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Corticotomy-Assisted Orthodontic Therapy: Biological Principles and Clinical Relevance

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ABSTRACT

The last few decades have witnessed an evolution in orthodontics and bone remodeling to meet contemporary aesthetic and therapeutic needs. Over the past century, various methods have been used and investigated, including invasive surgical and non-surgical methods. However, in certain circumstances, significant challenges may arise that can lead to adverse postherpetic outcomes. To minimize patient injury and destruction, a variety of surgical instruments and handpieces are used during corticotomy, such as burs, piezoelectric apparatus, hard blades, perforators, hammers, discs, and lasers. In addition, several modified approaches to minimize invasive operations have been introduced to reduce post-operative and pre-operative complications and discomfort caused by surgical treatments. This review summarizes and evaluates recent differing perspectives regarding the effects of corticotomies as an assistant surgical technique. Using the Electronic PubMed database, this review will discuss and analyze several journal articles, randomized controlled trials, and observational studies about corticotomy for orthodontic tooth movement. Information was collected from relevant journal articles, randomized controlled trials, and observational studies that contained the terms “Orthodontic,” “Corticotomy,” “Remodelling,” “Technologies,” “RAP,” and “FEA” in the title or abstract.
Since RAP is crucial in assisting and minimizing the process of tooth movement and healing, and corticotomy plays an important role in surgical turnovers and bone remodeling, new corticotomy techniques should be used to accelerate tooth movement and minimize any potential side effects.

Keywords: Orthodontic tooth movement, Corticotomy, Regional acceleratory phenomenon, Invasive surgical and non-surgical methods

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Introduction

The last few decades have seen an evolution in orthodontics and bone remodeling to meet contemporary aesthetic and therapeutic demands. Professionals were continuously exposed to new therapeutic approaches and strategic technology as a result of this exceptional surge in the demand for orthodontics. Various methods have been used and researched for a century, including both invasive and non-invasive surgical procedures. However, in certain circumstances, significant challenges may arise, which could lead to unfavorable postherpetic outcomes [1].
The length of orthodontic treatment is nearly two years or longer, and it is rarely dependent on the velocity of tooth movement. Thus, several appealing methods are seen to be a potential game-changer in terms of raising the likelihood of expediting prompt treatment and reducing the duration of orthodontic therapy. This remodeling

process and the grantees' positive outcomes are influenced by several elements. However, some patients still view these amazing powers as a tool that they want rather than a last resort [2].
To help and allow a rapid therapeutic improvement in surgical operations of orthodontic tooth movement, this review will summarise and assess recent differing perspectives regarding the effects of corticotomies as an assistant surgical technique.

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, and controlled and randomized clinical trials that were published and met 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. Bone-dispositioning osteoblasts are formed from multi-potential mesenchymal cells, while osteoclasts are derived from the macrophage lineage of bone marrow stem cells [3, 4]. Osteoclast formation and resorption are controlled and mediated by several biological agents, including the colony-stimulating factor (CSF1), cytokines, estrogen, parathyroid hormone (PTH), and the signaling system of osteoclast components (the receptor activator of nuclear factor κB (RANK)/RANK ligand/osteoprotegerin). On the other hand, the Wnt/β-catenin signaling pathway of the osteoblast components controls the formation of osteoblasts, beginning with the activation of the osteogenic transcription factors, also referred to as RUNX2 and Osteix. To promote osteogenesis, the Wnt/β-catenin signaling pathway, however, may crosslink with additional BMPs (bone morphogenic proteins) [4, 5].
Known as a regional acceleratory phenomenon (RAP), this crucial process of bone remodeling is mediated and controlled by biologically active substances and biochemical cellular responses. It is frequently regarded as a normal cellular and physiological event that occurs after corticotomy procedures. The cellular and tissue-level acceleration of normal metabolic responses functions as an "SOS" phenomenon to encourage bone remodeling and modeling in the injured area [6]. Three weeks after the operation, multiple corticotomy experimental trials on rats demonstrated the development of regional acceleratory phenomenon (RAP) beyond the normal bounds, supporting the idea that RAP aids in the healing process [7].
In contrast to adult cases where remineralization efficacy was not absolute, the accelerated osteogenic orthodontics tooth movement (AOOTM), also known as "Wilckodontics," was introduced in 2001 and showed that demineralization/remineralization occurs sufficiently in younger adolescents during tooth movements. At the location of the tooth movement process, this bone grafting approach was a better choice [8, 9]. More than 20 adult patients who underwent corticotomy and bone grafting to address the remineralization inadequacy of conventional orthodontic therapy were included in a 2017 retrospective analysis. The patients were followed up with for nine months [10].
Additionally, the hyaline tissue of the periodontal ligament and bone density and remodeling have a considerable impact on the process of tooth movement. However, the possible impact on tooth movement regions impacted by corticotomy had demonstrated reduced hyalinization at the periodontal ligament following the use of finite element analysis (FEA) software. Therefore, only over the corticotomized teeth, where the periodontal ligament was under less compressive stress, was this decrease in hyalinization seen [11, 12]. It was apically moved from the bracket slot coextending with the occlusal plane to improve the tooth movement process, according to recent studies on the impact of corticotomy on altering the center of resistance [13]. Furthermore, corticotomy procedures promote temporary and reversible bone damage, according to clinical trials on purposeful bone damage done to both mandibular second molars [7].

Corticotomy techniques

Conventional technique

To minimize damage and injury to the patient, a variety of surgical instruments and handpieces are used in corticotomy, such as burs, piezoelectric apparatus, hard blades, perforators, hammers, discs, and lasers. However, local anesthesia is typically adequate and is shown intravenously to guarantee complete patient comfort and sedation before the procedure.

Bone is sliced and exposed into vertical and horizontal sections when utilizing conventional procedures, which often include a one-stage process. Also, two-stage procedures where the alveolar bone is corticotomized in two weeks. The palatal and buccal portions of the alveolar bone are separated [11, 14, 15].

One-stage corticotomy technique

The vestibular incision, which is typically made following a surgical flap, is strongly advised to prevent and mostly minimize issues caused by changes in the blood circulation of the distal bone pieces. Both the use of cold saline for irrigation and the use of a piezoelectric device can reduce damage to soft tissues. The best outcomes and the avoidance of neurotic tissue formation following surgery are achieved by executing one-stage corticotomy gently [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. To eliminate the dead area behind the flap and avoid any potential sources of infection and pain, a periodontal pack is administered. 5 to 7 days after the surgery, the suture is taken out [18].

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

The AOO and PAOO techniques offer stable and sustained orthodontic tooth movement; in these cases, full-thickness flaps are typically raised after the apices to prevent the destruction of the neurovascular complex at the alveolus; in malpositioned teeth, round burs are used to perform premeditated perforation and put in corticotomy and the cortical bone. These changes must prevent perforation of the cancellous bone to stop injuring the underlying structures. Bone grafting is done over the decorticated regions. Applying force over the teeth is recommended on the day of the procedure. Increased osteoclastic activity may cause transient osteopenia [8].

Modified corticotomy

Corticision

By employing a malleting scalpel at the location where the cancellous bone enters the cortical bone by 10 mm and protecting the papillary gingiva below 5 mm, this invasive technique speeds up tooth movement and turnover rate without the need for elevated flaps [19].

Piezocision

An interdental gingival incision is made at the beginning of this surgery, which is followed by a corticotomy employing piezoelectric equipment. In contrast to traditional corticotomy, it was noted that the rate of tooth movement might be delayed. Additionally, it was noted that in certain experimental groups, the mandible's anterior alignment decreased by 59% [20-22].

Micro-osteoperforation

Profel for osteo-perforation with modified widths of 1.5 mm and depths of 2-3 mm is used in micro-osteoperforation; flap elevation is not required [18].

Discussion

This procedure involves four months of treatment and involves either suturing or inserting a disc saw with no incisional blades underneath the interdental papilla, making 3mm incisions between the bone and roots [23].

Laser-assisted flapless corticotomy

Without the requirement for elevated flaps, the laser approach creates tiny holes in the buccal gingiva and has been shown to produce tooth movement outcomes comparable to those of the Piezocision method without causing significant adverse effects [20].

Force application and rate of tooth movement following corticotomy

During the first two months of a clinical trial to track the average monthly range of the rate of tooth movement following corticotomy treatment and retention appliance, the test side's rate was twice as fast as the controlled side's, and over the following two months, it gradually decreased [24]. Another study assessing maxillary canine retraction at the premolar region following corticotomy found that it was twice as fast in the first two months, then slowed to 1.6 times in the third month and 1.06 times in the fourth [25]. Studies using laser-assisted flapless and piezocisions revealed that, in contrast to traditional corticotomy methods, the regional accelerated phenomena peaked in the first month but sharply decreased in the second [26]. According to other studies, when compared to traditional orthodontics, corticotomy-facilitated orthodontics exhibits 1.5–2 times faster tooth movement [20]. However, some research found that, in contrast to conventional therapy, which takes an average of 16.4 months, assisted orthodontics requires a shorter treatment period of 8.85 months [27].

Two groups participated in orthodontic forces testing in numerous research. Forces should be applied soon after corticotomies, according to several studies. Additionally, the other group was examined two weeks after the corticotomy [11, 18]. The results of a recent experimental trial on rats that examined rapid tooth movement following force application revealed no modification or difference in the alveolar bone or root resorption between the groups that received a light force application of 10 g and those that received a strong force application of 50 g [28].

Indications and limitations

Corticotomies are necessary in several disciplines. When wide-linear corticotomy was used in place of orthognathic surgery for patients with a bimaxillary protrusion, satisfactory outcomes were observed [29]. Additionally, decrowding, canine retraction, rapid maxillary expansion, molar uprighting, scissor bite correction, open bite patients with class 1 malocclusion, and impacted maxillary teeth can all be fixed with corticotomies [11, 18].

Due to the suppression of periodontal ligaments, corticotomies may also be insufficient in individuals receiving corticosteroids. Additionally, it is not helpful for people on nonsteroidal anti-inflammatory medications and bisphosphonates who have endodontic issues or active periodontal disease [8]. Additionally, people who have received radiation therapy shouldn't get corticotomies [30].

Complications

It is well-recognized that complications are contentious. There were reports of decreased root resorption and connected gingiva. Additionally, recent clinical research found that root resorption occurred in 40% of individuals who had corticotomies [25, 31]. Furthermore, the patient's dread of surgery prevented them from choosing corticotomy [32].

Conclusion

Since many fields require corticotomy skills, new corticotomy techniques must be adopted in experimental and clinical trial cases to ensure efficacy and modification of this approach, even though corticotomy plays a significant role in surgical turnovers and bone remodeling and RAP plays a major role in aiding and reducing the process of tooth movement and healing. To minimize invasive procedures, more research using the finite element method is needed to emphasize the significance of alveolar bone regions and thicknesses in conjunction with novel approaches.

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