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ACCELERATED ORTHODONTICS: A REVIEW ARTICLE

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Abstract

A Reconstruction of skeletal and dental tissues is a primary objective in orthodontic treatment, aimed at improving both function and aesthetics. For individuals undergoing cancer treatment, the duration of traditional orthodontic therapy can be a significant concern due to the prolonged nature of conventional fixed braces, which often leads to issues such as a higher risk of root infections, resorption, dental cavities, and gingival recession. To address these challenges and enhance the efficiency of orthodontic care, researchers have developed strategies to accelerate tooth movement while minimizing potential drawbacks. The term "accelerated orthodontics" refers to these advanced techniques designed to shorten treatment time. This paper aims to define and evaluate various methods of accelerated orthodontics, exploring their effectiveness in speeding up the process of tooth alignment and addressing the limitations associated with traditional approaches.

Key words: Accelerated orthodontics, Orthodontic treatment, Procedures

Introduction

Orthodontic treatment is of critical importance due to its comprehensive benefits that extend beyond mere aesthetic improvements. By addressing malocclusion, orthodontic procedures not only enhance the alignment and appearance of the teeth but also play a significant role in preventing various future dental issues. Properly aligned teeth are easier to clean, which helps reduce the risk of dental caries by minimizing plaque accumulation in hard-to-reach areas. Additionally, straightening teeth can improve speech clarity and reduce the likelihood of periodontal problems by ensuring that the gums and surrounding tissues are not subjected to excessive stress. Balanced masticatory forces resulting from well-aligned teeth also help in preventing excessive wear and damage. Furthermore, orthodontic treatment can alleviate or prevent temporomandibular joint (TMJ) disorders, which are often associated with misaligned teeth and improper bites. By addressing these issues, orthodontics also reduces the risk of early edentulism and root resorption, conditions that can compromise long-term dental health. Overall, orthodontic treatment offers a holistic approach to improving both the function and appearance of the smile, contributing to overall oral health and well-being [1]. But, these treatments demand a sincere patient commitment and patience as they last for a prolonged time.

In today's fast-paced world, where efficiency and quick results are highly valued, advancements in orthodontic treatment have become increasingly necessary. One notable development in this regard is accelerated orthodontics, a modification of traditional orthodontic procedures designed to expedite the process of teeth alignment. This innovative approach aims to align teeth more quickly than conventional methods, catering to the demand for faster results without compromising the quality of treatment. Accelerated orthodontics employs techniques such as the use of high-frequency vibration devices, surgical interventions like corticotomy, and advanced materials to enhance the movement of teeth. These methods work by stimulating bone remodelling and increasing the rate at which teeth move, significantly reducing the overall duration of treatment. As a result, patients benefit from a more efficient process that aligns with the rapid pace of modern life, making orthodontic care more convenient and accessible.

This innovative approach utilizes various techniques to expedite tooth movement, offering patients the potential to achieve the desired results in a considerably shorter duration.

The AO developments both invasive and pharmacological agents undoubtedly hold the potential to increase the overall efficiency of orthodontic treatment, a significant challenge persists for orthodontists and researchers' alike—namely, (1) safety, and (2) overall clinical significance of AO treatment modality in comparison to the conventional orthodontic treatment (does AO modalities really impact orthodontic treatment efficiency in a meaningful manner). Despite advancements, there is an ongoing effort within the field to address the above factors and find ways to streamline orthodontic procedures further. Therefore, with any novel approach comes a responsibility for thorough evaluation.

LITERATURE REVIEW

Surgical intervention to affect the alveolar housing, and thereby tooth movement has been described in different forms over the past 100 years. Heinrich Kole was the first to describe corticotomy-facilitated orthodontics in 1959. They believed that the continuity and thickness of the denser layer of cortical bone offers the most resistance to rapid tooth movement. Kole attributed the accelerated tooth movement by selective corticotomy to moving "blocks of bone" and this interpretation of the rapid tooth movement prevailed until Wilcko's publication in 2001. Wilcko discovered that the rapid tooth movement was due to transient localized demineralization-remineralization process in the bony alveolar housing and was not the result of bony block movement as suggested by Kole.

Various methods involved in accelerated orthodontics can be subdivided into three categories:

- Biologic methods
- Mechanical stimulation or device assisted methods
- Surgical methods

BIOLOGIC METHODS

To expedite orthodontic treatment, extensive research has been conducted on various molecules that influence bone remodelling and tooth movement. Studies have explored the effects of compounds such as vitamin D3, prostaglandin E, parathyroid hormone, cytokines, M-CSF (Macrophage Colony-Stimulating Factor), and RANKL (Receptor Activator of Nuclear Factor Kappa-B Ligand). Vitamin D3 is known for its role in bone health and mineral metabolism, potentially enhancing bone response to orthodontic forces. Prostaglandin E has been investigated for its ability to modulate inflammation and bone resorption, which can speed up tooth movement. Parathyroid hormone, which influences bone density and turnover, has shown promise in accelerating orthodontic treatment by promoting faster bone remodelling. Cytokines and growth factors like M-CSF and RANKL are also crucial as they regulate the activity of osteoclasts, cells responsible for bone resorption, thereby affecting the speed of tooth movement. By understanding and leveraging the effects of these molecules, researchers aim to refine orthodontic treatments, making them more efficient and aligned with the need for faster results in today's fast-paced world.[2-4]

Vitamin D3: Calcium reabsorption is a function of vitamin D that is comparable to that of parathyroid hormone.

Calcium reabsorption in the small intestine is facilitated by 1, 25 dihydroxy vitamin D3, which is the active form of vitamin D. It has a comparable effect on bone, resulting in bone resorption. Controlled release mechanisms, used by local government, may help mitigate these drawbacks.The number of osteoclasts was found to be larger on the pressure side, which was reinforced by vitamin D, than on the PGE2 side, showing that vitamin D plays an important role in bone remodelling [10].

Prostaglandins: Inflammatory mediators such as Prostaglandins (PGs) are a type of inflammatory mediator. These paracrine lipid inflammation mediators, known as PGEs, directly increase the number of osteoclasts and so trigger bone resorption in the immediate vicinity.

The majority of studies on the impact of PGs on OTM acceleration and root resorption have been conducted on animals. According to these investigations, PGs boosted OTM speed by 1.6 times more than the control group. Enhanced resorption, substantial loss of bone matrix, fibrous replacement, and increased vascularity were all seen in the alveolar bone as a result of this treatment.

Hormone parathyroid: Calcium balance and bone remodelling in the human body are mostly controlled by parathyroid hormone (PTH) [11]. The primary role of PTH is to reabsorb calcium from the small intestine, which raises the blood calcium level. Bone resorption is the result of calcium ions being absorbed from the bone by the body. In accelerated orthodontics, this advantage is exploited to speed up the movement of teeth.

Cytokines: Cytokines help accelerate the movement of the tooth by changing the pattern of bone remodelling and inflammatory processes that occur during the movement of the tooth. They help in the proliferation, stimulation, and death of bone and PDL cells. Interleukin-1 (IL-1), Interleukin-2 (IL-2), Interleukin-3 (IL-3), Interleukin-6 (IL-6) and Tumour Necrosis Factor alpha (TNF) all play a role in the remodelling process, with Interleukin-1 boosting osteoclastic activity via its receptors. Together with interleukins and TNF alpha, RANKL on osteoblasts binds to RANK on osteoclasts and initiates osteoclast formation. Osteoclastogenesis is inhibited as a result of Osteoprotegerin (OPG) binding to the binding site, which competes with RANKL. During bone remodelling, this process keeps RANKL, RANK, and OPG in balance.

Relaxin: During parturition, it causes expansion of pubic ligament seen precisely in women. It is also seen in PDL and cranial sutures. It induces soft tissue remodelling instead of bone remodelling. When the quantity of collagen on the tension zone is increased, the rate of tooth movement increases. Relaxin's remodelling of PDL may lower the rate of recurrence after orthodontic therapy [12].

Osteocalcin: Osteocalcin appears to increase the number of osteoclasts, according to histological data. The effect of osteocalcin on local administration accelerated OTM due to an increase in osteoclastogenesis on the pressure side [13].

Thyroxin: It has an effect on calcium absorption in the intestines. It accelerates tooth movement by accelerating bone resorption. It has an indirect effect on bone turn over and osteoporosis development.

Chemokines: These are cytokines that bind to heparin. They stimulate osteoclast and enhance the resorption of bone, causing tooth movement to accelerate it.

MECHANICAL STIMULATION

Lower Level Laser Therapy (LLLT): One of the brightest prospects now is photo biomodulation, often known as Low Level Laser Therapy (LLLT). Laser light stimulates the development of osteoclasts, osteoblasts and fibroblasts, which alters bone remodelling and enhances tooth mobility. Tooth movement is accelerated by ATP synthesis and cytochrome C30 activation, while RANK or RANKL and macrophage colony stimulating factor and its receptor expression improve tooth moving velocity [14].

Cyclic vibrations: Light alternating forces operate on the teeth via mechanical radiations, with the initial response to stress happening within 30 minutes. The vibration controller receives signals from the force sensor and accelerometer. These impulses are then sent to the vibrator, which causes it to vibrate, causing excitement. At around 1 meter per square second (m/s2), the acceleration is maintained. The vibrator's top adheres to the tooth with glue. In experiments, the rate of tooth movement increased dramatically [15].

Electromagnetic field: By modifying the rate of sodium calcium exchange in the cell membrane, an electromagnetic field increases the amount of a group of enzymes involved in the regulation of intracellular metabolism and, as a result, cellular proliferation. Alveolar bone remodelling enhances not only bone cell activity in the magnetic field, but also the production of new bone in the stress zone, according to histological investigations [16].

Electric current: Electric current causes a rise in the population of osteoblasts in the periodontal ligament due to increased cellular activity, according to histological investigations [17-23]. Electric currents can produce difficulties such as ionic reactions, which cause tissue injury and bone connective tissue displacement. According to Kim, et al., the exogenous electric current from the electric gadget could speed up OTM by a third [24]. The evidence currently available is insufficient. This method does not appear to be relevant in people at this time due to the method's lack of reliability.

SURGICAL APPROACHES

There are a couple of surgical techniques that help obtain faster results during orthodontic treatment. Tooth movement mainly depends upon the resorption and deposition of the bone and the periodontal ligament. Following grafting, fracture and osteotomy, bone regeneration is shown to increase. To speed up the treatment process, surgeons use a variety of surgical methods [25].

Corticomyotomy: When a full-thickness mucoperiosteal flap is lifted buccally and/or lingually, the corticotomy incisions are made using either a micromotor under irrigation or piezosurgical tools, respectively. After that, graft material might be used to increase the bone's thickness as needed [26].

Wilco, et al. observed in 2001 that a superficial CT assessment of people who have undergone corticomyotomy revealed a temporary localized demineralization and remineralisation process compatible with the regional acceleratory phenomenon's faster wound healing pattern [27].

Corticision: (MYRO) Minimally Invasive Rapid Orthodontics is the other name for corticision introduced by Kim, et al. It involves less surgical intervention.

Method: To achieve the separation of the interproximal cortices without the need for flap reflection, a reinforced scalpel can be employed as a chisel in conjunction with a mallet, utilizing a trans-mucosal approach. In this technique, a sharpened surgical blade with a nominal thickness of approximately 400 micrometers is positioned along the long axis of the canine, angled at 45°-60° relative to the gingiva. This precise angling allows the blade to access the inter-radicular connection effectively. To safeguard the alveolar crest, it is crucial to ensure that the post-operative incision is made at least 2 mm away from the papillary edge of the gingiva and 1 mm beyond the mucogingival junction. A swing action should be employed to carefully draw the blade out, minimizing trauma. Studies have shown that corticision, a technique that involves making controlled cuts to the cortical bone, can effectively halt tooth movement similar to corticotomy but with less aggressive intervention. This approach offers a more conservative method while still achieving the desired acceleration of orthodontic treatment[28].

Piezocision: It is a technique which is introduced by Dibart, et al which involves creating micro incisions in addition to selective tunnelling which helps in bone grafting. The incisions given are limited to buccal gingiva.

This technique does not only accelerate the tooth movement but provides an advantage of grafting which is associated with the tunnel approach. There is no use of suturing in this technique. Later on, they fused this technique with the use of Invisalign which proved to provide more efficient and aesthetically acceptable results [29].

Micro Osteo Perforations (MOPs): Alveocentesis, or piercing bone, was the treatment name given to PropelTM by Propel orthodontics in order to minimize the intrusiveness of the careful disturbing of bone. After creating soft tissue flaps in the premolar and molar areas, a round bur and hand piece were used to puncture the cortical bone. Micro-osteo perforations were the subject of two RCTs, one using animals and the other involving humans.[30].

Interseptal alveolar surgery: Distraction osteogenesis is a technique that involves the gradual displacement of a surgically created fracture to expand both bone and soft tissue through mechanical stretching. Known also as subperiosteal osteotomy with incremental traction, this method facilitates the progressive enlargement of the treated area by slowly widening the gap created during surgery. This approach is particularly useful in orthodontics and oral surgery for enhancing bone structure and correcting misalignments. There are two main types of distraction **osteogenesis:** dentoalveolar bone distraction and periodontal ligament distraction. Dentoalveolar bone distraction focuses on expanding the bone around the teeth to address issues related to the dental arch or increase alveolar bone height, aiding in orthodontic alignment. Periodontal ligament distraction, on the other hand, involves the gradual stretching of the periodontal ligament and surrounding bone to facilitate tooth movement and repositioning with minimal disruption to adjacent structures. Both techniques aim to achieve controlled and effective expansion, contributing to improved outcomes in dental and orthodontic treatments[31].

Method: During removal of the first premolar, interseptal bone presents distally from canine is surgically undermined by 1 to 1.5 mm, resulting in lower resistance at the pressure site. For distraction, a stainless steel custom made tooth born gadget is employed. Because the compact bone gets replaced by woven bone, the procedure causes tooth movement to accelerate, especially in the first week. It also makes tooth migration easier. Twenty four experiments have shown that the canine motility channel is more effective as a result of less resistance.

CONCLUSION

The acceleration of tooth migration during orthodontic treatment has gained popularity as patients increasingly seek to complete their treatment in a shorter timeframe. This preference for faster results is driven by the desire to save time and reduce the frequency of dental visits. Fortunately, advancements in orthodontic procedures and resources now enable both adults and children to undergo treatment more efficiently and comfortably. Techniques such as accelerated orthodontics, which utilize methods to enhance the rate of tooth movement, represent a significant step forward. These innovations, while not without their limitations, bring patients closer to achieving their orthodontic goals more quickly. By shortening the duration of treatment, these advancements not only improve convenience but also contribute to a more positive overall experience, bringing patients closer to their desired outcome of a healthy, well-aligned smile.

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