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An Overview of Periodontally Accelerated Osteogenic Orthodontics

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ABSTRACT

Surgically assisted orthodontic tooth movement has been used since 1800s. Corticotomy-facilitated tooth movement first described by L.C. Bryan, was published by Guilford. As dentoalveolar development ceases after adolescence, the average orthodontic treatment for adults is considerably longer than for adolescent patients. Therefore, some treatment modifications in regard to surgical modalities have been suggested to reduce the treatment time and achieve optimal clinical results with long- term stability in adults undergoing orthodontic therapy. PAOO is a promising adjuvant technique based on the transient nature of demineralization-remineralization process in healthy tissues, PAOO consists of alveolar corticotomy and bone grafting of labial and palatal/lingual surfaces, followed by orthodontic force.

Keywords: Accelerated orthodontics, alveolar corticotomy, bone augmentation, demineralization, remineralisation.

1. INTRODUCTION

A number of surgical techniques have been developed to meet increasing request of short orthodontic treatment time of adult patients. PAOO (Periodontally accelerated osteogenic orthodontics) technique is defined as the combination of selective alveolar periodontal corticotomy and bone augmentation grafting resulting in an acceleration of orthodontic treatment, enhanced stability of orthodontic results, and long term improvement of the periodontium (Wilcko et al., 2003). Dr William Wilcko and Dr Thomas Wilcko of Erie PA in 1995 developed the phrase Accelerated Osteogenic Orthodontics (AOO) and more recently as Periodontally accelerated osteogenic orthodontics (PAOO). In a recent study, it was stated that the correction of malocclusion in adults leads to periodontal health and increased psychosocial status (Rusanen et al., 2010). Achieving success in orthodontic therapy for adults is clinically challenging and lengthened in time especially due to the cease of dentoalveolar development after adolescence.

2. HISTORICAL PERSPECTIVE

Application of corticotomy surgery to correct malocclusion was first described in 1892 by L.C. Bryan and published by Guilford in a textbook called 'Orthodontia: Or Malposition of the Human Teeth, Its Prevention and Remedy', but it was Heinrich Kole in 1959 who re-introduced corticotomy to resolve malocclusion (Kole, 1959; Nowzari et al., 2008). He combined interdental alveolar corticotomy surgery with through and through osteotomy apical to the teeth.

Decortication or corticotomy means simply the intentional cutting or injury of cortical bone. Medullary bone is not altered.

Kole believed that teeth were embedded and moved in "blocks of bone" connected to each other by medullary bone only, instead of today's understanding of how teeth move through alveolar bone. Therefore, he postulated that with less resistance from medullary bone compared with that from the denser cortical plate, rapid tooth movement could be achieved. Kole's procedure involves the reflection of full thickness flaps to expose buccal and lingual alveolar bone, followed by interdental cuts through the cortical bone and barely penetrating the medullary bone. The sub-apical horizontal cuts connecting the interdental cuts were osteotomy style, penetrating the full thickness of the alveolus approximately 1mm beyond the apices of the roots. Because of the invasive nature of Kole's technique, it was never widely accepted.

The first experimental study of alveolar corticotomy was performed in monkeys (Bel and Levy, 1972). Duker used Kole's basic technique on beagle dogs to investigate how rapid tooth movement with corticotomy affects the vitality of the teeth and the marginal periodontium. The health of the periodontium was preserved by avoiding the marginal crest bone during corticotomy cuts. It was concluded that neither the pulp nor the periodontium was damaged following orthodontic tooth movement after corticotomy surgery. The results helped to substantiate the belief regarding the health of crestal bone in relation to the corticotomy cuts. Design of the subsequent techniques has taken this into consideration; the interdental cuts are always left at least 2 mm short of the alveolar crestal bone level.

In 1991, Suya replaced subapical horizontal osteotomy with horizontal corticotomy to facilitate luxation of the corticotimized bone blocks.

A more recent surgical orthodontic therapy was introduced by Wilcko et al., in 2001 which included the innovative strategy of combining corticotomy surgery with alveolar grafting in technique referred to as Accelerated Osteogenic Orthodontics(AOO) and more recently to as PAOO (Wilcko et al., 2001).

3. RATIONALE/ BIOLOGIC PRINCIPLE/ BIOLOGIC FOUNDATION

The clinical technique involving selective alveolar decortication is a form of periodontal tissue engineering resulting in a transient osteopenia and high turnover adjacent to the injury site.

Unlike a usual corticotomy, PAOO does not just cut into the bone, but decorticates it on both labial and lingual side of the teeth to be moved followed by grafting. The patient is seen every 2 weeks, and the rapid tooth movement produced after PAOO is substantially different than periodontal ligament cell –mediated tooth movement. Recent evidence suggests a localized osteoporosis state, as a part of healing event called regional acceleratory phenomenon (RAP) responsible for the rapid tooth movement after PAOO.

The regional accelerated phenomenon (RAP), reconised by Frost (Frost, 1989) defines a complex physiologic healing process involving accelerated bone turnover and decreased regional bone density in response to surgical wounding of osseous tissue. As a local response to noxious stimuli in sites of decortications extending to the marrow, RAP is an intensified bone response and rapid remodeling process featuring increase in osteoclastic-osteoblastic activity and in levels of local and systemic inflammation markers. RAP varies in duration, size and intensity in regard to the magnitude of the stimulus and type of the tissue. In human bone RAP usually lasts about 4 months with 5- fold increase in meduallary bone turnover and is considered as a physiological emergency mechanism due to potentiating tissue reorganization by transient burst of localized remodeling. A sum of experimental and clinical data

demonstrated RAP in different bone types including alveolar bone and reported strong indirect evidence associated with RAP following surgical trauma which, in turn, results in rapid tooth movement due to calcium depletion and diminished bone density.

As surgical injury causes transient local osteopenia in alveolar bone, biomechanical resistance of the bony structure decreases and enables rapid tooth movement through trabecular bone. Utilizing orthodontic power may prolong the transient osteopenia and perpetuates a therapeutic osteopenic state, considering having a limited window to limit the RAP to the teeth surrounded by corticotomy for an estimated time of 3-4 months. During this process continuous tensional stress altered in frequency and magnitude via the roots every 1 to 2 weeks is clinically imperative to maintain the osteopenic state, accelerated tooth movement and host treatment phenotype stability where the alveolar bone adapts to an inactive 'steady state' equilibrium under constant force.

The following was observed adjacent to the decortication site at 3 weeks after surgery:
(1) A 2-fold increase in decalcified trabecular bone (histomorphometric analysis using hematoxylin & eosin staining, Figure 1)
(2) A 15-fold increase in new trabecular bone formation (vital staining &libitum)
(3) A 4-fold increase in osteoclast count (after TRAP staining)
(4) A 2-fold increase in lamina dura apposition (vital stain injection series; Figure 2).

These findings collectively indicate high tissue turnover immediately adjacent to the decortication site (Sebaoun, 2005). Collectively, surgically-assisted or periodontally driven orthodontic treatment is a combination of somatic cell therapy (bone regeneration) and gene therapy (alteration of gene expression). In vivo tissue engineering principles shared by the PAOO protocol and signs of periodontal regeneration is as an entirely new dimension in dentofacial orthopedics, claiming to elicit an optimal and steady tissue response to accomplish OTM rapidly. The 2 main features of RAP in bone healing include decreased regional bone density and accelerated bone turnover which, are believed to facilitate orthodontic tooth movement.

4. CLINICAL PERSPECTIVE

Case selection:

PAOO can be used to accelerate tooth movement in most of the cases requiring orthodontic treatment of any age as long as they have a healthy periodontal situation. It has been shown to be particularly effective in treating moderate to severe crowding, in class-II malocclusions requiring expansions or extractions and mild class-III malocclusions. PAOO can be used in both maxillary and mandibular arches. Orthodontic bracketing and activation of arch wires should be performed no later than 2 weeks post-operatively.

Indications: (Hassan et al., 2010; Roblee et al., 2009)

1. To accelerate corrective orthodontic treatment, as a whole.
2. To facilitate the implantation of mechanically challenging orthodontic movements.
3. To enhance the correction of moderate to severe skeletal malocclusions.
4. Enhance post orthodontic stability.
5. Enhancement of patient's profile when indicated.
6. Manipulation of anchorage.
7. Facilitate slow orthodontic expansion.
8. Molar intrusion and open bite correction.
9. Facilitate eruption of impacted teeth.

Contraindications: (Hassan et al., 2010; Roblee et al., 2009)

1. Patients with active periodontal disease or gingival recession.
2. Patients with insufficient attached gingiva, dental caries, uncontrolled diabetes mellitus, compromised immune system and patient in compliance.
3. PAOO should not be considered as an alternative for surgically assisted palatal expansion in the treatment of severe posterior cross-bite.
4. Osteoporosis or other bone diseases.
5. PAOO should not be used in cases where bimaxillary protrusion is accompanied with a gummy smile, which might benefit more from segmental osteotomy.
6. Long term use of medication (anti-inflammatory, immunosuppressive, bisphosphonates or steroids).
7. Inadequately performed or prognostic poor endodontic treatment.

5. TREATMENT PLAN

Case selection and treatment planning are the mutual tasks of the orthodontist and the periodontist as the orthodontist determines the orthodontic tooth movement (OTM) plan, identify the teeth to provide anchorage and arch segments to be expanded or contracted while the periodontist considers the clinical periodontal status, mucogingival structure, options for minimally invasive surgery and incorporation of aesthetic needs of the patient into the treatment plan (Murphy et al., 2009).

Orthodontic bracketing and activation of the arch wires should be performed no later than two weeks postoperatively. During active orthodontic treatment, adjustments at least every two weeks is obligatory to sustain the osteopenic state, decrease the risk of recalcification in mid treatment and facilitate OTM.

6. TECHNIQUE

The placement of orthodontic brackets and activation of the arch wires are typically done the week before the surgical aspect of PAOO is performed. If complex mucogingival procedures are combined with the PAOO surgery, the lack of fixed orthodontic appliances may enable easier flap manipulation and suturing.

7. SURGICAL TECHNIQUE

A. FLAP DESIGN: (Murphy et al., 2009)

The flap design should provide full access to corticotomy site, gain tissue coverage for the graft material, maintain interdental tissue dimensions and enhance the gingival aesthetics where necessary. As coronal aspect of the flap is full thickness, a split-thickness approach in apical portions might be preferred to provide closure with minimal tension. Mesial and distal extensions are suggested to avoid the need for vertical releasing incisions. Interdental tissues regarding palatal or lingual gingival collars should be preserved in minimum and a tunnelling approach should be performed in maxillary central incisors area to enhance vascular supply and aesthetic outcome.

B. DECORTICATION: (Murphy et al., 2009)

It is performed on both labial and palatal (lingual) aspects of the alveolar bone to initiate the RAP, without creating movable segments of bone. Typically vertical corticotomies in mid-interdental areas are connected with circular corticotomies. There is no superior technique defining specific pattern, selective decortications depth or extent. A high-speed handpiece or a piezosurgical knife might be used in regard to general principles of bone surgery and local anatomic structure.

C. BONE GRAFTING: (Murphy et al., 2009)

It is commonly required in corticotomy areas. Predicted direction and amount of OTM and architecture of the existing alveolar bone in regard to buccolingual direction and the need for labial support dictates the volume of the material to be used. A typical volume of 0.25 to 0.5 ml of graft material per tooth is used as decorticated areas elicits the necessary mesenchymal stem cells and help to stabilize the graft material. Deproteinized bovine bone, decalcified freeze- dried bone allograft and autologenous bone have been used solely or in combination within or with platelet concentrations such as platelet rich plasma, usage of barrier membranes is discouraged. Up- to –date, there is no data comparing different graft materials in terms of clinical success.

PRIMARY CLOSURE: (Murphy et al., 2009)

Primary closure without excessive tension is essential to predictable bone augmentation. Typical choice of material is non-resorbable sutures with features respecting the thickness of the soft tissue. As a principle, interproximal sutures follow approximating sutures in the midline and are followed by closure of vertical sutures if necessary. Suture removal is scheduled at one or two weeks postoperatively. Periodontal packing is not required.

PATIENT MANAGEMENT

Surgical session of PAOO may cost several hours especially for bimaxillary approach suggesting the sedation of the patient. Short term steroids, antibiotics and analgesics are prescribed to enhance clinical healing and patient comfort. On the other hand, long term administration of NSAIDS postoperatively is discouraged due to the reason that NSAIDS are considered to be interfering with the RAP. Post operative application of ice packs for suppressing swelling and oedema is suggested. Oedema, ecchymosis and moderate pain are the most commonly reported post surgical complications which are not challenging for the clinician in general. (Murphy et al., 2009) Although no adverse effect on pulp vitality and periodontium due to PAOO procedures was reported, long term researches are still needed (Hassan et al., 2010).

TECHNIQUE MODIFICATIONS

Although quite effective, the traumas generated by the necessity to raise large flaps and to the extensive nature of the corticotomies have met with some resistance in patients and the dental community. The following are the modifications:

1. An alternative approach has been recently introduced by Park et al, consisting of incisions directly through the gingival and bone using a combination of blades and a surgical mallet. While decreasing the surgical time (no flaps or sutures; only cortical incisions), this technique did not offer the benefits of bone grafting to increase periodontal support in the areas where expansive tooth movement was desired. In addition, the extensive hammering in office to perform the cortical incisions appears to certain patients to be somewhat aggressive.
2. Moreover, dizziness and benign paroxysmal positional vertigo have been reported, following the use of the hammer and chisels in the maxilla (Dibart et al, 2009)
3. Dibart et al developed Piezocision a minimally invasive procedure combining microincisions, minimal piezoelectric osseous cuts to buccal cortex only and bone and soft tissue grafting concomitant with tunnel procedure.
4. PAOO can be successfully combined with gingival augmentation procedure. This is particularly important to the adult patient who presents with significant gingival recession. In these situations, a sub-epithelial connective tissue graft is placed over the denuded root surface in addition to particulate graft placement. The graft is harvested by removing a 1-2mm thickness of gingival connective tissue from the elevated palatal flap (Murphy et al., 2009)
5. Palatal and lingual corticotomy can be eliminated to reduce the length and the extent of the surgery and avoided the risk of violating vital lingual anatomy (Germec et al., 2006)

COMPLICATIONS AND SIDE EFFECTS

Although PAOO is comparatively a less invasive procedure than osteotomy-assisted orthodontics but still several reports have come regarding its adverse effects.

1.Slight interdental bone loss
2.Loss of attached gingival
3.Sub-cutaneous hematomos of face & neck
4.Post-operative swelling & pain

ADVANTAGES

1. Maintenance of periodontal stability, tooth vitality and nutritive function of the bone which avoids the risk of aseptic bone necrosis.
2. It contributes greater stability of orthodontic clinical outcomes and less relapse.
3. Enhanced scope of malocclusion treatment (that is, an increase in the limits of tooth movement and a decreased need for extractions).
4. Decreased treatment times (increased rate of tooth movement).Teeth can be moved 2 to 3 times further in $1/3^{rd}$ to $1/4^{th}$ the time required for traditional orthodontic therapy.
5. Increased alveolar volume and a more structurally complete periodontium(correction of preexisting fenestrations and dehiscence)
6. Alveolar reshaping, enhances patient's profile.
7. Simultaneous recovery of shallow unerupted teeth.
8. In certain situations, the additional alveolar bone can also provide improved lip posture.
9. Less likelihood of root resorption.
10. History of relapse has been very low.
11. There is less need for appliances and head gear.
12. Both metal and ceramic brackets can be used.

DISADVANTAGES

1. Expensive procedure.
2. Mildly invasive procedure and like all surgeries it has a risk of some pain, swelling and the possibility of infection.
3. Patients who take NSAIDS on a regular basis or have other chronic health problems will not be treated with this technique.

8. CLINICAL APPLICATIONS

It is considered an intermediate therapy between orthognathic surgery and conventional orthodontics. PAOO is a demineralization/remineralisation process, rather than bony block movement or resorption/apposition. This perspective is substantiated by the fact that there is a growth protein component in the soft tissue matrix of bone. Following cessation of the active tooth movement, this growth protein component may assist in stimulating an increase in osteoblastic activity, resulting in remineralization of the soft tissue matrix.

The corticotomy-assisted orthodontic treatment has been demonstrated to be effective in several distinct clinical situations such as crowded dentition, canine retraction after premolar extraction, facilitation of impacted tooth eruption, facilitation of slow orthodontic expansion, molar intrusion with open bit correction and enhancement of post-orthodontic stability. Innovative approach of Wilko (Wilcko et al., 2001), addressing the need for surgical orthopaedics of the alveolus, combined corticotomy (selective alveolar decortications) with alveolar augmentation (bone grafting) and orthodontic (mechanic) force, suggested PAOO to be used in cases of traditional fixed orthodontic therapy such as class I malocclusions with moderate-to-severe crowing, Class-II malocclusions requiring expansion or extractions and mild class III malocclusions (Murphy et al., 2009). Relying on this concept, a number of reports described the relevant clinical efficiency in enhanced correction of severe bimaxillary protrusion, closure of complex skeletal open bites, facilitated molar intrusion with removable appliances, intrusion and molar up righting with mini-implants and optimization of treatment of patients with cleft lip and palate (Cano et al., 2012).

Germec et al. (2006) reported an adult case with a modified corticotomy technique proposing the elimination of vertical and subapical selective decortication on the lingual aspect, for retracting mandibular anterior teeth after the extraction of four premolars. Nowzari et al. (2008) who were first to document the use of particulate autogenous bone graft with PAOO, initiated orthodontic movement immediately after surgery and completed the treatment in 8 months for the case of a 41- year-old male with class II, division 2 crowded occlusion. They also performed re- entry one year after the corticotomy procedure and reported that the thickness of buccal plate in both the arches remained unchanged, alveolar height maintained and no new fenestration or dehiscence was observed.

Wilcko et al. (2009) reported the usefulness of PAOO for the treatment of two adult cases with severe crowding as they demonstrated rapid OTM in both cases and stability up to 8 years of retention. Dibart et al. (2009) reported a 26- year -old female with a class I pattern with slightly retruded maxilla and mandible and a normodivergent mandible, presenting her chief complaint as 'I have an unpleasant smile'. They utilized PAOO technique to shorten the treatment time and finalized the active orthodontic treatment in 17 weeks. They also suggested piezoincisions combined with a localized tunneling approach in order to perform hard and soft tissue augmentation, enhance the periodontium and increase the scope of the OTM.

Einy et al. (2011) presented six cases of adult patients from both genders, with a malocclusal variety of Angle class II and class III relationships, a constricted maxilla and maxillary dental arch, a bilateral posterior cross- bite and an anterior open bite, seeking a quick orthodontic solution for aesthetic and functional disorders. They concluded that PAOO could serve as a reasonable and safe option in adult patients for the growing demand of shortened treatment duration of OTM in three dimensions.

Kim et al. (2011) demontrated two adult cases with class III malocclusion undergoing anterior decompensation for mandibular setback surgery. They compared the efficiency of conventional decompensation with temporary skeletal anchorage decompensation by using a device combined with guided tissue regeneration. They referred PAOO as a safe and effective technique for the facilitation of decompression of mandibular anterior teeth in severely compromised dentitions.

Aljhani and Zawawi (Aljhani and Zawawi, 2012) reported a 25 year old female with a chief complaint of 'I want my teeth fixed quickly', drafted for PAOO. They bonded initial fixed orthodontic appliances one week before corticotomy and orthodontic activation was performed every two weeks. Total treatment ended in 8 months without adverse effects.

Yezdani (Yezdani, 2012) demonstrated a 29 year old female with Class I malocclusion and increased bidentoalveolar protrusion, treated with PAOO. H e stated that periodontal alveolar augmentation with an alloplastic graft material repaired the dehiscence's, enhanced the bone volume and improved soft tissue profile remarkably, as the case was concluded at seventh month post operatively.

9. CONCLUSION

From an esthetic perspective the PAOO technique not only addresses tooth alignment but also facial features and, as such, is truly in vivo tissue engineering. The following conclusions follow:

1. PAOO is an effective treatment approach in adults to decrease treatment time and reduce the risk of root resorption.

2. Using a modified surgical approach and limiting the corticotomy to the buccal and labial aspects produced the RAP needed to significantly reduce treatment time.
3. The reduction of surgery time and patient discomfort are basic advantages to a modified surgical approach.
4. More clinical research is needed to determine the optimal amount of autogenous bone graft.

By combining the talents of the periodontist and the orthodontist a viable and a safe orthodontic treatment can be completed in a fraction of the time required for conventional orthodontics.

REFERENCES

1. Wilcko WM, Ferguson DJ, Bouquot JE,Wilcko MT. Rapid orth odontic decrowding with alveolar augmentation : case report. *World J.Orthod,* 2003, 4,197-205
2. Rusanen JS,Tolvanen M,Pirttiniemi P. Quality of life in patients with severe malocclusion before treatment. *Eur J Orthod,* 2010,32 (1), 43-8
3. Kole H. Surgical operations on the alveolar ridge to correct occlusal abnormalities. *Oral Surg.Oral Med.Oral patho,* 1959, 12, 515-529
4. Nowzari H, Yorita FK, Chang HC. Peridontally accelerated osteogenic orthodontics combined with autogenous bone grafting. *Compend Contin Educ Dent*, 2008, 29(4), 200-6
5. Bell WH, Levy BM. Revascularization and bone healing after maxillary corticotomies. *J Oral Surg*,1972, 30(9), 640-8
6. Wilcko WM, Wilcko MT, Bouquot JE. Rapid orthodontics with alveolar reshaping: two case reports of decrowding. *Int J Periodontics Restorative Dent*, 2001, 21, 9-19
7. Frost HM. The biology of fracture healing. An overview for clinicians. Part I. *Clin Orthop Relat Res*, 1989, 248, 283-93
8. Frost HM. The biology of fracture healing. An overview for clinicians. Part II. *Clin Orthop Relat Res*, 1989, 248, 294-309
9. Sebaoun JD. Trabecular bone modeling and RAP following selective alveolar decortications. Master's degree thesis in orthodontics, Boston University, 2005
10. Hassan AH, Al-Fraidi AA, Saeed SH. Corticotomy- Assisted Orthodontics Treatment: Review. *The open dentistry Journal*, 2010, 4, 159-64
11. Roblee RD, Bulding SL, Landers JM. Surgically Facilitated orthodontic Therapy: A New Tool for optimal Interdisciplinary Results. *Compendium*, 2009, 30, 264-76
12. Murphy KG, Wikcko MT, Wilcko WM, Ferguson DJ. Periodontal accelerated osteogenic orthodontics: a description of surgical technique. *J Oral Maxillofac Surg*, 2009, 67(10), 2160-6
13. Hassan AH, Al-Fraidi AA, Al-Saeed SH. Corticotomy- assisted orthodontic treatment: review. *Open Dent J*, 2010, 4, 159-64
14. Dibart S, Sebaoun JD, Surmenian J. Piezocision: a minimally invasive, periodontally accelerated orthodontic tooth movement procedure. Case report. *Compendium Contin Edue Dent,* 2009, 30, 342-50
15. Cano J, Campo J, Bonilla E, Colmenero C. Corticotomy-assisted orthodontics. *J Clin Exp Dent,* 2012, 4, e54-9
16. Murphy KG, Wilcko MT, Wilcko WM, Ferguson DJ. Periodontal accelerated osteogenic orthodontics: a description of the surgical technique. *J Oral Maxillofac. Surg*, 2009, 67, 2160-66
17. Germec D, Curay B, Kocadereli I. Lower incisor retraction with a modified corticotomy. *Angle Orthod*, 2006, 76(5), 882-890
18. 18.Wilcko MT, Wilcko WM, Pulver JJ, Bissada NF, Bouquot JE. Accelerated Osteogenic Orthodontics technique : a 1-stage surgically facilitated rapid orthodontic technique with alveolar augmentation. *J Oral Maxillofac Surg*, 2009, 67 (10), 2149-59
19. Einy S, Horwitz J, Aizenbud D. Wilckodontics- an alternative adult orthodontic treatment method : rationale and application.*Alpha Omegan*, 2011, 104(3-4), 102-11
20. 20.Kim SH, Kim I, Jeong DM, Chung KR , Zadeh H. Corticotomy – assisted decompensation for augmentation of the mandibular anterior ridge. *Am J orthod Dentofacial Orthop*, 2011, 140 (5), 720 – 31
21. Aljhani AS,Zawawi KH. Non extraction Treatment of Severe Crowding with the Aid of Corticotomy – Assisted Orthodontics. *Case Rep Dent*, 2012, 694527
22. Yezdani AA. Accelerated orthodontics with alveolar decortications and augmentation: A case report. *Orthodontics (Chic.)*, 2012, 13(1), 146-55

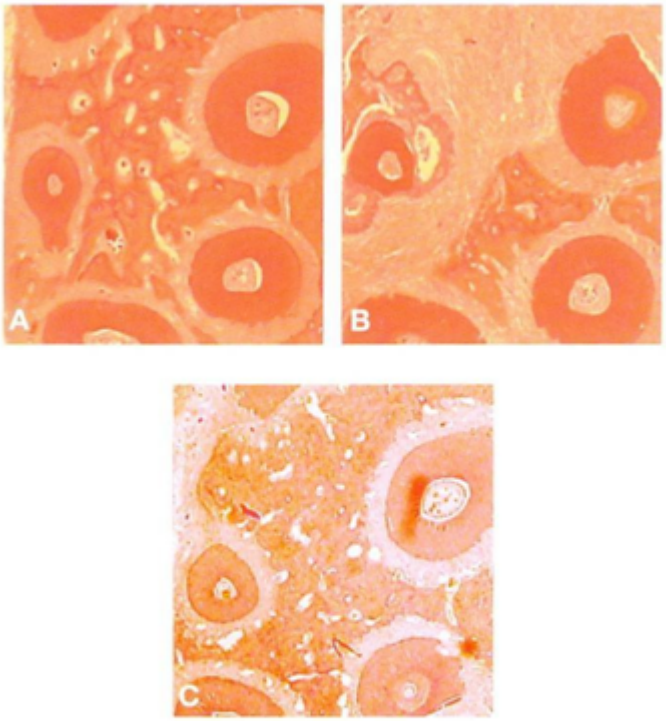

FIG.1 Cross section of the dentoalveolus of the rat showing 4 of the 5 upper first molar roots at 3 weeks control (**A**), 3 weeks decortication (**B**), and 11 weeks decortication (**C**). Testing of histomorphometric data resulted in significantly less calcified trabecular bone volume at 3 weeks on the decortication side except for 7 weeks decortication (not shown).

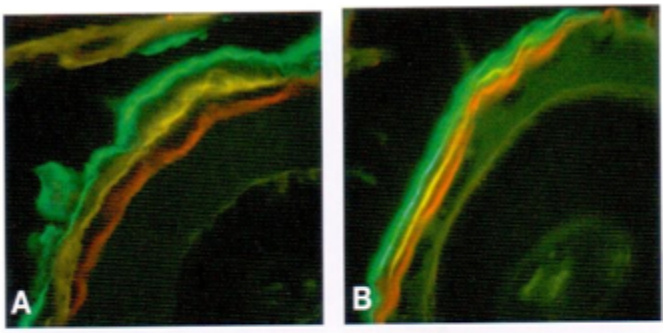

FIG.2 Amount of apposition of the lamina dura is shown in cross section of the dentoalveolus of the rat at 4 weeks, the end of the first series of vital stain injections. Total width of apposition as revealed by the three stains together was statistically greater on the decortication side (**A,** 0.051mm) at 3 weeks than the control side (**B,** 0.037mm) at 3 weeks.