Surgical Methods to Enhance Orthodontic Tooth Movement: A Review

Aggarwal Isha¹, Nanda Madhurima², Wadhawan Manu³, Dhir Vishesh⁴

¹Senior Lecturer, Department of Orthodontics and Dentofacial Orthopaedics, Gian Sagar Dental College and Hospital, Ramnagar, Banur, Punjab, India, ²Private Practitioner, Orthodontics and Dentofacial Orthopaedics, Noida, Uttar Pradesh, India, ³Private Practitioner, Mohali, Punjab, India, ⁴Post-Graduate Student, Department of Periodontics, B.R.S Dental College and Hospital Panchkula, Haryana, India

ABSTRACT

The duration of orthodontic treatment is the most important concern of orthodontic patients. Long orthodontic treatment time poses several disadvantages to the patients such as higher predisposition to dental caries, root resorption, and gingival recession. Therefore, this increases the demand to find the best methods to increase the rate of tooth movement with the less possible disadvantages. Orthodontic treatment is based on the fact that when force is delivered to a tooth, it is transmitted to the adjacent investing tissues, certain mechanical, chemical, and cellular events take place within these tissues, which allow for structural alterations and contribute to the movement of that tooth. Conventionally, this process is slow and orthodontic treatment times can range anywhere between 12 and 48 months. By increasing the body’s response to these forces, tooth movement can be accelerated. Many methods are available in the literature to accelerate tooth movement; among them, surgical techniques are increasingly becoming popular such as corticotomy and piezosurgery. The aim of this article is to review these surgical techniques, offering a clear idea of the scientific evidence available in literature and the possible implications of these techniques in the future.

Key words: Interseptal alveolar surgery corticotomy, Orthodontic tooth movement, Piezocision

INTRODUCTION

In orthodontics, duration of the treatment is most important for both the patient and the orthodontist. In the past, a variety of techniques have been published in literature focusing on the biological acceleration of orthodontic tooth movement (OTM). Low-level laser therapy, drug-related and surgical procedures, or gene therapy¹⁻⁶ are some of these techniques. The procedures are varied, and in most of the cases, the molecular base lying underneath remains yet unclear. Out of these, surgical methods or surgically facilitated orthodontic techniques have achieved increasing interest. Corticotomy¹⁻⁷,⁹ osteotomy⁸,¹⁰ and piezocision¹¹,¹² have been the most frequently reported procedures and different processes, regional acceleratory phenomenon (RAP),¹³ or bone distraction¹⁴ have been suggested to be the base underlying the clinical acceleration of OTM observed. In this review, we will go through them, to draw a clear sketch of the “state of the art” that could be useful for clinicians and researchers with an interest in this area.

The surgical technique has been documented in many case reports. It is a clinically effective technique used for adult patients, where the duration of orthodontic treatment may be critical in selected groups of patients. The periodontal ligament (PDL) and alveolar bone remodeling are the important parameters in tooth movement, and bone turnover is known to increase after bone grafting, fracture, and osteotomy. Several surgical approaches that have been tried to accelerate OTM such as interseptal alveolar surgery, osteotomy, corticotomy, and piezocision techniques.

INTERSEPTAL ALVEOLAR SURGERY

Interseptal alveolar surgery or distraction osteogenesis is divided into the distraction of PDL or distraction of the dentoalveolar bone; an example of both is the rapid canine distraction. The concept of distraction osteogenesis came from the early studies¹⁵ of limb lengthening. Furthermore, from surgical treatments of craniofacial skeletal dysplasia,
this concept was later adapted in relation to the rapid tooth movement. In the rapid canine distraction of PDL, the interseptal bone distal to the canine is undermined surgically at the same time of extraction of the first premolars; thus, this will reduce the resistance on the pressure site. In this concept, the compact bone is replaced by the woven bone, and tooth movement is easier and quicker due to reduced resistance of the bone. It was found that these rapid movements are during the initial phases of tooth movement, especially in the first week. In this technique, the interseptal bone is undermined 1-1.5 mm in thickness distal to the canine after the extraction of the first premolar, and the socket is deepened by a round bur to the length of the canine. The retraction of the canine is done by the activation of an intraoral device directly after the surgery. It has been shown that it took 3 weeks to achieve 6-7 mm of full retraction of the canine to the socket of the extracted first premolars. Rapid canine distraction of the dentoalveolar bone is done by the same principle of the distraction of PDL, with the addition of more dissection and osteotomies performed at the vestibule. In all the studies done, both techniques accelerated tooth movement with no evidence of significant root resorption, ankylosis, and root fracture. However, there were contradictory results regarding the electrical vitality test of the retracted canines. Liu and Huang reported 9 out of 26 teeth showed positive vitality, whereas Sukurica et al. reported that 7 out of 20 showed positive vitality after the 6th month of retraction. Hence, there are still some uncertainties regarding this technique.

CORTICOTOMY

Over the past several years, corticotomies have become a popular means of increasing the rate of tooth movement. In corticotomy, the cortical layer is cut or perforated to the depth of the medullary bone which is preserved. During the bone healing process, an RAP takes place in the periodontium. RAP is a natural localized reaction of soft and hard tissues in response to an injury and is associated with increased perfusion, bone turnover, and decreased bone density. It is similar to the processes associated with normal fracture healing which include a reactive phase, reparative phase, and remodeling phase. The reactive phase lasts 7 days, and it is characterized by immediate constriction of blood vessels to mitigate bleeding followed by hematoma within a few hours. The cells within the hematoma die and a loose aggregate of fibroblasts, intercellular materials, and other supporting cells are then formed. This granulation tissue is formed within approximately 2 weeks. A few days later, periosteal cells surrounding the injury site and the granulation-tissue fibroblasts are transformed into chondroblasts and form hyaline cartilage. Periosteal cells in the vicinity of the injury site develop into osteoblasts which form woven bone. The association of the mass of hyaline cartilage and woven bone is called callus which is then replaced by lamellar bone in the subsequent phase. In fracture healing, the time between callus formation and mineralization is of 1-4 months; corticotomies are expected to heal faster than fractures (2-3 months). The last phase of healing takes 1-4 years, and it is characterized by complete remodeling of the bone into functionally mature lamellar bone.

Tooth movement should be faster in less dense alveolar bone which is rapidly remodeled. For the same reasons, tooth movement is faster in growing children than in adults. Moreover, animal studies showed that corticotomies provide three times as many osteoclasts, three times greater bone apposition rate, and a twofold decrease in calcified trabecular bone. Another study by Teixeira et al., in 2010, demonstrated that perforations in the cortical bone increase the expression of 37 inflammatory cytokines, which leads to more osteoclasts, and consequently, greater bone remodeling process. Corticotomy-assisted orthodontic treatment is quite invasive as it requires extensive flap elevation and bone surgery. A previous study proposed by Kotrikova et al., in 2006, stated the use of a piezoelectric knife instead of a high-speed surgical bur to decrease surgical trauma and still achieve rapid tooth movement. Due to their micrometric and selective cut, piezoelectric devices have been claimed to produce safe and precise osteotomies without osteonecrotic damage. Taken all together, there is twice as much tooth movement with than without corticotomies. However, this window of opportunity used to accelerate tooth movement is limited to 2-3 months, in which 4-6 mm of tooth movement might be expected (twice as much the normal rate). Nevertheless, further controlled clinical trials are needed to determine the actual effects of corticotomies.

DISTRACTION OSTEOGENESIS

Interseptal alveolar surgery or distraction osteogenesis is divided into the distraction of PDL or distraction of the dentoalveolar bone. The concept of distraction osteogenesis came from the early studies by Ilizarov of limb lengthening in 1988. Furthermore, from surgical treatments of craniofacial skeletal dysplasia, this concept was later adapted in relation to the rapid tooth movement. In the rapid canine distraction of PDL, the interseptal bone distal to the canine is undermined surgically at the same time of extraction of the first premolars; thus, this will reduce the resistance on the pressure site. The majority of the individual canine distractors currently used are custom made, intraoral, tooth-borne devices. The distraction device is fabricated from stainless steel and typically consists of: An anterior segment adapted onto the canine, a posterior segment...
that includes a retention arm adapted onto the molar and a grooved screw slot, a screw of standardized diameter and a pitch, sliding rod that acts as a guidance bar through which the anterior segment slides, and a screw wrench or driver to advance the screw. In this concept, the compact bone is replaced by the woven bone, and tooth movement is easier and quicker due to reduced resistance of the bone. It was found that these rapid movements are during the initial phases of tooth movement, especially in the first week. In this technique, the interseptal bone is undermined 1-1.5 mm in thickness distal to the canine after the extraction of the first premolar, and the socket is deepened by a round bur to the length of the canine. The retraction of the canine is done by the activation of an intraoral device directly after the surgery. It has been shown that it took 3 weeks to achieve 6-7 mm of full retraction of the canine to the socket of the extracted first premolars.

PIEZOCISION

Rapid canine distraction of the dentoalveolar bone is done by the same principle of the distraction of PDL, with the addition of more dissection and osteotomies performed at the vestibule. In all the studies done, both techniques accelerated tooth movement with no evidence of significant root resorption, ankylosis, and root fracture. Liou and Huang, in 1998, reported 9 out of 26 teeth showed positive vitality, whereas Sukurica et al., in 2007, reported that 7 out of 20 showed positive vitality after the 6th month of retraction. Hence, there are still some uncertainties regarding this technique.

Surgical Steps

1. The surgery is performed 1 week following placement of the fixed orthodontic appliance.
2. After local anesthesia, vertical interproximal incisions are made, below the interdental papilla, on the buccal aspect of each jaw using a microsurgical blade or a blade No. 11.
3. These incisions are kept minimal (microincisions) except when made in the areas of bone grafting.
4. The incisions go though the periosteum, which allows the blade to reach the alveolar bone.
5. A piezo surgical knife (BS 1 insert, Piezotome™, Satelec Acteon Group, Merignac, France) is used to create the cortical alveolar incision through the gingival micro-opening to a depth of approximately 3 mm.
6. When the corticotomies are finished, the areas requiring bone or soft tissue augmentations are tunneled using a small periosteal elevator through the vertical incisions followed by grafting in the tunneled areas. Vertical incisions are then closed using a resorbable 5-0 suture.
7. The areas that have not been “tunneled” do not need suturing.
8. If the patient is comfortable, he/she may go home under antibiotic and analgesic cover.

It is of paramount importance for the orthodontist and surgeon to understand that the surgically induced high tissue turnover is restricted to the immediate proximity of the surgical cuts, creating what might be referred to as a localized spatio-temporal window of opportunity. Attention must be given to perform the bony incisions only around the teeth where tooth movement is planned. As such, the relative anchorage value of the teeth away from the surgical site remains high, and anchorage value of teeth adjacent to the surgical site is low. RAP is transient, but continuous mechanical stimulation of the teeth would prolong the osteopenic effect induced by the procedure. Hence, it is imperative to see the patient and adjust the orthodontic appliance every 2 weeks.

During treatment, a sharp increase in tooth mobility may be observed, resulting from the transient osteopenia induced by the surgery. Furthermore, it is important to emphasize that higher forces are applied to the teeth as compared to conventional orthodontic treatment to maintain mechanical stimulation of the alveolar bone and the osteopenic state, allowing rapid treatment.
MICRO-OSTEOPERFORATIONS (MOP)

To further reduce the invasive nature of surgical irritation of bone, a device, called propel, was introduced by propel orthodontics. They called this process as alveocentesis, which literally translates to puncturing bone. This device comes as ready-to-use sterile disposable device. The device has an adjustable depth dial and an indicating arrow on the driver body. The adjustable depth dial can be positioned to 0, 3, 5, and 7 mm of tip depth depending on the area of operation. Previous animal studies have shown that performing MOPs on alveolar bone during OTM can stimulate the expression of inflammatory markers, leading to increases in osteoclast activity and the rate of tooth movement.

Alikhani et al. (2013) performed a single blinded study to investigate this procedure on humans. They used a nickel titanium closed coil spring, delivering a constant force of 100 g to distalize the maxillary canine after first premolar extraction. The spring was anchored to temporary anchorage devices distal to the second premolar and attached to the canine using a power arm through the vertical slot of the canine bracket. Gingival crevicular fluid (GCF) samples were collected from each subject to evaluate the level of inflammatory response. GCF was collected before orthodontic treatment, immediately before the start of canine retraction and at each subsequent visit between 10 am and 12 noon. These samples were taken from the distobuccal crevices of the maxillary canine. GCF samples were collected with filter-paper strips (Oraflow, Smithtown, NY) inserted 1 mm below the gingival margin into the distobuccal crevices of the canine for 10 s. Cytokine levels were measured using a custom protein array for the following cytokines: CCL-2 (MCP1), CCL-3, CCL-5 (RANTES), interleukin-8 (IL-8) (CXCL8), IL-1a, IL-1b, IL-6, and tumor necrosis factor-alpha (Raybiotech, Norcross, Ga) according to the manufacturer’s instructions. Alginate impressions were taken at the beginning of the study, immediately before canine retraction and 28 days after canine retraction began to monitor the rate of tooth movement. The impressions were immediately poured with plaster (calcium sulfate). Vertical lines were drawn on the cast over the palatal surface of the canine and lateral incisor from the middle of the incisal edge to the middle of the cervical line. The distance between the canine and the lateral incisor was assessed before and after canine retraction at 3 points: Incisal, middle, and cervical thirds of the crowns. All cast measurements were made using an electric digital caliper (Orthopli Corp, Philadelphia, PA) with an accuracy of 0.01 mm. They concluded their study by stating that: MOPs significantly increased the expression of cytokines and chemokines known to recruit osteoclast precursors and stimulate osteoclast differentiation. MOPs increase the rate of canine retraction 3-fold compared with the control group. Patients reported only mild discomfort locally at the spot of the MOPs. At days 14 and 28, little or no pain was experienced. MOPs are an effective, comfortable, and safe procedure to accelerate tooth movement during orthodontic treatment. MOPs could reduce orthodontic treatment time by 62%.  

CORTICISION

“Corticision” was introduced as a supplemental dentoalveolar surgery in orthodontic therapy to achieve accelerated tooth movement with minimal surgical intervention. In this technique, a reinforced scalpel is used as a thin chisel to separate the interproximal cortices transmucosally without reflecting a flap. In Young-Guk Park’s lecture, he described the procedure in detail in previously anesthetized subjects; the surgical blade is inserted interproximally and parallels to the occlusal plane 5 mm apical from the tip of the papilla. The blade is tapped with a mallet to a depth of approximately 8 mm. The angle of the blade to be changed to approximately 45° apically and the blade is tapped to a depth of 10-12 mm. The blade is changed after four to five slices. The goal is to cut the cancellous bone between the roots to 50-75% of the root length. To remove the blade, the blade and handle are grasped, and the scalpel is worked up and down a few times before pulling the blade out. The blade is pulled rather than the handle to avoid breaking the blade. Test the mobility of the teeth by forcibly trying to move them slightly. Apply orthodontic forces immediately. The patient is seen every 2 weeks and the teeth are forcibly mobilized to induce minor trauma to extend the effect; and according to Park, this is a minimally invasive technique to induce accelerated tooth movement by stimulating osteoblasts and bending alveolar bone that has been surgically separated. 

The administration of exogenous biological molecules to accelerate tooth movement during orthodontic treatments has been intensively tested in animal experiments. However, clinical trials on humans are limited since they must be administered occasionally by local injections that can be painful and cause discomfort to the patients to avoid systemic applications. Their side effects were also not tested for long periods of time. However, administration of certain molecules has shown promising results; for example, cytokine, parathyroid hormone, vitamin D, and RANKL/RANK/osteoprotegerin system play an important role in bone remodeling and tooth movement. Human relaxin does not accelerate tooth movement in rats but increases tooth mobility by decreasing the organization and mechanical strength of the PDL.

However, a lot of these mechanisms are not fully understood, and the dose-dependent mechanisms should also be further investigated. In the physical approach, the low-level laser therapy is the most promising method; however, contradictory results were shown. This is due to
the different energies, duration, and experimental design. Furthermore, most of these experiments were done in only a few weeks, which are a very short time to notice any side effects.

CONCLUSION

Surgical techniques, particularly corticotomy, are an increasingly popular method to accelerate OTM. It is generally considered in literature that they enhance tooth movement by an average of two-fold. However, there is still a lack of randomized clinical trials, as most of the published articles are animal studies or case reports. Range of force, design of the appliances, or times of study are too varied to establish fair comparisons between them. Scientific innovation in this field needs to standardize the procedures used, to optimize the efficiency in the advancements obtained. Methods based on higher scientific consistency need to generalize their designs to be able to compare the results. Although a tendency can be observed on making the surgeries less aggressive, the risks and benefits must be evaluated when it comes to speed up OTM, such as the decay on the rate of acceleration after 4 months.

In general, all these techniques had drawbacks and uncertainties that made them not commonly used clinically. However, there has been a rapid increase in the interest levels of product companies to enhance the effects of biology in orthodontics. These new approaches have the potential to be the next frontier for orthodontics and its resources.

REFERENCES

27. Hoogeveen EJ, Jansma J, Ren Y. Surgically facilitated...


Source of Support: Nil. Conflict of Interest: None declared.

Month of Submission: 02-2016  Month of Peer Review: 03-2016  Month of Acceptance: 04-2016  Month of Publishing: 04-2016