



FASCIA SCIENCE AND CLINICAL APPLICATIONS: FASCIA PHYSIOLOGY

## A comparative study of cervical hysteresis characteristics after various osteopathic manipulative treatment (OMT) modalities

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Received 9 September 2012; received in revised form 27 September 2012; accepted 1 October 2012

### KEYWORDS

Balance ligamentous tension;  
Counterstrain;  
Durometer;  
Fixation;  
Frequency;  
High velocity low amplitude;  
Hysteresis;  
Mobility;  
Motoricity;  
Muscle energy;  
Osteopathic manipulative treatment;  
SA201®;  
Sham;  
Somatic dysfunction

**Summary Background:** Few objective measures have been used to document change in myofascial tissues after OMT.

**Hypothesis:** Paraspinal tissues associated with cervical somatic dysfunction (SD) will demonstrate quantifiable change in myofascial hysteresis characteristics after a given OMT technique but not after a Sham intervention.

**Materials & methods:** 240 subjects were palpated for cervical articular SD. A randomly selected intervention (5 OMT techniques or a Sham) was applied to the cervical SD clinically considered to be most severe. A durometer (SA201®; Sigma Instruments, Cranberry, PA, USA) objectively measured myofascial structures overlying each cervical spinal segment pre- and post- intervention. Using a single consistent piezoelectric impulse, this durometer quantified four hysteresis (tissue texture) characteristics – fixation, mobility, frequency, and motoricity.

**Results:** Baseline changes in median hysteresis values were noted for each OMT technique but not for Sham interventions. Notably, segmental counterstrain OMT resulted in significant motoricity change compared to adjacent segmental myofascial measures ( $p$ -value 0.04) along with a suggestive trend in the mobility component ( $p$ -value 0.12).

**Conclusion:** When comparing treated to untreated cervical segments, the most significant change occurred post-counterstrain OMT with no overall change following Sham. Overall, quantifiable objective change occurs in myofascial tissues post-OMT, in addition to the noted clinical palpable change.

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## Background

Worldwide and independently, healthcare professionals have identified an entity identified by palpation that is responsive to a variety of manual therapeutic maneuvers; under various names, they consider this to be a “manipulable lesion” (Fryer, 2003). Many groups and indexing professionals have adopted the osteopathic glossary term, “somatic dysfunction”, to reference this entity.

The osteopathic profession defines somatic dysfunction as “impaired or altered function of related components of the somatic (body framework) system: skeletal, arthroal, and myofascial structures, and related vascular, lymphatic, and neural elements. Somatic dysfunction is treatable using osteopathic manipulative treatment” (Fryer, 2003). In addition to the subjective perceptions of their patients, osteopathic practitioners typically assess clinical changes in somatic dysfunction based on the four individual diagnostic elements: Sensitivity (or tenderness), Tissue texture abnormality, Asymmetry, and altered Range of motion (STAR) (Chila, 2010).

Admittedly, beyond the degree of tenderness few objective measurements have been made to actually quantify the component elements that constitute somatic dysfunction or to assess the degree of change following the application of hands-on treatment techniques (Cohen et al., 2005). This is particularly true for assessing myofascial tissue texture characteristics associated with somatic dysfunction before and after OMT. Since the initial physiological measurements made by Korr and Denslow of sweat gland activity, red reflex response, EMG activity in related paraspinal muscles, and galvanic skin responses (Peterson, 1979); few tissue studies that have been designed to measure such objective components of somatic dysfunction before and after OMT. Of these (Cohen et al., 2005, Warner et al., 1997), most have either not been blinded or were not linked to simultaneous palpatory findings, making it difficult to objectively associate the clinical complaints and their relief to either the somatic dysfunction or its treatment.

Clinical words included in the *Glossary of Osteopathic Terminology* are used to describe tissue texture findings and denote the “resilient”, “resistant”, “boggy”, “firm”, or “ropy” qualities found in viscoelastic myofascial structures. Many of these words also describe characteristics associated with the phenomenon of “hysteresis”. In a manual medicine context, hysteresis is the rate at which connective tissue responds to the loading and unloading of a compressive (deforming) force. More specifically it is defined as the difference in viscoelastic behavior (energy loss) (Chila, 2010).

Hysteresis has been recognized to account for a significant part of the nuanced diagnostic interpretation of the tissue texture characteristics considered by Doctors of Osteopathic Medicine (Warner et al., 1997). The time it takes for the deformation of targeted tissues to recoil to its normal state is specifically influenced by the acute or chronic pathophysiology in the somatic tissues and their related elements. In this fashion, altered hysteresis characteristics in tissues that were “boggy” or edematous might be recognized by a specific lag time in tissue recoil following diagnostic palpation compared to “normal” or to

“fibrotic” tissues. When referring to tissue response, experienced practitioners assess much more than just range of motion; they interpret motion quality and how the body reacts to energy transfer via titrated palpation of a segment or in response to specific manipulations (Warner et al., 1997).

Similar to industrial measures of magnetic materials (Seth, 1994), hysteresis loops may be recorded. Graphically, a hysteresis loop yields visibly useful information regarding how any structure (including the human body) reacts to energy as it is repetitively applied and withdrawn (Warner et al., 1997). When a force is added to a pliable system, over time the system begins to deform and then recoils when the force is taken out of that system. After altering particular aspects of a given system (fluid content, muscle tone, etc), repeated hysteresis measurements to the same force may document that the system recoils more or less quickly than ideal.

In a human system, hysteresis measures are not dictated solely by the physical structure; rather they reflect the individual’s and the site’s dynamic, functional anatomy as influenced by tissue texture characteristics covering the articular elements. Depending upon how the combined physiological and anatomical conditions differ from the original system, there can be measurable lag or acceleration (hysteresis) in reforming to its normal state (Ward, 2002).

The SA201<sup>®</sup> System (Sigma Instruments; Cranberry PA, USA) is an instrument commercially used for spinal analysis and treatment (see Fig. 1a and b). It incorporates technology that reports a unit-less “Durometer” to quantify “hardness”, or in this case, changes in human cervical tissue occurring in response to a consistent deforming force. This system can analyze selected regions of the spine for comparison to adjacent tissues as well as pre and post treatment changes using computer graphics that measure particular aspects of tissue texture characteristics in Durometers (Rustler and Tilscher, 2009).

There are four components used to calculate a Durometer: *motoricity*, *mobility*, *frequency*, and *fixation*. *Motoricity* (area under the curve) represents overall dysfunction of a segment. *Mobility* (time to peak/total time) corresponds to the range of motion for a segment. *Frequency* (length of the curve) is the time it takes to meet either a restrictive or physiologic barrier. Finally *fixation*, (peak of the curve) indicates the resistance within the tissues. These four characteristics were analyzed to document the change in cervical hysteresis after OMT (see Fig. 2).

## Hypothesis

Immediately adjacent paraspinal cervical tissues will show a quantifiable change in *fixation*, *frequency*, *mobility*, and *motoricity* after each OMT technique with no objective changes following Sham treatment.

## Materials & methods

A total of 240 subjects were recruited and consented according to the protocol approved by the Institutional Review Board of the Philadelphia College of Osteopathic Medicine. Subjects were treated with a pre-determined

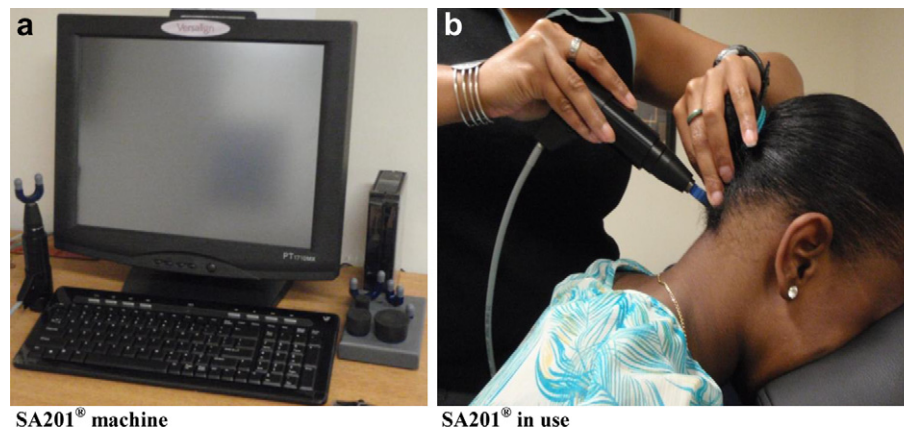


Figure 1 a SA201® machine. b SA201® in use.

OMT technique to the single cervical segment considered (by palpation) to have the most significant somatic dysfunction.

The four different pre-determined OMT techniques chosen represented commonly employed clinical manipulative techniques; Muscle Energy (ME), Counterstrain (CS), Balanced Ligamentous Tension (BLT), and High-Velocity Low-Amplitude (HVLA). The fifth intervention was a Sham procedure consisting of touching the mastoid processes bilaterally with two fingers while thinking through two verses of the "Happy Birthday" song. The palpating osteopathic physicians were instructed to pay careful attention to avoid accidentally engaging the soft tissues or any inherent body rhythm, which could potentially treat the subject and impact their Sham status.

The first 200 subjects were randomized prior to palpation into each of the five intervention groups: 40 HVLA, 40 BLT, 40 ME, 40 CS, and 40 Sham OMT groups. Subjects were then objectively measured using the SA201® durometer instrument before palpatory diagnosis for somatic dysfunction. The last 40 subjects were equally and randomly divided to receive either HVLA or ME interventions with the principal

investigator (MLK) wearing pressure sensitive sensors on his fingers.

In this study, the SA201® was used to analyze portions of the cervical hysteresis curves before and after OMT. A reproducibly constant force was induced by the SA201® sensor head which creates this precise impulse against the tissue after the introduction of 4 lbs (1.82 kg) of compression. This amount of pressure best approximated the finger forces verified by the principal investigator during palpatory diagnosis and treatment (Jean et al., 2007). Each very rapid gentle mechanical impulse and its subsequent tissue responses were recorded in conjunction with the same piezoelectric force sensor.

At the onset of the protocol each subject was placed in a standard massage chair in the modified kneeling position with their head positioned in a head rest locked roughly at a 60° angle and their arms placed comfortably on the arm rests in front of them. The durometer probe was applied at precise angles to the paraspinal muscles at each cervical level obtaining data from the occipitoatlantal region to the level of C7 (see Fig. 1b, The SA201® in use).

The study used a single SA201® technician (an osteopathic physician-in-training who trained in Austria with an experienced, published clinical researcher in this field and who practiced over 300 exams for consistency prior to the study; i.e. being able to produce two similar hysteresis curves using the SA201® on each individual in multiple settings).

Each subject blindly chose a number from an envelope which correlated with one of the five interventions. The palpator (a resident-level osteopathic physician or senior osteopathic physician, each with additional specialty-level manual medicine training) then implemented the chosen technique after examining the entire cervical spine and documenting a specific descriptive diagnosis on the basis of its STAR characteristics before treatment. After the intervention, the same individual reexamined the site and denoted if it was "resolved, improved, unchanged, or worse".

The subject returned in approximately 10 min (after filling out a post treatment evaluation form) for reexamination with the SA201® by the same technician who remained blinded to the site treated and the intervention used. Pre- and post- intervention SA201® data was collected, and hard-copy printouts were also created for each of the 240 subjects (for cervical SA201® chart examples see Fig. 3a

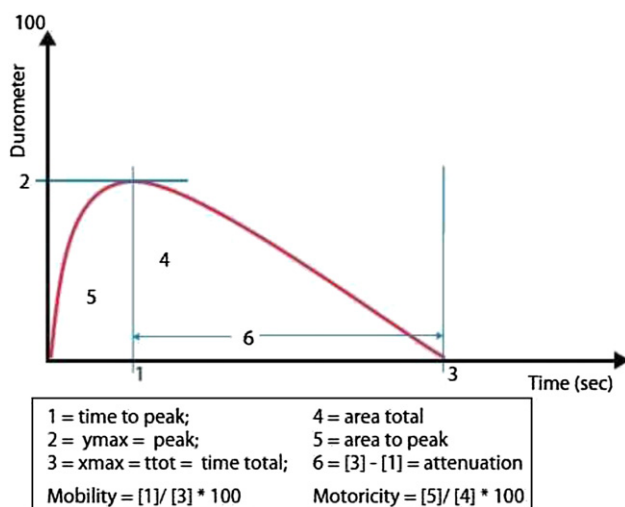


Figure 2 Portion of a hysteresis graph used to calculate a Durometer by the SA201® durometer equipment (courtesy of Thomas Rustler, MD; Vienna, Austria).

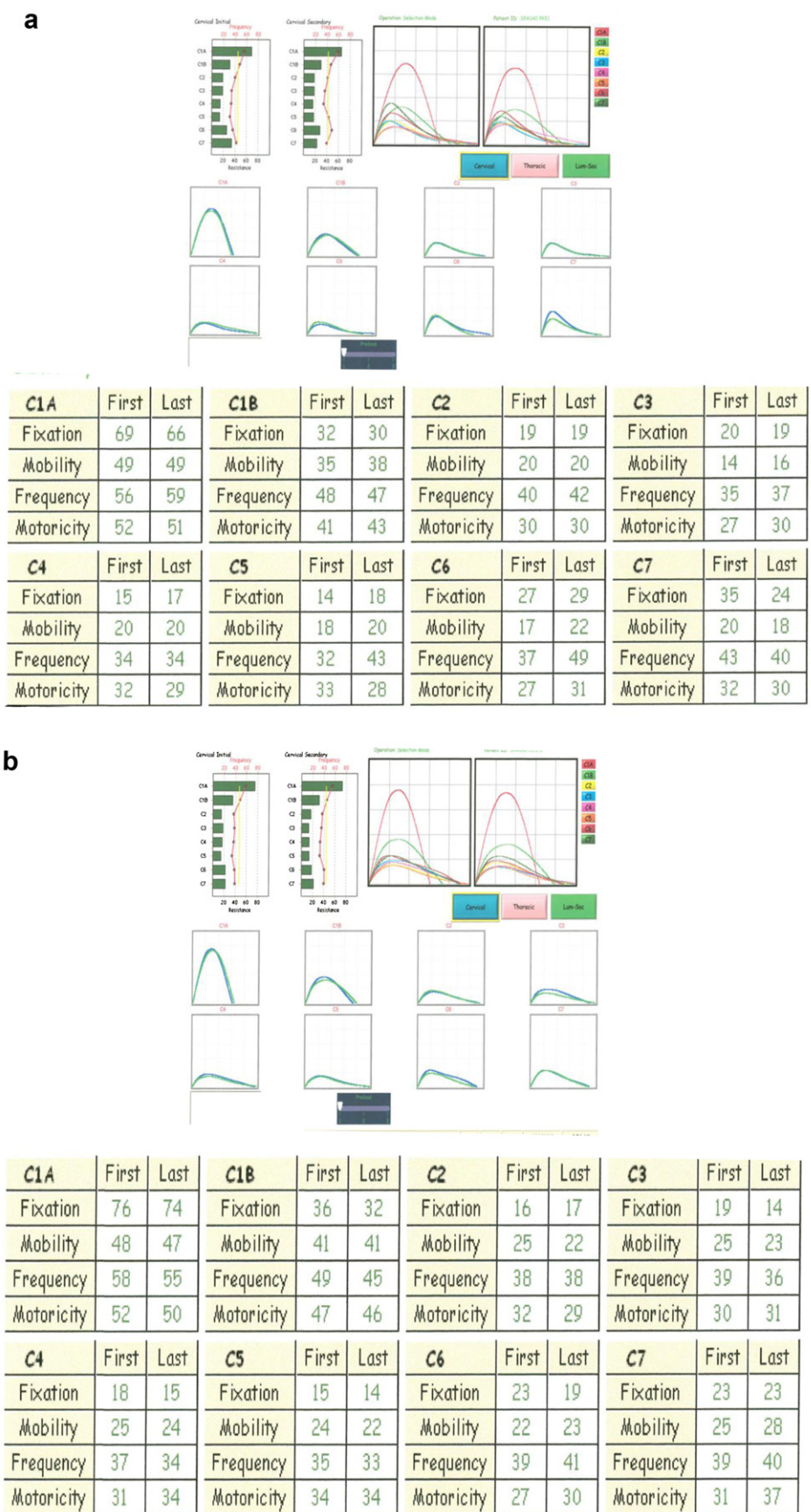
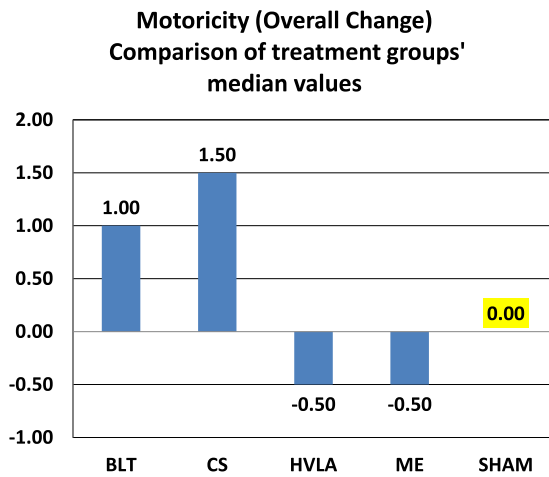


Figure 3 a SA201<sup>®</sup> graphical and objective pretreatment readings. b SA20<sup>®</sup>1 graphical and objective post treatment readings of same subject.

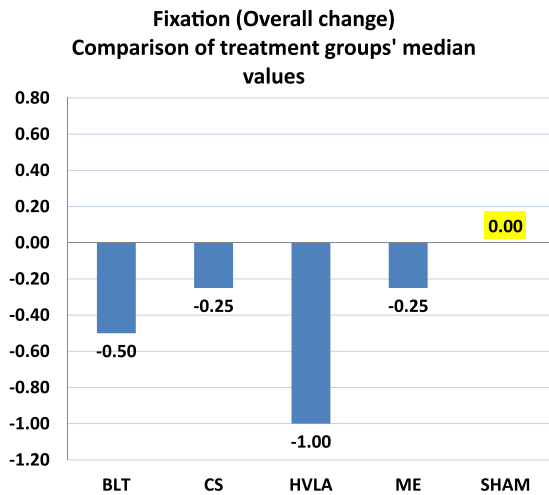


**Figure 4** Change in segmental paraspinal median motoricity measure from baseline after each type of OMT technique and a Sham intervention.

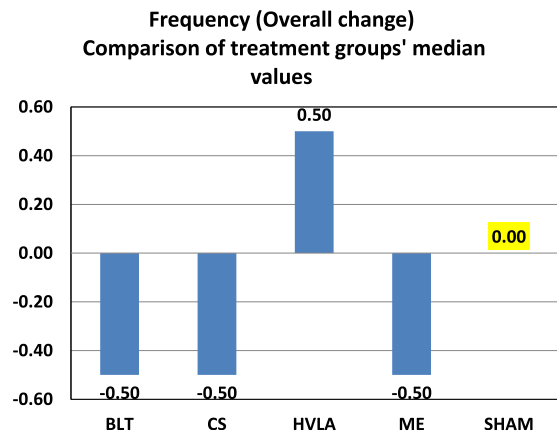
and b). To decrease potential operator error, two pre- and two post-measurements were performed consecutively on each subject. Then both pre-values were averaged together to constitute the recorded pre-OMT measurement for each subject; this method was also used in recording post-OMT measurement values. (Although, scientifically three measurements would have been ideally taken and averaged, the SA201<sup>®</sup> software at this time is preset to obtain only two measurements. This is why it was considered particularly important for the SA201<sup>®</sup> operator to become as proficient as possible before beginning the study and to demonstrate an exemplary degree of intra-examiner consistency).

**Results**

When comparing the median values of each Durometer component, a change from baseline regardless of



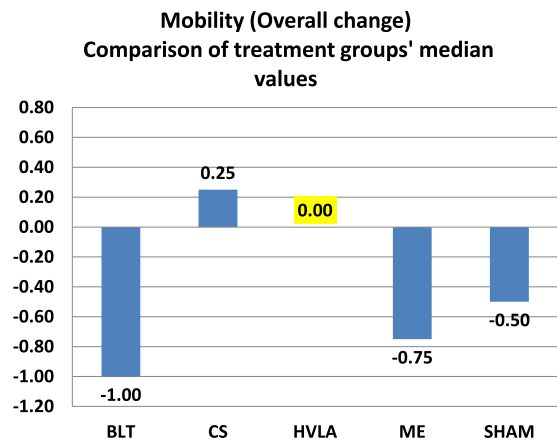
**Figure 5** Change in segmental paraspinal median fixation measure from baseline after each type of OMT technique and a Sham intervention.



**Figure 6** Change in segmental paraspinal median frequency measure from baseline after each type of OMT technique and a Sham intervention.

treatment was displayed in motoricity, fixation, and frequency. This was true except for the Sham intervention which showed no change from baseline (see Figs. 4–7) Mobility also showed a change from baseline post OMT with ME, CS, and BLT interventions; however, there was a slight change in the Sham cohort and no Mobility change in HVLA (see Fig. 7).

The Analysis of Variance test (ANOVA) was used to notate the difference between the means of two or more of the treatment groups simultaneously. When using the ANOVA test to analyze the four Durometer components each one had statistically significant and suggestive values at various levels. However, the Motoricity component displayed the most individual levels of statistical significance followed by frequency, fixation, and then mobility. Evaluating each treatment group, it seemed that CS appeared to display the most significant changes post OMT with a *p*-value of 0.04 in motoricity and a suggestive trend for CS in mobility with a *p*-value of 0.12.



**Figure 7** Change in segmental median mobility measure from baseline after each type of OMT technique and a Sham intervention.

## Conclusion

This study confirmed that using a durometer (in this case, the SA201<sup>®</sup>) to objectively measure tissue texture responses to mechanical deformation provides objective data capable of denoting change to manual treatment. The treatment modality that yielded the most segmental tissue response in this nonhomogeneous and largely asymptomatic population was counterstrain. When comparing treated to untreated cervical somatic dysfunction, an appreciable objective change is noted in some aspect of each of the four SA201<sup>®</sup> Durometer components post OMT. There are no overwhelming changes in such findings associated with Sham, and only slight changes in mobility. Overall, it is evident that not only does a subjective change in the myofascial structures occur post-OMT, but a quantifiable objective change transpires as well.

## Discussion

Each of the four components of the Durometer measures its own unique characteristic of hysteresis. Numerous suggestive trends were appreciated and could best be further investigated by increasing the number of subjects in each treatment group or perhaps by selecting a more homogenous population (possibly with a given symptomatic complaint or specific type/location of somatic dysfunction). It is apparent that treating one segment can produce a change; however, the study design did not fully test the manner in which OMT techniques are typically used in constructing a cohesive, integrated OMM treatment in a clinical situation. It could also be argued that the randomization of technique type might lead to use of an activating force less suited to making a change than one chosen for the type or site of the dysfunction. Furthermore, in this study design, it became apparent that in many instances, treating a single identified key dysfunction sometimes modified other underlying or adjacent somatic dysfunctions.

We will be exploring further the effects that each treatment technique has on each cervical segmental level as the data seemed to suggest that different cervical levels responded better to specific treatments. Classification of the dysfunctions as "acute" (ostensibly containing more fluid in the tissues) or "chronic" (ostensibly stiffer tissues)

might also lead to sub analysis and better interpretation of the direction of the measured Durometer changes.

## Acknowledgments

The researchers wish to thank John Crunick and Sigma Instruments for the donation of the SA201<sup>®</sup> equipment needed for objectively documenting change in tissue response, Bruce Stouch, PhD for his statistical analysis with the data, and to Thomas Rustler, MD (Vienna) for patience, guidance and training that resulted in those skills with the equipment needed for consistent application and measurement (Rustler and Tilscher, 2009).

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