THE EUROPEAN SOCIETY OF MEDICINE
Medical Research Archives, Volume 13 Issue 12

REVIEW ARTICLE

Accelerated Orthodontics: A Prisma-2020 Systematic Review of Biological and Surgical Acceleration Techniques

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OPEN ACCESS

PUBLISHED
31 December 2025

CITATION
Author1, X., Author2, Z., et al., 2025. Accelerated Orthodontics: A Prisma-2020 Systematic Review of Biological and Surgical Acceleration Techniques. Medical Research Archives, [online] 13(12).
https://doi.org/10.18103/mra.v13i12.7112

DOI
https://doi.org/10.18103/mra.v13i12.7112

ISSN
2375-1924

ABSTRACT

Objective: To systematically evaluate the effectiveness, biological mechanisms, clinical outcomes, and safety of contemporary accelerated orthodontic techniques, including micro-osteoperforations (MOPs), corticotomy, piezocision, low-level laser therapy (LLLT), photobiomodulation, high-frequency vibration, and pharmacologic adjuncts.

Methods: A PRISMA-2020 compliant search was conducted across PubMed, Scopus, Web of Science, and Cochrane Library using predefined keywords. Randomized controlled trials, cohort studies, and split-mouth trials evaluating the rate of tooth movement were included. Data extraction focused on movement rate, treatment duration, biological rationale, and reported side effects.

Results: Thirty-seven studies qualified for final analysis. Corticotomy and piezocision produced the greatest acceleration (2–3× increase in tooth movement). MOPs resulted in moderate acceleration (1.5–2×). LLLT and photobiomodulation showed variable effectiveness. Vibration devices demonstrated inconsistent results, with several trials reporting no significant acceleration. Pharmacologic methods showed strong experimental potential but limited clinical applicability.

Conclusion: Accelerated orthodontic techniques significantly enhance movement rates and reduce treatment duration. Surgical interventions demonstrate the most consistent effectiveness, while non-invasive methods remain protocol-dependent. Additional well-designed RCTs are needed to standardize parameters and establish long-term safety.

Keywords: accelerated orthodontics, corticotomy, micro-osteoperforations, LLLT, vibration therapy, piezocision, photobiomodulation, PRISMA systematic review

1. Introduction

Orthodontic treatment traditionally requires 18–30 months, creating concerns related to prolonged chairside time, oral hygiene challenges, enamel demineralization, periodontal risks, and patient compliance. Increasing demand for faster yet predictable treatment has led to the development of **accelerated orthodontic techniques** designed to enhance tooth movement without compromising biological integrity.

Acceleration strategies target the underlying processes of bone remodeling through:

1. **Surgical stimulation** (regional acceleratory phenomenon)
2. **Non-invasive biostimulation** (laser, light-based therapies)
3. **Mechanical stimulation** (vibration)
4. **Cytokine-mediated bone turnover** (pharmacologic adjuncts)

The purpose of this systematic review is to provide a comprehensive, evidence-based evaluation of all major acceleration modalities, identifying their effectiveness, biological foundations, clinical benefits, and limitations.

2. Biological Background

Tooth movement occurs through controlled remodeling of the periodontal ligament and alveolar bone. Acceleration techniques enhance:

- Osteoclastic activity (breakdown of bone on pressure side)
- Osteoblastic activity (bone deposition on tension side)
- Cellular metabolism
- Inflammatory mediator release
- Bone turnover rate

The **regional acceleratory phenomenon (RAP)**, described by Frost, provides the biological basis for surgical acceleration techniques such as corticotomy and piezocision.

3. Methods (PRISMA-2020)

3.1 SEARCH STRATEGY

A structured PRISMA-2020 search was performed across:

- PubMed
- Scopus
- Web of Science
- Cochrane Library

3.2 KEYWORDS

"accelerated orthodontics," "corticotomy," "piezocision," "MOPs," "orthodontic acceleration," "LLLT," "photobiomodulation," "orthodontic vibration," "pharmacologic acceleration."

3.3 INCLUSION CRITERIA

- Human studies
- RCTs, CCTs, cohort, split-mouth studies
- Evaluation of tooth movement rate or treatment duration

3.4 EXCLUSION CRITERIA

- Case reports
- Animal studies
- Opinion or narrative papers
- Studies lacking measurable outcomes

3.5 DATA EXTRACTION

Extracted variables:

- Type of acceleration technique
- Biological mechanism
- Tooth movement measured (mm/week or % increase)
- Pain/discomfort
- Side effects
- Patient acceptance

4. Results

A total of 37 studies met inclusion criteria.

4.1 MICRO-OSTEOPERFORATIONS (MOPS)

- Increase tooth movement by **1.5–2×**
- Minimally invasive
- Create small perforations stimulating inflammatory response
- Effects last 3–4 months
- Minor discomfort reported

Advantages:

✓ Easy to perform

✓ Patient-friendly

Limitations:

• Requires repeated applications

• Moderate acceleration

4.2 CORTICOTOMY-ASSISTED ORTHODONTICS

- Produces **2–3× acceleration**
- Based on RAP
- Shortens treatment duration significantly
- High predictability

Advantages:

✓ Strongest acceleration

✓ Beneficial for complex cases

Limitations:

• Surgical morbidity

• Increased cost

• Requires surgical expertise

4.3 PIEZOCISION

- Minimally invasive corticotomy using piezoelectric incisions
- Provides **~2× acceleration**
- No flap elevation needed

Advantages:

✓ Better patient acceptance than traditional corticotomy

✓ Minimal scarring

Limitations:

• Operator-sensitive

• Limited research on long-term stability

4.4 LOW-LEVEL LASER THERAPY (LLLT) / PHOTOBIO-MODULATION

- Stimulates mitochondrial activity
- Enhances osteoblast & osteoclast function
- Acceleration ranges **0–30%** depending on wavelength & protocol

Advantages:

✓ Painless

✓ Non-invasive

Limitations:

• Inconsistent evidence

• Requires protocol standardization

4.5 HIGH-FREQUENCY VIBRATION DEVICES

- Provide 20–120 Hz forces
- Theoretical mechanism: PDL mechanotransduction
- Clinical effectiveness inconsistent
- Some studies show **no significant acceleration**

4.6 PHARMACOLOGIC ADJUNCTS

Agents include:

- Prostaglandins
- Parathyroid hormone (PTH)
- RANKL modulators

Advantages:

✓ Strong biological rationale

Limitations:

• Safety concerns

• Lack of standardized dosage

• Not clinically adopted

5. Discussion

Evidence strongly supports the effectiveness of **surgical techniques** as the most predictable acceleration methods. **Corticotomy** and **piezocision** demonstrate consistent results backed by biological rationale through RAP. **MOPs** provide a minimally invasive compromise with moderate effectiveness.

Non-invasive methods (LLLT, vibration) show promise but are heavily dependent on device specifications, dosage, wavelength, and individual biological response. Heterogeneity of methodologies across studies remains a significant limitation.

CLINICAL IMPLICATIONS:

- Personalized treatment planning is essential
- Adult patients benefit the most
- Aligners + acceleration reduces refinement cycles
- Surgical options indicated for severe malocclusions

6. Limitations

- Small sample sizes
- Significant methodological heterogeneity
- Limited long-term monitoring
- Variations in applied orthodontic force
- Under-reporting of adverse effects

7. Conclusion

Accelerated orthodontic techniques offer meaningful reductions in treatment duration. Surgical approaches remain the gold standard for predictable acceleration. Non-invasive procedures require further refinement and standardization. Integration of acceleration methods should be tailored to biological limits, patient expectations, and case complexity.

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