A COMPARISON OF TWO SOFT TISSUE GINGIVECTOMY TECHNIQUES

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A THESIS

Submitted to the graduate faculty of The University of Alabama at Birmingham,
in partial fulfillment of the requirements for the degree of
Master of Science

BIRMINGHAM, ALABAMA

2009

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ABSTRACT

Gingival position and shape plays a vital role in the esthetics of an orthodontic case. Unfortunately, after orthodontic treatment the gingival position and shape commonly possesses non-ideal properties, negatively impacting the end result. For these patients, a soft tissue gingivectomy procedure is needed to position the gingival unit in the correct position. Traditionally, gingivectomies were performed using a scalpel with satisfactory results however, with the advent of laser technology, diode lasers have been increasingly utilized for intraoral soft tissue applications such as gingivectomies. The purpose of the present study was to compare gingivectomies performed with a scalpel and those performed with an 810 nanometer diode laser in regards to postoperative pain, gingival healing, gingival relapse, and operative time.

Fifteen consecutive patients, ages 12-17 years, needing a soft tissue gingivectomy procedure in two quadrants of the same arch were enrolled in the study. Patients received scalpel gingivectomies in the right quadrant of the arch needing treatment, and received laser gingivectomies in the left quadrant of the same arch. Patients were given visual analog scales to rate their experience of pain for the first seven days postsurgically. Crown heights were measured immediately postsurgically, and at all follow-up appointments. Plaque index and gingival index measurements were also taken at follow-up appointments. The study found no significant difference in postoperative pain between the two procedures except for a small difference on day 3, where the laser treated quadrant

had less pain. Gingivectomies performed with the laser required less chair time, had less postoperative inflammation, but had more coronal relapse. In conclusion, the diode laser is an adequate alternative to the traditionally-used scalpel for soft tissue gingivectomies and may provide an added benefit of faster chair time and better gingival healing.

Keywords: GINGIVECTOMY, LASER, SCALPEL, ORTHODONTICS, DIODE, ESTHETICS

ACKNOWLEDGMENTS

I would like to thank Drs. Andre' Ferreira, Philip Vassilopoulous, P. Lionel Sadowsky, and Ms. Sandre McNeil for their guidance and support in preparing this thesis. I would also like to acknowledge the full and part-time faculty of the University of Alabama-Birmingham orthodontic department. I will forever be thankful for their assistance with this thesis but also for their contribution to my orthodontic education. Finally, I would like to thank my fellow residents who will be lifelong friends.

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Literature Review

Esthetic improvement is one of the most common reasons a patient wishes to undergo orthodontic treatment. Smile attractiveness can have profound effects on a patient's psychosocial development, often influencing their behavior and traits.[1] Orthodontist's have traditionally planned treatment for patients to obtain a Class I functional occlusion, a favorable profile, and acceptable stability as the primary treatment goals. Very often, achieving these goals result in an enhanced and improved esthetic smile. However, in an effort to obtain optimal esthetic, other factors must be considered when planning treatment. The clinician must analyze not only the position of the teeth, but also that of the gingiva and lips when designing treatment to achieve the most esthetic smile possible. This often requires a multidisciplinary treatment plan, including not only the orthodontist but often the dentist, periodontist, and prosthodontist.[2]

In the past, smile esthetics was limited to alterations of the teeth themselves, changing their alignment, shape, and color. However, it has been shown that the basic tenets of a beautiful smile include not only the teeth, but also the lips and gingival scaffold.[3] These three elements, present in the proper proportion, position, and shape, can create an esthetically pleasing smile. Sarver[4] discussed the elements of the smile based on its mini- and microesthetic components. These included gingival display on smile and gingival height symmetry (miniesthetic components), as well as tooth width-to-height ratios, gingival margin shape and location, and other dental attributes (Microesthetic components). The article emphasized the importance of these elements in

creating an esthetic smile. Research has shown that while esthetics is not entirely subjective, there are rules and values that can be considered ideal within certain ranges. These ranges allow the clinician to compare their patients to the norm and help determine a proper course of treatment and outcome.

IDEAL CHARACTERISTICS OF A SMILE

Gingival Display

When a patient smiles, the upper lip moves apically, displaying the maxillary anterior teeth. In analyzing the lips affect on the smile, orthodontist's often evaluate the amount of incisor/gingival show on smiling. This analysis should be done clinically, measuring the lip to tooth relationship at high smile. Video imaging has been advocated to help record the dynamics of the patient's smile, allowing for a more accurate representation to aid in treatment planning.[5] Garber and Salama[3] consider the lips to form the frame of the smile and thus define the aesthetic zone. They define the lip lines as being high, medium, or low depending on their position. A low lip line only displays a small amount of teeth below the upper lip, whereas a high lip line shows a large amount of gingiva below the upper lip. According to Garber and Salama[3], American culture tends to find the medium lip line the most esthetic, showing 1-3mm of gingiva below the inferior border of the upper lip.

Ker et al.[6] recently studied the ideal characteristics of a smile from the layperson's perspective. Two hundred and forty-three laypersons judged numerous smile photographs which were altered for different smile characteristics in order to find ideal

values for those characteristics. They found the ideal gingival display on smile to be 2.1 millimeters with an acceptable range from 4 millimeters of gingival display to 3.6mm of crown coverage. A similar study by Kokich[7] examined ideal smile characteristics as perceived by orthodontists, dentists, and laypersons. They found that 0 millimeters of gingival display on smiling was the most esthetic for all groups and the smile was not found unaesthetic by laypersons and dentists until the gingival display exceeded 4 millimeters. A later study by Kokich[8] indicated that orthodontists and laypeople find a gingival display greater than 3 millimeters unattractive whereas dentists did not even rate the maximum value tested of 4 millimeters as unattractive.

Numerous investigators have found similar values as ideal for gingival display on smiling, showing 75% of the crown of the incisor[9], 1-2mm of gingival display[10], and up to 3mm of gingival display[2]. According to a study by Dunn et al.[11], patients prefer a smile that shows the maximum amount of incisor crown and is symmetrical. Any display of the incisor crown below that which is ideal results in a less youthful appearance, whereas a display of gingiva greater than the ideal results in a "gummy", unaesthetic smile. This excessive gingival display can occur for a multitude of reasons, but most commonly is a result of excessive vertical maxillary growth, coronally positioned gingival tissue on the tooth, or malpositioned or over erupted maxillary anterior teeth.[10]

Tooth Dimensions

It is obvious the alignment of the teeth is important in creating an optimally esthetic smile, but there are also other attributes of the teeth that are equally as important.

Elements such as tooth size and proportionality must be assessed to ensure that they are in harmony with the face and smile. Levin[12] suggested using the Greek ideas of the golden proportions to describe the ideal dental esthetics in the anterior region. This indicates that in the ideal smile, from the frontal perspective, the central incisor is 1.62 times (162%) wider than the lateral incisor, and in turn, the lateral incisor is 1.62 times (162%) wider than the canine. Ward[13] found this ratio to be somewhat larger at 1.7(170%). Therefore, the width of each tooth should be proportional to the adjacent teeth but also each individual tooth width should be proportional to its own height. The ideal width-to-height ratio has been found to be 78% with an acceptable range of 66% to 80%.[13,14] When examining this ratio, it is important to know the average values for the height and width of the anterior teeth so that when there is a disproportion in the width-to-height ratio, the clinician can determine which aspect is at fault. Wheeler[15] has shown the average clinical crown heights of the maxillary central incisor, lateral incisor, and canine to be 10.5 millimeters, 9.0 millimeters, and 10 millimeters, respectively.

Gingival Margin Shape and Location

The location and shape of the gingival margins of the maxillary anterior teeth plays an important role in maximizing the esthetic appearance of those teeth and thus the smile.[16] It is especially important in those patients who have some amount of gingival display when smiling. The gingival margin location of the two maxillary central incisors should be at the same level as well as at the same level as the canines. In his study of smile characteristics, Ker[6] found that the gingival margin of the two central incisors

should ideally be at the same level, but laypeople did not find a discrepancy in this relationship unaesthetic until it was greater than 2 millimeters. This finding is in agreement with Kokich's[8] similar study, where he found that general dentists and laypeople found discrepancies greater than 2 millimeters unaesthetic, however orthodontist's perceived a 0.5 mm gingival margin discrepancy between the central incisors as unaesthetic.

The position of the maxillary lateral incisor gingival margin relative to the central incisor and canine is another important smile characteristic. There is, however, some variation in the literature as to the ideal location for the gingival margin of the lateral incisor. One report indicates the lateral incisor gingival margin should be located 1mm coronally as compared to the central incisor and canine gingival margin.[17] Ker[6] found that the ideal value of the lateral incisor gingival margin to be 0.4mm coronal to the central incisor and canine. However, the laypeople in that study reported a wide range of values acceptable, anywhere from 1.2 millimeters apical to 2.9 mm coronal of the central incisor and canine.

The shape of the gingival margin also contributes significantly to the esthetics of a smile. The gingival margin shape of the maxillary central incisors and canines should be more elliptical and the gingival zenith (the most apical point of the gingival margin) should be located distal to the longitudinal axis of their crowns.[18] The gingival margin shape for the maxillary laterals should be different from that of the central incisors and canines, having a more half-circular shape with the zenith corresponding to the longitudinal axis of the clinical crown.[18] Finally, there should be an interdental papilla

with the tip of the papilla halfway between the incisal edge and the labial gingival height of contour of each anterior tooth.[10]

GINGIVAL PROBLEMS IN ORTHODONTIC PATIENTS

It is apparent from past literature that the gingival tissues play as important of a role in the esthetics of a smile as does the alignment of the teeth. Unfortunately, often times in our orthodontic patient population, the gingival unit has less than ideal characteristics at the conclusion of treatment. A study by Konikoff et al.[19] found that greater than 65% of patients finishing orthodontic treatment had higher than ideal width-to-height ratios of their maxillary anterior teeth. They also found that greater than 60% of patients finishing orthodontic treatment had some type of gingival asymmetry. This gingival encroachment of the clinical crowns was most often due to either inflammatory changes of the soft tissue or an altered or delayed passive eruption of the teeth. Thus, Konikoff et al.[19] concluded that in order to achieve an ideal smile in a majority of orthodontic patients, esthetic crown lengthening should be considered to increase the width-to-height ratios of the maxillary anterior teeth in addition to correcting any asymmetries.

Gingival Inflammation/Enlargement during Orthodontic Treatment

At the commencement of orthodontic treatment, appliances are typically bonded to the facial surface of the patient's teeth. The introduction of these appliances into the

oral environment results in more plaque retention sites for the patient.[20] Unfortunately, the proximity of these appliances to the gingival sulcus often inhibits proper oral hygiene maintenance by the patient and therefore greater plaque accumulation.[21] As plaque accumulates, the subgingival microflora changes from a more benign Gram-positive cocci culture to a pathogenic Gram-negative rod and spirochete culture.[22] A study by Naranjo et al.[23] measured the clinical parameters and subgingival microbiota of 30 patients before and after orthodontic bracket placement. Periodontopathic bacteria such as *Porphyromonas gingivalis, Prevotella Intermedia/Prevotella nigrescens, Tannerella forsythia,* and *Fusobacterium* species were all found to be elevated after bracket placement as compared to the controls. Eventually, the homeostasis tips in the favor of the pathogenic organisms and it appears clinically evident by an increased bleeding on probing, plaque index, and gingival index.[23]

According to a study by Zachrisson[24], patients who had excellent oral hygiene prior to orthodontic treatment suffered from plaque induced gingivitis within 1-2 months after orthodontic appliance placement. Also, even the patients who appeared to have excellent oral hygiene during the course of treatment showed increased levels of gingival inflammation compared to when they started treatment[20]. In a study by Kloehn and Pfeifer[25], the percentage of patients who could maintain proper oral hygiene dropped from 20% to 6.5% with the introduction of orthodontic appliances.

The chronic inflammation caused by the accumulation of plaque around orthodontic brackets can lead to several different outcomes, such as gingival recession and attachment loss, but most commonly it results in an inflammatory hyperplasia.[22] In a study by Zachrisson[24], biopsies were taken of gingival margin tissue before and

throughout the course of orthodontic treatment. At the beginning of treatment (subchronic stage), these tissues showed an increase in inflammatory cells, predominantly lymphocytes, but most often progressed to a chronic inflammation in which plasma cells predominate and produce hyperplasia and proliferation of the pocket epithelium. Studies have shown that this hyperplastic tissue occurs more frequently adjacent to the premolars and molars, where it is found five times more often than in the canine and incisor region. The hyperplastic tissue was also shown to be four times as prevalent in the interproximal areas as the center of the crown.[20,25]

The hyperplastic inflammatory changes created in the gingival tissue create pseudopockets. Several studies have shown increased probing depths during orthodontic treatment.[22] However, studies have also shown that in adolescent orthodontic patients, there is typically no attachment loss.[25] The increased probing depth that occurs during treatment is due to an increased height of the inflamed gingival margin. Once orthodontic appliances are removed, the inflammation and hyperplasia often resolve, but there could be some benign thickening, or incomplete resolution, of the gingival epithelium that remains.[20] It has been shown that adolescent patients have better gingival and plaque indices after orthodontic treatment than before[26], but the question remains as to whether this increased proficiency at oral hygiene is sufficient to completely resolve the enlarged gingival tissue. A study by Kouraki et al.[27] measured gingival heights pre-treatment, immediately post-treatment, and three to twelve months post-treatment of thirty patients to determine if complete resolution of gingival enlargement occurred spontaneously. Kouraki et al.[27] found that the gingival enlargement that occurred during the course of treatment did not correct itself after

appliance removal. This study did find a significant decrease in gingival enlargement post-treatment; however it was still significantly larger than the pre-treatment level. Kouraki et al.[27] concluded that due to the chronic inflammation, fibrotic changes may have occurred in the gingival tissues. These fibrotic changes would not allow the gingiva to return to its normal physiologic architecture regardless of the oral hygiene of the patient and thus creates a pseudopocket that is difficult to clean and could result in attachment loss if not corrected. Correction of such a problem would consist of a soft-tissue gingivectomy.

Altered Passive Eruption

One other cause of an unaesthetic, "gummy" smile or an increased width-to-height ratio is a delayed apical migration of the gingival margin of the maxillary anterior teeth. As teeth actively erupt to the level of the occlusal plane, the gingival margin is typically located at the junction of the cervical and middle thirds of the clinical crown.[28] At this point, passive eruption occurs, which is the apical migration of the gingival tissue to its normal physiologic position. Altered passive eruption is an aberration in normal eruption of the anatomic crown, resulting in a large portion remaining covered with gingival tissue.[3] It has been shown that up to 12.1% of patients exhibit a delayed passive eruption.[29] This is a detriment to smile esthetics for two reasons. First, the coronally positioned tissue typically has very little scallop, resulting in an unattractive square-shaped crown rather than the attractive elliptical or ovoid shape. Secondly, the excess

tissue can often be displayed below the lip at high smile, resulting in an unaesthetic amount of gingival display on smiling.

In most adult patients, the gingival margin should migrate to a final position approximately 1mm coronal to the cementoenamel junction.[10] The age at which completion of passive eruption should occur is important for the clinician in treatment planning the final position of the maxillary anterior teeth for optimal smile esthetics. A young patient with excessive gingival display may not need incisor intrusion once passive eruption is complete and the gingival margin has migrated to its final position.

Volchansky[30], using study casts of preorthodontic patients ranging from 6-16 years of age and measuring clinical crown heights, found no statistically significant increase in clinical crown height after the age of 12 years for the mandibular anterior teeth. The maxillary anterior teeth however, continued to show an increase in clinical crown height up to the age of 16, which was the oldest age tested. A more recent longitudinal study by Morrow et al.[31] measured the clinical crown length on study casts of four hundred and fifty-six patients taken at three different time points; 11-12 years of age, 14-15 years, and 18-19 years. The maxillary central incisor, lateral incisor, and canine had 0.5 millimeter increases in clinical crown height through the ages of 14-15 and 18-19 years of age. Their results indicate that the normal process of passive eruption, resulting in an increase in the clinical crown height, continues throughout the teenage years.

From the past research, one may assume the process of passive eruption will be completed by the late teenage years. However, in post-orthodontic patients, the chronic

inflammation induced by poor oral hygiene and plaque accumulation around appliances during treatment results in more fibrotic gingival tissue posttreatment, even though the inflammation has subsided. This thickening of the gingival tissue may delay the normal apical migration of the tissue, thus creating shorter clinical crowns post treatment.[10] If a sulcular depth of 3-4 millimeters is measured in a patient with thick, fibrotic tissue, it may take years before the gingival margin migrates to its proper position just coronal to the cementoenamel junction. In such cases, surgical correction by means of a gingivectomy would provide esthetic and biological benefits for the patient.

GINGIVECTOMY

As reported previously, orthodontic patients often finish treatment with a less than ideal smile. Poor oral hygiene induced inflammatory hyperplasia and/or altered passive eruption can affect several key elements of the smile such as tooth proportionality, proper gingival architecture, and even gingival display on smiling. In order to correct these deviations from the ideal, a periodontic-orthodontic collaboration must often be utilized to optimize the patient's esthetic result. Whether the excessive gingival encroachment of the anatomic crown is due to inflammatory hyperplasia or an altered passive eruption, correction is done primarily with a soft tissue gingivectomy technique. A gingivectomy is defined as "the surgical excision of unsupported gingival tissue to the level where it is attached, creating a new gingival margin apical in position to the old".[32] In doing so, the complete anatomical crown becomes exposed, thus enhancing the esthetic appearance of

the teeth and reducing the gingival display on smile. Pseudopockets are also eliminated, creating a better environment for periodontal health.

When considering a gingivectomy, several factors should be taken into account to determine the proper method. Occasionally, altered passive eruption of the gingival tissue is accompanied by an arrested active eruption of the teeth. In this instance, the crest of the alveolus could be coronal to the cementoenamel junction.[28] In normal situations, it has been shown that the alveolar crest should be approximately 2 millimeters apical to the cementoenamel junction.[33] In the case of an arrested active eruption with the alveolar crest at or coronal to the cementoenamel junction, a simple soft tissue gingivectomy exposing the entire anatomic crown will fail because it violates the biologic width of the gingival attachment.[28]

Biologic width is defined as "the combined height of connective tissue and epithelium that isolates the bone from the oral cavity. It is the distance considered necessary for the existence of healthy bone and tissue from the most apical extent of a dental restoration".[32] The biologic width contains the junctional epithelium, the connective tissue fibrous attachment and the sulcus.[3] Studies have shown the dimension of the biologic width to be approximately 2.7 millimeters; 0.97 millimeters for the epithelial attachment, 1.07 millimeters for the connective tissue attachment, and approximately 0.69 millimeters for the sulcus depth.[33] These dimensions of the biologic width are considered necessary for gingival health, and thus cannot be encroached upon when performing a gingivectomy. According to Levine and McGuire[29], encroaching on the biologic width can have different consequences depending on the patient. Patients with a thin gingival tissue biotype may experience recession while those with a thick

gingival tissue biotype may encounter gingival rebound. In order to preserve the biologic width for a patient experiencing an arrested active eruption, a flap procedure must be performed with osseous recontouring that lowers the alveolar crest to its normal position in conjunction with lowering the gingival margin.

The amount of keratinized tissue available should also be considered prior to a gingivectomy procedure. An adequate zone of keratinized tissue is required after surgery for optimal tissue health. Allen[34] suggests maintaining 3-5 millimeters of keratinized gingival tissue post surgery. If 3-5 millimeters is not available, an apically positioned flap procedure must be used, rather than a simple gingivectomy, to maintain the proper quantity of keratinized tissue.

The type of surgery required to lower the gingival margins, whether soft tissue alone or in conjunction with an osseous recontouring, is dependent on the relationship of the alveolar crest to the cementoenamel junction. To determine the level of the alveolar crest, Kokich[10] recommends bone sounding. Bone sounding is done by pushing a periodontal probe past the bottom of the sulcus, through the epithelial attachment and connective tissue to stop at the level of the bone. If the bone is 2 millimeters from the cementoenamel junction, soft tissue resection alone is adequate to expose the anatomical crown to its ideal dimensions. However, if the bone level is within 0.5 millimeters of the cementoenamel junction, it is recommended to proceed with osseous recontouring along with an apically positioned flap.

Scalpel Gingivectomy

Scalpels have been used for many years to perform soft tissue procedures such as gingivectomies. The scalpel gingivectomy method uses small blades and often other periodontal surgical instruments to place the gingival margin in its more ideal location and thus create a more esthetically pleasing result. The use of the scalpel with the internal bevel technique has been shown to be well suited for gingivectomy procedures.[35] The internal and external bevel techniques are the procedure of choice for patients with adequate keratinized tissue and no need for osseous recontouring due to its high predictability, reduced risk of losing the interdental papilla, lower discomfort, and more rapid healing.[34] The advantage of using the scalpel technique over other modalities, such as soft tissue lasers or electrosurgery, is the lack of tissue damage beyond the edge of the incision. These other modalaties generate heat during use and can cause collateral tissue damage adjacent to the incision.[36] The disadvantages of using the scalpel include the lack of hemorrhage control and resultant difficulty in visualizing the surgical field as well as difficulty in thinning and recontouring gingival tissues.[37]

Laser Gingivectomy

The word “laser” is an acronym for “light amplification by stimulated emission of radiation”.[38] Lasers use a single wavelength of light that is collimated, delivering a very concentrated source of energy and have become increasingly popular in medicine and surgery since their development by Maiman in 1960.[39] In 1968, the carbon dioxide laser was used for the first time in a soft tissue surgery. In 1997, the US Food and Drug

Administration approved the erbium:YAG (Er:YAG) laser for hard-tissue surgery and the next year approved the first diode laser for use in soft-tissue surgery.[40] In dentistry, the most frequent applications for lasers include gingivectomies, frenectomies, removal of mucocutaneous lesions, and gingival sculpting around implants.[41]

There are four main laser types used in dentistry; the carbon dioxide laser, the neodymium: Aluminum-Yttrium-Garnet (Nd:YAG), the diode laser, and the Erbium: Aluminum-Yttrium-Garnet (Er:YAG).[39] These lasers differ due to their different wavelengths of light energy emitted and thus their clinical applications. Different bodily tissues absorb light at different wavelengths so the appropriate laser and corresponding wavelength must be chosen that coincides with the target tissue. Longer wavelengths (3,000 nanometers), such as those produced by the Er:YAG laser (2,940 nanometers), are readily absorbed by water and hydroxyapatite, making this laser well suited for hard-tissue use.[40] The wavelengths produced by the diode lasers (810-980 nanometers) are well absorbed by hemoglobin and pigmented tissues, and poorly absorbed by bone and tooth structure, making this laser a great choice for soft-tissue ablation.[40] It is therefore important to have knowledge of the exact wavelength absorption of the intended target tissue for optimal laser performance as well as preventing iatrogenic damage to other nearby tissues.

When the target tissues absorb the light energy from the laser, a photothermal event takes place. The intracellular water in the target tissue elevates in temperature and once it reaches its boiling point of 100 degrees Celsius, vaporization occurs within the tissue – this process is known as ablation.[40] There are other possible interactions of the light energy on the target tissue, depending on the composition of that tissue. The light

energy could be redirected off of the surface of the tissue having no effect. This is termed reflection. The light could also simply pass through the tissue having no effect. Lastly, the light energy could be scattered, weakening the intended energy and possibly resulting in no useful biologic effect.[40]

In the orthodontic community, there has been an increasing popularity in the diode laser for soft tissue gingivectomy procedures. Previously, the carbon dioxide laser was commonly used for such procedures but with the advent of the diode laser, with its wavelength specific for pigmented tissue and hemoglobin, it has the advantage of increased hemostasis. The diode laser has also been shown to have similar effects as the Nd:YAG laser, which also targets pigmentation, but with less thermal effects.[39] The compactness and high efficiency of the diode lasers also set it apart from its counterparts which are often very large in size and may require three-phase power and water cooling to operate.[42]

The increased use of the diode laser can also be attributed to its proposed advantage over the traditional scalpel technique for soft tissue removal. The excision created by a soft tissue laser can be more precise, while also coagulating blood vessels, sealing lymphatics, and sterilizing the wound, maintaining a clearer and clean surgical field when compared with using a scalpel.[38] By sealing the blood vessels and lymphatics, postsurgical bacteremia is greatly reduced when using a diode laser.[37] In addition, most often only topical anesthetic is needed when using the diode laser[43], which in the open orthodontic setting is much preferred over using injection syringes where other patients may see and become anxious.[44] Other claimed advantages of the diode laser over the traditional scalpel include less bleeding, minimal swelling, less scar tissue,

less discomfort, and fewer analgesics needed post-operatively.[38] A report prepared by the Research, Science and Therapy Committee of the American Academy of Periodontology[39] stated that past research supports the claim of less bleeding with soft tissue laser use compared with the scalpel but claims of less pain postoperatively and reduced need for local anesthesia injection operatively are more anecdotal and have not been validated scientifically. This same report[39] also found conflicting evidence on whether wounds heal faster after laser use compared to use of the scalpel and concluded by issuing the following recommendation: "The decision to use a laser for periodontal surgery should be based on the proven benefits of hemostasis keeping in mind the claimed (but undocumented) advantage of less postoperative pain with gingivectomy, frenectomy, or other procedures".

There are some disadvantages of soft tissue laser surgery, in particular the diode laser. The first disadvantage is the expense. Buying and maintaining a diode laser costs more than an electrosurgery unit, and much more than scalpels.[36] Next, is the possible retinal injury to the eyes of the patient or practitioner with use of the diode laser. The eye is engineered to focus light and even the smallest exposure to the laser radiation is sufficient to cause permanent retinal damage, including retinal burns and cataracts.[38] This retinal damage can even occur with reflection of the laser beam off of any reflective surface such as a table, jewelry, or possibly even orthodontic appliances.[38] In addition, some clinicians have reported less tactile sense, slower cutting, poorer wound healing, and greater tissue dessication when using the diode laser as compared with use of a scalpel.[36,38] Finally, the plume that is created when removing the soft tissue with a diode

laser can contain certain pathogens and have a burning flesh odor and therefore, a high-filtration face mask is recommended.[36]

As soft tissue lasers become more commonly used for dental applications, more science emerges supporting and refuting the previously anecdotal claims of improved wound healing and less pain with laser use over use of a scalpel. A study by Haytac and Ozcelik[45] compared forty frenectomies done with scalpels and carbon dioxide lasers. They found that the patients receiving a frenectomy with the carbon dioxide laser had less postoperative pain, fewer functional complications (speaking and chewing), and required fewer analgesics than did the patients receiving treatment with the traditional scalpel technique. Some studies have shown that using low level laser therapy after procedures such as gingivectomies improved and accelerated the wound healing process[46,47,48,49], while another study indicated there to be no difference in healing[50]. Also, laser wounds have fewer myofibroblasts than do scalpel wounds, which could result in reduced wound contraction and scarring and improved postsurgical function.[37]

To date, there are few studies comparing the soft tissue diode laser with the traditional scalpel technique when performing a soft tissue gingivectomy procedure. The soft tissue gingivectomy procedure is often necessary before, during, or after orthodontic treatment and would be beneficial for the orthodontist to know whether using a laser or scalpel for this procedure is more advantageous. If the diode laser is equally effective in removing soft tissue while possibly providing the benefits of increased hemostasis, better wound healing, and less pain without any major side effects, it would benefit the patient to have the laser procedure performed rather than using the scalpel procedure. The laser procedure could be carried out when needed in the orthodontic setting during a routine

orthodontic appointment rather than having to schedule a separate appointment with the periodontist to have the scalpel procedure performed. The purpose of this study was to compare the laser and scalpel gingivectomy procedures and determine any differences in pain, operative time, healing, and tissue rebound.

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In preparation for *The Angle Orthodontist*

Format adapted for thesis

Abstract

Gingival position and shape plays a vital role in the esthetics of an orthodontic case. Unfortunately, after orthodontic treatment the gingival position and shape commonly possesses non-ideal properties, negatively impacting the end result. For these patients, a soft tissue gingivectomy procedure is needed to position the gingival unit in the correct position. Traditionally, gingivectomies were performed using a scalpel with satisfactory results however, with the advent of laser technology, diode lasers have been increasingly utilized for intraoral soft tissue applications such as gingivectomies. The purpose of the present study was to compare gingivectomies performed with a scalpel and those performed with an 810 nanometer diode laser in regards to postoperative pain, gingival healing, gingival relapse, and operative time.

Fifteen consecutive patients, ages 12-17 years, needing a soft tissue gingivectomy procedure in two quadrants of the same arch were enrolled in the study. Patients received scalpel gingivectomies in the right quadrant of the arch needing treatment, and received laser gingivectomies in the left quadrant of the same arch. Patients were given visual analog scales to rate their experience of pain for the first seven days postsurgically. Crown heights were measured immediately postsurgically, and at all follow-up appointments. Plaque index and gingival index measurements were also taken at follow-up appointments. The study found no significant difference in postoperative pain between the two procedures except for a small difference on day 3, where the laser treated quadrant had less pain. Gingivectomies performed with the laser required less chair time, had less postoperative inflammation, but had more coronal relapse. In conclusion, the diode laser is an adequate alternative to the traditionally-used scalpel for

soft tissue gingivectomies and may provide an added benefit of faster chair time and better gingival healing.

Introduction

Esthetic improvement is one of the most common reasons a patient wishes to undergo orthodontic treatment. Smile attractiveness can have profound effects on a patient's psychosocial development, often influencing their behavior and traits.[1] Orthodontist's have traditionally planned treatment for patients to obtain a Class I functional occlusion, a favorable profile, and acceptable stability as the primary treatment goals. Very often, achieving these goals result in an enhanced and improved esthetic smile. However, in an effort to obtain optimal esthetic, other factors must be considered when planning treatment. The clinician must analyze not only the position of the teeth, but also that of the gingiva and lips when designing treatment to achieve the most esthetic smile possible. This often requires a multidisciplinary treatment plan, including not only the orthodontist but often the dentist, periodontist, and prosthodontist.[2]

In the past, smile esthetics was limited to alterations of the teeth themselves, changing their alignment, shape, and color. However, it has been shown that the basic tenets of a beautiful smile include not only the teeth, but also the lips and gingival scaffold.[3] These three elements, present in the proper proportion, position, and shape, can create an esthetically pleasing smile. Sarver[4] discussed the elements of the smile based on its mini- and microesthetic components. These included gingival display on smile and gingival height symmetry (miniesthetic components), as well as tooth width-to-

height ratios, gingival margin shape and location, and other dental attributes (Microesthetic components). The article emphasized the importance of these elements in creating an esthetic smile. Research has shown that while esthetics is not entirely subjective, there are rules and values that can be considered ideal within certain ranges. These ranges allow the clinician to compare their patients to the norm and help determine a proper course of treatment and outcome.

It is apparent from past literature that the gingival tissues play as important of a role in the esthetics of a smile as does the alignment of the teeth. Unfortunately, often times in our orthodontic patient population, the gingival unit has less than ideal characteristics at the conclusion of treatment. A study by Konikoff et al.[5] found that greater than 65% of patients finishing orthodontic treatment had higher than ideal width-to-height ratios of their maxillary anterior teeth. They also found that greater than 60% of patients finishing orthodontic treatment had some type of gingival asymmetry. This gingival encroachment of the clinical crowns was most often due to either inflammatory changes of the soft tissue or an altered or delayed passive eruption of the teeth. Thus, Konikoff et al.[5] concluded that in order to achieve an ideal smile in a majority of orthodontic patients, esthetic crown lengthening should be considered to increase the width-to-height ratios of the maxillary anterior teeth in addition to correcting any asymmetries.

The less than ideal gingival characteristics post orthodontic treatment can often be attributed to either poor oral hygiene during treatment and/or an altered passive eruption of the teeth. Poor oral hygiene induced inflammatory hyperplasia and/or altered passive eruption can affect several key elements of the smile such as tooth proportionality, proper

gingival architecture, and even gingival display on smiling. In order to correct these deviations from the ideal, a periodontic-orthodontic collaboration must often be utilized to optimize the patient's esthetic result. Whether the excessive gingival encroachment of the anatomic crown is due to inflammatory hyperplasia or altered passive eruption, correction is done primarily with a soft tissue gingivectomy technique. A gingivectomy is defined as the surgical excision of unsupported gingival tissue to the level where it is attached, creating a new gingival margin apical in position to the old.[6] In doing so, the complete anatomical crown becomes exposed, thus enhancing the esthetic appearance of the teeth and reducing the gingival display on smile. Pseudopockets are also eliminated, creating a better environment for periodontal health.

Traditionally, gingivectomies have been performed utilizing the scalpel to remove the excess gingival tissue. More recently, there has been an increasing popularity in the diode laser for performing soft tissue gingivectomy procedures. The increased use of the diode laser can also be attributed to its proposed advantages over the traditional scalpel technique for soft tissue removal. The excision created by a soft tissue laser can be more precise, while also coagulating blood vessels, sealing lymphatics, and sterilizing the wound, maintaining a clearer and clean surgical field as well as a lower postsurgical bacteremia when compared to using a scalpel.[7,8] In addition, most often only topical anesthetic is needed when using the diode laser[9], which in the open orthodontic setting is much preferred over using injection syringes where other patients may see and become anxious.[10] Other claimed advantages of the diode laser over the traditional scalpel include less bleeding, minimal swelling, less scar tissue, less discomfort, and fewer analgesics needed post-operatively.[8]

There are some disadvantages of soft tissue laser surgery, in particular the diode laser. The first disadvantage is the expense. Buying and maintaining a diode laser costs more than an electrosurgery unit, and much more than scalpels.[11] Next, is the possible retinal injury to the eyes of the patient or practitioner with use of the diode laser. The eye is engineered to focus light and even the smallest exposure to the laser radiation is sufficient to cause permanent retinal damage, including retinal burns and cataracts.[8] This retinal damage can even occur with reflection of the laser beam off of any reflective surface such as a table, jewelry, or possibly even orthodontic appliances.[8] In addition, some clinicians have reported less tactile sense, slower cutting, poorer wound healing, and greater tissue dessication when using the diode laser as compared with use of a scalpel.[8,11] Finally, the plume that is created when removing the soft tissue with a diode laser can contain certain pathogens and have a burning flesh odor and therefore, a high-filtration face mask is recommended.[11]

To date, there are few studies comparing the soft tissue diode laser with the traditional scalpel technique when performing a soft tissue gingivectomy procedure. The soft tissue gingivectomy procedure is often necessary before, during, or after orthodontic treatment and would be beneficial for the orthodontist to know whether using a laser or scalpel for this procedure is more advantageous. If the diode laser is equally effective in removing soft tissue while possibly providing the benefits of increased hemostasis, better wound healing, and less pain without any major side effects, it would benefit the patient to have the laser procedure performed rather than using the scalpel procedure. The laser procedure could be carried out when needed in the orthodontic setting during a routine orthodontic appointment rather than having to schedule a separate appointment with the

periodontist to have the scalpel procedure performed. The purpose of this study was to compare the laser and scalpel gingivectomy procedures and determine any differences in postoperative pain, operative time, tissue healing, and tissue relapse.

Materials and Methods

Study Design

The study was designed as a self-contained split mouth study comparing the scalpel gingivectomy to the laser gingivectomy. The sample was selected from patients treated at the University of Alabama School of Dentistry, Department of Orthodontics, who needed a soft tissue gingivectomy procedure on an entire anterior segment (at least cuspid to cuspid). Patients were excluded from the study if they were taking any systemic medications or had any systemic illnesses. The final sample consisted of 15 patients, 10 females (average age of 14.5 years) and 5 males (average age of 13.8 years) ranging in ages from 12-17 years, in various stages of orthodontic treatment. In all, a total of 105 teeth were treated, 53 had the scalpel gingivectomy and 52 had the laser gingivectomy. The study was reviewed and approved by the institutional review board and informed written consent was obtained from all of the patient's parents as well as receiving the assent of the patient.

One week prior to surgery, patients were given a dental prophylaxis as well as oral hygiene instructions. The gingivectomy was carried out in one appointment for both the left and right quadrant of the arch requiring the gingivectomy. The same periodontist (P.V.) performed all scalpel gingivectomies on the patients right quadrant whereas the

same orthodontic resident (J.D.) carried out the laser gingivectomy on the contralateral (left) quadrant. Prior to surgery, patients were asked to rinse with a chlorhexidine gluconate oral rinse for 30 seconds. Local anesthetic (lidocaine with HCl) was administered to each patient in both quadrants. Probing depths were measured and bleeding points created to establish ideal locations for the gingival margins, approximately 1 millimeter coronal to the cemento-enamel junction. Probing was also performed to determine bone height and allow for an adequate biologic width (2.5mm).

For the scalpel gingivectomy, the periodontist used an internal bevel technique utilizing a number 15C surgical blade. The laser gingivectomy was carried out using an 810nm diode laser (Odyssey Navigator, Ivoclar Vivodent, Inc, Amherst, NY) on continuous mode at 1.5-2 watts, depending on the tissue thickness. The thicker, more fibrous tissue required the higher 2 watt setting. The time required to complete each procedure was recorded for each patient and rounded to the nearest minute. Post-operative crown heights were measured to the nearest hundredth of a millimeter using an electronic digital caliper. Crown heights were measured from the zenith of the gingival margin to the incisal edge of the incisors and to the cusp tip of the canines and premolars. Patient's were given postoperative instructions and advised to use over-the-counter analgesics if needed for pain.

The patients were also asked to rate the degree of pain on two 10 centimeter horizontal visual analog scales (VAS), one for the patients right side and one for the left side. The left endpoint of the scale was designated as "no pain" and the right endpoint designated as "worst pain imaginable". Patients were instructed to place a vertical mark at the position between the two endpoints that best described their personal perception of

the pain they experienced on that particular side. This was done on the evening of the surgery and for the following six days. The mark placed by the patient was measured to the nearest millimeter, therefore the scores for pain perception were between 0.0 and 10.0. These measurements were performed by the same operator on postoperative day 7 when the patient returned the questionnaire.

Patients appeared for follow-up appointments at 1 week, 1 month, and 2 months. Crown heights were measured at all appointments in the manner described previously. At the 2 month follow-up, the gingival margin position was considered to have stabilized and these crown heights were used to compare with the immediate post-operative crown heights to determine the gingival relapse. A positive crown height change indicates an apical migration of the gingival margin postoperative, and a negative crown height change indicates a coronal gingival migration during the postoperative period. In addition, to assess the soft tissue inflammation/healing postoperatively, the plaque index (PI) and gingival index (GI) for each tooth receiving either procedure was recorded at the 1 week and 1 month postoperative appointments using the criteria described by Loë[12] (see Table 1 and Table 2). All measurements were recorded by the same operator (J.D.).

Table 1

Plaque Index Criteria[12]

Score	Criteria
0	No plaque
1	Tooth appears clean, but plaque made visible by probe in gingival third
2	Moderate accumulation of plaque that isvisible to naked eye
3	Heavy accumulation of soft material which fills out the niche produced by gingival margin and tooth surface

Table 2

Gingival Index Criteria[12]

Score	Criteria
0	No inflammation, normal appearance
1	Mild inflammation, slight change in color, mild edema, no bleeding on probing
2	Moderate inflammation, redness, edema, hypertrophy, bleeding on probing
3	Severe inflammation: marked redness, edema, ulceration, hypertrophy; spontaneous bleeding

Statistical Analysis

Statistical significance for categorical variables, such as the plaque index and gingival index, was determined by using logistical models which controlled for repeated measures. For the continuous measurements, linear models (ANOVAs) controlling for repeated measures were used. Statistical significance was determined at $p<0.05$. All analysis was performed using SAS v9.1 software (Cary, NC).

Results

The results of the present study are summarized in Tables 3 and 4. For pain perception, the VAS score was significantly lower on day 3 for the laser group as compared to the scalpel group but, on all other days, there were no statistically significant differences between the two groups. Also, the teeth that received the laser gingivectomy experienced a significantly higher amount of tissue relapse, i.e. coronal migration of gingival margin postoperatively, as compared to the teeth that received the scalpel gingivectomy. The laser group had significantly less soft tissue inflammation postoperatively as compared to the scalpel although there were no significant differences

in the plaque index. In addition, the operative time required for the laser gingivectomy was significantly less than that of the scalpel gingivectomy.

Table 3

Comparison of Plaque and Gingival Index between Groups

	Scalpel	Laser	Total	P Value
PI at 1 week				
0	29	26	55	
1	10	13	23	0.5881
2	14	13	27	
PI at 1 month				
0	14	14	28	
1	21	24	45	0.2966
2	18	14	32	
GI at 1 week				
0	0	0	0	
1	3	12	15	
2	38	34	72	0.0100
3	12	6	18	
GI at 1 month				
0	4	4	8	
1	29	35	64	0.0473
2	20	13	33	
3	0	0	0	

Table 4

Comparison of Laser Gingivectomy vs. Scalpel Gingivectomy

	Scalpel (mean ± SD)	Laser (mean ± SD)	P Value
Pain at 1 day	1.4 ± 1.6	1.9 ± 2.3	0.4316
Pain at 2 days	0.9 ± 1.3	0.5 ± 0.6	0.062
Pain at 3 days	0.4 ± 0.6	0.3 ± 0.4	0.0343
Pain at 4 days	0.4 ± 0.7	0.2 ± 0.3	0.1639
Pain at 5 days	0.2 ± 0.3	0.1 ± 0.3	0.6525
Pain at 6 days	0.1 ± 0.1	0.1 ± 0.1	0.1527
Pain at 7 days	0.0 ± 0.1	0.1 ± 0.2	0.3006
Operative time	19 ± 7	12 ± 3	<.0001
Crown height change	-0.30 ± 0.43	-0.47 ± 0.37	0.0098

Discussion

Diode lasers have become increasingly popular in orthodontics for soft tissue gingivectomy procedures, most likely because a majority of orthodontic patients finish treatment with non-ideal gingival architecture and position.[5] The diode lasers' affinity for ablating pigmented tissue, especially hemoglobin, make it superior for the soft tissue gingivectomy procedures compared with the traditionally-used scalpel in regards to hemostasis. However, little scientific evidence is available to support the anecdotal claims that the diode lasers are superior to the traditional scalpel for postoperative pain and soft tissue healing.[13] The aim of the present study was to compare gingivectomies performed with a scalpel and a soft tissue diode laser in regards to postoperative pain, operative time, gingival healing, and gingival relapse.

For the first seven days postoperatively, the only significant difference in pain between the diode laser group and the scalpel group was on day 3. This difference was very small and on all other days measured (1,2,4-7), there were no statistically significant differences. This contradicts some reports that state the diode laser produces less pain due to the protein coagulum formation acting as a biologic dressing and sealing off nerve endings.[8,13,14] This disagreement may be due to the fact that the diode laser used in this study was operated in continuous mode rather than in a pulsed mode. Some have suggested that use of the laser in the pulsed mode allows for thermal relaxation of the tissue and thus less collateral tissue damage and consequently less postoperative pain.[14] Also, a local anesthetic was delivered to both the scalpel and laser quadrants to provide adequate operative anesthesia and some have advocated that only a topical anesthetic is needed for diode laser procedures.[8] The infiltration of the local anesthetic could have

increased the patient's postoperative perception of pain for the diode laser treated quadrant when compared to studies where only a topical anesthetic was given.

The present study did find a significantly lower degree of gingival inflammation in the laser treated side as compared to the scalpel treated side at 1 week and 1 month postoperatively, even though there were no differences in the plaque index for the two sides. This agrees with previous studies that found low level laser therapy to have a greater healing effect on soft tissue after similar gingival procedures than non-laser treated tissue.[15,16,17,18] It has been shown that low level diode laser irradiation can stimulate fibroblast proliferation without impairing procollagen synthesis and thus possibly explain the improved wound healing on the diode laser treated side.[17] Another possible explanation for the improved healing with the diode laser side compared to the scalpel treated side could be the fact that the diode laser sterilizes the wound as it ablates the tissue.[8] Pigmented bacteria are vaporized along with the target tissue and this sterilized field possibly creates an improved environment for soft tissue healing.

Gingival shape and position, along with tooth proportionality play a very important role in the esthetics of the smile. One of the primary reasons to perform a gingivectomy procedure during orthodontic treatment is to establish the ideal gingival form and tooth proportions to enhance the finished result. There are certain values and guidelines in positioning of the gingival margin as well as in tooth proportions that have been shown to be ideal and should be the goal when performing a soft tissue gingivectomy. Unfortunately, postsurgical relapse or re-establishment of the gingival margin position is common and can compromise the end result. The clinician should choose the procedure with the least amount of tissue relapse to more accurately place the

gingival margin in its ideal position. In the present study, it was found that the gingivectomies performed using the scalpel experienced significantly less gingival relapse, repositioning 0.3 millimeters coronally from the position placed during surgery. The laser treated teeth had a relapse value of 0.46 millimeters coronally. Numerous factors can influence the amount of relapse of the gingival margin postsurgically such as encroachment of the biologic width and oral hygiene of the patient.[19] In the present study, plaque index scores postsurgically showed no significant differences among the two groups and probing was done presurgically to ensure adequate biologic width preservation.

The final statistically significant difference found in the present study between the laser gingivectomy group and scalpel gingivectomy group was the time elapsed to complete each procedure. For efficiency, the procedure that requires the least amount of time would be preferred over the other, with all else being equal. Our study found that laser gingivectomies require significantly less chair time that do scalpel gingivectomies. For the laser group, the average time to complete each quadrant was 12 minutes compared to the scalpel group which averaged 19 minutes. Although the scalpel is a more efficient cutting tool than the laser, the scalpel's inability for proper hemostasis and keeping a clear and clean surgical field increased the time required to complete the procedure. The scalpel procedure required consistent irrigation and compression of the tissue for hemorrhage control. Also, blades must be changed frequently for the scalpel technique which added to the procedure time. For the laser group, once initial setup of the equipment is completed (which was done prior to the appointment and not timed in this study), an entire quadrant was completed with clear visibility due to the excellent

hemorrhage control and, in most cases, there was no pause in the procedure except a rare instance to re-cleave the fiber tip. Ensuring adequate safety precautions with the diode laser is a time expense that was included in our study and is important for every procedure utilizing a diode laser. This includes ensuring adequate safety glass wear of the patient and clinicians as well as covering all reflective surfaces in the operatory to protect from beam reflection.

While conducting the present study, the author did note that the only concern expressed by patients during post surgery follow-up phone calls was the hemorrhage on the scalpel quadrant. The hemorrhage on the scalpel quadrant did cause some patient distress, however this information was not a part of the patient questionnaire and thus not included in the study. One limitation of the study is the lack of randomization of assigning the quadrants to a specific procedure, and thus any difference found statistically between the two groups could not be distinguish as being due to the procedure used (scalpel or laser) or due to the side on which it occurred (right or left).

Conclusions

The diode laser provides an adequate alternative to the traditional scalpel for soft tissue gingivectomy procedures. The diode laser performs the procedure more efficiently with greater hemostasis than does the scalpel. Also, gingival healing and inflammation, measured with the gingival index, are significantly improved post surgically with the diode laser as compared to the scalpel, although relapse of the gingival tissue in a coronal direction is greater with the laser than with the scalpel. Finally, there is very little

difference in patients' perception of pain associated with laser gingivectomies and scalpel gingivectomies. Although the diode laser does provide some added benefit over the scalpel technique, there are some drawbacks, so the clinician must decide if the added expense of the laser unit is worth the benefit that is achieved.

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GENERAL CONCLUSIONS

The aim of the present study was to compare gingivectomies performed with a scalpel and a soft tissue diode laser in regards to postoperative pain, operative time, gingival healing, and gingival relapse. Fifteen consecutive patients, ages 12-17 years, needing a soft tissue gingivectomy procedure in two quadrants of the same arch were enrolled in the study. Patients received scalpel gingivectomies in the right quadrant of the arch needing treatment, and received laser gingivectomies in the left quadrant of the same arch. Patients were given visual analog scales to rate their experience of pain for the first seven days postsurgically. Crown heights were measured immediately postsurgically, and at all follow-up appointments. Plaque index and gingival index measurements were also taken at follow-up appointments.

The present study found no significant difference in postoperative pain between the two procedures except for a small difference on day 3, where the laser treated quadrant had less pain. Gingivectomies performed with the laser required less chair time, had less postoperative inflammation, but had more coronal relapse. In conclusion, the diode laser is an adequate alternative to the traditionally-used scalpel for soft tissue gingivectomies and may provide an added benefit of faster chair time and better gingival healing.

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APPENDIX

INSTITUTIONAL REVIEW BOARD APPROVAL FORM

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM

Institutional Review Board for Human Use

Form 4: IRB Approval Form
Identification and Certification of Research
Projects Involving Human Subjects

UAB's Institutional Review Boards for Human Use (IRBs) have an approved Federalwide Assurance with the Office for Human Research Protections (OHRP). The UAB IRBs are also in compliance with 21 CFR Parts 50 and 56 and ICH GCP Guidelines. The Assurance became effective on November 24, 2003 and expires on January 23, 2012. The Assurance number is FWA00005960.

Principal Investigator:	DURHAM, JAMES RUSSELL
Co-Investigator(s):	VASSILOPOULOS, PHILIP J
Protocol Number:	**F071019013**
Protocol Title:	*Comparison of Two Soft Tissue Gingivectomy Techniques*

The IRB reviewed and approved the above named project on 2/4/2009. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services. This Project will be subject to Annual continuing review as provided in that Assurance.

This project received FULL COMMITTEE review.

IRB Approval Date: 2/4/2009

Date IRB Approval Issued: 2/12/09

Identification Number: IRB00000196

Ferdinand Urthaler, MD

Ferdinand Urthaler, M.D.
Chairman of the Institutional Review
Board for Human Use (IRB)

Investigators please note:

The IRB approved consent form used in the study must contain the IRB approval date and expiration date.

IRB approval is given for one year unless otherwise noted. For projects subject to annual review research activities may not continue past the one year anniversary of the IRB approval date.

Any modifications in the study methodology, protocol and/or consent form must be submitted for review and approval to the IRB prior to implementation.

Adverse Events and/or unanticipated risks to subjects or others at UAB or other participating institutions must be reported promptly to the IRB.

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