Keratinized Gingiva Height Increases After Alveolar Corticotomy and Augmentation Bone Grafting

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Background: To compare the keratinized gingival tissue (KT) height labial to the mandibular incisors after orthodontic treatment with and without alveolar corticotomy and bone grafting. Methods: Two orthodontically treated groups of 35 patients each, with (Cort) and without (Conv) alveolar decortication and augmentation bone grafting, were matched in this case controlled study for sample size, gender, mandibular premolar extractions, pretreatment age, post treatment observation period and pretreatment KT height. Standardized digital frontal occlusion photographs taken at pretreatment and at least one year after active orthodontic treatment, were adjusted to 96 dpi and measured with ImageJ software for vertical KT height labial to each mandibular incisor. Results: An average of 1.5 years after completion of active orthodontic therapy, KT height had increased significantly 0.78 mm (*P*=.000) in the Cort group and decreased 0.38 mm (*P*=.002) in Conv; a 1.28 mm KT height gain was demonstrated in the subgroup representing the lowest half of Cort KT height at pretreatment. Mandibular incisor inclination and prominence explained neither the decrease in keratinized gingiva height in Conv nor the KT height gain in Cort. Conclusions: Orthodontic therapy combined with alveolar decortication and augmentation bone grafting resulted in a significant increase in keratinized gingiva height. Although KT height surrounding the dentition has been devalued by evidence-based studies, the value added protection of KT height increase after decortication and augmentation bone grafting offsets the concerns of orthodontically proclining or expanding mandibular incisors facially.

KEY WORDS:

case-control studies, humans, orthodontics, keratinized gingiva, bone transplantation, alveolar process

The notion of what constitutes a healthy and robust periodontium prior to orthodontic tooth movement has undergone substantial reconsideration over the past half century.[1] It is as certain today as in the past that pre-orthodontic periodontal health includes sulcus pocket depths that are minimal with accessible intrasulcular cleansing, teeth free of hard accretions and plaque controlled by satisfactory oral hygiene. But the arguments for an adequate height of keratinized tissue or attached gingiva[1] as well as a vigorous, thick periodontal biotype[2] have changed substantially over the past 50 years.

ADEQUACY OF ATTACHED GINGIVA

The concept that a certain apico-coronal dimension of gingiva is critical for the protection of the periodontium proper has been refuted by evidence-based studies over the years. Prior to the mid-1970s, a height (width or zone) of attached gingival of at least one millimeter was considered necessary to maintain gingival health.[3] But since the mid-1970s, the biological significance of a sufficiently wide keratinized has been diminished by the following evidence-based studies:

Height of attached gingiva was deemed an insignificant, non-pathogenic factor in periodontal health [4-7] if oral hygiene was satisfactory [8,9] or unsatisfactory [10,11]. The conclusion drawn was that a certain quantity of gingiva is not essential for the maintenance of periodontal health or for precluding a gingival recession. [12-15]

ORTHODONTIC TOOTH MOVEMENT AND ATTACHED GINGIVA

Gingival and osseous architecture has been related to the orthodontic outcome. In a thin scalloped biotype, plaque-associated inflammation may create a greater risk for gingival recession apical to the cement-enamel junction[16], and proclining teeth, especially mandibular incisors, may result in labial bone dehiscence accompanied by gingival recession [4,17]. Cautious, judicious incisor proclination more often results in biotype thinning and greater crown lengthening but not gingival recession.[18-20] But thinness of gingiva in orthodontic patients was found to be more relevant to gingival recession than final tooth inclination.[15,21]

At a fundamental level, periodontal pathogenesis is strongly related to the bacterial flora and how an individual manages it in terms of both hygiene and immune.[15,22] Individual patients have varying susceptibility to loss of the attachment apparatus, and it is important for the orthodontist to evaluate both periodontal soft tissue status and susceptibility to change when treatment is planned.[13,23,24] A patient with thin, friable tissue and little attached gingiva labial to the mandibular incisors is at greater risk for gingival recession apical to the cement-enamel junction (CEJ) especially if the tooth is moved facially.[25] If facial tooth movement is accompanied by inflammation due to plaque retention, there is even greater risk of recession. Orthodontists must remain vigilant and acknowledge that gingival recession defect and dehiscence of the alveolar bone may occur with orthodontic expansion when the periodontal biotype is thin scalloped, especially when accompanied by plaque accumulation and inflammation.[23]

Altering the position of a tooth may bring about changes in the dimensions of the gingiva and in the position of the soft tissue margin (clinical crown height), and some patients may respond to labial movement of incisors with gingival recession and/or attachment loss. Concern has been expressed in scholarly orthodontic literature about proclining or advancing incisors and recession of the marginal soft tissue resulting in increased clinical crown height [26-28], if the gingiva is thin[21] and inflamed [29-31], if keratinized gingiva is lacking [13,18,25] or if mandibular incisors are excessively proclined [4].Others have expressed little or no concerns about marginal soft tissue gingiva status or health when mandibular incisor proclination or prominence is increased [13,20,32] in the absence of preexisting gingival recession defects [19] or if there is an adequate height of keratinized tissue [18].

ORTHODONTIC COMBINED WITH ALVEOLAR CORTICOTOMY AND AUGMENTATION BONE GRAFTING

The unique combination of orthodontic therapy with selective alveolar corticotomy and augmentation bone grafting***** was introduced in 2001.[33] This protocol was performed within one week of active fixed orthodontic appliance placement. The bone graft is typically comprised of a combination of demineralized freeze-dried bone allograft (DFDBA) and bovine bone xenograph wetted with clindamycin phosphate antibiotic. Orthodontic adjustments are made every 2 weeks instead of every 4 to 6 weeks in order to prevent alveolar osteopenia from dissipating (healing) thereby facilitating rapid tooth movement.[34] Alveolar decortication induces localized osteopenia

primarily affecting trabecular bone immediately adjacent to the injury resulting in demineralization and accelerated tooth movement.[35,36]

Patients with periodontal or bone disease and/or severe epithelial attachment loss accompanied by non-vital root surfaces are typically precluded from corticotomy and bone grafting therapy. Although effective in eliminating dehiscence and fenestrations, the technique is not a regenerative periodontal treatment but rather an empowerment tool for orthodontists that permits expanding the scope of malocclusion treatment such as skeletal open bite or cross bite as well as severe dental arch crowding without extractions.[37] Moreover, augmentation bone grafting increases alveolar cortex thickness which likely leads to greater long-term stability of orthodontic outcomes.[38,39]

Alveolar corticotomy plus augmentation bone grafting is not offered as a patient service to increase KT height but rather to expand the scope of malocclusions treatable by outpatient orthodontics and to satisfy patient requests for reduced orthodontic treatment time. The corticotomy facilitates accelerated tooth movement and the bone grafting likely leads to greater stability of orthodontic treatment outcomes. Increased keratinized gingiva height following the corticotomy and augmentation bone grafting therapy has been anecdotally observed but this topic has never been studied or documented. The purpose of the study was to evaluate the keratinized gingiva height labial to the mandibular incisors following orthodontics with and without corticotomy and bone grafting. The null hypothesis tested was no difference in height of keratinized gingiva labial to mandibular incisors in orthodontic patients treated with and without a history of corticotomy and augmentation bone grafting.

MATERIALS & METHODS

The approval of the Institutional Review Board at European University College was obtained to conduct this research project.

Sample:

The sample was comprised of 70 patients with healthy, intact periodontium without recession defect treated with comprehensive orthodontic therapy. Primary target variable was height of keratinized gingiva labial to mandibular central and lateral permanent incisors; a secondary focus was on mandibular incisor position and relationship to keratinized tissue (KT) height.

Prior to treatment, all patients signed a written informed consent authorizing use of their dental records to participate in a scientific investigation. Selection criteria for all patients in this case control study included the following: 1) comprehensive orthodontic treatment in the permanent dentition using fixed, straightwire orthodontic appliances .022” slot size with and without premolar extractions, 2) post orthodontic treatment retainer wear with removable thermoplastic and/or Hawley-type retainers, and 3) availability of intraoral frontal occlusion photographs showing mandibular keratinized gingiva at pretreatment and at least one year following active orthodontic therapy.

Subjects were excluded on the basis of any of the following criteria: 1) inability to measure the labial keratinized tissue on the intraoral frontal photograph, 2) pretreatment open bite malocclusion, 3) congenitally absent or orthodontically extracted mandibular incisor(s), 4) diagnosis of any syndrome including cleft lip and palate, and 5) history of orthognathic surgery.

From the private practices of William M. and M. Thomas Wilcko, the records of all patients, with no exception, treated with mandibular anterior alveolar corticotomy and augmentation grafting therapy (Cort) were screened using the study selection criteria. Patients who had been treated by conventional orthodontics (Conv) were then matched to the Cort sample for sample size, gender, mandibular premolar extractions, pretreatment age, length of post treatment observation period as well as pretreatment KT height. The Conv orthodontic patient records from European University College archives were reviewed starting with most current available extending back no more than two years and continued until matched groups were achieved.

Both samples were comprised of 35 individuals with 69% female and the Conv sample represented one fewer lower premolar extraction patients. Length of post treatment observation time for Conv was 15.9 months and 19.4 months for Cort ($P>.05$). Mean pretreatment KT heights were no different ($P>.05$) between the Conv and Cort (3.24 vs 3.52 mm) groups. (Table 1) Minimal pretreatment KT heights recorded for Conv and Cort were 1.61 and 0.69 mm respectfully.

Procedures

Surgery: Alveolar decortication and bone grafting was performed in Cort patients within one week from the date of placement of the fixed orthodontic appliance. A sulcular releasing incision was used and not releasing incisions made in the mucosal tissues apical to the zone of keratinized gingiva. The full thickness mucoperiosteal flap reflection was extended 5 to 10 millimeters beyond the apices of the roots. The bone activation was accomplished with circumscribing corticotomy cuts and intramarrow penetration proximate to the area of desired tooth movement using a high speed handpiece number 2 round bur with copious irrigation. Cortical bone overlying the roots was intentionally injured if thick enough without threat to entering the periodontal ligament space or injuring the root itself; interproximal cortical bone was scarred with penetrations and/or circumscribing cuts. Following the placement of the particulate bone grafting material over the activated bone, the flap was sutured in its original position with non-resorbable/non-wicking suture material. The sutures were left in place for a minimum of 2 weeks to prevent retraction apically and root exposure especially when pre-existing bony dehiscence was present.[34] (Figure 1)

Utilized for all patients were study casts and digital frontal occlusion photographs taken at pretreatment and at least one year after active orthodontic therapy. All photographs were taken with a 105 mm lens in a standardized manner with the camera lens nearly perpendicular to the frontal occlusal plane. The resolution of all intraoral frontal occlusion photographs was adjusted to 96 dots per inch (DPI). The single examiner (LM) was blinded during data measurements.

1. Maximum mesio-distal width of a maxillary central incisor was measured to the nearest hundredth millimeter (0.01 mm) perpendicular to the incisor crown central vertical axis on the study cast using a digital caliper (Mitutoyo Digimatic®, Mitutoyo (UK) Ltd, Telford, Shropshire, UK).

2. With each frontal occlusal photograph adjusted to 96 DPI, the study cast caliper measurement was then used to adjust for any magnification error of the photographs. The same tooth measured on the study casts was measured on the photographs taken at pre-treatment and at observation time post treatment by a single investigator using ImageJ software (a public domain, Java-based image processing program developed at the National Institutes of Health). ImageJ

has been shown to be a reliable and valid photogrammetric method in general.[40] In order to obtain the adjusted (normalized) width of the keratinized gingival, a multiplication factor applied which was a modification of the equation utilized by Coatoam et al.[14] and was used by Trentini et al.[41] as follows:

$$\text{Adjusted Keratinized tissue height} = \frac{(\text{Width of cast incisor})}{(\text{Width of photo incisor})} = \text{Keratinized tissue height from photo}$$

3. After calculating the amount of millimeters contained in each pixel, measurements were made using ImageJ software on the pretreatment and post treatment photographs of the facial keratinized tissue height from the muco-gingival junction to the free gingival margin; each measurement was made in line with the central vertical axis of each of the four mandibular central incisor crowns.

4. Pre-treatment and post treatment cephalometric radiographs were used to measure and compare mandibular incisor inclination (mandibular central incisor axis to mandibular plane or L1-MnPl) and protrusion (mandibular central incisor distance from nasion-to-pogonion line or L1-NPo).

Data were collected and stored in Excel and later transformed for use with the Statistical Package for Social Services (SPSS) software, version 15.0.1 for analysis. Descriptive statistics were computed on KT height changes from the KT height scores. Intergroup differences were compared using the independent t-test. Oneway ANOVA parametric testing with Tukey's post hoc test was performed to determine inter-group differences in KT height mean scores. The 0.05 probability level of significance was used for all testing purposes. Intra-operator reliability

testing was conducted by repeating keratinized tissue height measurements on five individuals from each of the two subgroups weekly for five weeks. Paired t-tests revealed no differences in the means and reliability was judged as satisfactory.

RESULTS

A comparison between the two matched treatment samples (Table 1), with selective alveolar decortication and bone augmentation (Cort) and without (Conv), demonstrated a significantly shorter active orthodontic treatment time for the Cort sample compared to the Conv (7.1 ±1.7 vs 22.1 ±6.8 months, P=.000) sample.

Heights of pretreatment keratinized tissue labial to the mandibular incisors were matched between the two study samples and then compared at least one year following orthodontic appliance removal to determine treatment effect. At 1.5 years post treatment, KT height averaged significantly more for the Cort sample (4.3 ± 0.74 mm) when compared to the Conv group (2.9 ± 0.98 mm, P<.000). Moreover, the post treatment KT height of all individual mandibular incisors was significantly greater (P≤.003) in the Cort sample. (Table 2)

Mean KT height decreased significantly from pretreatment to 1.5 years post treatment for Conv (-0.38 mm, P=.001) patients. In contrast, mean KT height increased significantly for the Cort (0.78 mm, P<.000) patients. (Figure 2 and Table 3)

To further assess treatment effect on KT height change, Cort and Conv study groups were each divided into two groups above and below the 50th percentile level of mean pretreatment KT height. Paired t-testing demonstrated that Conv group KT height decreased significantly (-0.51 mm, *P*=.006) during treatment when mean pretreatment KT height was above 50th percentile but not below 50th percentile (-0.26 mm, *P*=.10). The Cort group KT height increased significantly (1.28 mm, *P*=.000) during therapy when mean pretreatment KT height was below 50th percentile, but above 50th percentile, mean KT height change post treatment was not statistically significant (0.26 mm, *P*=.194). (not shown)

Mandibular incisors of the Cort group were significantly more retroclined than in the Conv group at pre-treatment as measured by mandibular incisor axis to mandibular plane (94.3 vs 99.5, P=.004). Moreover, the amount of pre- to post treatment change in mandibular incisor protrusion in the Cort group was significantly greater than the control (1.2 vs 0.0, *P*=.043) group. (Table 4)

DISCUSSION

The main finding of this investigation was that keratinized tissue (KT) height increased significantly after orthodontic treatment was combined with alveolar corticotomy and augmentation bone grafting. KT height increased 0.78 mm (*P*<.000) in the Cort group an average of 19.4 months following active orthodontic treatment; this magnitude of gain was not only statistically significant but also clinically important. Moreover, the 1.28 mm of KT height therapy gain demonstrated in the Cort sample with KT height lowest at pretreatment was interesting in light of the fact that there was only a 0.26 mm average KT height gain in the Cort sample with KT height highest at pretreatment. Hence, KT height gained the most following alveolar decortication and grafting therapy when KT height was least at pretreatment.

Surgical wounding of the tooth bordering soft tissue influences the dimensions of the gingiva.[42] Healing of the periodontal wound is characterized by the formation of a granulation tissue over which epithelial cells migrate from surrounding gingiva and/or alveolar mucosa. Whether keratinization of the covering epithelium will occur is determined by the properties of the connective tissue from which the granulation tissue originates. Granulation tissue derived not only from the remaining or adjacent gingiva, but also from the periodontal membrane, will form a tissue in the wounded area which in most respects, clinically as well as histologically, is similar to that of a normal gingiva.[43]

The corticotomy and augmentation bone grafting procedure (Figure 1) is quite technique sensitive relative to the increased KT height issue because only a full thickness mucoperiosteal flap and particulate bone grafting material are involved. It is the sulcular releasing (not mucosal releasing) incision that is key because it allows the stretching of the immature tissues at the re-established epithelial attachment site on the root surface that apparently provides for the increased height of the keratinized gingiva. Splitting of the original zone of keratinized gingiva which permits the reflection of the apical portion of this keratinized gingiva with the flap while leaving the coronal portion in place will not suffice. Increasing keratinized tissue by stretching the full-thickness flap coronally is not a new concept[42], nor is the concept of a change in the height of the free gingival portion caused by a change in bucco-lingual thickness of the gingiva[15]. But increased keratinized tissue at the gingival free margin secondary to tension on the suture edges stretched over the bucco-lingual bulk of augmentation grafting material has not been previously reported per se. The rather vascular immature tissues of this re-established epithelial attachment have the ability to stretch as they continue to mature. Once the epithelial attachment

is re-established at it original position on the root surface, it is fairly resistant to apical migration. But it must be emphasized that decortication and bone grafting therapy is not a regenerative technique and that any increase in KT height occurs apical to the epithelial attachment.

Conventionally treated orthodontic patients demonstrated a statistically significant decrease in KT height (-0.38 mm, *P*=.001) observed 15.9 months after fixed orthodontic appliances were removed. A decrease in KT height of -0.38 mm is not clinically important and is consistent with Coatoam et al. (1981) who reported in orthodontically treated patients a -0.25 mm average decrease in KT height labial to mandibular incisors observed at immediate post treatment. In the present study, differences in active orthodontic treatment time between Cort and Conv, (7.1 vs 22.1 months, *P*=.000) was not considered a confounding factor.

Mandibular incisor inclination and prominence may be confounding factors in keratinized gingiva height change. But the Conv KT height does not appear to have been influenced by either factor because there was no significant pre- to 1.5 years post treatment change (*P*>.05) in either cephalometric variable. In the Cort group, mandibular incisors increased significantly in inclination 2.7 degrees (*P*=.049) and protrusion 1.6 mm (P=.001) while KT height increased significantly thereby having the opposite effect expected. The increased bucco-lingual alveolar dimension from the augmentation bone grafting explains best the increased KT height.

Recession of the free gingival margin is another confounding variable in measuring KT height change as Boke et al.[26] found a positive correlation between mandibular incisor position and gingival recession in patients treated with fixed appliances and extraction. In the current investigation, clinical crown heights of mandibular incisors could not be measured from the photographs.

Lastly, KT height increase in the Cort group may have been due to apical movement of the mucogingival junction but apical migration is highly unlikely.[44-46] In the present study, it would appear that the most cogent explanation for mandibular anterior labial KT height increase in the Cort group was stretching the full-thickness flap coronally over the bucco-lingual bulk of augmentation grafting material. Even though the main purpose of alveolar corticotomy and bone grafting is not to increase KT height, it would appear that the procedure results in this value-added outcome.

CONCLUSIONS

Two matched groups of orthodontically treated patient-patients, with and without alveolar decortication and augmentation bone grafting, were compared. The samples were matched for sample size, gender, mandibular premolar extractions, pretreatment age, post treatment observation period and baseline pretreatment KT height. A summary of the results pertaining to the mandibular incisors is as follows:

1. Labial keratinized gingiva heights were increased an average of 0.78 mm (*P*=.000) in the corticotomy group; a 1.28 mm KT height gain was demonstrated 19.4 months after orthodontic appliance removal in the subgroup representing mean KT heights below the 50th percentile at pretreatment.

2. Keratinized gingiva heights deceased an average of 0.38 mm (*P*=.001) in the conventionally treated group; a -0.51 mm KT height loss was found 15.9 months after

orthodontic appliance removal in the subgroup representing mean KT heights above the 50th percentile at pretreatment.

3. Mandibular incisor inclination and prominence did not explain the decrease in keratinized gingiva height in the conventionally treated group nor the KT height increase in the alveolar corticotomy and augmentation bone grafting group.

Based upon the conditions of this study, it may be concluded that orthodontics combined with alveolar decortication and augmentation bone grafting results in a significant increase in keratinized tissue height thereby offsetting the concerns of orthodontically proclining or expanding mandibular incisors facially.

CONFLICT OF INTEREST AND SOURCES OF FUNDING STATEMENT

Sources of Funding: There was no "Conflict of Interest" regarding funding. This retrospective case-controlled study was self-funded by the authors and their institution.

Authors D. Ferguson and L. Makki claim no "Conflict of Interest" of any type related to the investigation entitled, *Keratinized gingiva height increases after alveolar corticotomy and augmentation bone grafting.*

Authors W. Thomas Wilcko and William M. Wilcko have a conflicts of interest related to the investigation entitled, *Keratinized gingiva height increases after alveolar corticotomy and augmentation bone grafting;* they hold a patent related to Accelerated Osteogeneic Orthodontics and Periodontially Accelerated Osteogenic Orthodontics. COI forms from website http://www.icmje.org/#conflicts are submitted by the two Wilcko co-authors.

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Submitted February 02, 2015; accepted for publication June 07, 2015.

Figure 1:

Pre-treatment (1A), flap reflection and bone activation (1B), bone grafting material placement (1C), suturing (1D), day of debracketing (1E), and two years post debracketing ((1F). Note the cortical bone dehiscence in 1B and the increase in KT height in 1F.

Figure 2:

Keratinized tissue height labial to mandibular incisors was measured using ImageJ software from normalized (note bracket sizes) photographs. In the Cort sample (A1 to A2), KT height increased 0.78 mm from pretreatment to 19.9 months after active orthodontic treatment; in the Conv sample (B1 to B2), KT height decreased 0.38 mm from pretreatment to 15.9 months after completion of active orthodontic treatment.

Table I:

Description of study samples including, code, sample size, gender, extraction of mandibular premolars, mean age at pre-treatment, mean active orthodontic treatment time, and mean post treatment time and pretreatment KT height labial to mandibular incisors. M=male, F=female; L = mandibular or lower.

Sample Description	Code	Si	Gender		L Premolar Extraction		Pre-Tx Age (years)	Post Tx (months)	Pre-Tx KT Ht (millimeters)
			M	F	No	Yes			
Conventional orthodontics *removable retainers*	Conv	35	11	24	30	5	30.1 ±11.4	15.9 ±13.6	3.24 ±0.8
Corticotomy + grafting + ortho *removable retainers*	Cort	35	11	24	29	6	29.7 ±13.1	19.4 ±12.9	3.52 ±0.9

Table 2:

Descriptive data and independent t-test results comparing KT heights labial to each mandibular incisor for Conv and Cort groups at pretreatment and at least one year after active orthodontic treatment. Note that variables were not different at pretreatment and mean KT height was greater (*P*≤ .003) at post treatment for all Cort mandibular incisor locations and 1.44 mm greater (*P*≤ .000) for Cort mean KT height.

Mandibular incisors	Pretreatment KT height					Post treatment KT height				
	Conv (n=35)		Cort (n=35)			Conv (n=35)		Cort (n=35)		
	mean	SD	mean	SD	*P* sig	mean	SD	mean	SD	*P* sig
	(millimeters)		(millimeters)			(millimeters)		(millimeters)		
Right lateral	3.46	1.14	3.69	1.30	.446	3.01	1.15	4.47	0.84	.003
Right central	3.32	0.91	3.40	1.08	.743	2.86	0.98	4.33	0.96	.000
Left central	2.91	0.81	3.27	0.94	.088	2.65	0.94	4.16	0.92	.000
Left lateral	3.24	0.91	3.73	1.14	.061	2.84	1.11	4.26	0.91	.000
mean KT height	3.24	0.82	3.52	0.92	.178	2.86	0.98	4.30	0.74	.000

Table 3:

Paired t-test results comparing keratinized tissue heights within each group at pretreatment and post orthodontic treatment observation times. Note that Cort KT height increased significantly at all labial mandibular incisor locations and that all labial mandibular incisor KT heights significantly decreased in the Conv subgroup except for left central.

Mandibular incisors	Change in keratinized tissue height					
	Conv (n=35)			Cort (n=35)		
	15.9 months post tx			19.4 months post tx		
	mean dif	t value	*P* sig	mean dif	t value	*P* sig
Right lateral	-0.37	-2.74	.010	0.78	3.95	.000
Right central	-0.46	-3.25	.003	0.93	4.46	.000
Left central	-0.27	-1.96	.058	0.89	4.26	.000
Left lateral	-0.42	-3.11	.004	0.53	2.46	.019
mean KT height	-0.38	-3.46	.001	0.78	4.75	.000

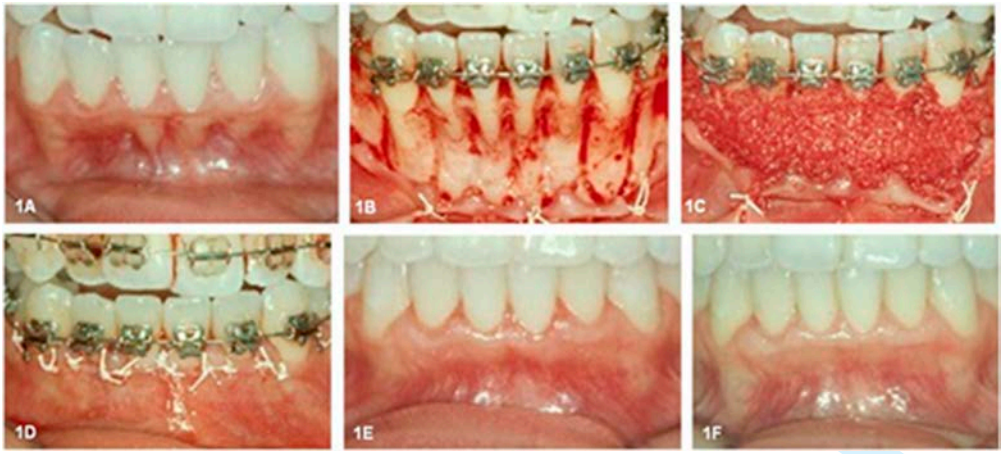
Table 4:

Independent t-test results comparing mandibular central incisor inclination (L1-MnPl) in degrees and protrusion (L1-NPo) in millimeters at pretreatment and at the post orthodontic treatment as well as amount of change in pre- to post treatment inclination and protrusion. Note that Cort group mandibular central incisor inclination was significantly more retroclined at pre-treatment and demonstrated greater protrusion change during therapy.

	Pretreatment KT height					Post treatment KT height				
Cephalometric measurements	Conv (n=35)		Cort (n=35)			Conv (n=35)		Cort (n=35)		
	mean	SD	mean	SD	*P* sig	mean	SD	mean	SD	*P* sig
Inclination (L1-MnPl)	99.5	7.5	94.3	7.0	.004	100.3	9.5	96.9	7.6	NS
Protrusion (L1-NPo)	5.0	2.9	3.8	3.4	NS	5.0	2.7	5.0	3.3	NS
	Pre- to post treatment change									
Inclination change	0.8	6.7	2.7	7.7	NS					
Protrusion change	0.0	2.5	1.2	2.0	.043					

***** footnote: Periodontally Accelerated Osteogenic Orthodontics or PAOO

 DOI: 10.1902/jop.2015.150074



 DOI: 10.1902/jop.2015.150074