O

over the past few years, clinicians have increasingly used accelerated orthodontic treatment modalities. Currently, over 400,000 manual osteo-perforations (MOPs) have been performed and are believed to have contributed significant value to orthodontic treatments. Nonetheless, some practitioners remain reluctant to offer adjunctive treatment to their patients or feel that MOPs are too invasive. However, many professionals have regarded pulse vibration technology as a reasonable and less invasive alternative to MOPs.

The number of patients who accept MOP treatment is impressive, especially adults and teens between the ages of 15-19-years old and anxious to shorten their treatment times. More importantly, some patients have expressed interest in reducing their time in treatment but were unwilling to undergo MOPs. For these patients, pulse vibration devices may present a viable alternative.

The potential benefits of pulse vibration in orthodontics

With so many physiologic systems demonstrating sensitivity to specific ranges of vibration frequency (i.e., digestion, hearing, breathing, sight, etc.), it would seem logical that bone would also respond to a range of vibrational frequencies. A number of studies have described the potential benefits of pulse vibration in orthodontic tooth movement:

1. non-pharmacological analgesic effects
2. enhanced clear aligner fit
3. accelerated tooth movement
4. promotion of stability in orthodontic retention

Non-pharmacological analgesic effects

The non-pharmacologic analgesic effects diminish the discomfort associated with both fixed appliance delivery/adjustment and with new clear aligner delivery/exchange. Lobry, et al., reported a significant decrease in pain in a randomized clinical trial of fixed appliance patients using a low-frequency vibration device when compared with controls. However, the study did not include a sham device to evaluate a placebo effect. Regardless, clinicians have reported that their patients have experienced a significant decrease in pain and increased appliance comfort when they included pulse vibration.

Clear aligner fit

Clinicians understand the importance of continuous, exacting fit in aligner treatment. Continuation of aligner exchange with improper tracking can undermine effective tooth movement. This results in aberrant and unanticipated tooth movement and prolonged treatment, which frustrates patients and doctors. Pulse vibration devices may enhance tracking and tooth movement, assuming patients cooperate and doctors use correct aligner protocol. Moreover, pulse vibration has prevented potential tracking issues generated when patients wear aligners less than the prescribed time. This benefits patients, as successful tracking is fundamental to accelerated aligner exchange and reduces treatment time significantly.

Tooth movement

Reports of accelerated tooth movement with pulse vibration have been equivocal. Animal research (rats and rabbits) has shown that vibrating forces can cause separation of cranial sutures, induce cranial growth, and accelerate tooth movement (rats). The manufacturer of the first-to-market pulse vibrator operating at a low frequency of 30 Hz; 25g, used these animal studies to validate its claim for accelerated tooth movement. Using a low-frequency pulse vibration prototype in 2009, Kau, et al., reported accelerated tooth movement in both arches of 14 patients. In a more recent retrospective study, Bowman reported statistical in arch leveling in a group of patients with fixed appliances treated with low-frequency pulse vibrations in contrast to a group of control patients. The clinician, however, determined the degree of leveling subjectively without any objective calibration. A company that produces a low-frequency vibratory device funded a randomized, controlled clinical trial with 45 patients, and the authors reported statistically significant tooth movement and canine retraction compared to patients using a sham device.

Recently in a randomized clinical trial using a low-frequency vibratory device, Woodhouse, et al., studied its effect on tooth alignment of 81 premolar extraction patients with fixed appliances. This study found no evidence of acceleration in tooth alignment compared to control patients. Yadav, et al., investigated low-frequency mechanical vibration in the tooth movement of mice and found no significant acceleration in movement at frequencies of 5, 10, and 20 Hz. Significantly, Kalajzic, et al., evaluated vibrational forces (30Hz, 0.4N) in a study of movement in 26 rat molars (n=9), and concluded that tooth movement was significantly inhibited by the application of cyclical forces at this frequency, possibly due to a decrease in the number of osteoclasts. They suggested that cyclical forces may cause contrary effects depending upon force magnitude, the frequency of vibration (Hertz level), or the point of application.

In a review of vibrational therapy effects on tooth movement, Lala hypothesized that vibration may require a significantly higher frequency to cause consistently accelerated tooth movement. By citing studies by Judex and Rubin and Alikhani, et al., that found...
greater osteogenic effects at higher frequencies of vibration, Lala arbitrarily defined low frequency as any vibration at or below 45 HZ and high frequency as any vibration at or higher than 90 HZ.

Nishimura, et al.,¹³ used a resonant frequency of 60 HZ on maxillary molars and reported an acceleration of tooth movement with vibration. Additionally, Leethanakul, et al.,²⁴ reported significant acceleration of canine retraction in 15 patients following first premolar extractions. Using high-frequency electric toothbrushes (125 HZ) applied to the canines, they also noted a threefold increase in IL-1ẞ, a cytokine protein associated with osteoclastic activity.

Stability in orthodontic retention

Results of some research suggest that pulse vibration may have a stabilizing effect for orthodontic retention. Low vibration frequency (5, 10, and 20 HZ) has been found to increase bone volume factor and collagen tissue density in periodontal ligaments,¹⁹ while Rubin, et al.,²⁵ have reported low level vibration frequency (15-90 HZ) as strongly anabolic, which increases the quantity and quality of bone volume in sheep.

Pulse vibration devices in orthodontics

Clinicians currently use one of two principal pulse vibration devices now available. One, a low-frequency device (Figure 1), and the other, a high-frequency mechanism. The low-frequency device vibrates at 30HZ, and 0.25 N and recommends that patients use the vibratory device continuously for 20 minutes daily to affect the accelerated tooth movement.

The high-frequency option (Figure 2) vibrates at 120 HZ and 0.3G, and the manufacturer recommends that patients

Both clinical trials and experience suggest that pulse vibrational orthodontic devices may have a role in orthodontic therapy.
use the device for only 5 minutes each day for the indication of achieving proper aligner seating. Some preliminary research suggests that high-frequency vibratory devices may accelerate tooth movement.22-24

The high-frequency vibrator initially starts at a lower frequency and rapidly increases to the 120 HZ. The low-frequency device vibrates at 30 HZ immediately.

Independent, randomized, controlled trials have not yet established the efficacy of these appliances. Nevertheless, the website for the low-frequency vibrator along with testimonials by clinicians claims significantly reduced treatment times when patients use them with either fixed appliances or aligners. Additionally, numerous clinicians and patients attest to the relief of patient discomfort with the use of pulse vibration.

Conclusion

Bone resorption remains a critical factor in tooth movement, and increasing studies indicate that low-frequency pulse vibration has an anabolic effect that accelerates tooth movement. This has caused some researchers to speculate that accelerated tooth movement would require pulse vibration to also accelerate the catabolic phase of bone remodeling. Light orthodontic forces are needed in conjunction with vibration to effect accelerated movements, and research has shown that light forces with the application of vibration enhances the secretion of IL-1B, one of the pro-inflammatory cytokines associated with bone resorption. Thus, clinicians might hypothesize that pulse vibration may also increase the secretion of a host of pro-inflammatory cytokines that facilitate bone resorption. Moreover, this cascade of cytokines could simultaneously stimulate a reactionary secretion of modulating glycoproteins that constrain cytokine activity and stimulate osteoblastic activity in response to osteoclasts.

Some clinicians, including myself, have begun incorporating both MOPs and high-frequency vibration (many times simultaneously) to accelerate treatment. The intent is to use MOPs on the more difficult movements, and high-frequency vibration to improve aligner seating.

Both clinical trials and experience suggest that pulse vibrational orthodontic devices may have a role in orthodontic therapy. Pulse vibration appears to have a non-pharmacological analgesic effect, which reduces patient discomfort. Additionally, these devices have a potential for accelerating treatment and reducing treatment time, particularly when used in aligner treatment. However, the molecular and cellular mechanisms by which various pulse vibration frequencies become anabolic or catabolic remain unidentified. Most importantly, the ultimate effectiveness of pulse vibration remains largely dependent upon patient compliance, as do the other features of orthodontic therapy. Additional research regarding the most effective frequencies, or range of frequencies to produce the desired clinical effects is necessary.

While there is scientific evidence that vibration produces a dynamic force to assist in remodeling bone, it may be of benefit in orthodontic treatment with aligners simply by providing consistently well seated aligners. After using these devices with patients, I would encourage clinicians to familiarize themselves with the research and experience with pulse vibration, and consider how these might benefit their patients.

REFERENCES