

Orthodontic Root Resorption: A New Perspective

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Do the results of in-vivo, short-term experiments¹⁻³ reflect the processes that lead to apical root shortening during orthodontic treatment?

The influence of the results and, especially, the conclusions of previous in-vivo short-term experiments on our daily orthodontic clinical procedures and on the standard of care in orthodontics is immense. This Guest Editorial attempts to challenge the specialty by analyzing the results of such experiments and their clinical conclusions using different concepts.

For example, let us look at all the published material on this topic that studied the effect of different force levels applied to experimental and control teeth. These teeth were extracted after anywhere between 4 days up to 4 months of treatment and examined carefully using different methods. Almost all of the studies reported that the higher the force, the more root resorption was found, as if this was an inevitable outcome. These data serve as a milestone in our specialty. However, when this issue is examined carefully and with a critical eye, it seems that the resorption observed in different areas of the roots under the microscope was not necessarily the process that leads to apical root shortening, the process which is described frequently as the devastating and debilitating outcome of orthodontic tooth movement.

An article published in 1951 by Henry and Weimann⁴ is worth rereading because it describes the pattern of resorption and repair of human cementum that is unrelated to orthodontics. They found that surface root resorption is found in more than 85% of normal teeth, and much more in the apical region. Most resorption lacunae were fully repaired and those that were partially repaired were probably on their way to becoming fully repaired. Further, all of the current in-vivo short-term experiments confirm this phenomenon in all of the control, extracted teeth. That means that for certain reasons, whether they be natural mesial drift, minute traumatic injury to the cementum, or other

unknown reasons, a remodeling process is activated. This may protect the integrity of the cementum or represent a homeostatic relationship among the cementum, the periodontal ligament (PDL), and the bone.

Orthodontic force application alters the homeostasis of this environment. Fortunately, the cells, tissues, and organs are embedded with non-specific and specific defense mechanisms that are activated immediately upon detecting those changes. They do their best to bring back the homeostatic relationships to the cells, tissues, or organs. Each tissue reacts to these changes in its own way. The immediate local reaction of the calcified tissues on both sides of the PDL demonstrates major differences between the alveolar bone, which is stress-strain sensitive, and the cementum, which is not. On the bone side, stress and strain activate resorption and apposition processes, respectively, allowing the tooth to move in space. The cementum, however, reacts only by its remodeling process. In between, the PDL recovers by regenerating completely in its new location.

It can be argued that the remodeling process of the cementum, which is divided into 6 steps: quiescence, activation, resorption, reversal, apposition, and again, quiescence, is the defense mechanism of the cementum. One of the defense mechanisms our human bodies exhibit (such as the one that the airway system mounts against invaders or the stomach mucosa has against acids and pepsin) is the defense mechanism against cold temperatures. Such a defense mechanism is divided into 2 levels: the reversible and irreversible levels. The reversible level defense against cold is shivering, development of goose bumps, and the decrease of blood flow to the peripheral tissues. The irreversible level, which is activated when the reversible mechanism is exhausted and ineffective includes among others, hypothermia, heart failure, coma, fibrillation and, in extreme circumstances, even death.

Examining the amount and distribution of resorption along the root observed in most in-vivo short-term experiments, it is obvious that areas exposed to higher stresses generally demonstrate more remodeling activity. In areas closer to the center of rotation during tooth movement, where the stress levels are low, the number of cells in the cementum are less and show lower levels of remodeling activity. It is possible that the

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remodeling activity observed in in-vivo short-term experiments is being misclassified or confused with the amount of resorption reported. Obviously, there is no way to know whether the resorbed areas seen under the microscope were destined to become repaired partially or fully as a result of the remodeling processes since the extracted teeth no longer remain in the body. It is important to note that none of these in-vivo short-term experiments show the teeth becoming thinner or shorter due to the remodeling process or resorption! It is possible that the remodeling process, which has been found to be related not only to the level of force applied but also to the duration of force and many other factors such as ultrasound, vibration, fluoride intake, etc., is all an expression of the reversible remodeling defense mechanism process and actually has no relationship to orthodontic apical root shortening.

Furthermore, it might be that the irreversible apical root shortening is a result of a different defense mechanism or a different reaction to extreme conditions developed around this area of the tooth. By definition, it is not the remodeling defense mechanism since remodeling is the regeneration of damaged tissue. Apical root shortening always begins in the apical region and advances toward the cervical region, never the other way, and it can be minor, moderate, or severe. Fortunately, this irreversible defense mechanism stops when the applied force is eliminated. This process destroys part of the living tissue totally and irreversibly. It resembles the body's defense mechanism reaction as part of the hemodynamic shock cascade: when the kidneys, under extreme conditions, might be damaged irreversibly as well.

Unlike most of the root surface, the apical region is different. The blood-nerve bundle that penetrates the alveolar bone to the apex through the PDL is not indifferent to orthodontic force application. Uniquely, this bundle experiences stress during intrusion, and strain during extrusion and other root movements. Studies in rats have demonstrated several major changes in this bundle relative to PDL remodeling, bony reaction, and surface cemental resorption.⁵ The bundle's direct connection to apical root resorption observed in humans remains obscure. However, the possibility exists that it is an important contributor to the phenomenon observed. Other factors have also never been ruled out as possible causes of orthodontic apical root shortening: a) the exposed apical predentin and dentin, which serves as the scaffold of the root and can be removed by inflammatory cells directly, thus

eliminating the possibility to rebuild the root, and b) the condensed, unbendable bone that surrounds the tooth apex, in contrast to the loose and bendable cervical bone, preventing the immediate decrease and dissipation of local pressures developed by orthodontic forces.

Even when roots are moved a few millimeters during orthodontic treatment, the teeth do not lose vitality. Perhaps the apical root shortening observed is a defense mechanism to release the blood-nerve bundle to prevent it from being injured severely during the tooth movement process.

In a previous Guest Editorial, we presented the term, "Orthodontitis".⁶ Now, we would like to follow up by proposing that Instrumental Orthodontitis, the aseptic inflammation developed in the PDL following orthodontic force application where no apical root shortening can be detected clinically using external imaging techniques, is the process where the remodeling defense mechanism is activated on the root surface. In contrast, Instrumental Detrimental Orthodontitis, where apical root shortening following treatment is evident, is when both the reversible and irreversible defense mechanisms or reactions are activated around the root surface and the apex, respectively.

Since the opening question posed has important medical (prediction and prevention) and legal implications, the specialty of orthodontics should redefine its route in this effort and find new ways to study apical root shortening.

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