

Australian Society
of Orthodontists



THE UNIVERSITY OF
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Accelerated Tooth Movement in Orthodontics

*Creating **Brighter** Futures*

Rapid, efficient orthodontic tooth movement has always been the 'holy grail' of orthodontics. Movement through alveolar bone occurs when a force is applied to a tooth causing compression of the periodontal ligament on the side of movement and tension on the opposite side.

While there are various theories about the biological mechanisms initiating orthodontic tooth movement – The Pressure-Tension theory, the Stress-Generated Electrical theory, and the Bone Bending theory¹ – all are reliant on precursor cells differentiating into either osteoclasts (e.g., monocyte precursors from the blood), osteoblasts (from the adjacent periodontal ligament and alveolar bone) or osteocytes (osteoblasts embedded in the bone matrix). These cells then deliver the bony resorption and apposition required to achieve tooth movement².

The force that produces the maximum rate of tooth movement is known as the Optimal force¹. Beyond the optimal force¹, further increases of applied force do not result in increased rate of tooth movement⁹ (Figure 1). Schwartz believed the optimal force for tooth movement was 20-25gm/cm²,³. Though a theoretical resorption rate of 100µm/day (i.e. 3mm/month) is possible⁴, in clinical practice a more realistic rate of movement is 0.8-1.2mm/

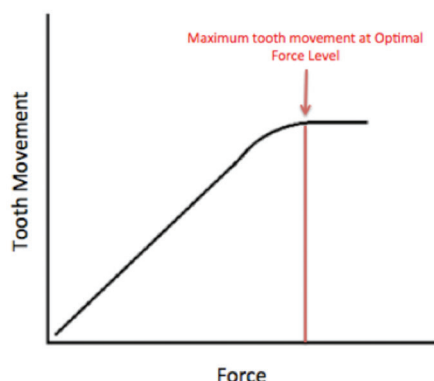


Figure 1: Currently accepted hypothesis of the relation between force and tooth movement (Quinn, Yoshikawa 1985)⁹

Methods for speeding up orthodontic tooth movement

Surgical Block Corticotomies

Surgical alveolar corticotomies, where cortical bone is sectioned and the associated block of teeth and bone are bodily moved, have been used in the correction of malocclusions for over 100 years¹⁴. This is a very invasive technique with some healing concerns but, for ankylosed teeth, may still have an application. It is also occasionally used in some orthognathic surgery procedures.

Distraction Osteogenesis

Distraction osteogenesis involves sectioning bone and rapidly separating it with a screw expansion device to create new bone. This has been used more for lengthening mandibles than moving individual teeth. Liou et al (2000) found that when an alveolar distractor was used between premolars, they were able to achieve rates of tooth movement of up to 1.2mm/week with faster movement being achieved by waiting for completion of the distraction before applying force to the tooth as opposed to moving the tooth simultaneously with distraction¹⁵. Iseri et al (2005) in a human study found that they could achieve tooth movement of 0.8mm per day when moving a canine and its associated block of bone into a premolar extraction space via a distractor appliance (Figure 2). There were no adverse side effects such as root resorption, periodontal problems and ankylosis¹⁶.



Figure 2: Distraction device placed to distalise canines (Iseri et al 2005)¹⁶

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Cochrane Review of Triclosan/copolymer containing toothpastes for oral health

A Cochrane review of Triclosan/copolymer containing toothpastes has recently been conducted and published. It was carried out using 30 studies of at least six months duration, that collectively analysed over 14,000 participants. This number of studies and participants in a Cochrane review makes it the most extensively researched oral health product following standard fluoride toothpastes and fluoride mouthrinses.

The results of this systematic review are summarised as:

- Toothpastes containing triclosan/copolymer in addition to fluoride, reduced plaque, gingival inflammation and gingival bleeding when compared with fluoride toothpastes without triclosan/copolymer by the following percentages when compared to standard fluoride toothpaste:
 - 22% reduction in plaque
 - 22% reduction in gingivitis
 - 48% reduction in bleeding gums
 - 5% reduction in coronal tooth decay (above fluoride only toothpaste)
- These reductions were evident regardless of initial plaque and gingival levels or whether a baseline oral prophylaxis had taken place or not.
- There was no evidence of any harmful effects associated with the use of triclosan/copolymer toothpastes in studies of up to three years duration.
- The quality of the evidence relating to plaque and gingivitis was considered to be of moderate quality and high quality for tooth decay.

Reference: 1. Riley P, Lamont T. Triclosan/copolymer containing toothpastes for oral health. Cochrane Database of Systematic Reviews 2013, Issue 12. Art. No.: CD010514. DOI: 10.1002/14651858. CD010514.pub2.

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Alveolar Decortication Corticotomies

Regional Acceleratory Phenomenon (RAP), first described by Frost in 1983¹⁰⁻¹², refers to accelerated hard and soft tissue healing to facilitate rapid healing of a bony injury. The RAP effect is temporary, with an active window of 1-2 months⁵ and can be considered an 'SOS mechanism' as a local tissue defensive reaction and to potentiate tissue healing¹³. This theory forms the basis of Alveolar Decortication or 'Corticotomies' in orthodontic tooth movement.

"Wilckodontics"

The Wilcko brothers popularised the corticotomy procedure for orthodontic tooth movement. Through the use of their patented 'Accelerated Osteogenic Orthodontics (AOO)' procedure, they have claimed total treatment times 1/4 to 1/3 that of routine non-extraction and extraction approaches¹⁷. The AOO procedure doesn't rely on movement of blocks of alveolar bone with teeth, but rather on the development of a transient 'localized demineralization-remineralisation phenomenon consistent with the wound healing pattern of the RAP'¹⁸.

AOO involves raising labial and lingual full thickness flaps to fully expose the alveolus. Then a bur is used to create labial and lingual 'decorticating' incisions into the alveolar bone cortical plates of the anteriors and premolars. Finally, a bone allograft is placed over the decorticated regions and the flaps are closed¹⁹ (Figure 3).

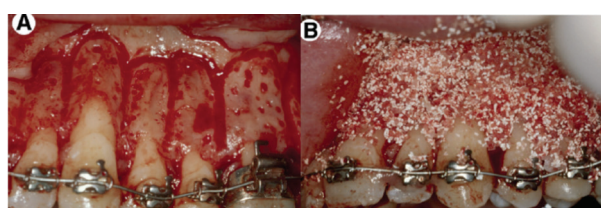


Figure 3: Accelerated Osteogenic Orthodontics: Corticotomy incisions (A), and placement of overlying bone graft (B) (Wilcko, Wilcko, Pulver et al 2009)¹⁹

Other Corticotomy techniques

Other, less invasive techniques that utilise the RAP effect have been developed.

Vercellotti and Podesta²⁰ described a technique where flaps were raised then a Piezocision tool (an ultrasonic cutting instrument) was used to selectively perform osteotomies with minimal soft tissue, nerve and osteonecrotic damage²¹.

Kim et al²² and Park et al²³ described a technique called 'Corticism', which did not require a flap to be raised. On the buccal and lingual surfaces a mallet and hardened scalpel were used to cut through gingiva and into the cortical plate.

Dibart et al²⁴ described another 'flapless' approach using the Piezocision tool. Under local anaesthesia, vertical interproximal incisions are made through the periosteum and below the interdental papilla on the buccal aspect of the jaws²⁴. A Piezo surgical knife is then used to make the cortical alveolar incisions through the vertical soft tissue incisions. The blade is inserted into the cortical plate to a depth of 3mm (Figure 4). Areas that require bone grafting can have the soft tissue incision 'tunneled' to allow the placement of a bone graft. The areas of grafting require closure with sutures; areas that are not grafted don't require closing.

High mechanical forces are required with the Piezocision technique to maintain the mechanical stimulation of the alveolar bone and the transient osteopaenic state allowing for rapid treatment²⁵. Dibart claims a 3-fold average reduction of the active treatment time²⁴.

Piezopuncture is a more recently developed technique²¹. This involves the use of a piezotome, which resembles a light ultrasonic scaler. The piezotome is used to penetrate the mucosa and then generate a 3mm deep 'puncture' in the alveolar cortical plate. This is said to elicit the RAP effect. Piezopuncture has been successfully tested in the animal model.



Figure 4: Piezocision (Keser, Dibart 2013)²⁷

Alveolar decortication corticotomies have not become popular due to their invasive nature. Most orthodontic practitioners do not offer this to their patients.

Chemotherapeutic substances

The use of drugs and chemical mediators to increase the rate of tooth movement has also been investigated. By selectively manipulating the hormones and mediators involved in the metabolism of bone turnover, calcium homeostasis and inflammatory activity, it is possible to accelerate tooth movement by promoting osteoclastic activity and/or suppressing osteoblastic activity²⁶. Animal studies using substances such as Prostaglandin E1 and E2^{27, 28}, Osteocalcin²⁹, RANKL gene transfer³⁰, Parathyroid Hormone³¹, Thyroid hormone³² and Vitamin D³³ have all shown increased rates of orthodontic tooth movement. While currently untested in the clinic, these substances show potential for the future.

Vibration

Vibration has also been suggested as a means of accelerating orthodontic tooth movement. Nishimura et al (2008), in an animal model, successfully increased the rate of tooth movement by up to 15%³⁴. The vibration (60Hz, for 8 minute periods at 0, 7 and 14 days) resulted in increased osteoclast numbers compared to controls. Human research is currently limited, but preliminary results show acceleration in the rate of tooth movement coupled with reduced levels of root resorption³⁵ (Figure 5).



Figure 5: Space closure study using the Aceledent® system on one side of the arch (Courtesy Dr. Carolyn Ng, University of Sydney)

The Aceledent® vibration appliance is being heavily marketed as a means of accelerating tooth movement to enhance orthodontic treatment. Currently, there are studies underway to verify the manufacturer's claims³⁵.



Figure 6: Aceledent® appliance, with the charging unit, in the mouth and being used.

Low Intensity Pulsed Ultrasound (LIPUS)

LIPUS (Figure 7), which is still experimental at this stage, has been investigated for the use of bony healing³⁶. It has been shown to stimulate human periosteal cells to proliferate and differentiate into an Osteogenic cell lineage³⁷. Animal research has also shown LIPUS to have a stimulatory effect on osteoclast numbers and activity,

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while also increasing cell numbers, in both the tension and compression sides of the periodontal ligament³⁸.



Figure 7: Low Intensity Pulsed Ultrasound Machine (Leung et al 2004)³⁷

Laser

Local application of Low Level Laser Irradiation has shown potential to accelerate tooth movement without any increases in side effects such as root resorption and alveolar bone resorption of supporting teeth. This has been demonstrated in both animal^{39, 41} and human clinical research^{40, 41}. The reasons for the stimulatory effect of the Low Level Laser are currently unknown, but are believed to relate to accelerated metabolism in cells, and increased rates of bone resorption and new bone formation^{40, 41}.

Self-ligating brackets

The orthodontic literature regarding the benefits of self-ligating brackets is divided. Some have suggested that there is less friction with sliding mechanics resulting in quicker tooth movement when space closure is required⁴². Others argue that there is no advantage over conventional bracket systems in terms of total treatment time, rate of tooth movement and space closure⁴³. The 2012-2 issue of Brighter Futures looked specifically at the use of Self-ligating brackets.

Magnetic fields

Rare earth magnets such as Samarium Cobalt or Neodymium-Iron-Boron have been used in research to generate orthodontic force to aid in accelerated tooth movement^{44, 45}. The magnets are capable of generating more constant forces with less patient co-operation⁴⁴. Application of Pulsed Electromagnetic Fields (PEMF) has also been shown to accelerate tooth movement⁴⁴.

The magnetic fields produced by these methods are believed to accelerate tooth movement by reducing the 'lag' phase normally encountered during tooth movement and by influencing the rate of bone resorption and deposition⁴⁴.

Combination of techniques

It may also be possible to apply a combination of methods to accelerate tooth movement. For example, the use of Pulsed Electromagnetic Field induced vibration has been shown to have potential for accelerating tooth movement⁴⁶. Further research is required before combining techniques becomes a viable option.

Conclusion

Most potential methods of accelerating orthodontic tooth movement are in the early stages of research; testing the potential benefits as well as their safety and side effects. Since accelerating tooth movement necessitates increasing the rate of alveolar bone turnover, there is also the potential for undesirable consequences such as Orthodontically Induced Inflammatory Root resorption. Should the efficacy of these experimental procedures be substantiated, then they may become a part of routine orthodontic therapy.

References available on request



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