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Review Article

Various Interventions for accelerating orthodontic tooth movement

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Abstract
Objective: To evaluate the effectiveness of various interventions on accelerating orthodontic tooth movement.
Materials and Methods: We searched the databases of PubMed, AJodo, Angle orthodontist. The processes of study search, selection, and quality assessment were conducted independently. Original outcome data, if possible, underwent statistical pooling .
Results: Through a predefined search strategy, we finally included nine eligible studies. Among them, five interventions were studied (ie, low-level laser therapy, corticotomy, electrical current, pulsed electromagnetic fields, and dentoalveolar or periodontal distraction). Six outcomes were evaluated in these studies (ie, accumulative moved distance or movement rate, time required to move tooth to its destination, anchorage loss, periodontal health, pulp vitality, and root resorption).
Conclusion: Among the five interventions, corticotomy is effective and safe to accelerate orthodontic tooth movement, low-level laser therapy was unable to accelerate orthodontic tooth movement, current evidence does not reveal whether electrical current and pulsed electromagnetic fields are effective in accelerating orthodontic tooth movement, and dentoalveolar or periodontal distraction is promising in accelerating orthodontic tooth movement but lacks convincing evidence. (Angle Orthod. 2013;83:164–171.)

Key Words
Accelerate; Corticotomy; Orthodontic tooth movement

Introduction
When can I get my braces off?! , the frequently asked question in day to day practice
Currently, fixed orthodontic treatment requires a long duration of about 2–3 years,[1,2] which is a great concern and poses high risks of caries,[3,4] external root resorption,[5,6] and decreased patient compliance.[7] Thus, accelerating orthodontic tooth movement and the resulting shortening of the treatment duration would be quite beneficial. To date, several novel modalities have been reported to accelerate orthodontic tooth movement, including low-level laser therapy,[8,9] pulsed electromagnetic fields,[10] electrical currents,[11] corticotomy,[12,13] distraction osteogenesis,[14–16] and mechanical vibration.[17] However, pertinent results are inconclusive, and some are unreliable, which may bias clinicians' understandings and mislead clinical practice. Thus, a critical systematic review would be quite beneficial for clinicians. In this study, we conducted a critical systematic review on randomized or quasi-randomized controlled trials to assess the effectiveness of the interventions on accelerating orthodontic tooth movement.

Materials And Methods
Inclusion Criteria for Included Studies
Types of studies. We included studies that evaluate or compare interventions for accelerating orthodontic tooth movement.
Types of participants. Subjects would be otherwise healthy patients who require orthodontic treatment. However, subjects with defects in oral and maxillofacial regions (eg, cleft lip), dental pathologies (eg, dental ankylosis), and medical conditions (eg, diabetes mellitus) would be excluded.
Types of interventions. Only interventions, adjunct to conventional orthodontic treatment, for accelerating orthodontic tooth movement would be considered (eg, laser irradiation, corticotomy, and pulsed electromagnetic fields). Interventions that are improvements of conventional orthodontic treatment modalities (eg, improvements in anchorage, brackets, and force magnitudes) would be excluded.
Search methods. We searched the electronic databases of PubMed, Ajodo, Angle orthodontist
Data Analysis. Data analysis was done based on the data obtained by the previously published articles.

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Results
Description of Studies
Finally, we included nine studies. Among them, one was published in Chinese,[20] one was in Korean,[11] and the remaining seven were in English. One[11] included only females, while the other eight included both genders. The details of the included studies and their quality assessment are presented.

Description of Interventions
Low-level laser therapy. Low-level laser therapy was performed through a laser device from which the laser was emitted to the desired mucosa areas. Four studies investigated this intervention.[8,20–22] Corticotomy. Corticotomy was performed by making small perforations on the alveolar bones along the way by which the tooth would be moved. Two studies

evaluated this intervention.[13,23] Electrical current. Electrical current was delivered to the mucosa of canines through a fixed electrical
appliance assembly (20 mA, 5 hours per day) on canines. One study[11] assessed this intervention. Pulsed electromagnetic fields. Pulsed electromagnetic fields are produced by an integrated circuit embedded in a removable denture (0.5 mT and 1 Hz, 8 hours per day overnight). One study[10] investigated this intervention. Dentoalveolar distraction vs periodontal distraction. Dentoalveolar distraction was performed by making monocortical perforations on alveolar bones around canines, followed by distracting canines using distractors; periodontal distraction was performed by making vertical grooves on the mesial side of the first premolar extraction sockets followed by the same distracting technique. The distractor was composed of an anterior segment fixed on the canine, a posterior segment fixed on the first molar, and a connecting sliding rod. Canine distraction (0.5 mm/d) was achieved by sliding the anterior segment toward the posterior segment. One study24 compared the effectiveness of the two techniques.

Description of outcomes

Among the outcomes proposed above, six were evaluated in the included studies: accumulative moved distance or movement rate, time required to move tooth to its destination, anchorage loss, periodontal health, pulp vitality, and root resorption.

Effects of Interventions

1. Low-Level Laser Therapy vs No Intervention

Accumulative moved distance or movement rate. Four studies[8,20–22] investigated this outcome. Because of existing heterogeneity, a random-effect model was adopted. As presented
mean differences regarding accumulative moved distances were 0.32 (95% confidence interval [CI], 20.04, 0.68), 0.76 (95% CI, 20.14, 1.65), and 0.73 (95% CI, 20.68, 2.14) for 1 month, 2 months, and 3 months, respectively. Periodontal health. Two studies8,22 evaluated this outcome, and neither study reported any differences regarding periodontal health. Root resorption. Two studies 8,22 investigated this outcome, and neither study found root resorption in either group.

2. Corticotomy vs No Intervention

Accumulative moved distance or movement rate. Two studies[13,23] investigated this outcome. Because of no comparability of data, meta-analysis was not performed. Fischer23 reported that the movement rate was significantly higher in the corticotomy group (0.265 6 0.036 mm/wk vs 0.185 6 0.014 mm/wk, P 5 .001); Aboul-Ela et al.13 found that the accumulative moved distance was significantly larger in the corticotomy group for 1 month (1.89 vs 0.75 mm), 2 months (1.83 vs 0.86 mm), 3 months (1.07 vs 0.93 mm), and 4 months (0.89 vs 0.85 mm; P , .01 for all).

Anchorage loss. One study[13] reported that no significant anchorage loss occurred in either group (pretreatment vs posttreatment: 13.79 6 1.16 mm vs 13.73 6 1.16 mm or 13.62 6 1.06 mm vs 13.50 6 1.10 mm, respectively). Although this author did not compare anchorage loss between the two groups, we can deduce from the data presented above that anchorage loss did not differ between two groups. Periodontal health. Both studies[13,23] revealed no difference regarding periodontal health between the two groups, except that gingival index scores were significantly higher in the corticotomy group in the latter.

3. Electrical Current vs No Intervention

Accumulative moved distance or movement rate. Kim et al. [11] reported that the accumulative moved distance was significantly larger in the experimental group for 1 month (2.42 6 0.26 vs 1.89 6 0.27 mm, P 5 .001).

4. Pulsed Electromagnetic Field vs No Intervention

Accumulative moved distance or movement rate. Showkatbakhsh et al.[10] reported that the accumulative moved distance was significantly larger in the experimental group (5.0 6 1.3 vs 3.5 6 1.6 mm, P , .001) for 5 6 0.6 months.

5. Dentoalveolar Distraction vs Periodontal Distraction

Time required to move tooth to its destination. Kharkar et al.24 revealed that the required time was significantly shorter in the dentoalveolar distraction group than in the periodontal distraction group (12.5 6 0.50 vs 19.5 6 1.70 days, P , .01). Anchorage loss. Kharkar et al.[24] showed that the dentoalveolar distraction group presented significantly less anchorage loss in the sagittal plane but significantly more in the vertical plane than in the periodontal distraction group (P , .01 for both). Pulp vitality. Kharkar et al.[24] revealed that the moved teeth in both groups were vital after 1 year. Root resorption. Kharkar et al.[24] reported that no root resorption was found in the dentoalveolar distraction group, but 1 of 6 cases presented root resorption in the periodontal distraction group.

Assessment of Publication Bias

Because of a limited number of studies in the metaanalysis, we employed Egger's test and Begg's test rather than funnel plot to detect publication bias. Begg's test revealed no evidence of publication bias regarding accumulative moved distance at 1 month (P 5 1.000 . .05), 2 months (P 5 1.000 . .05), and 3 months (P 5 1.000 . .05). Likewise, Egger's test found similar results at 1 month (P 5 .872 . .05), 2 months (P 5 .420 . .05), and 3 months (P value was inapplicable because there were only two studies for this item).

Sensitivity Analysis

Among the three studies in the meta-analysis, Gui and Qu20 and Sousa et al.22 were of medium quality, and Limpanichkul et al.21 was of high quality. The exclusion of the two studies of medium quality in the meta-analysis resulted in no significant changes in the pooled results: 1 month (95% CI: 20.04, 0.68 vs 20.12, 0.00), 2 months (95% CI: 20.14, 1.65 vs 20.11, 0.09), and 3 months (95% CI: 20.68, 2.14 vs 20.12, 0.22), which was indicative of the robustness of the results in the meta-analysis.

Discussion

In this review, we analyzed nine eligible studies of five types of interventions, within which six outcomes were evaluated. Among the nine included studies, Kim et al.11 and Aboul-Ela et al.[13] used miniscrews as anchorage to retract canines, while the remaining seven studies used first molars. For the seven studies, measurements of the moved distances of canines may be influenced by mesial movements of the first molars. However, in consideration of the methods for the measurements **(Table 4)**, we suggest that Limpanichkul et al.,[21] Fischer,[23] Kim et al.,[11] and Aboul-Ela et al.[13] employed reliable methods and were not influenced by the mesial movement of first molars.

Low-Level Laser Therapy

For this intervention, accumulative moved distance, periodontal health, and root resorption were evaluated, but a meta-analysis was conducted only for accumulative moved distance. The pooled mean differences between the two groups regarding accumulative moved distance were 0.32 (95% CI: 20.04, 0.68), 0.76 (95% CI: 20.14, 1.65), and 0.73 (95% CI: 20.68, 2.14) for 1 month, 2 months, and 3 months, respectively, indicating that low-level laser therapy was unable to accelerate orthodontic tooth movement. Begg's test and Egger's test revealed no publication bias, and the sensitivity analysis indicated the robustness of the results analyzed through meta-analysis. Moreover, two studies[8,22] showed consistent results that laser therapy wassafe intermsofperiodontalandroothealth. Therefore, we suggest that low-level laser therapy is safe regarding periodontal and root health and that it is unable to accelerate orthodontic tooth movement.

Corticotomy

The results from two included studies showed consistent results that corticotomy can accelerate orthodontic tooth movement. Moreover, both employed reliable methods to measure tooth movement **(Table 4)** and specified and used a similar start time of force applications between two groups **(Table 2)**, which would lend more credence to their results since the rates of tooth movement into healed and recent extraction sites are significantly different.[25] Moreover, the results showed that corticotomy in conjunction with mini-screws can dramatically augment posterior anchorage, which is of prime importance since effective anchorage would greatly improve orthodontic treatment results.[26] Since corticotomy is per se a surgical intervention on alveolar bones, it may have adverse effects on periodontal tissues, which was addressed in Gantes et al.[27] but not in Iino et al.[28] However, in this systematic review, neither study indicated that corticotomy would damage periodontal health, except that gingival index scoresincreased intheexperimental group in Aboul-Ela et al.[13] We suggest this may be simply a response of gingiva to alveolar healing, since alveolar healing following surgery takes at least 4 months.[29] Thus, dental hygiene should be paid special attention during the healing stage after corticotomy. Therefore, we suggest that corticotomy is relatively safe and is an effective intervention to accelerate orthodontic tooth movement.

Electrical Current

In this systematic review, only accumulative moved distance was evaluated. Kim et al.[11] revealed that electrical current was capable of accelerating orthodontic tooth movement. This study employed a reliable method to measure tooth movement **(Table 4)**. However, it did not specify the start time of canine retraction after first premolar extraction, which decreases the reliability of the results since canine retraction speed into healed and recent extraction sites differ.[25] Moreover, since only females were included in this study, we do not know the intervention effects in males. Therefore, regarding unreliable methodology and results, we cannot determine whether electrical current would accelerate orthodontic tooth movement.

Pulsed Electromagnetic Fields

In this systematic review, only accumulative moved distance was assessed. Showkatbakhsh et al.[10] showed that a pulsed electromagnetic field was capable of accelerating orthodontic tooth movement. However, this study suffered from several drawbacks. First, the study measured moved distance using an unreliable method **(Table 4)**. Second, this study did not specify the start time of canine retractions after extractions of the first premolars. Furthermore, the quality assessment indicates that this study is of low quality, which further limits the reliability of this study. Therefore, with regard to unreliable methodology and results, we cannot determine the effectiveness of pulsed electromagnetic fields on accelerating orthodontic tooth movement.

Dentoalveolar Distraction vs Periodontal Distraction

Kharkar et al.[24] showed that dentoalveolar distraction can accelerate orthodontic tooth movement compared with periodontal distraction. However, this study suffered from a significant drawback: the distractors were activated 2 days after first premolar extractions for dentoalveolar distraction, while they were activated immediately after first premolar extractions for periodontal distraction, rendering the two modalities incomparable. In addition, this study was of low quality **(Table 3)**. Thus, we cannot determine which modality would be more effective in accelerating orthodontic tooth movement. But with regard to the great differences in treatment duration between dentoalveolar or periodontal distraction and conventional treatment (10–20 days vs 6–9 months), we suggest that dentoalveolar or periodontal distraction is promising in clinical practice. Moreover, both techniques cause negligible anchorage loss, and all the moved teeth were vital after 1 year for both techniques. Dentoalveolar distraction did not cause root resorption, while periodontal distraction did (incidence:1/6),whichmay be attributedtoextended duration of applied force required for periodontal distraction. Thus, we suggest that dentoalveolar or periodontal distraction is safe and that the unreliable methodology and results limited the interpretation that these techniques are effective in accelerating orthodontic tooth movement. The results of this systematic review must be interpreted with caution because of several limitations, including the small number of high-quality studies and limitation of statistical pooling due to clinical or methodological heterogeneity and noncomparability of outcome data.

Conclusions

N Low-level laser therapy is safe but unable to accelerate orthodontic tooth movement; corticotomy is safe and able to accelerate orthodontic tooth movement. N Current evidence does not reveal whether electrical current and pulsed electromagnetic fields are effective in accelerating orthodontic tooth movement; dentoalveolar or periodontal distraction is promising in accelerating orthodontic tooth movement but lacks convincing evidence.

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