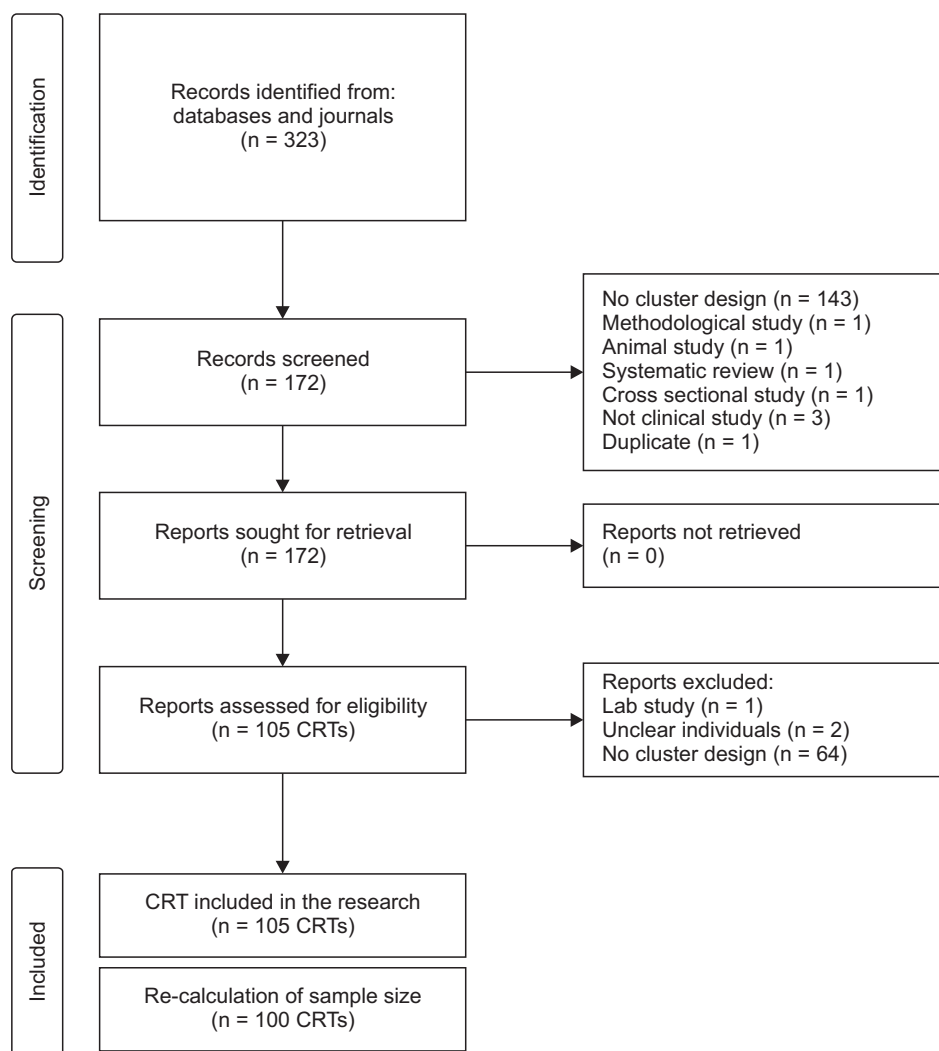
Within this cohort, 100 CRTs (95.0%) reported a sample size calculation, with a median of four participating authors (IQR: 3–6), mostly originating from Europe (48/105; 45.7%). Most CRTs were single-center trials (99/105; 94.3%) with a parallel design (76/105; 72.4%) and two arms (84/105; 80.0%). More than half (58/105; 55.2%) had prior protocol registration, while approximately one-third (33/105; 31.4%) lacked optimal reporting of protocol registration (Table 1).

### Sample size parameters reported in 100 CRTs

Of the included CRTs that reported the sample size calculation, 31 of 100 (31.0%) based the calculation on effect size, 44 of 100 (44.0%) reported the mean difference, and 9.0% did not report any effect measure. More than half of the included CRTs opted for 80% power to calculate the sample size, whereas a few CRTs did not report the power assumptions at all (2.0%). The vast majority of the included CRTs used the value 0.05 for alpha (type I error) to estimate the sample size, while a few CRTs (8.0%) did not report a significance level (Table 2). Only one included CRT<sup>13</sup> reported the design effect and adjusted the sample size accordingly.

### Sample size recalculation and sensitivity analysis

Table 3 lists the parameters used to recalculate the sample size. The median number of participants was 67.6 after recalculation, which was greater than the median number of participants provided by the included papers (40 participants). This can be interpreted as follows: the median increase in the sample size was 50% (IQR: 30%, 90%) based on the number of teeth in each cluster when the value of 0.1 was used as the ICC, maintaining the same power and level of statistical significance (Figure 2). A sensitivity analysis based solely on



**Figure 1.** Flowchart of the selected cluster randomized trials (CRTs).

72 parallel studies yielded similar results, with a median increase in sample size of 50% (IQR: 30%, 120%).

## DISCUSSION

The present study confirmed a miscalculation of the expected sample size in orthodontic CRTs published in the last 7 years, with more than 50 percent underestimation of the actual sample size requirements being a typical flaw.

Cluster design is frequently encountered in orthodontic and dental RCTs<sup>5,6</sup> due to the fact that several teeth from the same individual are allocated to an intervention in the trial and constitute subunits of the patient-cluster. Consequently, the unique information obtained from cluster data is less than that obtained from independent data, thus requiring a mandatory increase in sample size to compensate for the clustering effect in

CRTs.<sup>16</sup> The design effect, which is a typical correction factor for the required adjustment in sample size calculations in CRTs, was rarely reported in the present sample. This raises concerns about whether cluster design is actually being employed in orthodontics, and reflects a lack of awareness of potential clustering effects in orthodontic RCTs,<sup>5</sup> starting from sample size assumptions. Ignoring the data structure and the correlation arising from multiple measurements was also evident in longitudinal and repeated-measure design in orthodontics.<sup>8</sup> Of the 147 included trials, no single study reported an optimal calculation. A recent empirical report that examined clustering effects across all types of studies published in three orthodontic journals over a 3-year period reported that only one-fifth to one-fourth of published research of any kind accounted for clustering effects in sample size calculations. However, no attempt at recalculation was made, nor were CRTs explicitly assessed;

**Table 1.** Characteristics of included cluster randomized trials according to whether sample size calculations were reported

Characteristic	Overall (n = 105)	No (n = 5)	Yes (n = 100)
Authors' number	4 (3, 6)	4 (2, 5)	4 (3, 6)
Continent			
Americas	18 (17.1)	0 (0)	18 (18.0)
Asia/others	39 (37.1)	2 (40.0)	37 (37.0)
Europe	48 (45.7)	3 (60.0)	45 (45.0)
Journal/book			
AJODO	31 (29.5)	2 (40.0)	29 (29.0)
AO	35 (33.3)	1 (20.0)	34 (34.0)
EJO	27 (25.7)	2 (40.0)	25 (25.0)
KJO	5 (4.8)	0 (0)	5 (5.0)
OCR	1 (1.0)	0 (0)	1 (1.0)
PIO	6 (5.7)	0 (0)	6 (6.0)
Publication year			
2017	8 (7.6)	2 (40.0)	6 (6.0)
2018	18 (17.1)	3 (60.0)	15 (15.0)
2019	13 (12.4)	0 (0)	13 (13.0)
2020	15 (14.3)	0 (0)	15 (15.0)
2021	20 (19.0)	0 (0)	20 (20.0)
2022	14 (13.3)	0 (0)	14 (14.0)
2023	17 (16.2)	0 (0)	17 (17.0)
Centers			
Multi	6 (5.7)	1 (20.0)	5 (5.0)
Single	99 (94.3)	4 (80.0)	95 (95.0)
Number of arms			
2	84 (80.0)	3 (60.0)	81 (81.0)
3	15 (14.3)	2 (40.0)	13 (13.0)
4	6 (5.7)	0 (0)	6 (6.0)
Design			
Crossover	2 (1.9)	0 (0)	2 (2.0)
Parallel	76 (72.4)	4 (80.0)	72 (72.0)
Split mouth	27 (25.7)	1 (20.0)	26 (26.0)
Protocol registration			
Yes	58 (55.2)	1 (20.0)	57 (57.0)
No	14 (13.3)	0 (0)	14 (14.0)
Not reported	33 (31.4)	4 (80.0)	29 (29.0)

Values are presented as median (interquartile range) or number (%).

AJODO, *American Journal of Orthodontics and Dentofacial Orthopedics*; AO, *The Angle Orthodontist*; EJO, *European Journal of Orthodontics*; KJO, *Korean Journal of Orthodontics*; OCR, *Orthodontics & Craniofacial Research*; PIO, *Progress in Orthodontics*.

**Table 2.** Reporting of sample size calculation in cluster randomized trials when it was feasible

Item	n = 100
Effect measure	
Effect size	31 (31.0)
Mean difference	44 (44.0)
Relative risk reduction	4 (4.0)
Risk difference	12 (12.0)
ni	9 (9.0)
Value of the effect measure	
Effect size	0.50 (0.43, 0.80)
Mean difference	1.04 (0.50, 2.00)
Relative risk reduction	0.15 (0.08, 0.20)
Risk difference	0.25 (0.20, 0.66)
Level of significance ( $\alpha$ )	
0.001	1 (1.0)
0.01	3 (3.0)
0.0125	1 (1.0)
0.025	1 (1.0)
0.05	86 (86.0)
Not reported	8 (8.0)
Power	
80%	60 (60.0)
81–85%	11 (11.0)
90%	19 (19.0)
> 90%	8 (8.0)
Not reported	2 (2.0)
Accounting for cluster effect	
Yes	1 (1.0)
No	99 (99.0)
ICC	
None	100 (100.0)

Values are presented as number (%) or median (interquartile range).

ICC, intra-cluster correlation coefficient; ni, no information.

thus, further direct comparisons with this report cannot be made.<sup>17</sup> In contrast, a previous healthcare report found that elements specific to CRTs were the worst reported when calculating the sample size, whereas only 22% reported all recommended elements.<sup>18</sup> Similarly, in dentistry and orthodontics, it is still difficult to handle participants as clusters in specific cases, or there is a lack of understanding of the theoretical and scientific background of the different structures of study designs.

Accurate and transparent reporting of sample size cal-

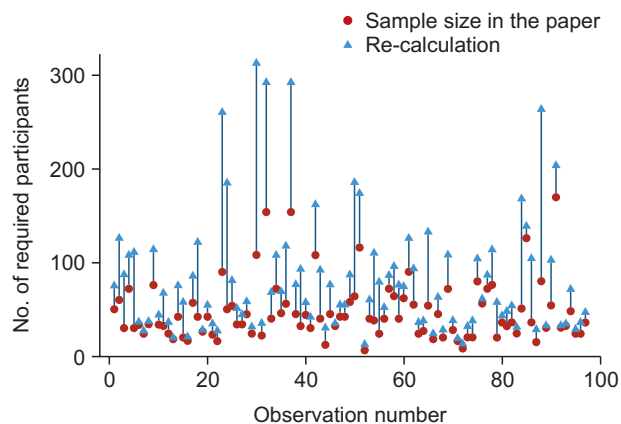
**Table 3.** Recalculation of sample size and sensitivity analysis for CRT with parallel design

	Re-calculation (100 CRTs)	Sensitivity analysis (72 CRTs)
Design effect	1.5 (1.3, 1.9)	1.5 (1.3, 2.2)
Number of individuals per cluster	6 (4, 10)	6 (4, 13)
Number of clusters	18.5 (12.5, 27.0)	18.0 (14.0, 24.5)
Sample size in the paper	40 (26.5, 59.0)	40 (30.0, 57.5)
Number of required participants	67.6 (36.2, 108.0)	68.5 (36.9, 114.0)
Percentage	50% (30%, 90%)	50% (30%, 120%)

Values are presented as median (interquartile range).  
CRTs, cluster randomized trials.

calculation is essential for RCTs according to the Consolidated Standards of Reporting Trials (CONSORT) group.<sup>19</sup> One might argue that a significant improvement could be confirmed in this assessment compared with a study undertaken 10 years ago regarding sample size calculation in orthodontic RCTs.<sup>20</sup> This early study found a lack of complete reporting of the sample size components in 70% of the included RCTs, while this was less than 10% in our assessment of CRTs. This should be interpreted with caution owing to the inclusion of only one specific design in the present study. However, cluster trial reporting requires more details and information related to the number of clusters, the cluster size (usually the number of teeth in orthodontics), and the ICC according to the CONSORT extension for cluster design.<sup>21</sup> A previous study<sup>22</sup> found that journals promoting CONSORT adherence are associated with superior reporting of RCTs. However, a survey<sup>23</sup> found that only 12 of 165 high-impact journals mentioned the extension to cluster trials in their online instructions for authors. Thus, more rigorous editorial policies regarding CONSORT extensions are required to bring substantial improvement to CRT reporting.

It is worth mentioning that a higher ICC value or number of teeth per cluster ( $m$ ), requires an increase in the sample size to maintain the same power of the study. Failing to increase the sample size may lead to an underpowered trial, as increasing the power from 50% to 80% would require a two-fold increase in the trial size.<sup>24</sup> The present study found that the number of participants in orthodontic CRTs should be increased by a median of 50% to maintain the same statistical power. This was also confirmed when we focused on the simplest design of the randomized trials assessed, the parallel-arm design, to avoid any effects from the more complex structures encountered, which would potentially involve the evaluation of additional parameters,



**Figure 2.** A scatter plot comparing the sample size of cluster trials before and after considering the intra-cluster correlation coefficient and the design effect. The red circle represents the original sample size in the paper, and the blue triangle shows the recalculated sample size.

further implicating between cluster variability issues. Consistent with previous studies,<sup>20,25</sup> the majority of the included trials assumed a significance level (alpha error) of 0.05 and a power of 80% for the sample size assumptions. Thirty-one CRTs (31/100; 31.0%) reported the use of effect size rather than the mean or risk difference based on previous studies; however, a larger effect size may result in a smaller required sample size.<sup>26</sup> The effect size used in these trials was considered to be large in some RCTs (the maximum value was 0.8), thus targeting a small sample size. Upon planning and designing a study, practices such as those referred to as “sample size samba”, which involve incremental retrofitting of the effect size to achieve more easily acquired and convenient sample sizes, have been heavily criticized and linked to flawed approaches and malpractice in research conduct.<sup>24</sup>

A potential limitation of this study was that the relevant records were retrieved from a single database; thus, some studies might have been missed. Nevertheless, all the targeted orthodontic journals are indexed in MEDLINE, and the timeframe assessed was large, including the last 7 years of publication records. Moreover, the reporting of the cluster design is still lacking, thus making the search within journals and other databases challenging. However, a clear picture of non-optimal sample size calculations in CRTs in orthodontics has emerged through both the main and sensitivity analyses conducted in the present report. Notwithstanding, the aim of this assessment was to shed light on and trigger awareness of the problem, rather than provide an exact estimate of sample size miscalculation in orthodontic CRTs. The study design and its variants, statistical power, ICC, and variability between and within clusters play a vital

role in adjusting the sample sizes in CRTs.

## CONCLUSIONS

We documented empirical evidence that sample size calculations in cluster randomized orthodontic trials are suboptimal. A greater understanding of cluster design and all the parameters required to undertake the correct sample size calculation is of paramount importance. The CONSORT statement extension for cluster design should be more closely adhered to by authors and journal editors when such studies are submitted for publication to support credible findings and appropriate inferences disseminated to the scientific community.

## AUTHOR CONTRIBUTIONS

Conceptualization: SM, DK, MA. Data curation: All authors. Formal analysis: SM, DK. Investigation: HK, MA. Methodology: All authors. Project administration: DK, SM. Resources: SM. Software: SM, DK. Supervision: DK. Validation: MA, HK. Visualization: SM. Writing—original draft: SM, HK. Writing—review & editing: SM, DK, MA.

## CONFLICTS OF INTEREST

No potential conflict of interest relevant to this article was reported.

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None to declare.

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**Appendix 1. Search strategy**

Query	Filter	Result
orthodonti*		86,806
"Orthodontics"[Mesh]		55,478
malocclusion		39,090
"Malocclusion"[Mesh] AND "Malocclusion, Angle Class III"[Mesh] AND "Malocclusion, Angle Class II"[Mesh] AND "Malocclusion, Angle Class I"[Mesh]		289
(orthodonti*) OR ("Orthodontics"[Mesh])		94,115
(malocclusion) OR ("Malocclusion"[Mesh] AND "Malocclusion, Angle Class III"[Mesh] AND "Malocclusion, Angle Class II"[Mesh] AND "Malocclusion, Angle Class I"[Mesh])		39,090
((orthodonti*) OR ("Orthodontics"[Mesh])) OR ((malocclusion) OR ("Malocclusion"[Mesh] AND "Malocclusion, Angle Class III"[Mesh] AND "Malocclusion, Angle Class II"[Mesh] AND "Malocclusion, Angle Class I"[Mesh]))		108,393
((orthodonti*) OR ("Orthodontics"[Mesh])) OR ((malocclusion) OR ("Malocclusion"[Mesh] AND "Malocclusion, Angle Class III"[Mesh] AND "Malocclusion, Angle Class II"[Mesh] AND "Malocclusion, Angle Class I"[Mesh]))	From 2017-2023	32,741
((orthodonti*) OR ("Orthodontics"[Mesh])) OR ((malocclusion) OR ("Malocclusion"[Mesh] AND "Malocclusion, Angle Class III"[Mesh] AND "Malocclusion, Angle Class II"[Mesh] AND "Malocclusion, Angle Class I"[Mesh]))	Clinical Trial, Randomized Controlled Trial, from 2017-2023	1,325

## Appendix 2. Reason for exclusion

Exclude from	Reason	Title
Abstract	Not cluster	Changes of bite force and occlusal contacts in the retention phase of orthodontic treatment: A controlled clinical trial
Abstract	Not cluster	Effects of low-level laser irradiation on the rate of orthodontic tooth movement and associated pain with self-ligating brackets
Abstract	Not cluster	Effectiveness of pulsed electromagnetic field for pain caused by placement of initial orthodontic wire in female orthodontic patients: A preliminary single-blind randomized clinical trial
Abstract	Not cluster	Efficacy of combined orthodontic-periodontic treatment for patients with periodontitis and its effect on inflammatory cytokines: A comparative study
Abstract	Not cluster	Comparison of in-vivo failure of single-thread and dual-thread temporary anchorage devices over 18 months: A split-mouth randomized controlled trial
Abstract	Not cluster	Surgery-first orthognathic approach vs traditional orthognathic approach: Oral health-related quality of life assessed with 2 questionnaires
Abstract	Not cluster	Individualized intervention to reduce anxiety in adult orthodontic patients based on Q methodology
Abstract	Not cluster	Randomized controlled trial of a patient decision-making aid for orthodontics
Abstract	Not cluster	Comparative evaluation of salivary bisphenol A levels in patients wearing vacuum-formed and Hawley retainers: An in-vivo study
Abstract	Not cluster	Comparison of survival time and comfort between 2 clear overlay retainers with different thicknesses: A pilot randomized controlled trial
Abstract	Not cluster	Indirect vs direct bonding of mandibular fixed retainers in orthodontic patients: Comparison of retainer failures and posttreatment stability. A 2-year follow-up of a single-center randomized controlled trial
Abstract	Not cluster	Treatment outcomes of Class II malocclusion cases treated with miniscrew-anchored Forsus Fatigue Resistant Device: A randomized controlled trial
Abstract	Not cluster	Effects of skeletally anchored Class II elastics: A pilot study and new approach for treating Class II malocclusion
Abstract	Not cluster	Low-level laser therapy effectiveness in accelerating orthodontic tooth movement: A randomized controlled clinical trial
Abstract	Not cluster	Microbial evaluation of the effectiveness of different methods for cleansing clear orthodontic retainers: A randomized clinical trial
Abstract	Not cluster	Class II subdivision treatment with the Forsus Fatigue Resistant Device vs intermaxillary elastics
Abstract	Not cluster	Dimensional changes of dental arches produced by fixed and removable palatal cribs: A prospective, randomized, controlled study
Abstract	Not cluster	Speech effects of Hawley and vacuum-formed retainers by acoustic analysis: A single-center randomized controlled trial
Abstract	Not cluster	Acceptability comparison between Hawley retainers and vacuum-formed retainers in orthodontic adult patients: a single-centre, randomized controlled trial
Abstract	Not cluster	Comparing the effects of Essix and Hawley retainers on the acoustics of speech
Abstract	Not cluster	Speed of human tooth movement in growers and non-growers: Selection of applied stress matters
Abstract	Not cluster	Mandibular response after rapid maxillary expansion in class II growing patients: a pilot randomized controlled trial
Full	Not cluster	Alignment efficiency and esthetic performance of 4 coated nickel-titanium archwires in orthodontic patients over 8 weeks: A multicenter randomized clinical trial
Full	Not cluster	Efficiency of piezosurgery technique in miniscrew supported en-masse retraction: a single-centre, randomized controlled trial
Full	Not cluster	Efficiency of piezotome-corticision assisted orthodontics in alleviating mandibular anterior crowding-a randomized clinical trial

## Appendix 2. Continued

Exclude from	Reason	Title
Abstract	Not cluster	Anchorage reinforcement with miniscrews and molar blocks in adolescents: A randomized controlled trial
Abstract	Not cluster	Physical properties of root cementum: Part 27. Effect of low-level laser therapy on the repair of orthodontically induced inflammatory root resorption: A double-blind, split-mouth, randomized controlled clinical trial
Abstract	Not cluster	Treatment outcomes and patient-reported quality of life after orthognathic surgery with computer-assisted 2- or 3-dimensional planning: A randomized double-blind active-controlled clinical trial
Abstract	Not cluster	Comparison of two early treatment protocols for anterior dental crossbite in the mixed dentition: A randomized trial
Abstract	Not cluster	Closed vs open surgical exposure of palatally displaced canines: surgery time, postoperative complications, and patients' perceptions: a multicentre, randomized, controlled trial
Abstract	Not cluster	The use of panoramic radiographs to decide when interceptive extraction is beneficial in children with palatally displaced canines based on a randomized clinical trial
Abstract	Not cluster	A cost-minimization analysis of large overjet reduction with two removable functional appliances based on a randomized controlled trial
Abstract	Not cluster	Effects on nasal airflow and resistance using two different RME appliances: a randomized controlled trial
Abstract	Not cluster	Comparative assessment of conventional and light-curable fluoride varnish in the prevention of enamel demineralization during fixed appliance therapy: a split-mouth randomized controlled trial
Abstract	Not cluster	Evaluating low-level laser therapy effect on reducing orthodontic pain using two laser energy values: a split-mouth randomized placebo-controlled trial
Full	Not cluster	Which orthodontic appliance is best for oral hygiene? A randomized clinical trial
Full	Not cluster	Evaluation of miniscrew-supported rapid maxillary expansion in adolescents: A prospective randomized clinical trial
Full	Not cluster	Dentoalveolar effects produced by different appliances on early treatment of anterior open bite: A randomized clinical trial
Full	Not cluster	Comparative evaluation of treatment effects between two fixed functional appliances for correction of Class II malocclusion: A single-center, randomized controlled trial
Full	Not cluster	Comparison of changes in irregularity and transverse width with nickel-titanium and niobium-titanium-tantalum-zirconium archwires during initial orthodontic alignment in adolescents: A double-blind randomized clinical trial
Full	Not cluster	Clinical and microbiological effects of the use of a cetylpyridinium chloride dentifrice and mouth rinse in orthodontic patients: a 3-month randomized clinical trial
Full	Not clear individual	Long-term remineralizing effect of MI Paste Plus on regression of early caries after orthodontic fixed appliance treatment: a 12-month follow-up randomized controlled trial
Full	Not cluster	Bonded versus vacuum-formed retainers: a randomized controlled trial. Part 1: stability, retainer survival, and patient satisfaction outcomes after 12 months
Full	Not cluster	Airway and hard tissue dimensions in children treated with early and later timed cervical headgear-a randomized controlled trial
Abstract	Not cluster	Objective evaluation of compliance after orthodontic treatment using Hawley or vacuum-formed retainers: A 2-center randomized controlled trial over a 3-month period
Abstract	Not cluster	Oral health-related quality of life of children before, during, and after anterior open bite correction: A single-blinded randomized controlled trial
Abstract	Not cluster	Information retention of orthodontic patients and parents: A randomized controlled trial
Abstract	Not cluster	Effectiveness of part-time vs full-time wear protocols of Twin-block appliance on dental and skeletal changes: A randomized controlled trial

## Appendix 2. Continued

Exclude from	Reason	Title
Abstract	Not cluster	Cephalometric evaluation of rapid and slow maxillary expansion in patients with BCLP: Secondary data analysis from a randomized clinical trial
Abstract	Not cluster	Evaluation of the miniplate-anchored Forsus Fatigue Resistant Device in skeletal Class II growing subjects: A randomized controlled trial
Abstract	Not cluster	Comparison of effects of cervical headgear treatment on skeletal facial changes when the treatment time is altered: a randomized controlled trial
Abstract	Not cluster	Dental arch effects after early and later timed cervical headgear treatment-a randomized controlled trial
Abstract	Not cluster	Piezocision-assisted orthodontic treatment using CAD/CAM customized orthodontic appliances: a randomized controlled trial in adults
Abstract	Not cluster	Pain relief after orthodontic archwire installation-a comparison between intervention with paracetamol and chewing gum: a randomized controlled trial
Abstract	Not cluster	A cost-effectiveness analysis of anchorage reinforcement with miniscrews and molar blocks in adolescents: a randomized controlled trial
Abstract	Not cluster	Effect of orthodontic force magnitude on cytokine networks in gingival crevicular fluid: a longitudinal randomized split-mouth study
Abstract	Not cluster	A randomized clinical trial of the effectiveness of 0.018-inch and 0.022-inch slot orthodontic bracket systems: part 2-quality of treatment
Abstract	Not cluster	A randomized clinical trial of the effectiveness of 0.018-inch and 0.022-inch slot orthodontic bracket systems: part 1-duration of treatment
Abstract	Not cluster	Efficacy of piezocision-based flapless corticotomy in the orthodontic correction of severely crowded lower anterior teeth: a randomized controlled trial
Abstract	Not cluster	Use of bibloc and monobloc oral appliances in obstructive sleep apnoea: a multicentre, randomized, blinded, parallel-group equivalence trial
Abstract	Not cluster	Soft- and hard-tissue changes following treatment of Class II division 1 malocclusion with Activator versus Trainer: a randomized controlled trial
Abstract	Not cluster	Palatal morphology in unilateral cleft lip and palate patients: Association with infant cleft dimensions and timing of hard palate repair
Abstract	Not cluster	Effects of two frequencies of vibration on the maxillary canine distalization rate and RANKL and OPG secretion: A randomized controlled trial
Abstract	Not cluster	Alignment efficiency of coaxial tubular superelastic nickel-titanium vs single-stranded superelastic nickel-titanium in relieving mandibular anterior crowding in extraction cases: A single-centre randomized controlled clinical trial
Abstract	Not cluster	A comparative assessment of clinical efficiency between premium heat-activated copper nickel-titanium and superelastic nickel-titanium archwires during initial orthodontic alignment in adolescents: a randomized clinical trial
Abstract	Not cluster	Does audiovisual information affect anxiety and perceived pain levels in miniscrew application? - a within-person randomized controlled trial
Abstract	Not cluster	Effect of micro-osteoperforation on the rate of canine retraction: a split-mouth randomized controlled trial
Full	Not cluster	Effects of low-level laser therapy and mechanical vibration on orthodontic pain caused by initial archwire
Full	Lab	Particulate production during debonding of fixed appliances: Laboratory investigation and randomized clinical trial to assess the effect of using flash-free ceramic brackets
Full	Not cluster	Does anchorage loss differ with 0.018-inch and 0.022-inch slot bracket systems?
Full	Not cluster	A randomized, single-blind, placebo-controlled trial to evaluate the effectiveness of verbal behavior modification and acetaminophen on orthodontic pain

## Appendix 2. Continued

Exclude from	Reason	Title
Full	Not cluster	Tooth movement rate and anchorage lost during canine retraction: A maxillary and mandibular comparison
Full	Not cluster	A prospective, split-mouth, clinical study of orthodontic titanium miniscrews with machined and acid-etched surfaces
Full	Not cluster	A randomized clinical trial to evaluate the plaque removal efficacy of an oscillating-rotating toothbrush versus a sonic toothbrush in orthodontic patients using digital imaging analysis of the anterior dentition
Full	Not cluster	Comparison of anterior retraction and anchorage control between en masse retraction and two-step retraction: A randomized prospective clinical trial
Full	Not cluster	Mini-implant supported canine retraction with micro-osteoperforation: A split-mouth randomized clinical trial
Full	Not cluster	Long-term follow-up of camouflage effects following resin infiltration of post orthodontic white-spot lesions in vivo
Full	Not cluster	The influence of text messages on the cooperation of Class II patients regarding the use of intermaxillary elastics
Full	Not clear individual	Effects of orthodontic treatment and different fluoride regimens on numbers of cariogenic bacteria and caries risk: a randomized controlled trial
Title	Not cluster	Effectiveness of incremental vs maximum bite advancement during Herbst appliance therapy in late adolescent and young adult patients
Abstract	Not cluster	The impact of tooth-borne vs computer-guided bone-borne rapid maxillary expansion on pain and oral health-related quality of life: A parallel cohort study
Abstract	Not cluster	Distalization rate of maxillary canines in an alveolus filled with leukocyte-platelet-rich fibrin in adults: A randomized controlled clinical split-mouth trial
Abstract	Not cluster	Efficacy of botulinum toxin for treating a gummy smile
Abstract	Not cluster	The effects of a clinically feasible application of low-level laser therapy on the rate of orthodontic tooth movement: A triple-blind, split-mouth, randomized controlled trial
Abstract	Not cluster	A comparison of conventional vs automated digital Peer Assessment Rating scoring using the Carestream 3600 scanner and CS Model+ software system: A randomized controlled trial
Abstract	Not cluster	Frankel 2 appliance versus the Modified Twin Block appliance for Phase 1 treatment of Class II division 1 malocclusion in children and adolescents: A randomized clinical trial
Abstract	Not cluster	A comparative assessment of orthodontic treatment outcomes of mild skeletal Class III malocclusion between facemask and facemask in combination with a miniscrew for anchorage in growing patients: A single-center, prospective randomized controlled trial
Abstract	Not cluster	Rapid maxillary expansion in children with nocturnal enuresis: A randomized placebo-controlled trial
Abstract	Not cluster	Evaluation of the effectiveness of a tailored mobile application in increasing the duration of wear of thermoplastic retainers: a randomized controlled trial
Abstract	Not cluster	Vacuum-formed retainer versus bonded retainer for dental stabilization in the mandible—a randomized controlled trial. Part I: retentive capacity 6 and 18 months after orthodontic treatment
Abstract	Not cluster	Biomarkers of orthodontic tooth movement with fixed appliances and vibration appliance therapy: a pilot study
Abstract	Not cluster	Three-dimensional evaluation of forced unilateral posterior crossbite correction in the mixed dentition: a randomized controlled trial
Abstract	Not cluster	Treatment compliance of adolescent orthodontic patients with headgear activator and twin-block appliance assessed prospectively using microelectronic wear-time documentation

## Appendix 2. Continued

Exclude from	Reason	Title
Abstract	Not cluster	Post-treatment cephalometric changes in adolescent patients with Class II malocclusion treated using two different functional appliance systems for an extended time period: a randomized clinical trial
Abstract	Not cluster	Scandcleft randomized trials of primary surgery for unilateral cleft lip and palate: maxillary growth at eight years of age
Abstract	Not cluster	Scandcleft randomized trials of primary surgery for unilateral cleft lip and palate: occlusion in 8-year-olds according to the Modified Huddart and Bodenham index
Abstract	Not cluster	Scandcleft randomized trials of primary surgery for unilateral cleft lip and palate. Dental arch relationships in 8 year-olds
Abstract	Not cluster	Conventional versus laser gingivectomy in the management of gingival enlargement during orthodontic treatment: a randomized controlled trial
Abstract	Not cluster	An RCT on clinical effectiveness and cost analysis of correction of unilateral posterior crossbite with functional shift in specialist and general dentistry
Abstract	Not cluster	Effect of mini-screw-facilitated micro-osteoperforation on the rate of orthodontic tooth movement: a single-center, split-mouth, randomized, controlled trial
Full	Not cluster	Influence of type of radiograph and levels of experience and training on reproducibility of the cervical vertebral maturation method
Full	Not cluster	A visual evaluation of oral plaque removal utilizing an adjunct enzyme pre-rinse in orthodontic subjects
Full	Not cluster	Double vs single primary tooth extraction in interceptive treatment of palatally displaced canines
Full	Not cluster	A prospective clinical trial of the effects produced by the Connecticut intrusion arch on the maxillary dental arch
Full	Not cluster	Effect of platelet-rich plasma on the rate of orthodontic tooth movement
Full	Not cluster	Effect of verbal and written information on pain perception in patients undergoing fixed orthodontic treatment: a randomized controlled trial
Title	Systematic review	Stainless steel or titanium mini-implants?
Abstract	Not cluster	Dentoskeletal comparison of miniscrew-anchored maxillary protraction with hybrid and conventional hyrax expanders: A randomized clinical trial
Abstract	Not cluster	Effectiveness of microosteoperforations in accelerating alignment of maxillary anterior crowding in adults: A randomized controlled clinical trial
Abstract	Not cluster	Assessment of the effects of local platelet-rich fibrin injection and piezocision on orthodontic tooth movement during canine distalization
Abstract	Not cluster	A comparative assessment of information recall and comprehension between conventional leaflets and an animated video in adolescent patients undergoing fixed orthodontic treatment: A single-center, randomized controlled trial
Abstract	Not cluster	Traditional vs digital communication channels for improving compliance with fixed orthodontic treatment
Abstract	Not cluster	Early headgear activator treatment of Class II malocclusion with excessive overjet: a randomized controlled trial
Abstract	Methodology	The presence and characteristics of 'spin' among randomized controlled trial abstracts in orthodontics
Abstract	Not cluster	Open and closed surgical exposure of palatally displaced canines: a cost-minimization analysis of a multicentre, randomized controlled trial
Abstract	Not cluster	Open vs closed surgical exposure of palatally displaced canines: a comparison of clinical and patient-reported outcomes-a multicentre, randomized controlled trial
Abstract	Not cluster	Scandcleft trial of primary surgery for unilateral cleft lip and palate: Craniofacial cephalometrics at 8 years

## Appendix 2. Continued

Exclude from	Reason	Title
Abstract	Not cluster	Nasal ventilation and rapid maxillary expansion (RME): a randomized trial
Abstract	Not cluster	Cephalometric effects of Pushing Splints 3 compared with rapid maxillary expansion and facemask therapy in Class III malocclusion children: a randomized controlled trial
Abstract	Not cluster	Skeletal and dentoalveolar effects using tooth-borne and tooth-bone-borne RME appliances: a randomized controlled trial with 1-year follow-up
Abstract	Not cluster	The upper airway volume effects produced by Hyrax, Hybrid-Hyrax, and Keles keyless expanders: a single-centre randomized controlled trial
Abstract	Not cluster	Impact of oral-health-related quality of life and self-esteem on patients with missing maxillary lateral incisor after orthodontic space closure: a single-blinded, randomized, controlled trial
Abstract	Not cluster	Perception of pain in Class II malocclusion children treated with cervical headgear: a randomized controlled trial
Abstract	Not cluster	Vacuum-formed retainers and bonded retainers for dental stabilization-a randomized controlled trial. Part II: patients' perceptions 6 and 18 months after orthodontic treatment
Abstract	Not cluster	PASS versus MBT™ for evaluation of anchorage control in three-dimensional measurements: a randomized controlled trial
Abstract	Not cluster	Short-term efficacy of vacuum-formed maintainer for deciduous second molar space maintenance in the mixed dentition: A single-centre, randomized controlled clinical trial
Abstract	Not cluster	Tooth-borne versus tooth-bone-borne rapid maxillary expanders according to a stereophotogrammetric evaluation of facial soft tissues: A randomized clinical trial
Abstract	Not cluster	Maximum insertion torque loss after miniscrew placement in orthodontic patients: A randomized controlled trial
Abstract	Not cluster	Lactobacillus brevis CD2 attenuates traumatic oral lesions induced by fixed orthodontic appliance: A randomized phase 2 trial
Abstract	Not cluster	Influence of surgical technique and timing of primary repair on interarch relationship in UCLP: A randomized clinical trial
Abstract	Not cluster	Evaluation of pain intensity in patients treated with aligners and conventional fixed appliances: Randomized clinical trial
Abstract	Not cluster	The effects of corticotomy and piezoscision in orthodontic canine retraction: a randomized controlled clinical trial
Abstract	Not cluster	The prediction of impacted versus spontaneously erupted mandibular third molars
Abstract	Not cluster	Mini Hyrax vs Hyrax expanders in the rapid palatal expansion in adolescents with posterior crossbite: a randomized controlled clinical trial
Abstract	Not cluster	The efficiency of mandibular mini-implants in reducing adverse effects of class II elastics in adolescent female patients: a single blinded, randomized controlled trial
Abstract	Not cluster	Three-dimensional assessment of two different canine retraction techniques: a randomized split-mouth clinical trial
Abstract	Not cluster	Effect of miniscrew insertion angle in the maxillary buccal plate on its clinical survival: a randomized clinical trial
Abstract	Not cluster	Factors influencing the removal torque of palatal implant used for orthodontic anchorage
Abstract	Not cluster	The effect of sandblasting and acid etching on survival rate of orthodontic miniscrews: a split-mouth randomized controlled trial
Full	Not cluster	Effects of orthodontic treatment with aligners and fixed appliances on speech
Full	Not cluster	Can text messages encourage flossing among orthodontic patients?
Full	Not cluster	Comprehensive comparison of canine retraction using NiTi closed coil springs vs elastomeric chains
Full	Not cluster	Perceived pain during rapid maxillary expansion in children with different expanders
Full	Not cluster	Effects of different lingual retainers on periodontal health and stability

## Appendix 2. Continued

Exclude from	Reason	Title
Full	Not cluster	The effect of platelet-rich fibrin (PRF) on maxillary incisor retraction rate
Full	Not cluster	Comparison of skeletal maxillary transverse deficiency treated by microimplant-assisted rapid palatal expansion and tooth-borne expansion during the post-pubertal growth spurt stage
Full	Not cluster	Factors influencing treatment efficiency
Full	Not cluster	Comparison between two screws for maxillary expansion: a multicenter randomized controlled trial on patient's reported outcome measures
Full	Not cluster	Three-dimensional assessment of accelerating orthodontic tooth movement-micro-osteoperforations vs piezocision: A randomized, parallel-group and split-mouth controlled clinical trial
Full	Not cluster	Comparing the effects of CAD/CAM nickel-titanium lingual retainers on teeth stability and periodontal health with conventional fixed and removable retainers: A randomized clinical trial
Title	Not cluster	Effect of light-emitting diode-mediated photobiomodulation on extraction space closure in adolescents and young adults: A split-mouth, randomized controlled trial
Title	Not cluster	Dental arch changes after open bite treatment with spurs associated with posterior build-ups in the mixed dentition: A randomized clinical trial
Abstract	Not cluster	Accuracy of convolutional neural networks-based automatic segmentation of pharyngeal airway sections according to craniofacial skeletal pattern
Abstract	Not cluster	Effect of a mouth rinse and a high-fluoride toothpaste on caries incidence in orthodontic patients: A randomized controlled trial
Abstract	Not cluster	Comparison of changes in skeletal, dentoalveolar, periodontal, and nasal structures after tooth-borne or bone-borne rapid maxillary expansion: A parallel cohort study
Abstract	Not cluster	Rehearsal's effect on long-term recall and comprehension of orthodontic informed consent
Abstract	Not cluster	The effect of piezocision vs no piezocision on maxillary extraction space closure: A split-mouth, randomized controlled clinical trial
Abstract	Not cluster	Long-term assessment of conventional and mini-screw-assisted rapid palatal expansion on the nasal cavity
Abstract	Not cluster	The impact of non-extraction orthodontic treatment on oral health-related quality of life: clear aligners versus fixed appliances-a randomized controlled trial
Abstract	Not cluster	Duration of toothbrushing with fixed appliances: a randomized crossover clinical trial
Abstract	Not cluster	Comparison of the dento-skeletal effects produced by Leaf expander versus rapid maxillary expander in prepubertal patients: a two-center randomized controlled trial
Abstract	Not cluster	Wearability and preference of mouthguard during sport in patients undergoing orthodontic treatment with fixed appliances: a randomized clinical trial
Abstract	Not cluster	Comparisons of costs and treatment effects-an RCT on headgear activator treatment of excessive overjet in the mixed and late mixed dentition
Abstract	Not cluster	Dentoskeletal changes due to rapid maxillary expansion in growing patients with tooth-borne and tooth-bone-borne expanders: A randomized clinical trial
Full	Not cluster	The effectiveness of a bespoke mobile application in improving adherence with removable orthodontic retention over 12 months: A randomized controlled trial
Full	Not cluster	Evaluation of the rate of anterior segment retraction in orthodontic patients with bimaxillary protrusion using friction vs frictionless mechanics: a single-center, single-blind randomized clinical trial
Full	Not cluster	Analysis of canine retraction and anchorage loss in different facial types with and without piezocision: a split-mouth-design, randomized clinical trial
Full	Not cluster	Comparing patient-centered outcomes and efficiency of space closure between nickel-titanium closed-coil springs and elastomeric power chains during orthodontic treatment
Full	Not cluster	Effect of low-level laser therapy on the time needed for leveling and alignment of mandibular anterior crowding



## Appendix 2. Continued

Exclude from	Reason	Title
Full	Not cluster	Dental arch changes after anterior open bite treatment in the mixed dentition produced by miniscrew-supported palatal crib vs conventional fixed palatal crib
Full	Not cluster	Differences in finished case quality between Invisalign and traditional fixed appliances
Full	Not cluster	One-year comparative assessment of retention of arch width increases between modified vacuum-formed and Hawley retainers
Full	Not cluster	Comparative assessment of relapse and failure between CAD/CAM stainless steel and standard stainless steel fixed retainers in orthodontic retention patients
Full	Not cluster	Short-term skeletal and dentoalveolar effects of overexpansion
Full	Not cluster	Physical properties of root cementum: Part 29. The effects of LED-mediated photobiomodulation on orthodontically induced root resorption and pain: a pilot split-mouth randomized controlled trial
Full	Not cluster	The effect of micro-osteoperforations on orthodontic space closure investigated over 12 weeks: a split-mouth, randomized controlled clinical trial
Full	Not cluster	Success rate of surface-treated and non-treated orthodontic miniscrews as anchorage reinforcement in the lower arch for the Herbst appliance: A single-centre, randomised split-mouth clinical trial
Full	Not cluster	Cost analysis of two types of fixed maxillary retainers and a removable vacuum-formed maxillary retainer: a randomized controlled trial
Full	Not cluster	Effect of the timing of second molar bonding on the duration of the mandibular arch levelling: a randomized clinical trial
Full	Not cluster	A two-year comparative assessment of retention of arch width increases between modified vacuum-formed and Hawley retainers: a multi-center randomized clinical trial
Full	Not cluster	Mini-implant assisted rapid palatal expansion (MARPE) effects on adult obstructive sleep apnea (OSA) and quality of life: a multi-center prospective controlled trial
Title	Not cluster	Effect of treatment of transverse maxillary deficiency using rapid palatal expansion on oral health-related quality of life in children: A randomized controlled trial
Abstract	Animal	Effect of stretch frequency on osteogenesis of periodontium during periodontal ligament distraction
Full	Not cluster	Comparison between clear aligners and 2 × 4 mechanics in the mixed dentition: a randomized clinical trial
Abstract	Not cluster	The use of the Hanks Herbst vs Twin-block in Class II malocclusion: A randomized controlled trial
Abstract	Not cluster	Influence of social media and corrected smile photographs in patients with malocclusion
Abstract	Not cluster	Effect of clear aligner attachment design on extrusion of maxillary lateral incisors: A multicenter, single-blind randomized clinical trial
Abstract	Not cluster	Comparison of the effectiveness of piezocision and microosteoperforation in leveling mandibular anterior teeth
Abstract	Not cluster	Comparison of in vivo failure of precipitation-coated hydroxyapatite temporary anchorage devices with that of uncoated temporary anchorage devices over 18 months
Abstract	Not cluster	Comparative assessment of treatment efficiency and patient experience between Dental Monitoring and conventional monitoring of clear aligner therapy: A single-center randomized controlled trial
Title	Not cluster	Machine-learning-based detection of degenerative temporomandibular joint diseases using lateral cephalograms
Abstract	Not cluster	Assessment of microbial contamination in removable orthodontic appliances with and without the use of antimicrobial agents by checkerboard DNA-DNA hybridization analysis
Full	Not cluster	Evaluation of the bisphenol released in the saliva after residual adhesive removal in orthodontic patients by using ultrasonic scaling and rotary system: A single-center randomized clinical trial

## Appendix 2. Continued

Exclude from	Reason	Title
Full	Not cluster	Effect of chlorhexidine mouthwashes on periodontal parameters and extrinsic tooth staining in orthodontic patients
Full	Not cluster	Comparison between clear aligners and 2 × 4 mechanics in the mixed dentition: a randomized clinical trial
Full	Not cluster	A comparison of maxillary canine retraction into healed and recent extraction sites using cone beam computed tomography: a randomized clinical trial
Full	Not cluster	Comparison of periodontal status and failure rates with different retainer bonding methods and adhesives: a randomized clinical trial
Full	Not cluster	Efficacy of aloe vera and probiotic mouthwashes vs fluoride mouthwash on <i>Streptococcus mutans</i> in plaque around brackets of orthodontic patients: a randomized clinical trial
Abstract	Not cluster	Early prevention of maxillary canine impaction: a randomized clinical trial
Abstract	Not cluster	The effect of tooth borne versus skeletally anchored Alt-RAMEC protocol in early treatment of Class III malocclusion: a single-centre randomized clinical trial
Abstract	Not cluster	Patient compliance with Twin Block appliance during treatment of Class II malocclusion: a randomized controlled trial on two check-up prescriptions
Abstract	Not clinical	Deep convolutional neural network-based automated segmentation and classification of teeth with orthodontic brackets on cone-beam computed-tomographic images: a validation study
Abstract	Not cluster	Post-treatment stability after 5 years of retention with vacuum-formed and bonded retainers-a randomized controlled trial
Abstract	Not cluster	Three-dimensional comparison of tooth-borne and tooth-bone-borne RME appliances: a randomized controlled trial with 5-year follow-up
Full	Not cluster	Failure frequency of fixed mandibular retainers after pre-treatment of the enamel surface with pumice versus sandblasting-a randomized controlled trial
Abstract	Not cluster	Pain and discomfort during the first week of maxillary expansion using two different expanders: patient-reported outcomes in a randomized controlled trial
Abstract	Not cluster	Stability of maxillary anterior teeth during retention and 1 year after removal of retention-an RCT on adolescents retained with two different bonded retainers and a vacuum-formed retainer
Full	Not cluster	Effects of headgear timing on dental arch changes from 7 to 18 years of age: a follow-up study
Abstract	Not cluster	The effect of micro-osteoperforation on the rate of tooth movement during the alignment stage in patients with mandibular crowding: a randomised controlled trial
Full	Not cluster	The effect of mastic mouthwash on halitosis and oral hygiene in orthodontic patients: a randomized clinical trial
Abstract	Not clinical	Artificial intelligence-assisted determination of available sites for palatal orthodontic mini implants based on palatal thickness through CBCT
Abstract	Not clinical	Effect of stretch frequency on osteogenesis of periodontium during periodontal ligament distraction
Abstract	Cross sectional	Evaluating video-based lectures on YouTube for dental education
Abstract	Not cluster	Rate and anchorage loss during en-masse retraction between friction and frictionless mechanics: A randomized clinical trial
Abstract	Not cluster	Comparison between digital and conventional impression techniques in children on preference, time and comfort: A crossover randomized controlled trial
Abstract	Not cluster	Dentofacial effects of miniscrew-anchored maxillary protraction on prepubertal children with maxillary deficiency: a randomized controlled trial
Abstract	Not cluster	Effect of functional appliances on sleep-disordered breathing in Class II division 1 malocclusion children: Randomized controlled trial
Abstract	Not cluster	Comparison of treatment effects during en-masse retraction of upper anterior teeth placed using mini-implants placed at infrazygomatic crest and interradicular sites: A randomized controlled trial