Review Article

AN OVERVIEW ON CORTICOTOMY FOR ORTHODONTIC TOOTH MOVEMENT

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ABSTRACT

Orthodontics and bone remodeling have evolved to match modern aesthetic and therapeutic demands during the last decades. Different techniques were adopted and studied for 100 years involving invasive surgical and non-surgical procedures have been performed, but serious difficulties might appear in various situations and this might progress into undesirable postherpetic results. Various handpieces and surgical devices including burs, piezoelectric apparatus, hard blades, perforators, hammers, disc, and laser are used in corticotomy to lower destruction and damages to the patient. Also, various modified methods to minimize invasive procedures have been introduced to reduce the post and pre-operative complications and discomfort due to surgical interventions. This review will discuss and examine several journal articles, randomized controlled trials, and observational studies regarding corticotomy for orthodontic tooth movement**.** Electronic PubMed database was applied in this review and data was gathered from significant journal articles, randomized controlled trials, and observational studies containing the term used in the mesh "Orthodontic" "Corticotomy" "Remodeling" "Technologies" RAP" "FEA" within the title or abstract.
Corticotomy plays a great role in surgical turnovers and bone remodeling and RAP takes a major role in aiding and reducing the process of tooth movement and healing, thereby new corticotomy techniques need to be adopted to speed up teeth movement and reduce any possible side effects.

Key words: Orthodontic tooth movement, Corticotomy, Regional acceleratory phenomenon, Orthodontic tooth movement.

Introduction

Orthodontics and bone remodeling have evolved to match modern aesthetic and therapeutic demands during the last decades. With this unusual increase in the demand for orthodontics, professionals were constantly exposed to new therapeutic methods and strategical technologies. Different techniques were adopted and studied for 100 years involving invasive surgical and non-surgical procedures have been performed, but serious difficulties might appear in various situations and this might progress into undesirable postherpetic results [1].

Orthodontic treatment duration requires almost two years or more and hardly relies upon the dental movement rate. Therefore, various attractive techniques are considered a possible game-changer in increasing the probability to accelerate speedy treatment and shortening the orthodontic treatment time. Several factors influence this remodeling procedure and grantees satisfactory results. However, these remarkable capabilities are still not considered to be a final resort but rather a tool that is preferable by some patients [2].

This review will outline and evaluate recent various opinions in corticotomies effects, as an assistant surgical technique, and will aid and will facilitate a speedy therapeutic improvement in surgical procedures of orthodontic tooth movement.

Materials and Methods

Electronic database PubMed was used in this review and data was collected from relevant journal articles, randomized controlled trials, and observational studies containing the term used in the mesh (("Corticotomy "[Mesh] AND "Orthodontic" Mesh] AND "Technologies"[Mesh]AND "Remodeling"[Mesh] AND "RAP"[Mesh]AND "FEA"[Mesh] within the title or abstract. English and translated English articles, documents, controlled and randomized clinical trials that are published and met with the needed criteria were included only.

Results and Discussion

Bone remodeling is a comprised process of osteoclast-mediated bone reabsorption that is linked with osteoblast-mediated bone formation. Moreover, the bone mass at the site of the turnover is determined by the stability between bone resorption and formation. The origination of the osteoclasts is derived from the macrophage's lineage of the stem cells in the bone marrow and the bone-dispositioning osteoblast is derived from the multi-potential mesenchymal cell [3, 4].

The formation and resorption of osteoclasts are regulated and mediated by various biological agents such as the CSF1 (colony-stimulating factor), the signaling system of osteoclast components (the receptor activator of nuclear factor κB (RANK)/RANK ligand/osteoprotegerin), cytokines, estrogen and parathyroid hormone (PTH). In contrast osteoblast creation is regulated by the Wnt/ β-catenin signaling pathway of the osteoblast components starting with the activation of the RUNX2 and osterix also known as osteogenic transcription factors. However, the Wnt/ β-catenin signaling pathway might crosslink with other BMPs (Bone morphogenic proteins) to stimulate osteogenesis [4, 5].

This essential process of bone remodeling that is mediated and regulated by the biologically active agents and biochemical cellular responses is often considered as part of the normal cellular and physiological events following corticotomy procedures, also known as a regional acceleratory phenomenon (RAP). The acceleration of normal biochemical responses at a cellular level and a tissue level work as an 'SOS' phenomenon to promote bone modeling and remodeling on the damaged area [6]. Adopting the regional acceleratory phenomenon (RAP) as a helping healing process, several corticotomy experimental trials performed on rats confirmed the occurrence of regional acceleratory phenomenon (RAP) beyond the normal bounds after 3 weeks of operation [7].

The accelerated osteogenic orthodontics tooth movement (AOOTM) or the "Wilckodontics" was introduced back in 2001, demonstrating that demineralization/remineralization occurs sufficiently in younger adolescents during tooth movements, unlike in adult cases where remineralization efficacy was not absolute. This technique of bone grafts was a preferable option at the site of the tooth movement process [8, 9]. Recently a retrospective analysis was done in 2017 and included over 20 adult patients who experienced corticotomy combined with bone grafting to overcome remineralization insufficiency of traditional orthodontic therapy on 9 months follow-up [10].

Furthermore, the process of tooth movement is affected majorly by the bone density and remodeling and the hyaline tissue of the periodontal ligament. However, after using finite element analysis (FEA)software, the potential influence over tooth movement regions that are affected by corticotomy had shown decreased hyalinization at the periodontal ligament. Thus, this reduction of hyalinization was observed only over the corticotomized teeth where there were lower levels of compressive stresses in the periodontal ligament [11, 12]. Recent studies regarding the effect of corticotomy on changing the center of resistance reported that it was apically repositioned from the bracket slot coextending with the occlusal plane to enhance the tooth movement process [13]. Moreover, clinical trials on an intentional bone injury that were performed within bilateral mandibular second molars reported that these corticotomy procedures encourage reversible and transient bone injury [7].

Corticotomy techniques

Conventional technique

Various handpieces and surgical devices including burs, piezoelectric apparatus, hard blades, perforators, hammers, disc, and laser are used in corticotomy to lower destruction and damages to the patient. On the other hand, local anesthesia is usually sufficient and is demonstrated intravenously to ensure full comfort and sedation for the patient before starting the procedure. On using conventional techniques generally, one stage technique is used, the procedure involves bone is cut and exposed into vertical and horizontal parts. Also, two-stage techniques were the alveolar bone is corticotomized in two weeks. The alveolar bone is divided separately into palatal and buccal sections [11, 14, 15].

One stage corticotomy technique

The vestibular incision is highly recommended to prevent and mostly reduce complications influenced by the alterations in the blood circulation of the distal bony fragments and is usually performed after a surgical flap. The use of a piezoelectric device can minimize soft tissue harm as well as the use of cooling saline for irrigation. Being gentle in performing one-stage corticotomy provides the best results and prevents neurotic tissue formation after surgery [16, 17].

The vertical corticotomy is carried carefully on the lateral side of the root from 2-3 mm underneath the alveolar crest. While the horizontal corticotomy is operated 3-5mm distant from the lower apical root. This procedure divides the vertical and horizontal grooves to avoid root damage. After corticotomy, the surgical flap is restored to its authentic position with suture placement. In eliminating the dead space underneath the flap, a periodontal pack is applied to prevent any possible causes of pain and infection. The placed suture is removed 5 to 7 days post the surgical procedure [18].

Accelerated osteogenic orthodontics technique (AOO) and Periodontal accelerated osteogenic orthodontics (PAOO)

AOO and PAOO techniques provide stable and maintained orthodontic tooth movement. In these conditions, full-thickness flaps are usually raised after the apices to prevent neurovascular complex destruction at the alveolus. In malpositioned teeth, puts and premediated perforation that are performed in corticotomy and the cortical bone are done to using round burs. These alterations must avoid perforation of the cancellous bone to refrain from damaging the underlying structures. Bone grafting is done over the decorticated areas. It is advised on operation day to apply force over the teeth. If osteoclastic activity is increased this can result in temporary osteopenia [8].

Modified corticotomy

Corticision

This invasive procedure accelerates tooth movement and turnover rate without elevated flaps; using a malleting scalpel at the site of cancellous bone moving into the cortical bone by 10 mm and preserving the papillary gingiva below at 5mm [19].

Piezocision

The method of this procedure starts with an interdental gingival incision and precedes corticotomy using piezoelectric apparatus. However, it was reported that the rate of tooth movement might be delayed, unlike conventional corticotomy. It was also reported that the anterior alignment of the mandible is reduced by 59% in some experimental groups [20-22].

Micro-osteoperforation

Micro-osteoperforation uses profel for osteo-perforation with adjusted widths of 1.5 mm and depth of 2-3mm with no elevation of flaps needed [18].

Discussion

This method takes 4 months of treatment, where a disc saw is inserted underneath the interdental papilla without incisional blades, or suturing is performed. The cuts are done 3mm between the bone and roots [23].

Laser-assisted flapless corticotomy

The laser method forms small-scale perforations in the buccal gingiva and no elevated flaps are needed. It was reported to have a similar degree of results with the Piezocision method regarding tooth movement, without serious side effects [20].

Force application and rate of tooth movement following corticotomy

In a clinical trial done to monitor the average monthly range of the rate of tooth movement after corticotomy treatment and retention appliance, the rate was found to be twice faster in the test side than on the controlled side during the first 2 months and then gradually decreased speed in the next 2 months [24]. In another clinical trial done to evaluate maxillary canine retraction at the premolar region after corticotomy was also twice faster in the first 2 months, the rate gradually leaned to 1.6 times in the following 3rd month and became 1.06 times in the following 4th month [25]. Laser-assisted flapless and piezocisions trials were performed and it was found that the regional accelerated phenomenon was at its peaks in the first month however, drastically declined in the 2nd month compared to conventional corticotomy techniques [26]. Other trials stated that corticotomy-facilitated orthodontics displays 1.5 up to 2 times faster tooth movement in comparison with conventional orthodontics [20]. However, some studies reported that facilitated orthodontics requires a brief treatment period on average of 8.85 months, unlike conventional treatment that requires an average period of 16.4 months [27].

In many studies, orthodontic forces trials were divided into two groups. Several studies suggested applying forces shortly after corticotomies. Furthermore, the other group was studied in 2 weeks post-corticotomy [11, 18]. After a recent rapid tooth movement after force application experimental trial on rats, the results presented showed no difference or change in the alveolar bone or root resorption in heavy force application of 50 g compared to the light force group of 10 g [28].

Indications and limitations

Many fields require corticotomy. Acceptable results were shown in patients with bimaxillary protrusion after wide-linear corticotomy was performed instead of undergoing orthognathic surgery [29]. Corticotomies can also be used to fix impacted maxillary teeth, treat open bite patients with class 1 malocclusion, scissor bite correction, decrowding, canine retraction, rapid maxillary expansion, and molar uprighting, and more [11, 18].

Corticotomies can also be inadequate in patients on corticosteroids because periodontal ligaments are going to be suppressed. It is also not beneficial for patients with active periodontal disease and individuals with endodontic problems taking bisphosphonates and nonsteroidal anti-inflammatory drugs [8]. Also corticotomies not be appropriate with patients who underwent radiation therapy [30].

Complications

Complications are known to be controversial. Reduced attached gingiva and root resorption were reported. Furthermore, in a recent clinical trial, 40% of cases that underwent corticotomy were observed and confirmed root resorption occurrence [25, 31]. Moreover, corticotomy was not a preferable choice by the patient because of fear of surgical procedures [32].

Conclusion

Although corticotomy plays a great role in surgical turnovers and bone remodeling and RAP takes a major role

in aiding and reducing the process of tooth movement and healing, thereby new corticotomy techniques needs to be adopted in experimental and clinical trial cases to ensure efficacy and modification of this approach as many fields require corticotomy abilities. Further finite element method studies are required to highlight the role of alveolar bone areas and bone thicknesses in combination with new techniques to minimize invasive surgeries.

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