Seminars in Orthodontics

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Introduction

One of the main concerns in orthodontics is prolonged treatment duration. Lengthy orthodontic treatment may prompt many patients, especially adults, to either avoid treatment or to seek shorter alternative solutions with compromised results. Therefore, the search for treatment modalities that decrease treatment time without compromising the treatment outcome is an active area of research in orthodontics today.

To overcome the treatment time challenge, one must understand the variables that control treatment duration. In general, these variables can be grouped into three categories: practitioner-dependent, patient-dependent, and biological factors. Practitioner-dependent factors include accurate diagnosis and treatment planning, sound mechanotherapy, appropriate appliance design, and delivery of treatment in a timely fashion. Patient-dependent factors include attending scheduled appointments, compliance with practitioners' instructions, good oral hygiene, and maintaining the integrity of the appliances. Biological factors are tightly regulated by different molecular and cellular pathways and vary in magnitude for each individual. In an ideal scenario where both the treatment rendered by clinicians and patient cooperation are flawless, biology would be the only factor that dictates the rate of tooth movement in response to orthodontic forces.

In this issue of *Seminars in Orthodontics*, we first review the biological principles and molecular mechanisms that govern tooth movement, and the plausible points of intervention along the molecular pathways where we are able to stimulate target cells to achieve faster tooth movement. Based on these biological principles, we categorized the existing proposed techniques into two types: indirect and direct. The indirect techniques aim to activate target cells that control the rate of tooth movement by increasing the release of upstream cytokines, while the direct techniques utilize various stimulants to directly activate the target cells. The indirect techniques discussed in this Issue range from minimally invasive techniques such as micro-osteoperforations (MOPs) to more invasive approaches such as piezocision and the significantly aggressive corticotomy. The direct techniques selected for discussion in this Issue are vibration, laser and ultrasound, which are seemingly more practical in clinical settings, and have been studied more extensively than other direct techniques. Although other direct techniques may have significant academic value, they are not the main focus of discussion in this Issue due to the lack of extensive scientific evidence and/or the impracticality of their clinical application.

Where do we currently stand on accelerated tooth movement? As the articles in this Issue convey, the indirect techniques produce more consistent and predictable results compared with the direct techniques. While corticotomy and piezocision lack conclusive scientific research, the animal studies on MOPs have provided strong evidence supporting the role of cytokines in tooth movement in response to the indirect techniques. Therefore, the main query regarding indirect techniques is not on their effectiveness or mechanism of action, but rather the invasiveness of the procedures, the ability to repeat the procedure over the course of treatment, and the required intervals between each application to achieve the treatment goals while minimizing any disturbance or side effect for the patients.

Unlike the indirect techniques, there are more challenges as far as the direct techniques are concerned. First, the mechanism of action of these stimulants is either unclear or contradictory. For example, the studies on vibration and laser mostly demonstrate an osteogenic effect, which theoretically would slow down the rate of tooth movement. The fact that these

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stimulants are used in the medical field to increase bone density and accelerate bone healing supports their osteogenic role. Second, the human clinical trials on direct techniques have produced conflicting results, while some trials demonstrated positive effects on the rate of tooth movement, others did not show any effect. Third, even though some clinical trials showed positive effects, they did not demonstrate a significant increase in the rate of tooth movement that could justify the additional cost incurred by the device, the extra office visits, or the time spent on the at-home applications.

While the search for more practical, effective, inexpensive, and less invasive approaches continues, the question of how to incorporate acceleration techniques in orthodontic treatment remains the same regardless of the technique chosen. Orthodontics is not a single-stage mechanical approach where a clinician could merely use one arch wire throughout the treatment and count on acceleration techniques to shorten the time needed to establish an ideal, stable occlusion. In fact, orthodontists considering the use of acceleration techniques are cautioned that acceleration techniques do not take the place of sound biomechanical treatment plans—they are adjunctive to conventional orthodontic treatment approaches. Orthodontic treatment consists of many stages, and at each stage we need to target some teeth without moving the others. Some movements are prerequisites for others; for example, one should not engage a blocked tooth to the main arch wire until enough space is created. Application of acceleration technique around a blocked tooth does not change the forces and moments required to produce a desired type of tooth movement and therefore should not be applied until the tooth from a mechanical standpoint is ready to be moved. Since each stage of treatment has its specific target teeth, acceleration techniques should be simple, inexpensive, and comfortable enough to be repeated as often as needed throughout the course of treatment.

The impact of acceleration techniques extends beyond their effect on the rate of tooth movement to many other applications due to their temporary effect on bone density. From a mechanotherapeutic standpoint, these localized effects may change the anchorage properties of individual teeth, and as a result, the application of these techniques around a targeted tooth and away from anchor teeth can help in reducing the movement of anchor teeth. Another area of interest is the anabolic effect of these techniques that—when used wisely—could tremendously change the boundaries of orthodontic tooth movement and increase our ability to correct severe orthodontic malformations non-surgically. This phenomenon has been observed with some indirect techniques, as they not only produce the accelerating effect on tooth movement, but also stimulate the formation of both cortical and trabecular bone by stimulating the repair process.

Though many approaches discussed in this Issue of *Seminars in Orthodontics* show promising results in accelerating orthodontic tooth movement, more studies are needed to evaluate their efficiency, efficacy, and safety. Many questions remain:

- Does faster tooth movement result in less tipping and more bodily movement of teeth? It seems that since bone density can temporarily change in response to acceleration techniques, it can in turn result in temporary changes in the center of resistance and types of tooth movement.
- Is retention less stable when tooth movement is accelerated? On the contrary, current observations demonstrate that increasing bone-remodeling machinery increases the stability of movement, which emphasizes the need to understand the biology of relapse.
- Does activation of osteoclasts cause more root resorption? Currently, it seems that many of the acceleration techniques have a preventative effect on root resorption by either decreasing bone density or by directly stimulating cementoblasts.

The studies discussed in this Issue certainly have advanced our understanding of the biology controlling the rate of tooth movement, and the molecular players that could be used towards achieving shorter treatment duration. These are all very important steps in elevating the orthodontic specialty from art to science.

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