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Can we move teeth faster? The effectiveness of different approaches

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Abstract

An increase in the number of patients seeking orthodontic care at shorter treatment duration is a recurring request. Different approaches have been advocated and used to meet these expectations ranging from biological approaches using different types of molecules and devices to more aggressive and invasive procedures involving surgical interventions. Some of these methods have been proven to be effective in accelerating the amount of tooth movement in both animals and human. The biological approach, most of the molecules used has shown promising results however, the mechanism underlying their effect is still not fully understood and the dose and the duration of treatment is not fully established. Device assisted approach showed also promising results especially photo biomodulation but, there are still some un-certainties about the side effect and the dose, duration and the design of the experiments. Surgical procedure is the most clinically used and proved to be effective especially peiezocision however, it's aggressive, invasive, costly and requires patient's compliance and understanding. Most of those techniques proven to be effective in accelerating tooth movement, however the underlying mechanism of each technique is still not fully understood. Further studies are required to investigate the advantages and disadvantages of each approach and determine which approach is the best..

Introduction

The typical duration for orthodontic treatment ranges from 24-36 months depending on several factors, including severity of the case, treatment plan, patient compliance and clinical proficiency [1,2]. Long treatment duration might have several adverse effects on the teeth and the supporting tissue, such as root resorption, enamel calcification and caries of the teeth and gingival recession [3,4]. Thus, investigators in the past decades have developed a wide range of different approaches from less aggressive adjuncts to more aggressive procedures involving surgery in an attempt to reduce the treatment duration.

Orthodontic tooth movement is achieved through series of biological events that take place in remodelling of the alveolar bone, periodontal ligament, neural and vascular tissue under orthodontic forces stimulation [5]. Different preclinical and clinical attempts have been made to accelerate this biological process however, they are still not fully established and there are a lot of unanswered questions about their efficiency and effectiveness. There are two major approaches either biological using different molecules for example prostaglandin E or Cytokines or device assisted (low-laser therapy) and surgical approach (piezocision).

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Biological approach

A-Exogenous molecules

Prostaglandin E (PGE): Prostaglandins are paracrine hormone and inflammatory mediator that stimulate bone resorption directly via increasing the number of osteoclasts. Several in vitro and in vivo experiments have been carried out to investigate the effect of injecting PGE on the rate of tooth movement. In rats it has been shown that injections of exogenous PGE2 over a period of time (2 or 4 weeks) accelerate tooth movement[6]. Yamasaki et al, investigated the effect of PGE1, PGE2 injection in rats and monkeys and found a bone resorption similar to that induced by orthodontic mechanical forces [7,8].

In human, chemically produced prostagland in E1 was administrated in very low dose in split mouth technique, the rate of tooth movement was doubled on the tested side when compared to the control side [9].

However, root resorption was also reported in these experiments when PGs was used for the acceleration of tooth movement depending on the concentration and number of injection used.

Cytokines: Cytokines such as interleukins IL-1, [2,3,6,8] in addition to tumor necrosis factor alpha (TNF) were shown to play a major role in bone remodelling. Interleukin 1 stimulates osteoclastogenesis by its osteoclast's receptor [10]. Saito et al,reported an increase in the intensity of PGE and IL-1 beta expression on the tension side in the periodontal ligament after the application of mechanical forces in cats [11].

Other cytokines are Receptor activator of nuclear factor kappa-B ligand (RANKL) and RANK which bind to each other and initiate clastogenesis [12-14], whilst Osteoprotegerin (OPG) bind to RANK and inhibit oscteoclastogenesis. Consequently, the process of bone remodelling is a balance among these molecules. In rats, it has been demonstrated that the transfer of RANKL gene into the periodontal ligament enhance osteoclastogenesis and accelerate tooth movement While, the transfer of OPG gene inhibit tooth movement and it's useful in orthodontic retention [15].

A correlation was also found between RANK, OPG and root resorption during orthodontic tooth movement [16,17].

Relaxin: Relaxin is a hormone that helps during child birth and its present in the cranial sutures and periodontal ligament [18]. In rats, some reported acceleration in the early stages of tooth movement after the administration of Relaxin [19] while, others showed no acceleration of tooth movement but it can modulate the periodontal ligament organization [20]. A randomized clinical trial on human through weekly injection to accelerate tooth movement, no significant difference was found regarding both acceleration and retention [21].

Vitamin D3: 1, 25-dihydroxycholecalciferol (1,25D) is a form of vitamin D and plays a role in calcium homeostasis with calcitonin and parathyroid hormone. Vitamin D administration accelerated tooth movement in cats more than 50% when compared to the control side [22]. Vitamin D produced more osteoblasts on the pressure side when compared to PGEs in two different groups in rats however, no significant difference in the amount of tooth movement was found [23].

B-Device assisted acceleration Vibration (cyclical force device)

The concept behind this device is to induce accelerated remodelling of the bone surrounding the teeth which will enable the teeth to move faster. Several clinical trials have been conducted to test the efficiency of this technique using AcceleDent device. Some found no significant influence on the rate of tooth movement [24]. Others found an increase in the rate of tooth movement when a vibrational device is used during orthodontic tooth movement [25-27].

Direct electric current: The concept behind this technique is to use direct electric current at the pressure side (the anode) and tension side (the cathode) thus generating local acceleration of bone remodelling and consequently increasing the rate of tooth movement [28]. In a clinical trial on 7 orthodontic patients using electric appliance that provides a direct current of 20 μA applied for 5 hours per day. They reported 30% increase in the rate of tooth movement on the tested side when compared to the controlled side (Kim, Park, & Kang, 2008) [29].

Low Laser therapy: Low level laser Therapy (LLLT) or photobiomodulation has an effect on bone remodeling by stimulating the proliferation of osteoblast, osteoclast and fibroblast thus can accelerate tooth movement. At the molecular level this therapy accelerates tooth movement by ATP production and Cytochrome C activation [30]. It has been reported that during rapid palatal expansion (Saito & Shimizu, 1997), laser stimulate bone regeneration in the mid-palatal suture. And also promotes healing after bone fracture and in the extraction site [31-33].

Clinical trials reported an increase in the amount of tooth movement after the application of low-intensity laser therapy with an average increase of 30% [34]. Kau et al, found a significant increase in the rate of tooth movement when comparing the tested side 1.12 mm/week to the control side 0.49 mm/week [35]. While others reported no significant difference between the LLLT side and the control side [36]. In more recent study on 19 patients reported a significantly higher rate of tooth movement on the tested side 1.27 mm/week in comparison to the control side 0.44 mm/week, consequently this can reduce orthodontic treatment time [37].

Surgical approach

Distraction osteogenesis: Distraction osteogenesis is divided into two types either distraction of PDL or distraction of the alveolar bone. The concept of this therapy is to replace the compact dense bone by a woven bone to bone resistance which will facilitate and accelerate tooth movement.

In PDL distraction, the interseptal bone distal to the tooth for example the canine is undermined surgically at the time of extraction of the first premolar which will reduce the resistance on the pressure side. In a study on 15 orthodontic patients the rate of tooth movement was accelerated during canine retraction and a first premolar space of 6.5 mm was closed within 3 weeks [38].

The same principle is applied in rapid canine distraction with the addition of more cuts and osteotomies at the vestibule [39,40].

Most of the mentioned studies reported no significant root resorption, root fracture or ankylosis.

Corticotomy: Cortectomy is a surgical procedure made by producing cuts and perforations in the cortical bone only that will reduce the resistance in the cortical bone and accelerate tooth movement.

In a study on rats Baloul et al, reported accelerated tooth movement with significant decrease in the bone volume and mineral content [41].

In a clinical trial on 13 patients a significant higher rate of tooth movement was reported on the corticomy side when compared to the control side (twice the rate) in the first two months with no significant attachment loss or gingival recession in the teeth [42].

Piezocision: It's minimally invasive surgical intervention on the alveolar bone to accelerate tooth movement. Dibart et al reported two cases of orthodontic patients and reported an n accelerated tooth movement with minimal trauma using micro incisions and localized piezoelectric surgery [43].

Piezocision is considered as a minimally invasive procedure when compared to distraction osteogenesis and corticotomy with various advantages from the esthetic, periodontal and orthodontic aspects [44,45].

Conclusion

Clinically acceleration of tooth movement and reducing the treatment time has an impact on decreasing the side effect associated with long treatment duration. Most the techniques used to accelerate tooth movement have been proven to be effective in reducing the treatment time in both animals and human. What we don't know about the acceleration of tooth movement are the following variable response of individuals to orthodontic forces, multiple studies were done on animal models are not necessarily applicable for humans, Incomplete knowledge on how different molecular networks interact with each other and do actually some of the techniques increase side-effects such as root resorption.

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