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Low-Magnitude, High-Frequency Vibration as a Biophysical Adjunct in Dentistry: Applications to Teeth, Dental Implants, and Osseous Grafts

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Abstract

Low-magnitude, high-frequency vibration (LMHFV) delivers a controlled mechanical signal that may influence bone through mechanotransduction. This narrative review examines the biological rationale and available evidence for LMHFV as an adjunct around natural teeth, extraction sites, dental implants, peri-implant defects, and osseous grafts. Osteocytes detect mechanical stimuli and transmit signals that influence osteoblasts, osteoclasts, mesenchymal stem cells, and signaling pathways, including Wnt/β-catenin and RANK/RANKL/osteoprotegerin. Cellular and animal studies report osteogenic responses and changes in extraction-site healing, bone-to-implant contact, and osseous repair. Human orthodontic findings are mixed and address outcomes that differ from periodontal regeneration, implant survival, and graft maturation. Peripheral perfusion studies provide indirect mechanistic evidence rather than proof of improved oral vascularity. Evidence for the five proposed regenerative applications is predominantly preclinical or limited to uncontrolled clinical observations. Protocol heterogeneity, selection bias, and limited direct human evidence preclude the establishment of a universal dose or a conclusion of established clinical efficacy. LMHFV remains an investigational adjunct; it cannot replace disease control, implant stability, graft containment, vascularity, or appropriate prosthetic management. Controlled, indication-specific human trials are required to establish benefits, safety, and clinically meaningful outcomes.

Categories: Dentistry
Keywords: alveolar bone, bone grafting, dental implants, low-magnitude high-frequency vibration, mechanotransduction, osseointegration, periodontal support

Introduction And Background

Many dental procedures depend on the ability of alveolar bone to respond to injury and mechanical demand. A periodontally compromised tooth must function with reduced support, an extraction socket must heal while the ridge remodels, a dental implant must transition from primary mechanical stability to secondary biological stability, and a grafted site must become vascularized and progressively replaced by or integrated with vital bone. Although these situations differ clinically, each relies on coordinated cellular signaling, angiogenesis, bone formation, resorption, and maturation.

Low-magnitude, high-frequency vibration (LMHFV) refers to low-amplitude, rapidly repeated mechanical oscillations intended to stimulate tissue mechanosensing rather than provide the sustained forces of mastication or orthodontic loading. Frequency describes cycles per second, whereas displacement, acceleration, force, and exposure duration describe different aspects of the dose and should not be used interchangeably. Low-amplitude signals can be detected by osteocytes and translated into biochemical activity affecting osteoblast and osteoclast behavior [1,2]. Localized intraoral delivery transmits vibration through a mouthpiece, teeth, or an implant-related interface; whole-body vibration transmits signals from a platform through the skeleton. Their tissue exposure and clinical effects cannot be assumed to be equivalent. No single parameter set defines an effective dose across all dental indications.

This narrative review examines the biological rationale and available evidence for LMHFV around natural teeth, extraction sites, dental implants, peri-implant bone, and osseous grafts. The central knowledge gap is whether responses observed in cells and animal models translate into meaningful human regenerative outcomes. Bringing these applications together allows comparison of the directness and limitations of the supporting evidence, rather than treating a shared mechanism as proof of equivalent clinical benefit.

Review

Scope and methodology of the narrative review

This qualitative narrative review considered cellular mechanotransduction, vascular responses, alveolar remodeling, extraction healing, implant osseointegration, peri-implant defects, and osseous repair. The original manuscript described relevance-based selection but did not document the databases, dates,

language restrictions, or screening procedures used for its initial literature selection. Those historical details cannot be reconstructed reliably from the reference list. For the present revision, a focused web-assisted update was conducted on November 5, 2026, using searches directed to PubMed-indexed records, PubMed Central, and original journal websites. Searches combined vibration terms with dental implant, osseointegration, orthodontic, randomized trial, systematic review, and recent publication years, and explicitly sought neutral or contradictory findings. No lower publication-date limit was imposed on this supplemental update; recent human research was sought alongside foundational reports. English-language records and accessible English abstracts or full texts were used. This was not a comprehensive search of all records within each database and did not include a systematic search of Embase, Scopus, or Web of Science.

Eligible material for the qualitative synthesis comprised in vitro studies of relevant signaling, animal studies of alveolar bone, extraction, implant or osseous healing, human intraoral studies, relevant systematic reviews, and clinical case reports. Whole-body, peripheral vascular, and fracture studies were retained only as indirect mechanistic evidence. Reports of other physical modalities, records without a relevant vibration exposure or biological endpoint, and claims lacking an identifiable source were not used to establish efficacy. Neutral and unfavorable outcomes were considered alongside favorable results. These relevance criteria do not imply exhaustive screening or a prespecified systematic review protocol.

Evidence was summarized by model, design, sample size when verified, vibration parameters, outcome, and principal limitation. Human regenerative outcomes were distinguished from orthodontic and peripheral vascular endpoints. Appraisal considered control groups, randomization or blinding where reported, cointerventions, follow-up, and directness to the proposed dental indication. No independent duplicate screening, formal study-level risk-of-bias scoring, or de novo certainty grading was undertaken. Findings were synthesized descriptively without independent pooling, meta-regression, or new statistical testing; all numerical estimates were taken from identified publications. The comparative tables are selective summaries, not an inventory of every eligible study.

How bone responds to mechanical stimulation

Bone continually adapts to mechanical loading. When loading is reduced, bone density and mass can decrease. A response to mechanical stimulation nevertheless depends on the tissue state and the delivered signal; increased remodeling is not synonymous with net bone formation or clinical regeneration.

Researchers have found that osteocytes are central to this response. Lau E et al. demonstrated that LMHFV altered osteocyte signaling, reduced RANKL (receptor activator of nuclear factor kappa-B ligand) expression, and inhibited osteoclast formation [2]. Chen B et al. reported increased adhesion and osteogenic differentiation of bone marrow-derived mesenchymal stem cells exposed to LMHFV on hydroxyapatite-coated surfaces, together with increased osteogenic markers and activation of Wnt/β-catenin signaling, an important cellular pathway regulating osteoblast differentiation and bone formation [3].

Clinically, bone does not necessarily require a large force to recognize mechanical stimulation. Frequency, magnitude, acceleration, duration, and delivery can be as important as the amount of force itself [1]. The objective is not simply to vibrate bone but to provide a controlled mechanical signal that produces a favorable biological response. The mechanotransduction pathway begins when the LMHFV signal is detected by osteocytes, converted into biochemical signaling, and transmitted to osteoblasts and osteoclasts that regulate the balance between bone formation and resorption (Figure *1*) [1,2].

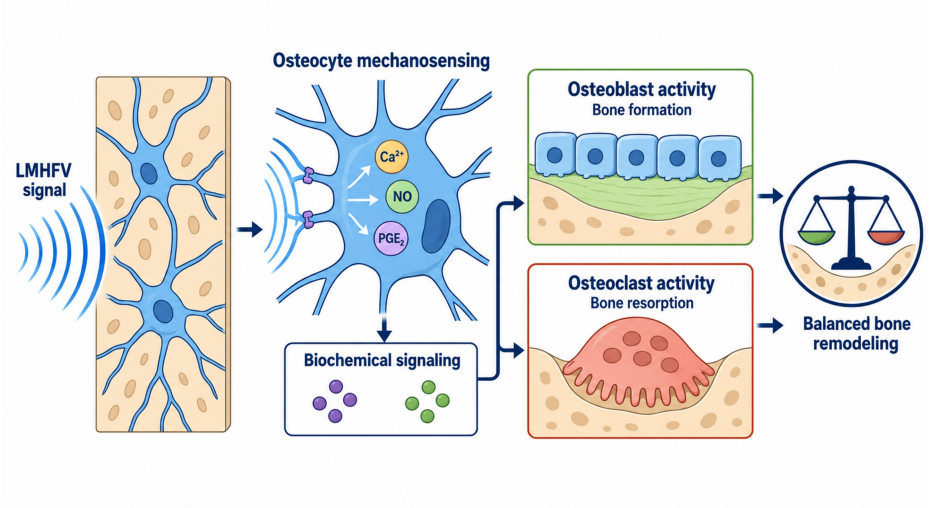


FIGURE 1: Proposed mechanism of low-magnitude, high-frequency vibration (LMHFV) in bone remodeling.

Mechanical stimulation is sensed by osteocytes and translated into biochemical signals involving calcium (Ca^{2+}), nitric oxide (NO), and prostaglandin E_2 (PGE_2). These signals may influence osteoblast-mediated bone formation and osteoclast-mediated bone resorption, contributing to coordinated bone remodeling. Scientific basis: [1,2].

Note: The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

Potential dental applications of LMHFV include support of periodontally compromised teeth, extraction-site healing and ridge preservation, implant osseointegration, peri-implant bone maintenance, and osseous graft maturation (Figure *2*) [1,4,5,6,7,8,9,10].

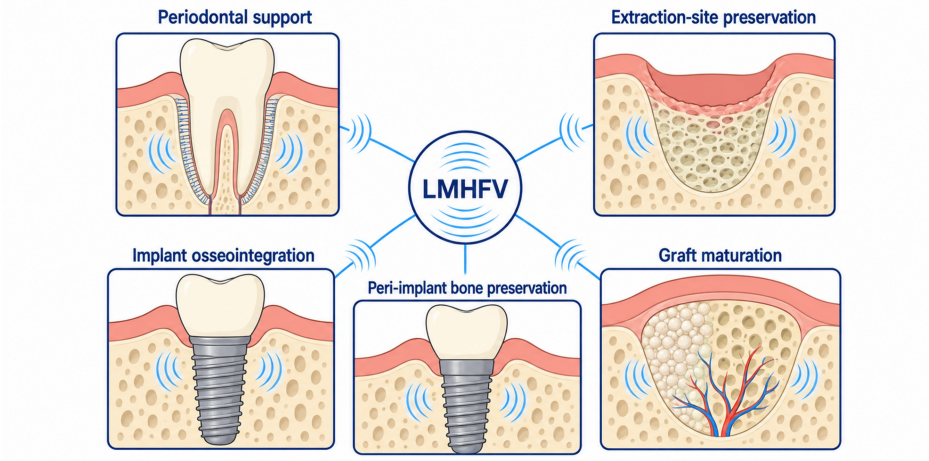


FIGURE 2: Potential dental applications of low-magnitude, high-frequency vibration (LMHFV).

Schematic illustration of proposed applications involving periodontal support, extraction-site preservation, implant osseointegration, peri-implant bone preservation, and graft maturation. Blue arcs represent mechanical stimulation of the surrounding tissues. Scientific basis: [1,4,5,6,7,8,9,10].

Note: The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

Perfusion, angiogenesis, and the healing environment

Bone regeneration requires a vascular supply. Early healing depends on clot organization, endothelial

response, vascular ingrowth, oxygenation, nutrient delivery, and recruitment of progenitor cells. Vibration can generate cyclic shear stress along the vascular endothelium, stimulate nitric oxide-dependent vasodilation, and increase regional perfusion. Human studies of vibration have reported changes in muscle blood volume and skin blood flow, although these models are not directly equivalent to intraoral application [11,12,13].

Preclinical evidence suggests that low-intensity vibration can influence angiogenesis and wound healing in metabolically compromised animals [14]. These findings provide a vascular hypothesis that complements skeletal mechanotransduction. Peripheral blood-flow changes and diabetic skin-wound healing cannot establish improved perfusion, angiogenesis, or regeneration at human intraoral surgical sites.

Applications around natural teeth

Tooth mobility after periodontal attachment and alveolar bone loss is influenced by remaining bone support, periodontal ligament inflammation, occlusal loading, root anatomy, and the crown-to-bone relationship. Treatment must first control inflammation and contributing factors through periodontal therapy, plaque control, correction of traumatic occlusal contacts when indicated, and selective splinting. LMHFV cannot regenerate attachment lost to uncontrolled periodontal disease and should not be presented as a substitute for those measures.

Once inflammation and occlusal factors have been controlled, residual mobility and a reduced osseous envelope may remain. Experimental studies have demonstrated an osteogenic response to high-frequency acceleration within alveolar bone [4,5]. A controlled LMHFV signal transmitted through the dentition and periodontal ligament may therefore provide an additional stimulus to osteocytes and the remaining alveolar bone without requiring increased functional loading of the compromised tooth (Figure 3) [4,5,7]. The reasonable clinical objective is to support the remodeling and maturation of existing bone, not to recover the original periodontal architecture.

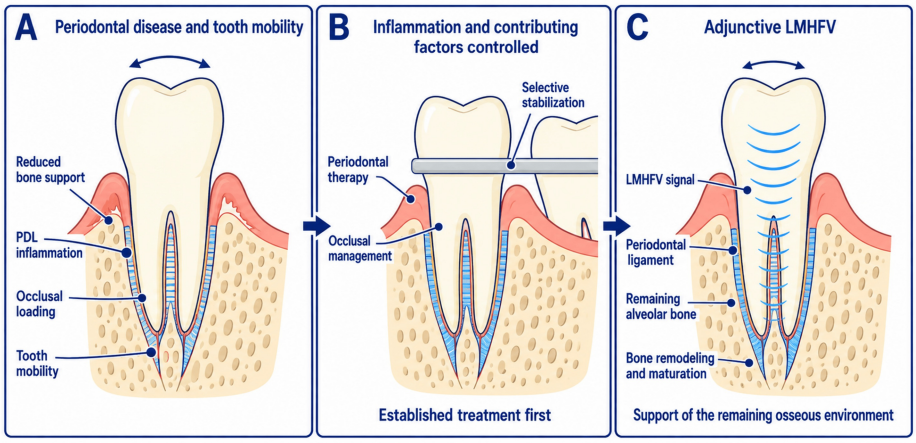


FIGURE 3: Proposed adjunctive role of low-magnitude, high-frequency vibration (LMHFV) in teeth with reduced periodontal support.

(A) Periodontal inflammation and reduced alveolar bone support contribute to tooth mobility. (B) Initial management addresses inflammation, occlusal factors, and stabilization when indicated. (C) Adjunctive LMHFV is illustrated as a potential stimulus for remodeling within the remaining periodontal and osseous tissues. The schematic does not imply regeneration of lost periodontal attachment. Scientific basis: [4,5,7].

The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

The human reports cited here do not establish a reduction in residual periodontal tooth mobility, gain in clinical attachment, or improvement in long-term tooth retention attributable to LMHFV. These outcomes require controlled studies after periodontal disease and occlusal factors have been managed. The proposed application should therefore be presented to patients as investigational rather than as an established method of restoring periodontal support.

Extraction sites and ridge preservation

Extraction changes both the biological and mechanical environment of the alveolus. Socket healing begins

immediately, while the surrounding ridge undergoes remodeling that can reduce alveolar width and height. An experimental model reported increased socket bone volume and preservation of ridge dimensions with daily high-frequency acceleration [6]. Human case reports described healing sufficient for later implant placement after LMHFV use [15]. These uncontrolled observations cannot separate a vibration effect from spontaneous healing, socket anatomy, or concomitant care and do not demonstrate equivalence to socket grafting.

Socket healing progresses from clot formation through vascular ingrowth and cellular recruitment to woven bone deposition, mineralization, and remodeling. LMHFV has been proposed as a mechanical stimulus to host tissues during this sequence, but its effect at each phase has not been established in human extraction or grafted sites (Figure *4*) [1,6,10,16,17,18].

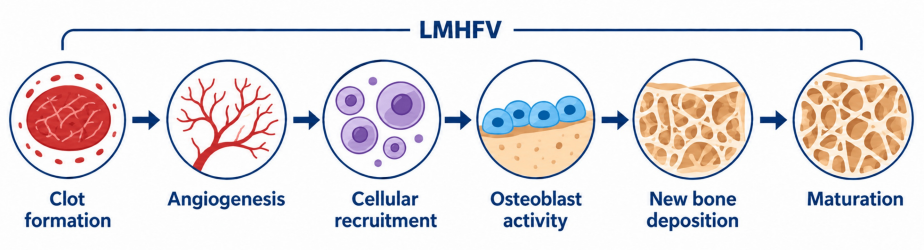


FIGURE 4: Biological sequence of socket healing and osseous graft maturation.

Healing begins with the formation of a stable blood clot, followed by angiogenesis and the recruitment of host progenitor cells. Osteoblast activity subsequently supports osteoid production and new bone deposition, followed by mineralization, remodeling, and maturation into trabecular bone. LMHFV is depicted as a proposed mechanical stimulus; the illustration does not establish a benefit at each stage of human socket healing or graft maturation. Scientific basis: [1,6,10,16,17,18].

The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

Atraumatic extraction, debridement, clot stability, and ridge-preservation procedures, when indicated, remain the basis of treatment. The proposed target of adjunctive LMHFV is the host tissue response around the socket or graft rather than an inert graft particle (Figure *5*) [6,7,15]. Evidence does not yet define whether immediate postoperative use improves human socket healing or how delivery should be modified to protect a fresh wound.

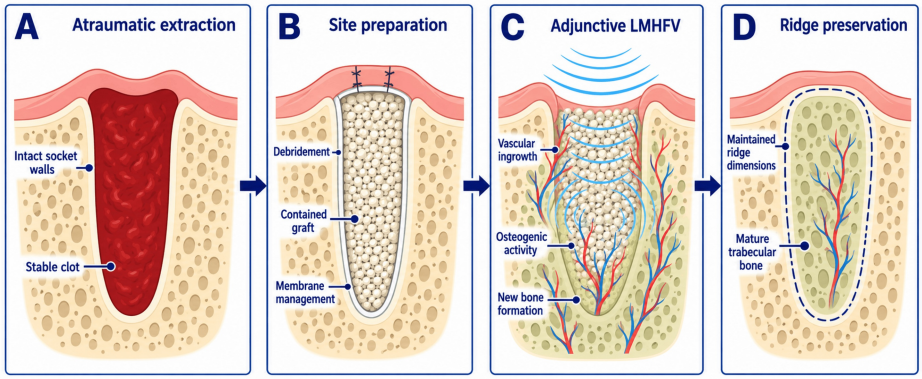


FIGURE 5: Clinical integration of LMHFV during extraction-site healing and ridge preservation.

(A) Atraumatic extraction helps preserve the socket walls and establish a stable blood clot. (B) Thorough debridement, graft containment, membrane management, and soft-tissue closure establish the conditions required for healing. (C) LMHFV is a proposed adjunctive mechanical stimulus. (D) Normal healing and remodeling may produce trabecular bone. These schematic stages do not demonstrate an incremental LMHFV benefit or establish equivalence to ridge-preservation grafting. Scientific basis: [6,7,15].

The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

A five-minute daily schedule has been reported in clinical applications around teeth and implants, in peri-implantitis case presentations, and after extraction [7,9,15]. That schedule is a description of those reports, not a validated dose for all extraction sites, graft materials, or healing stages. Controlled comparisons should measure ridge width and height, histologic new bone, the later need for augmentation, and adverse events before routine use or shorter healing intervals can be recommended.

Dental implant osseointegration

Primary implant stability is mechanical and depends on bone quantity and density, implant macrogeometry, osteotomy preparation, insertion technique, and implant position. During healing, some bone initially contacting the implant is resorbed, while new woven bone forms and subsequently remodels. The implant must pass through this transition without micromotion sufficient to disrupt osseointegration. LMHFV is of interest because it may stimulate the bone-implant environment while adding only a small, controlled mechanical signal during the transition from primary mechanical stability to secondary biological stability (Figure *6*) [8,19,20,21].

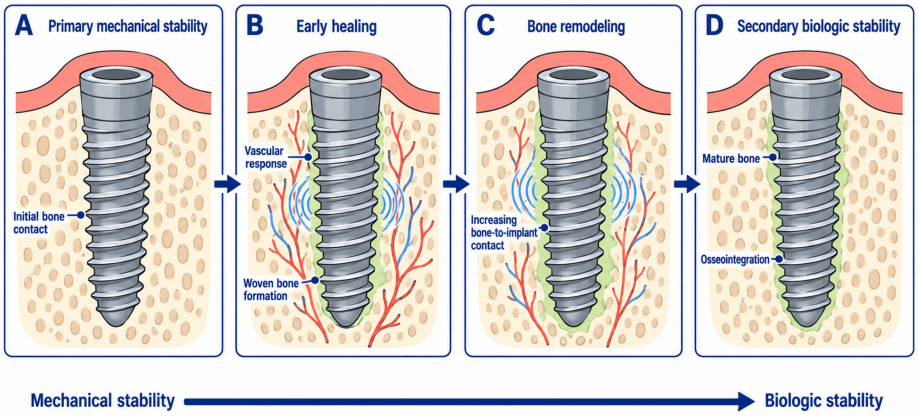


FIGURE 6: Implant healing from primary mechanical stability to secondary biological stability.

(A) Initial stability derives from mechanical engagement with existing bone. (B) Early healing involves vascular responses and woven bone formation. (C) Remodeling progressively increases bone-to-implant contact. (D) Bone maturation and osseointegration contribute to secondary biological stability. Blue arcs represent the proposed adjunctive application of low-magnitude, high-frequency vibration (LMHFV) during healing. Scientific basis: [8,19,20,21].

The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

Animal studies have reported changes in early osseointegration, bone-to-implant contact, peri-implant bone volume, or interfacial strength [19,20,21]. Ye X et al. synthesized 15 animal studies [8]. For bone-to-implant contact, 12 studies contributed 259 animals; the reported standardized effect was 1.67 (95% CI 0.97-2.37; I^2 = 81%). For bone volume fraction, 14 studies contributed 304 animals; the effect was 1.43 (95% CI 0.57-2.29; I^2 = 88%). The source methods and forest plots identify standardized mean differences, although the results text labels these estimates as MD. They are not percentage-point gains. The direct-loading subgroup did not show a statistically significant effect on bone volume fraction (0.73; 95% CI -0.37 to 1.83; P = 0.19). Most implants were placed in long bones; only one included study examined jaw implants. These findings support further investigation but cannot establish benefits for human implant survival, immediate loading, or marginal bone maintenance. Adequate primary stability, three-dimensional positioning, micromotion control, and appropriate restorative design remain prerequisites.

Delayed placement, immediate placement, gap-grafted sites, and full-arch loading should be investigated as separate clinical settings. LMHFV should not be used to justify loading an unstable implant or to shorten an established healing interval without supporting clinical evidence.

Peri-implant bone loss and maintenance

When peri-implant inflammation develops, treatment must first address microbial deposits and local etiologic factors. Depending on the diagnosis and defect, management may include nonsurgical or surgical debridement, implant-surface decontamination, correction of residual cement or unfavorable prosthetic contours, regenerative or resective therapy, and improved patient-performed plaque control. An LMHFV device is not a treatment for infection and should not be used as a stand-alone therapy for peri-implantitis.

After etiologic control, LMHFV has been proposed as an adjunct to wound healing and remodeling (Figure 7) [9]. Published case presentations using a five-minute daily protocol reported favorable changes following combined peri-implantitis treatment but lacked a concurrent control group. Debridement, decontamination, regeneration, maintenance, and natural healing confound the attribution of improvement to vibration. Radiographic defect fill alone does not establish re-osseointegration, prevention of recurrence, or a specific LMHFV effect.

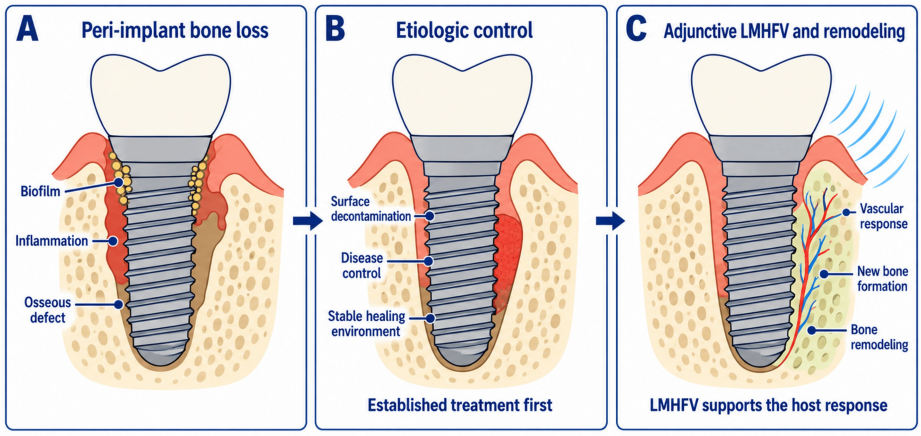


FIGURE 7: Proposed adjunctive role of low-magnitude, high-frequency vibration (LMHFV) in peri-implant bone remodeling.

(A) Biofilm-associated inflammation and peri-implant bone loss. (B) Established treatment addresses surface contamination and contributing factors to create conditions for healing. (C) LMHFV is depicted as a potential adjunctive stimulus for vascular responses and bone remodeling after disease control. Scientific basis: [9].

The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

Osseous grafts and graft maturation

Successful grafting requires more than the placement of a biomaterial. A stable clot must form, blood vessels must enter the site, host cells must migrate and differentiate, new bone must be deposited, and the grafted volume must remodel and mature. LMHFV does not stimulate an inert graft particle directly; the intended target is the host biological response within and around the graft (Figure *8*) [3,10,16,17,18].

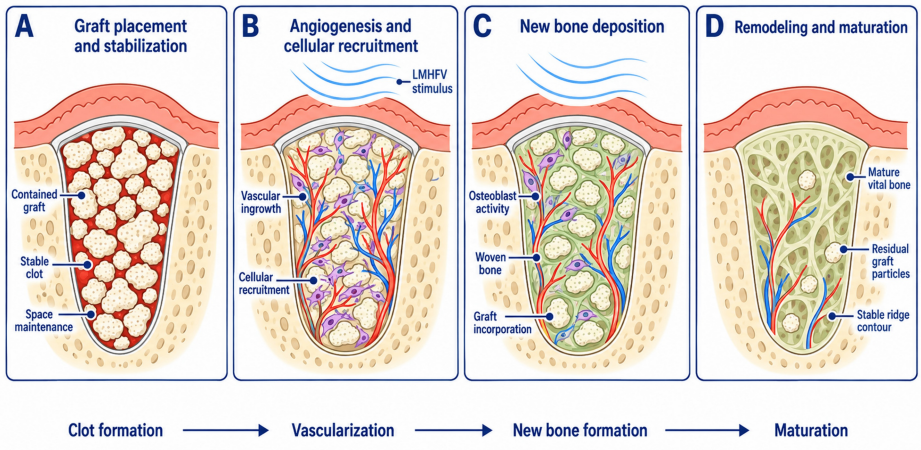


FIGURE 8: Osseous graft incorporation and maturation with proposed adjunctive low-magnitude, high-frequency vibration (LMHFV).

(A) Graft containment, clot stabilization, and space maintenance. (B) Vascular ingrowth and cellular recruitment. (C) Woven bone deposition and graft incorporation. (D) Remodeling into mature vital bone with residual graft particles. Blue waves depict LMHFV as a potential mechanical stimulus to the surrounding host tissues. Scientific basis: [3,10,16,17,18].

The illustration was created manually using the non-AI tools and features of Adobe Photoshop (Adobe Inc.) and Microsoft Paint (Microsoft Corp.). No AI image-generation or AI-assisted image-editing tools were used.

The ability of LMHFV to promote osteogenic differentiation of mesenchymal stem cells provides a mechanistic basis for this application [3]. In surgically created cranial defects, low-magnitude, high-frequency mechanical stimulation has influenced early healing and osteoid formation [10]. Fracture models have also demonstrated accelerated callus formation, mineralization, and remodeling [16,17,18]. Although a fracture callus or calvarial defect is not equivalent to a grafted extraction socket, ridge augmentation, or sinus graft, these models share processes that include progenitor-cell recruitment, vascularization, new bone deposition, mineralization, and remodeling.

Socket grafting, ridge augmentation, sinus augmentation, and grafting around immediate implants are proposed research settings rather than established LMHFV indications. Conventional regenerative principles remain primary: debridement, space maintenance, graft stability, vascular access, soft-tissue management, and protection from disruptive loading. Direct controlled human evidence for accelerated graft maturation in these settings is not established by the cited literature. Radiographic density alone cannot quantify vital bone because residual graft particles and imaging conditions affect appearance. Histomorphometry and standardized volumetric follow-up are needed to assess new bone, residual material, and contour maintenance.

Clinical integration

References 7, 9, and 15 support five-minute daily use in the clinical applications they describe [7,9,15]. This brief regimen provides a practical schedule for home use, although treatment duration alone does not specify the delivered mechanical dose. Frequency, displacement or acceleration, coupling, application site, session duration, and total treatment period must be reported. A regimen studied with one device or in orthodontics cannot be generalized to recently placed implants, fresh sockets, or grafted sites.

If LMHFV is considered, the clinician should explain the uncertainty of clinical benefit and assess disease control, implant and wound stability, graft containment, occlusion, and systemic healing factors. The timing of postoperative use requires indication-specific evaluation; a low nominal device output does not prove safe mechanical exposure at every tissue interface. Evidence does not establish a need for indefinite daily use to preserve alveolar or peri-implant bone.

Documentation should include device parameters, delivery method, start date, actual adherence, concomitant treatment, adverse events, and objective baseline and follow-up findings. Outcomes should match the indication, including mobility and clinical attachment for teeth, ridge dimensions for sockets, stability and survival for implants, and histologic or volumetric outcomes for grafts. Monitoring documents outcomes but does not establish causality in the absence of a comparator. Table *1* distinguishes the directness of evidence across the five proposed applications.

Application	Highest level of relevant evidence cited	Interpretation and key gap
Periodontally compromised teeth	Alveolar animal studies and clinical descriptions [4,5,7]	Biologic plausibility; controlled attachment, mobility, and retention benefits not established.
Extraction sites and ridge preservation	Animal extraction study and uncontrolled human case reports [6,15]	Human comparative efficacy and equivalence to grafting remain unestablished.
Dental implant osseointegration	Animal studies and animal meta-analysis [8,19,20,21]	Experimental osseointegration outcomes; benefits for human implant survival or loading have not been demonstrated.
Peri-implant bone loss and maintenance	Human case presentations with combined treatment [9]	Direct clinical observations with substantial confounding; no attributable LMHFV effect.
Osseous graft maturation	Cell, cranial-defect, and fracture models [3,10,16,17,18]	Predominantly indirect evidence; human histologic maturation benefit not established.

TABLE 1: Evidence hierarchy across proposed regenerative applications.

This hierarchy describes study design and directness of evidence within the cited literature; it is not a formal GRADE assessment. Clinical observations can be directly relevant to an indication while remaining weak evidence of causality.

Note: The table was created by the authors using the cited sources.

GRADE: Grading of Recommendations, Assessment, Development and Evaluation; LMHFV: Low-magnitude high-frequency vibration.

Discussion of the available evidence

Cellular and animal findings provide a mechanistic rationale for LMHFV, but their translational relevance differs by model, delivery method, and endpoint. The cited human clear-aligner study reported changes in gingival crevicular biomarkers and patient symptoms [22]. Such findings demonstrate a response in an orthodontic setting; they do not establish periodontal regeneration, implant survival, or graft maturation. A biomarker response, increased radiographic density, and histologic bone-to-implant contact are distinct outcomes and should not be interpreted as interchangeable measures of clinical effectiveness.

The strongest experimental designs available for an adjacent dental indication are human orthodontic trials, whereas the five regenerative applications rely more heavily on animal studies and case observations. Evidence strength must therefore be considered together with relevance to the clinical question. A well-controlled orthodontic trial may have stronger internal validity than a regenerative case report while remaining indirect evidence for implant or graft outcomes.

Case reports can identify feasibility and generate hypotheses, but they cannot estimate the incremental effect of LMHFV when conventional surgery, debridement, grafting, and maintenance are delivered concurrently [9,15]. They should not support claims of prevention, shortened healing, or long-term bone preservation. Variation in frequency, acceleration, coupling, baseline bone quality, and concurrent loading also limits the transfer of findings between experimental models and commercial devices.

Neutral and potentially unfavorable responses warrant the same attention as positive findings. Whole-body studies have not consistently shown skeletal benefits [1], and an experimental orthodontic model showed increased inflammatory activity and resorption during active tooth movement [23]. This context-dependent catabolic response cautions against assuming that vibration is uniformly anabolic. The absence of reported major adverse events in small or short-term studies does not establish long-term safety in periodontally compromised teeth, healing implants, or grafted sites.

Human orthodontic evidence and its limits

Recent controlled evidence illustrates both potential activity and uncertainty. Dutta and Patil randomized 20 adults to 120-Hz vibration for five minutes daily or sham treatment [24]. At four months, the maxillary retraction difference was 1.22 mm (95% CI 1.02-1.42). This small trial measured tooth movement, not bone gain or implant outcomes, and did not establish a shorter total treatment course.

In contrast, Katchooi M et al. randomized 27 aligner patients, of whom 26 were analyzed, and found no difference in completion of the prescribed aligner sequence: 77% with active vibration versus 85% with sham treatment (P = 1) [25]. This different regimen provides a relevant neutral finding but does not directly refute or validate a high-frequency regenerative protocol. Device and indication differences require explicit consideration.

A 2026 harm-focused review included 23 orthodontic randomized trials involving 902 participants [26]. Pain and biomarker effects were inconsistent, and evidence certainty was generally low or very low. Short-term orthodontic safety findings cannot establish long-term safety at healing implants or grafts. Table *2* presents selected quantitative examples while keeping experimental and clinical outcomes separate. These results support indication-specific trials rather than routine regenerative prescribing.

Study and design	Sample and exposure	Findings and principal limitation
Ye X et al. [8]: Animal meta-analysis	15 studies; 972 selected implants; whole-body or direct loading; heterogeneous protocols	BIC: 12 studies, 259 animals; standardized effect of 1.67 (95% CI 0.97-2.37); I^2 = 81%. High heterogeneity and predominantly long-bone sites.
Engen DW et al. [15]: Human case reports	Five patient cases; five-minute daily intraoral use	Healing and subsequent implant placement described; one case required subsequent grafting after incomplete bone fill. No randomized comparator; improvement cannot be attributed to vibration.
Alansari S et al. [22]: Human aligner study	60 participants in five groups; five-minute daily exposure in vibration groups	Biomarker and symptom responses reported. Different aligner schedules and surrogate endpoints limit regenerative inference.
Alikhani M et al. [23]: Animal orthodontic model	High-frequency acceleration with concurrent orthodontic force	Catabolic and anabolic effects depended on the loading context. Animal responses are not clinical periodontal endpoints.
Dutta S and Patil AS [24]: Sham-controlled RCT	20 adults; 120 Hz; 0.0003 N; five minutes daily; four months	Maxillary retraction difference of 1.22 mm (95% CI 1.02-1.42); small sample, short follow-up, and orthodontic endpoint.
Katchooi M et al. [25]: Sham-controlled aligner RCT	27 randomized; 26 analyzed; supplemental intraoral vibration	Sequence completion: 77% versus 85%; P = 1. Regimen differs from high-frequency regenerative protocols.
Sirri MR et al. [26]: Systematic review of harms	23 orthodontic RCTs; 902 participants; heterogeneous exposures	Mixed pain and biomarker findings; mostly low or very low certainty of evidence. Limited inference regarding long-term safety.

TABLE 2: Selected comparative studies and quantitative findings.

The table is selective. Sample sizes refer to the indicated analysis or study, not to a common pooled population. Unverified dose components and statistics are intentionally omitted. Numerical results are from the cited publications; no new meta-analysis was performed.

Note: The table was created by the authors.

BIC: Bone-to-implant contact; RCT: Randomized controlled trial; Hz: Hertz; LMHFV: Low-magnitude high-frequency vibration; N: Newton; I^2: I-squared heterogeneity statistic.

Limitations

This review has methodological limitations inherent in relevance-based narrative selection. The initial search process was not documented sufficiently for replication, and the focused supplemental update was not an exhaustive database search. English-language accessibility, selective publication, author overlap among cited clinical reports, and the lack of independent duplicate screening may introduce bias. No protocol registration, formal study-level risk-of-bias assessment, or de novo Grading of Recommendations, Assessment, Development and Evaluation (GRADE) evaluation was performed. The evidence hierarchy in Table *1* is descriptive and should not be mistaken for a formal certainty rating.

Clinical translation is limited by heterogeneous models and device parameters, predominantly short follow-up periods, uncontrolled concomitant treatment, and a scarcity of direct controlled human studies for the five regenerative applications. Sample sizes and quantitative outcomes could not be standardized across all cited reports; unverified values were not inferred. Orthodontic outcomes and peripheral perfusion responses cannot substitute for indication-specific endpoints. Adherence is relevant to delivered exposure, but its relationship to regenerative benefit remains uncertain. Future trials should prespecify patient-centered outcomes, monitor harms and actual use, and use appropriate sham or standard-care comparisons.

Conclusions

LMHFV has a biologically plausible role in oral tissue mechanotransduction. Cellular and animal findings support further investigation of its effects on alveolar remodeling, extraction-site healing, implant integration, and osseous repair. Direct clinical efficacy for periodontal support, ridge preservation, implant survival, peri-implant disease outcomes, and graft maturation remains unproven based on the evidence reviewed. Human orthodontic findings are mixed and should not be generalized to these regenerative applications.

Additional Information

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: Gregori M. Kurtzman, Robert A. Horowitz

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Drafting of the manuscript: Gregori M. Kurtzman

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