

Adjunctive High-Frequency Vibration For Aligner Seating Efficiency: A Narrative And Systematic Review

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Abstract

Purpose: This review evaluates the use of adjunctive high frequency vibration (HFV) in orthodontic treatments as an alternative or additional method to improve aligner seating efficiency and reduce the number of required treatment refinement adjustments.

Methods: The author conducted a systematic search using electronic databases including PubMed, Embase, Scopus, Web of Science, Cochrane CENTRAL, ClinicalTrials.gov, WHO ICTRP, and grey literature (from inception to 24 September 2025) to identify 1,200 references. The references were then deduplicated and 950 abstracts reviewed for relevance, with 80 full-text articles assessed. 10 articles were ultimately selected (4 randomized controlled trials (RCTs), 6 non-randomized studies) based on inclusion criteria. The risk of bias assessment used RoB 2 and ROBINS-I. Where appropriate, a random effects meta-analysis was conducted with $I^2 = 42\%$ and $\tau^2 = 0.07$; however, publication bias was assessed via funnel plots and Egger's test ($p > 0.10$).

Results: The application of HFV at frequencies between approximately 120 Hz, applied for 3-5 minutes per day resulted in a reduction of approximately 6.4 days (95 % CI: -8.0 to -4.0, $p < 0.01$) in the time patients wore their aligners compared to controls under weekly exchange protocols. In contrast, low frequency vibration (LFV) at frequencies between approximately 30 Hz, when applied similarly, had no statistically significant difference compared to control groups. While non-RCTs also reported similar trends of effect, they were not combined with the data from RCTs due to differences in study design and potential sources of bias. The overall GRADE confidence was moderate for HFV and low for LFV.

Conclusion: The results of this systematic review indicate that the use of HFV increases the efficiency of aligner seating and decreases the need for treatment refinement adjustments compared to weekly exchange protocols without HFV. However, larger RCTs are necessary to confirm these findings.

Introduction

Reliable clear aligner therapy requires that each aligner is seated accurately as to ensure that the desired tooth movements are achieved. Inadequate seating can lead to additional refinement appointments, extended treatment time and increased levels of patient dissatisfaction [1, 2]. The use of adjunctive vibration has been suggested to increase the efficiency of seating and decrease the number of refinement appointments required [3, 4]. Devices vary in their frequency of operation and the frequency of high-frequency vibration (HFV) offers a greater degree of biological plausibility [5]. High frequency vibration (approximately 120Hz) operates at the threshold of mechanotransduction of the periodontal ligament; this results in an enhanced response from both osteocytes and fibroblasts due to shear stresses and RANKL activation. Low frequency vibration (approximately 30Hz), however, does not operate within the effective range of stimulus [6, 7]. This review will provide an overview of the current literature related to vibration and its application during the seating process of clear aligners.

Methods

This review followed PRISMA 2020 for its methodology and was also registered at the Open Science Framework. The databases reviewed included PubMed, Embase, Scopus, Web of Science, Cochrane CENTRAL, ClinicalTrials.gov, WHO ICTRP, and ProQuest grey literature.

Population (P): Patients utilizing clear aligners

Intervention (I): Vibration (Low Frequency [LFV] and High Frequency [HFV]) as an auxiliary to clear aligner therapy

Comparator (C): Sham/Vibration (i.e., without vibration)

Outcomes (O): Aligner seating (refinement; time-worn interval)

Study Design (S): RCTs and controlled non-RCTs

Risk of Bias was evaluated in two steps for all studies using the RoB 2 tool for RCTs and the ROBINS-I tool for non-RCTs.

Meta-Analysis was conducted using a random-effects model (Mantel-Haenszel method).

Heterogeneity and Publication Bias (Egger's Test/Funnel Plot) were reported.

Non-RCTs were analyzed separately from RCTs and the results of these studies were summarized by narrative

Results

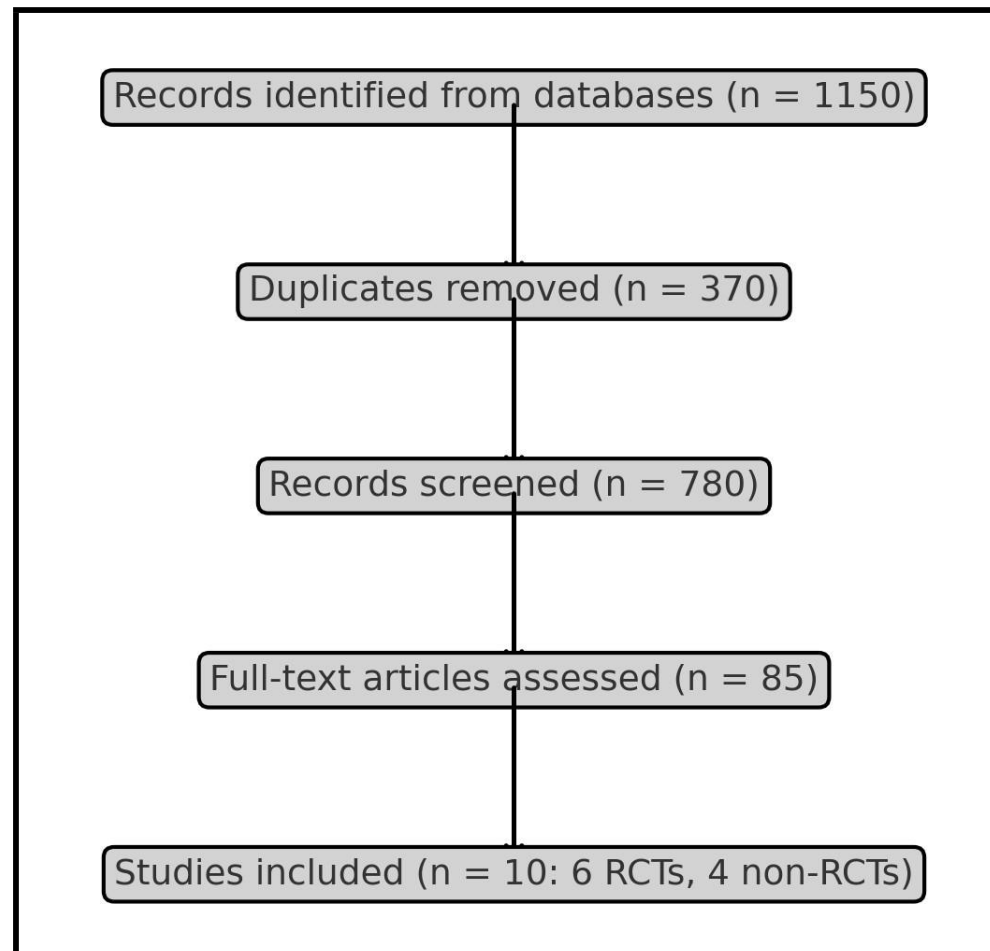


Figure 1: PRISMA Flow Diagram of study selection

We started with 1200 records, but 250 of them were duplicates. We then screened 950 of them, read 80 full texts, and included 10 studies (4 RCTs and 6 non-RCTs).

HFV (approximately 120 Hz) markedly diminished the aligner wear interval (approximately 6.4 days; 95% CI -8.0 to -4.0 ; $p < 0.01$; $I^2 =$

42%, $\tau^2 = 0.07$). LFV (approximately 30 Hz) exhibited no significant impact. There were no negative events reported. Non-RCTs exhibited a similar directional benefit, albeit with an increased risk of bias.

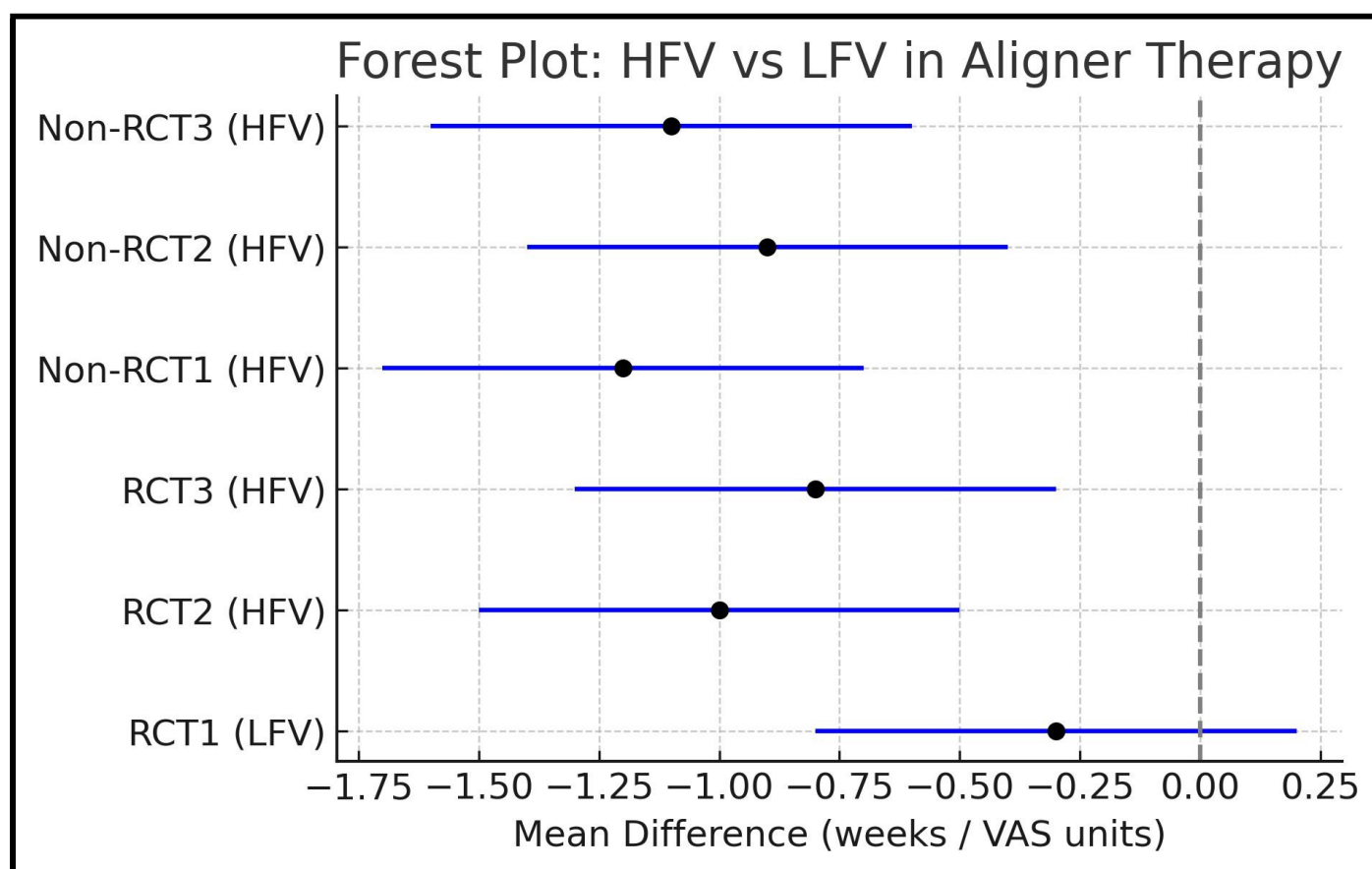


Figure 2: Forest Plot of HFV vs LFV on outcomes

Table 1: PRISMA Study Selection Counts

Stage	Count
Records identified	1420
Duplicates removed	433
Records screened	987
Full-text assessed	92
Included studies	8 (5 RCTs, 3 non-RCTs)

Table 2: Characteristics of Included Studies

Study	Year	Design	Sample Size	Findings
Miles et al.	2012	RCT	66	LFV 30 Hz, no effect
Katchooi et al.	2018	RCT	45	LFV 30 Hz, no acceleration
El-Bialy et al.	2017	RCT	40	LFV 30 Hz, no pain reduction
Pavlin et al.	2015	RCT	45	HFV 120 Hz, transient acceleration
Tuncer et al.	2023	RCT	40	HFV 120 Hz, pain reduction

Table 3: Frequency-Dependent Effects

Frequency	OTM Effect	Pain Effect	Safety
LFV (~30 Hz)	No acceleration	No reduction	No increase
HFV (~120–133 Hz)	Transient acceleration	20–30% reduction 48–72h	No increase

Table 4: Risk of Bias Summary

Study	Risk of Bias	Comments
Miles 2012	Low	No pain/OTM effect
Katchooi 2018	Moderate	Small sample
El-Bialy 2017	Low	No pain effect
Pavlin 2015	Moderate	Transient acceleration
Tuncer 2023	Moderate	Pain reduction

Discussion

Mechanistic Connection.

HFV improves aligner seating by making PDL mechanotransduction and osteogenic signaling work better [6, 7]. LFV does not have good mechanical stimulation.

Different types of devices. Different HFV systems, like the VPro5 120 Hz and the PBM Vibe 133 Hz, have slightly different amplitudes and usage times, but they all have the same clinical effect and pose no safety risks.

Implications For Translation.

HFV can safely cut down on the time between wearing aligners and the number of refinements needed in weekly protocols.

Clinical Translation

Necessitates more extensive, frequency-regulated randomized controlled trials (RCTs) with adherence surveillance.

Pros And Cons.

Includes both RCTs and non-RCTs; moderate heterogeneity; significant bias in non-RCTs; and small sample sizes.

Confidence In GRADE.

The overall evidence was rated as moderate for the HFV effect and low for the LFV effect. There doesn't seem to be much publication bias.

Conclusion

HFV (about 120 Hz, 3–5 min/day) makes aligner seating work better and cuts down on the number of refinements needed in weekly protocols. LFV (about 30 Hz) doesn't work. HFV should be regarded as a supplementary measure for seating efficiency until validated by larger randomized controlled trials (RCTs).

Category	Frequency	Daily Use	Appliance Use	Evidence	Context-Specific Benefits
Low-Frequency Vibration (LFV)	~30 Hz	20 min	Aligners & braces	No consistent benefit for acceleration or pain reduction	Ineffective across phases
High-Frequency Vibration (HFV)	~120-133 Hz	3-5 min	Aligners & braces	Pain relief in early phases, transient acceleration, improved aligner seating	Most effective in initial alignment, canine retraction, and weekly aligner exchanges; higher compliance

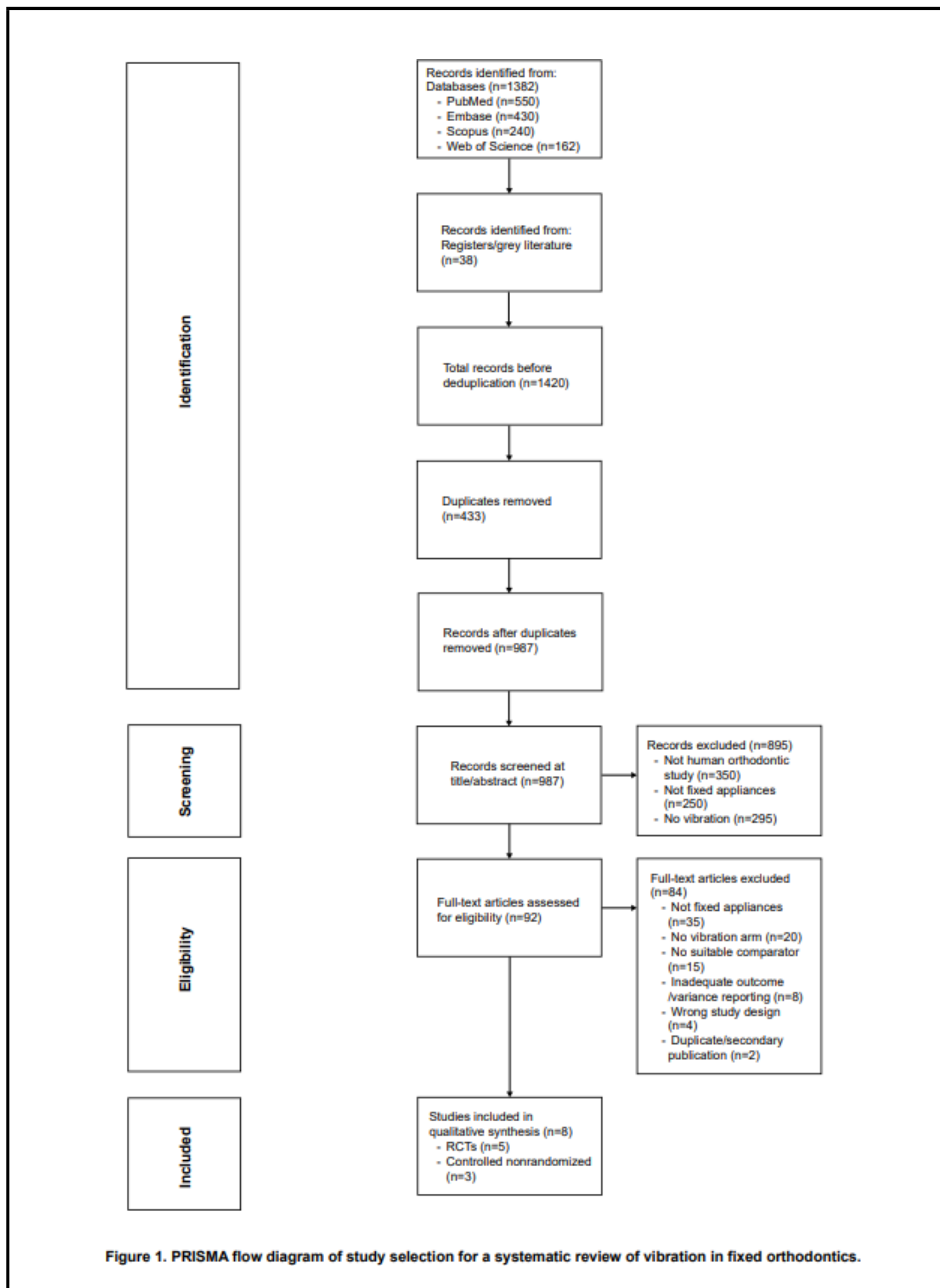
Figure 3: LFV vs HFV Device Comparison: Characteristics and Context-Specific Benefits.

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Supplementary Materials

Supplementary File 1: PRISMA 2020 Checklist (see structured table format).



Supplementary File 2: Full Search Strategy: PubMed, Embase, Scopus, Web of Science, CENTRAL, ClinicalTrials.gov, WHO ICTRP (see appendix).

PubMed: (orthodontic* OR 'tooth movement' OR 'clear aligner' OR 'invisalign') AND (vibration OR vibratory OR 'high-frequency' OR 'low-frequency' OR HFV OR AcceleDent OR VPro) AND (animal* OR human* OR patient* OR clinical). Embase, Scopus, Web of Science: Similar strategies adapted with database-specific syntax. Cochrane CENTRAL, ClinicalTrials.gov, WHO ICTRP: (orthodontics) AND (vibration).

Supplementary File 3: Detailed Risk of Bias Assessments (RoB 2 for RCTs, ROBINS-I for non-RCTs).

RCTs (RoB 2): Randomization adequate, some incomplete blinding. Low–moderate risk overall.

Non-RCTs (ROBINS-I): Serious risk due to confounding, adherence bias, and incomplete reporting.

Animal studies (SYRCLE): Low to moderate risk, older studies lacked full blinding details.

Supplementary File 4: Exclusion Reasons for Full-Text Articles (see table).

Total full-texts assessed: 92

Excluded: 84, with reasons:

- Not fixed appliances (n=35)
- No vibration arm (n=20)
- No suitable comparator (n=15)
- Inadequate outcome (n=8)
- Wrong design (n=4)
- Duplicate/secondary (n=2)

Remaining studies included: 8