Micro-CT Analysis of Osteopenia Following Selective Alveolar Decortication & Tooth Movement

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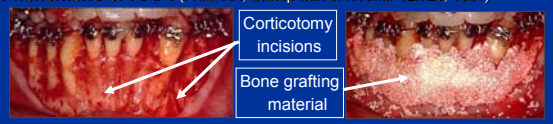
Introduction

Decortication-facilitated orthodontics is a relatively new technique combining braces and alveolar corticotomy plus grafting (PAOO™). (Wilcko, WM, et al. Internat J Perio Restor Dent 21:9-19, 2001) Malocclusions are resolved and dental arches decrowded 3X to 4X more rapidly than without PAOO™. (Wilcko WM, et al. World J Ortho 4:197-205, 2003)

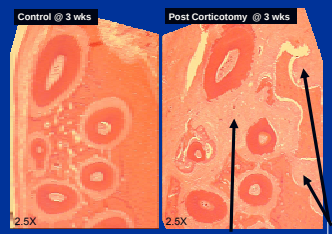
Pre-Tx | 6 months Post Tx | Pre-Tx | 6 months Post Tx

(after: Wilcko WM, et al: Internat J Perio Restor Dent 4:9-19, 2001)

Decortication is an incision made into cortical bone after the orthodontic appliances have been placed. Surgical scarring of alveolar bone induces a localized increase in hard and soft tissue turnover, a process collectively known as Regional Acceleratory Phenomena or RAP. (Frost HA, Orthop Clin of N Amer 12:725, 1981)

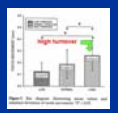


(after: Wilcko WM, et al: World J Ortho 4:197-205, 2003)



Sebaoun (MS Thesis, BU, 2005) demonstrated an increase in apposition and resorption of rat alveolar spongiosa adjacent to corticotomy incisions with 3X bone turnover and diminished bone density.

(from: Sebaoun J-D, Masters Thesis, BU, 2006)



Verna showed a significant increase in tooth movement when increased bone turnover was induced in rats. (EurJO 22:343, 2000)

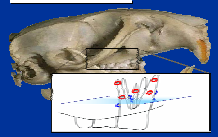
Osteopenia is a state of relative demineralization commensurate with bone modeling and may explain the rapid tooth movement. Micro-computed tomography (Micro-CT) is an emerging technology that allows nondestructive assessment and analysis of the three dimensional structure of bone.

Objectives

Using Micro-CT technology, to evaluate the osteopenic condition of alveolar bone (density and volume) after selective decortication and the effect of tooth movement on medullary bone re-mineralization over a six week period.

Methods & Materials

Procedure:



- 28 CRL-CD male rats underwent selective buccal & palatal alveolar decortication adjacent to the left maxillary first molar in a split mouth design.

- Mesial tooth movement using a 25 gram Sentalloy spring secured to a micro-screw lingual to the upper incisors.
- At least 5 animals sacrificed at post-op days 3, 7, 14, 21, and 42.
- Total maxillas prepared for Micro-CT volumetric imaging (SCANCO Medical uCT-40, a desktop cone beam scanner) and scanned at 70 kVP & 114 microA, with 200 msec. integration time per angle, at medium resolution (1024x1024 pixel slice), and 36 micron voxel size (slice thickness).
- All samples binarized using the same parameters for filter and threshold.

Data of Interest:

The volume of interest (VOI) surrounding the left maxillary first molar was defined as: mesial-most of 1st molar; mesial-most of 2nd molar; lateral-most of buccal & palatal alveolar cortical plates; apical-most of 1st molar root tip; and coronal-most of 1st molar root furcation. The following variables were calculated for control and treated sides: bone volume, bone volume/total volume (BV/TV), and average mineral density of hydroxyappatite (HA) taken over all voxels in the volume.

Results

Bone Volume

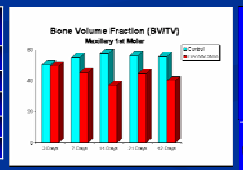
Oneway ANOVA with Scheffe post hoc testing showed a significant difference in the bone volume in the VOI at post-op day 14 (10.1) compared to control days 21 and 42 (16.3 and 17.0, p<.05).

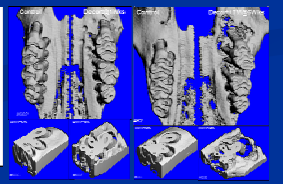
Bone Volume Fraction

Bone volume fraction (BV/TV) after decortication at post-op days 7, 14, 21, and 42 was significantly lower (p<.05), than all controls and 3-day post decortication; lowest BV/TV was 14 days after decortication (37.2%) compared to 3-day post decortication (49.5%) and all controls (50.5% to 57.8%).

BV/TV Group	Surgery	Control
3 Day	49.5%	50.5%
7 Day	45.5%*	55.1%
14 Day	37.2%*	57.8%
21 Day	44.8%*	56.3%
42 Day	40.0%*	55.9%

* = p<.05





Average Mineral Density (All Voxels)

In all post decortication groups (except 3-day post decortication), average mineral density of HA for all voxels was significantly lower than all controls (except 3-day control); lowest was 42-day post decortication (458.2 mg HA/ccm) and significantly lower than all controls (568.7 to 598.1 mg HA/ccm) except day 3 (530.0 mg HA/ccm).

Average Mineral Density	Surgery	Control
3 Day	542.8	530.0
7 Day	526.4*	568.7
14 Day	468.4*	598.1
21 Day	500.1*	583.6
42 Day	458.2*	584.9

* = p<.05

Conclusion

Using Micro-CT analysis, alveolar bone was studied in 3-D as an organ and a subtle modeling tissue subsequent to decortication and tooth movement. Decreases in bone fraction & density were evident as early as 7 days post decortication and tooth movement appeared to prolong the osteopenic effect initiated by selective decortication.