Gross and Histological Features of a Myofascial Trigger Point in the Upper Trapezius

Kathryn E. Levee

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GROSS AND HISTOLOGICAL FEATURES
OF A MYOFASCIAL TRIGGER POINT
IN THE UPPER TRAPEZIUS

A Dissertation
Presented to
the Faculty of the Department of Anatomy and Cell Biology
James H. Quillen College of Medicine
East Tennessee State University

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy in Biomedical Science

by
Kathryn E. LeVee
December 1996
APPROVAL

This is to certify that the Graduate Committee of
Kathryn E. LeVee
met on the
7th day of November, 1996

The committee read and examined her dissertation, supervised her
defense of it in an oral examination, and decided to recommend that her
study be submitted to the Graduate Council, in partial fulfillment of the
requirements for the degree of Doctor of Philosophy in Biomedical Science.

Chair, Graduate Committee

Signed on behalf of
the Graduate Council

Interim Dean, School of Graduate Studies
ABSTRACT
GROSS AND HISTOLOGICAL FEATURES
OF A MYOFASCIAL TRIGGER POINT
IN THE UPPER TRAPEZIUS
by
Kathryn E. LeVee

The purpose of this study was to precisely locate, in living humans, a myofascial trigger point associated with the upper portion of the trapezius muscle (TrP1) that refers pain to the head and neck and to determine if this point is associated with anatomical structures.

This study is descriptive and utilizes data from measurements of the location of TrP1 in relation to anatomical landmarks, of pressure sensitivity overlying the trigger point and electromyography recordings in localizing the trigger point. Information obtained from living humans was used to determine anatomical correlation to structures in cadavers.

Results indicated there is little variability in the location of TrP1 among individuals or from one extremity to the other, and this point may be associated with structures of the skin. A neurovascular supply (NAV) emerging from the upper trapezius to the skin was located in cadavers resembling the location of TrP1 in living humans. This NAV contained only small diameter nociceptive nerve fibers.

Conclusion from the study show that TrP1 in living humans can be precisely located and that the mechanism of pain referral may involve structures of the skin. Future studies to precisely locate other myofascial trigger points may aid in identifying mechanisms of trigger point activation as well as aid clinicians in more precisely locating trigger points for treatment.
INSTITUTIONAL REVIEW BOARD APPROVAL

This is to certify that the following study has been filed and approved by the Institutional Review Board of East Tennessee State University.

Title of Grant or Project Identification of a Myofascial Trigger Point in the Upper Trapezius Muscle

Principal Investigator Kathryn E. LeVee

Department Anatomy and Cell Biology

Date Submitted August 1994

Institutional Review Board, Chair [Signature]
ACKNOWLEDGEMENTS

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CHAPTER 1
INTRODUCTION

Pain is a major problem in the American workplace with the cost not only in billions of dollars, but in the quality of life. A 1995 study by Harris and others indicated that two-thirds of full-time workers (80 million people) reported having conditions that cause pain. The most common types of pain reported included headache (40 million) and neck pain (20 million).

The International Association for the Study of Pain (1979) defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage". It is a subjective and personal experience influenced by behavioral, psychosocial and physical factors (Pope and others 1980; Vasseljen and others 1995).

Pain Modalities

There are two different types of pain, fast pain and slow pain. Nerve fibers conducting impulses to the central nervous system, which are interpreted as pain, are neurons with C and A-delta (δ) axons whose diameters range from 0.2 to 1.5 μm and 1.0 to 5.0 μm respectively. Both types of fibers terminate as free nerve endings and are the most widely distributed receptors in the body (Carpenter and Sutin 1983). The Aδ axons are nociceptors that transmit the "first pain" (fast pain) at 6-30 m/s, producing a well-localized sensation of sharp pain. This fast pain lasts only as long as the acute stimulus (Guyton and Hall 1996). These are small myelinated fibers that transmit electrical impulses arising from mechanical or thermal stimuli. The response of the individual is a rapid withdrawal from the source of the stimulus. The C axons are unmyelinated, polymodal nociceptors carrying the sensation of "second pain" (slow pain) with velocities of between 0.5 and 2 m/sec. Second pain is more diffuse and conveys a more persistent
burning sensation that lasts beyond the termination of the acute stimulus. The slower conducting C fibers receive mechanical, thermal and chemical stimuli and represent the aching or deep pain sensation (Kandel and others 1991; Guyton and Hall 1996). Chemical stimuli activating nociceptors might include substances present as a result of an inflammatory process such as bradykinin, histamine, potassium, serotonin and others (Kandel and others 1991).

Both Aδ and C nerve fibers have their cell bodies in the dorsal root ganglia and have nerve receptors (nociceptors) located in the skin as well as deep structures. These receptors consist of free nerve endings. Both types of receptors are activated in response to nociceptive stimuli which occur at, or close to, the intensity to cause tissue damage. Upon reaching the spinal cord, these fibers bifurcate sending ascending and descending branches one to three spinal segments before entering the deeper dorsal horn; however, these two fiber types have divergent pathways once they reach the dorsal spinal cord.

The Aδ fibers terminate primarily in laminae I and V of the dorsal horn where they excite second-order neurons. The majority of the second order axons cross the spinal cord and ascend to terminate primarily in the ventral posterior lateral nucleus and intralaminar and posterior nuclei of the thalamus. Third order axons from these thalamic nuclei then finally terminate in the somatosensory areas of the cortex in a well-defined somatotopic representation. In addition to making synaptic connections with relay neurons, many make synaptic connections with interneurons at the spinal level, some of which are involved in motor reflexes. A neurotransmitter associated with these fibers is glutamate (Kandel and others 1991; Guyton and Hall 1996).

The C fibers, on the other hand, have more complex pathways. These fibers terminate almost entirely in laminae I, II and III of the dorsal horn where they make synaptic connections with the dendrites of interneurons located in deeper layers of the dorsal horn, primarily in lamina V. The majority of these fibers, after crossing to the
contralateral side of the cord, ascend to the brainstem reticular formation. But, some project to the hypothalamus and limbic structures to exert influences on autonomic and reflex responses and motivational systems (Norback 1996). The relatively few fibers of this system that reach the thalamus accounts for the lack of ability to precisely locate these sensory stimuli (Carpenter 1991; Kandel and others 1991; Guyton and Hall 1996).

There are multiple areas and several means of action which may modulate the stimulated nociceptor and thus influence the ultimate perception of pain. This is complex and not fully understood (Bennett 1996; Russell 1996). Suppression or attenuation of nociceptive signals may take place at higher cognitive levels as when an athlete or soldier attenuates or suppresses awareness of normally painful injuries. However, modulation of noxious stimuli may also take place at the spinal level. Modulation at this level is produced by tactile stimulation from larger myelinated touch fibers (Aα) which have conduction velocities of 35 to 120 m/s. One of the first theories explaining this type of modulation was espoused by Melzack and Wall in 1965 and is known as the “gate control theory”. This theory proposes the existence of inhibitory interneurons or “gate cells” which receive input from nociceptive Aδ and C fibers as well as non-nociceptive touch fibers. The nociceptive fibers provide an inhibitory effect on the “gate cell” which may be modified by a stimulatory effect from the non-nociceptive touch fibers. This “gate cell” then projects to neurons in lamina V which, if sufficiently stimulated by the “gate cell”, inhibits nociceptive relays to the thalamus (Melzack and Wall 1965). This theory has since been revised to reflect the advancement of recent research in describing the complexity in the modulation of pain perception, which may occur both centrally or peripherally.

Modulation or stimulation of pain transmission may occur at the periphery from a variety of sources which affect the C nerve fiber, such as inflammatory products, mechanical stimulation and heat (Kandel and others 1991; Carpenter 1991; Guyton and
Hail 1996). Stimulation of a fiber may occur through input of neighboring injured nerve fibers at the level of the cell body within the dorsal root ganglion by means of cross-excitation (Devor and Wall 1990). There is also the possibility of several afferents, including visceral and sympathetic, synapsing on the same interneuron, which is a possible mechanism for referred pain (Kandel and others 1991; Cailliet 1993; Waxman and deGroot 1995; Guyton and Hall 1996; Noback and others 1996).

Modulation of pain may also take place through the influence of descending pathways within the central nervous system. Neurotransmitters involved in pain inhibition include serotonin, the enkephalins, norepinephrine, the endorphins and other neuroactive substances which activate receptors in the brain and dorsal horn of the spinal cord to modulate nociceptive neurons (Yunus 1992; Noback 1996). There may also be interaction between nociceptive and innocuous touch pathways within higher centers of the CNS (Berkley and Hubscher 1995). In addition, there is evidence that the propensity to develop neuropathic pain symptoms may be inherited (Devor and Raber 1990).

Activation of the unmyelinated C fibers may be from firm pressure, heat intense enough to cause pain, and chemicals including histamine (Kenins 1995). Neurotransmitters (or neuromodulators) that have been associated with these fibers and are involved in the hyperexcitability of dorsal horn neurons and in generating and maintaining hyperalgesia include calcitonin gene-related peptide (CGRP) and substance P (SP) (Holzer 1992; Berkley and Hubscher 1995; Galeazza and others 1995; Liu and Sandkuhler 1995). Hyperalgesia is increased sensitivity to normally painful stimuli that can occur in the injured tissue (primary hyperalgesia) and in normal, undamaged tissue outside the area of injury (secondary hyperalgesia) (Lewis 1936). In addition the release of CGRP and SP from sensory nerves results in vasodilatation in a number of vascular beds (Holzer 1992; Galeazza and others 1995; Hill and Gould 1995) and is implicated in neurogenic inflammation of the skin (Tausk and Undem 1995). Thus
activation of C fibers causes release of inflammatory agents which in turn stimulate the C fibers to release CGRP and SP (Kandel and others 1991). This may set up a cycle of facilitated stimulation which can lead to chronic pain. It is stimulation of these C axons which are thought to be responsible for the referred pain phenomenon of myofascial trigger points (Bennett, 1996). The referred aspect of pain is thought to arise from multiple input of sensory and visceral afferents from different locations projecting to the same interneuron resulting in the brain's inability to interpret (localize) the origin of the pain (Kandel and others 1991).

**Sources of Pain**

The skin of the back is highly innervated by free nerve endings (including nociceptors) that extend to the epidermis from small nerve bundles in the upper dermis and that display axon branching and varicosities (Hilliges and others 1995). In addition to nociceptors in the skin, myofascial tissues (fascia overlying muscle) are considered the most common source of pain (Brattberg and others 1989). Myofascial pain is frequently associated with both head and neck pain and a myofascial trigger point can often be identified as a primary source for referred pain to the head and/or neck. A myofascial trigger point is considered a predisposing feature of myofascial pain and is defined as a "... hyperirritable spot, usually within a taut band of skeletal muscle or in the muscle's fascia, that is painful on compression and that can give rise to characteristic referred pain, tenderness, and autonomic phenomena" (Travell and Simons 1983). Autonomic phenomena might include pilomotor activity (goose flesh), or a localized vasoconstriction in the area of referred pain. A trigger point associated with the upper fibers of the trapezius muscle refers pain to the neck and/or head and is the most often observed of all myofascial trigger points in the body (Travell and Simons 1983).
The trapezius muscle which is a large superficial muscle of the neck and back is comprised of the upper, middle, and lower components. The upper portion (upper trapezius) is attached to the occipital bone, ligamentum nuchae and spinous processes of the first seven cervical vertebrae medially and the distal clavicle and acromion process of the scapula laterally. Contraction of these fibers elevates the scapula and extends, laterally flexes and contralaterally rotates the head and neck. The middle fibers of the trapezius attach to the upper thoracic spinous processes of the vertebra medially and the spine of the scapula laterally. Contraction of these fibers adduct the scapula (Williams and others 1989; Kendall and others 1993; Smith and others 1996). Although the nerve and blood supply to skeletal muscles of the upper back and neck is well documented, cutaneous nerves to this region are not as well defined. The innervation of the trapezius muscle is provided by cranial nerve XI (spinal accessory) which lies deep to the muscle throughout its course. Fibers from ventral rami of the third and fourth spinal segments are sensory (proprioceptive) to the muscle. The cutaneous nerve supply to the skin over the medial portion of the upper trapezius is from dorsal rami of cervical nerves 3, 4, 5 and over the lateral portion from supraclavicular nerves (ventral rami C3, 4); however, the innervation to the middle portion of the skin overlying the upper fibers of the trapezius is not well defined (Williams and others 1989).

The upper fibers of the trapezius muscle due to its action as an antigravity muscle has a constant demand placed on it in providing support for the upper extremity in sitting or standing postures. Although there is a constant tension on the muscle to maintain the scapula in position, there is little electromyographic activity at rest (Williams and others 1989; Smith and others 1996). Maintaining the arms in front of the body without support, as in computer work, requires isometric contraction of the trapezius muscle which makes it prone to develop trigger points (Rachlin 1994). Isometric contraction may increase the compressive forces on structures such as nerves and blood vessels that course through
the muscle to supply structures of the skin. It has been demonstrated that isometric contraction causes increased release of SP in the dorsal horn of the spinal cord (Wilson and others 1993).

Myofascial Pain and Trigger Points (TrPs)

Many different names have been used to describe myofascial pain including myalgia, fibromyalgia, nonarticular rheumatism and others which has led to confusion in defining a clinical diagnosis; however, while there may be some overlap in the description of symptoms of the aforementioned syndromes or diseases, a distinguishing feature of myofascial pain is that it is regional pain associated only with skeletal muscle (Simons, 1975; Simons and Travell, 1983). Greater strides have been made recently in defining and classifying syndromes exhibiting tender points associated with muscular pain. The terms most often used in describing tender points are fibromyalgia and myofascial pain. Specific criteria for classifying fibromyalgia was established by the American College of Rheumatology in 1990 and agreed upon (Consensus Document on Fibromyalgia: The Copenhagen Declaration, 1992) at the 2nd World Congress on Myofascial Pain and Fibromyalgia which set the parameters for making a clinical diagnosis of fibromyalgia. The criteria includes the following: widespread pain in both sides of the body above and below the waist, axial skeletal pain and 11 of 18 specified tender points producing pain with digital palpation (Wolfe and others 1990). Although there is to date no diagnostic laboratory or radiographic findings associated with myofascial pain, recent findings indicate significantly elevated levels of substance P in cerebrospinal fluid (CSF) of fibromyalgia patients (Russell and others 1994; Vaeroy and others 1988). Histological examination of muscles underlying TrPs or tender points have been inconclusive (Fassbender 1975; Kalyan-Raman and others 1984; Bengtsson and others 1986; Larsson and others 1988; Yunus and others 1989). Not unlike fibromyalgia, symptoms of
myofascial pain also include tender points; however, in myofascial pain syndromes these points are regional, usually unilateral, are associated with skeletal muscle and include trigger points (points which when palpated produce referred pain). Pain from a myofascial trigger point may result from a sudden onset following acute strain or overload of the affected muscle with either isotonic or isometric muscle activity, or from a gradual onset from chronic overload of the muscle such as poor posture or repetitive work (Fricton and Kroening 1982; Simons and Travell 1983; Rachlin 1994). These trigger points are extremely common in the adult population and when untreated, can lead to the production of additional trigger points, chronic pain, time lost from work, and a diminished quality of life (Rasmussen and others 1991). Many of the tender points described for fibromyalgia are also trigger points in myofascial pain syndromes. These include the trapezius, supraspinatus, and cervical muscles. Fibromyalgia and myofascial pain may coexist or one may lead to the other often making a clinical diagnosis difficult (Travell and Simons, 1983). In addition tender points and trigger points have been found together in both myofascial pain syndrome and fibromyalgia syndrome subjects (Bengtsson and others 1986; Durette and others 1991; Wolfe and others 1992) and it has been demonstrated that a large percentage (>50%) of normal healthy subjects report signs of referred pain from tender points in muscle (Sola and others 1955; Sola and Williams 1956; Scudds and others 1995). However, based on clinical findings, Simons proposed major and minor criteria for the diagnosis of myofascial pain. Major criteria include regional pain complaint or altered sensation in an expected distribution of referred pain from a myofascial trigger point (TrP), taut band palpable in an accessible muscle, exquisite spot tenderness at one point along the length of the taut band, and some degree of restricted range of motion, when measurable. Minor criteria include reproduction of clinical pain complaint, or altered sensation, by pressure on the tender spot, local twitch response by transverse snapping palpation of, or needle insertion into the tender spot in...
the taut band, and pain alleviated by stretching the muscle or by injecting the TrP (Simons 1990). However, the palpable taut band or nodule associated with trigger points has also been identified in muscle or in tissue overlying muscle which has no TrP (Njoo and others 1994).

A myofascial TrP may be classified as active or latent. Active TrPs cause pain either at rest or in relation to muscular activity and have a pattern of referred pain, while latent TrPs cause pain only with palpation and may not elicit referred pain (Simons 1975; Simons and Travell 1983). However, latent TrPs can be induced to become active following vigorous contraction or stretching of the involved muscle (Simons 1975). The local or referred pain pattern elicited by palpating the trigger point is consistent and characteristic of the muscles involved (Travell and Rinzler 1952; Bonica 1957; Kraus 1970; Simons and Travell 1983), and the patterns of referred pain do not correspond to myotomal or dermatomal patterns (Travell and Simons 1983; Rachlin 1994). Latent trigger points afflict nearly half the population by early adulthood (Sola and Kuitert, 1955), and the most common muscles in which latent trigger points are found are in the trapezius and the levator scapulae (Sola and Kuitert 1955; Sola and others 1955). Other clinical findings associated with the trigger point include a localized inflammation at the trigger point site as well as at sites of referred pain (Travell and Simons 1983).

For one particular TrP of the upper trapezius (TrP1), pain is referred unilaterally from the upper trapezius superiorly along the posterolateral aspect of the neck to the mastoid process, and is a major source of tension neckache or headache (Winter 1944; Long 1956; Jensen and others 1993; Sandrini and others 1994; Sakai and others 1995). The referred pain may extend to the side of the head, back of the orbit, the angle of the jaw, and the occiput (Travell and Rinzler 1952; Travell and Simons 1983). Sensory innervation to these areas of referred pain include spinal nerves from cervical vertebrae 2-4 and the trigeminal nerve which has convergence of upper cervical (C1-C3) afferents (Kerr
and Olafson 1961; Kerr 1972; Abrahams and others 1979; Sessle and others 1986; Marfurt and Rajchert 1991).

Although research indicates an association between myofascial trigger points and muscular involvement, the mechanisms of activating the TrP or the mechanisms of referred pain have not yet been determined. Myofascial trigger points have been identified using digital palpation, pressure algometry, and electromyography. Pressure algometry has been shown to be a reliable measure for detection of tender points with significant inter-tester and intra-tester reliability (Merskey and Spear 1964; Reeves and others 1986; Fischer 1987; Airaksinen and Pontinen 1989; Scudds and others 1989; Smythe and others 1991; Delaney and McKee 1993; Tunks and others 1995).

Successful treatment of the trigger points often relieves the symptoms of referred pain including palpable tenderness and edema. Treatment of these trigger points includes prolonged digital pressure over the trigger point and insertion of a needle into the skin (acupuncture) or the fascia overlying the trigger point or into the superficial muscle fibers. In addition injecting the skin, fascia, or muscle with saline or local anesthetic has also been effective in reducing pain (Travell and Simons 1983; Wreje and Brorsson 1995). Other treatment might include heat, cold, or electrical stimulation to the area of the trigger point. Prolonged relief of symptoms usually requires a program of muscle stretching and strengthening when indicated (Travell and Simons 1983; Rachlin 1994).

**Preliminary Findings**

Preliminary data on four volunteers with symptoms of referred pain from TrP1 of the upper trapezius indicated there is no difference in the location of this point among individuals or from right to left extremities of the body. In addition, referred pain could be elicited by pinching the skin over the TrP as well as by applying digital pressure. Anatomical landmarks used to identify the location of this point in living subjects was
used to approximate the location in cadavers. The results indicated that the point corresponding to the TrP was located in the inferior fibers of the upper trapezius directly over a site at which nerves and blood vessels emerge on their way to and from superficial structures of the skin.

Based on these preliminary findings, the following hypotheses were made: (1) TrP1 associated with the upper trapezius can be located precisely in living humans. (2) There is little variability among individuals in the location of TrP1. (3) TrP1 is likely to be in tissues which overlie the muscle rather than within the muscle itself. (4) In cadavers, TrP1 lies directly over a site at which nerves and blood vessels emerge from deep structures.
CHAPTER 2

METHODS AND MATERIALS

Methods for Clinical Study

Two physical therapists from a physical therapy outpatient clinic and two physical therapy faculty from the Department of Physical Therapy, East Tennessee State University (ETSU) participated in performing the evaluations and measurements. A patient's designated therapist or the designated evaluator in the case of ETSU faculty was identified as the neutral rater. This individual performed the initial evaluation and measurements for each of two visits. A designated second therapist acted as the second rater for the measurements made during each of the visits. Patients who exhibited symptoms of a myofascial trigger point (TrP1) in the upper trapezius muscle (with referred pain patterns in any of the appropriate areas associated with TrP1 when digital pressure was applied over the trigger point) were included in the study. All recorded data were blinded for between patient (volunteer) visits and between examiners.

Subjects

Of 20 subjects who volunteered for the study, 17 volunteers met the criteria for inclusion in the study. Subjects (2 males and 15 females) were selected from the general population of employees and students of East Tennessee State University. Information including age, sex, handedness, symptoms, and other pertinent information was obtained from the volunteers. Examination and testing procedures were explained to the subjects and they read and signed an informed consent form of the Institutional Review Board, East Tennessee State University, before participating in the study.
Examiners (Raters)

One examiner from a physical therapy outpatient clinic in the upper east Tennessee area and two examiners from the physical therapy faculty from ETSU participated in the study. All participating examiners were trained in the examination, evaluation, and measurement procedures by the principal investigator (KEL). Each examiner practiced with volunteer physical therapy staff members or ETSU staff as subjects until they were proficient before performing the procedures on subjects. For all subject evaluations, the examiner performing the initial evaluation and testing was designated the initial rater, and the examiner performing the second testing was designated the second rater.

Procedures

Subjects were interviewed to determine if they met the required criteria for inclusion in the study (appropriate symptoms of referred pain to the head and/or neck), as described above. The testing procedure was explained to subjects, and they read and signed an informed consent form. Personal information including age, sex, handedness, and a brief history of symptoms was obtained on the first day of testing. Subjects were tested at a time when they exhibited appropriate symptoms of referred pain for trigger point 1 (TrP1) of the upper trapezius.

On the date of testing, subjects were placed in a comfortable sitting position in a straight-back chair with their arms at their sides. The skin of the upper back and shoulders was exposed. The spinous process of C7 and the acromion process adjacent to the acromioclavicular joint were identified and marked with a felt tip pen. (These points represent the approximate medial and lateral attachment of the lower fibers of the trapezius muscle.) The subject indicated the side of their head or neck in which they were experiencing symptoms of pain on the symptomatic extremity. The examiner used digital palpation perpendicular to the surface of the skin (Fig. 1) over the approximate location...
Figure 1. A: TrP1 of the upper trapezius was located by digital palpation perpendicular to the skin. B: The skin overlying the identified TrP1 was pinched to determine if there was referred pain.
of TrPl of the upper trapezius to locate a point at which the jump sign was elicited, and
with continued pressure (5-20 sec) over the site, the subject complained of referred pain
which coincided with the appropriate pattern of pain referral for TrPl of the upper
trapezius. This point was marked with a felt tip pen. Subjects were asked to point to the
area of referred pain and the information was recorded. The trigger point was also
palpated for indication of a taut band or nodule and the muscle was plucked for signs of a
local twitch response as described in Myofascial Pain and Dysfunction: The Trigger
Point Manual Travell and Simons 1983). The examiner then pinched (using the thumb
and index or middle finger) the skin and subcutaneous connective tissue encompassing
the marked point overlying TrPl(see Fig. 1). The pinching motion was in a direction
parallel to the muscle fibers. Subjects were asked to indicate any area of referred pain
during the pinching of the skin by describing and pointing to the area of referred pain.
The procedure was repeated for the opposite extremity. If the subject was asymptomatic
on one side, it was used as a control.

Pressure sensitivity of the TrP and surrounding tissues was measured with a
commercially available mechanical pressure algometer (Pain Diagnostics and
Thermography Inc., Great Neck, New York). The pressure algometer consists of a
spring loaded pressure gauge that has a 1 cm diameter rubber tipped plunger attached to a
pressure gauge (range 0 to 11 kg/cm²). The plunger was placed in contact with the skin
and pressure was applied manually perpendicular to the surface of the skin (Fig. 2) at the
uniform rate of 1 kg/cm²/sec until the subject gave a verbal report of pain. The procedure
was demonstrated to the subject by applying the pressure gauge to an area on the hand or
forearm. The subject was instructed to give a verbal response when the pressure became
painful at which time the rater immediately stopped applying pressure. The pressure
algometer was placed directly over the point marked as TrPl and pressure was applied as
described above until the subject gave a verbal response of pain at which time the applied
Figure 2. Pressure sensitivity overlying TrP1 was measured with the use of a pressure algometer and recorded in kg/cm². A: Pressure was applied perpendicular to the surface of the skin. B: Pressure was applied in a pinching manner and recorded in kg/cm².
pressure was stopped and the reading on the gauge was recorded. Measurements were taken over the point marked as TrP1 of the upper trapezius and control measurements were taken approximately 1 cm to either side of the TrP (remaining parallel to the muscle fibers) as controls. Like measurements were taken using the tip of the pressure meter plunger and a fingertip to produce a pinching of the skin (see Fig. 2) overlying the marked TrP and, as described above, approximately 1 cm to either side as controls. Measurements were made on the right and left upper extremities of subjects.

The marked point for TrP1 of the upper trapezius was mapped by measuring, with a cloth tape measure, the distance of the trigger point from the spinous process of C7 and the total distance from the spinous process of C7 to the marked point on the acromion process. This provided a medial to lateral positioning for the trigger point within or overlying the muscle and the value of this medial to lateral location was recorded as the trigger point/total distance ratio. The superior to inferior position was determined by measuring the distance of the trigger point from the interface between the upper and middle trapezius. The interface was determined by identifying the superior fibers of the middle trapezius and the inferior fibers of the upper trapezius by means of manual muscle testing and surface electromyography (Pathway MR-20 dual channel surface EMG, The Prometheus Group, Portsmouth, NH). With manual muscle testing, the tester palpated the muscle where TrP1 was marked as the subject elevated and abducted the scapula while extending and rotating their head to the opposite side. (Shoulder abduction was incorporated in the movement to aid in eliminating the action of the middle trapezius.) The procedure was repeated with the tester progressing inferiorly with palpation until a point was reached where the action of the upper trapezius could no longer be palpated. This point was identified as the upper and middle trapezius interface. To verify the identity of the interface, the muscle fibers above and below the interface were palpated as the subject adducted the scapula to identify the contraction of the middle trapezius.
For surface electromyography, a two channel battery-operated portable unit with disposable self-adhesive pads was used. The skin was prepared by swabbing with an alcohol pad and wiped dry. Positioning of the subject was as described for manual muscle testing. Each disposable electrode containing two active and one ground (reference) terminal was placed parallel to the muscle fibers. Channel A electrode was secured directly over the point marked as TrP1. Channel B was secured one centimeter inferior to A (Fig. 3). The unit was turned on and the mode was set for WORK/REST. The subject was asked to sit with his/her shoulders and upper extremities completely relaxed. The subject was asked to perform the same motions as performed when doing the manual muscle testing procedure. The following three second recordings were made and stored on channels A and B for future retrieval: 1. no muscle activity (subject sat with the upper extremities relaxed), 2. contraction of the upper trapezius, 3. contraction of the middle trapezius in adduction of the scapula. Muscle activity was displayed in a bar graph. Digital readings in microvolts ($\mu V$) of the average three second muscle activity was stored in the portable EMG unit for later retrieval.

Marks made with the felt tip pen on the skin were removed with alcohol and a second rater repeated the procedures. A follow-up of the testing procedures was made by the first and second raters when the subject experienced a repeat of the symptoms.

**Statistical Analysis**

Pearson product moment was used to determine inter-rater and intra-rater reliability. A linear regression was utilized to determine the relationship of the distance of the spinous process of C7 to trigger point to the distance of the spinous process of C7 to the acromion process of the scapula in determining the location of TrP1 of the upper trapezius. All other analyses were descriptive and presented as means and standard deviations. Student's $t$-test was used for statistical comparison of data sets.
Figure 3. A two channel surface EMG was used to record muscle activity of the muscles associated with TrP1. Channel A electrode (a) was placed over the marked TrP. Channel B (b) electrode was placed one centimeter inferior to channel A electrode.
**Methods for Cadaver Study**

The data on the positions of the trigger point 1 of the upper trapezius in living subjects were used to find corresponding points in cadavers. Forty-four cadavers ranging in age at death from 46 to 103 (21 females and 24 males) were selected from available cadavers in the Department of Anatomy and Cell Biology, James H. Quillen College of Medicine, East Tennessee State University, Johnson City, TN. Skin (epidermis, dermis, and hypodermis) overlying the upper and middle trapezius muscles was grossly dissected to reveal the deep fascia, cutaneous nerves, and vasculature overlying the musculature. Landmarks (spinous process of C7 and the acromion process adjacent to the acromio-clavicular joint) utilized in the clinical study as well as the muscles of the upper and middle components of the trapezius muscle were identified on cadavers. An area of tissue in the upper trapezius at approximately midway between the spinous process of C7 and the acromion process and within 1 to 2 cm of the interface between upper and middle trapezius was examined for distinguishing features. It was noted a point of emergence for nerves and vessels supplying the overlying tissues of the skin was located in close proximity to this area.

Using the aforementioned landmarks as points of reference, a tape measure was used to determine the distance from the spinous process of C7 to the acromion process, and the distance from the spinous process of C7 to the point of emergence of the neurovascular (NAV) supply. The value of this medial to lateral location was recorded as a proportion of the C7 to neurovascular supply distance to the total distance from C7 to the acromion process. A measurement of the distance of the neurovascular supply from the interface between upper and middle trapezius was recorded. This provided the value for the superior to inferior location of the NAV. In (33) cadavers both right and left trapezius muscles were examined. In (11) cadavers only the right trapezius was examined.
In addition, in several cadavers, a scalpel was used to extract a sample of tissue approximately 2 cm wide (superior to inferior) and 4 cm long (paralleling the muscle fibers medial to lateral) that included the epidermis, dermis, hypodermis, and superficial muscle layer. This tissue was removed from the approximate area of the aforementioned neurovascular structures emanating from the upper trapezius prior to measurements determining positioning of the NAV within the upper trapezius. After removal of the tissue samples, gross dissection was used to expose the underlying structures as described above to determine the location of the neurovascular supply in relation to its position within the upper trapezius. The tissue was divided in three 1 cm$^2$ sections for processing. The center section contained tissue including the primary neurovascular supply. The other two sections contained tissue to either side of this supply to be used as controls. Tissue was post-fixed in 10% formalin or Buoiins, cleared with cedar wood oil, dehydrated, embedded in paraffin, and sectioned serially at 10$\mu$m with a rotary microtome. The sections were mounted on glass slides and stained with hematoxylin and eosin for demonstration of blood vessels, or with the Holmes procedure (Armed Forces Institute of Pathology 1968) for the demonstration of nerve fibers.

All sections were examined microscopically. In sections containing neurovascular elements, the nerve fascicles were identified, and their locations within the tissue and in relationship to each other were noted and recorded. The fascicles were identified as intramuscular (between muscle fibers with little surrounding connective tissue) or interstitial (surrounded by connective tissue). Interstitial fascicles were not intimately associated with skeletal muscle. The diameters of the nerve fascicles and of the nerve fibers within the fascicles were measured with a microprocessor-based image analysis system (Optimas) and recorded. Fibers with diameters of less than 1.0 $\mu$m were considered to be C fibers. Those with diameters of greater than 1.5 $\mu$m but less than 5 $\mu$m were considered to be A$\beta$. Fibers with diameters of 1.0 $\mu$m to 1.5 $\mu$m were designated...
Aδ or C fibers. Measurements were made of adjacent red blood cell diameters as a marker for comparison of diameters and as an indicator of general tissue shrinkage. Nerve fibers were measured at 400X magnification and measurements of fascicles or distances between fascicles were made at between 40X and 400X magnification.

In 5 cadavers, the cutaneous nerves within the identified neurovascular supply were grossly dissected retrogradely from the point of emergence through the muscle to their point of emergence from nerves emanating from the spinal cord. In addition, the relationship of this neurovascular supply to the spinal accessory nerve (innervation to the trapezius muscle) was noted and recorded.

**Statistical Analyses**

A linear regression was used to determine the relationship of the distance of the spinous process of C7 to NAV to the distance of the spinous process of C7 to the acromion process of the scapula in determining the location of the NAV of the upper trapezius. All other analyses were descriptive and presented as means and standard deviations. Student's t-test was used for statistical comparison of data sets.
CHAPTER 3
RESULTS

Clinical Results

Subjects

The 17 volunteers who participated in the study included 15 females and 2 males with ages ranging from 20 to 58 (41 ± 10.3; mean ± SD). Fourteen of the subjects had a primary complaint of head or neck pain (Table 1) on the first day of testing and 3 had pain the day prior to the first testing. Four subjects did not return for the retest. One subject presented with a 12 year history of loss of motor function of the right sternocleidomastoid muscle and all of the trapezius muscle with the exception of a few fibers in the most superior aspect of the muscle. Functional loss was of unknown etiology. Primary complaint of pain as well as referred pain with digital and pinch pressures in this subject were reported for the right extremity.

Identification of Trigger Point 1 (TrP1) of the Upper Trapezius

Using digital palpation to identify the TrP1 of the upper trapezius, all subjects exhibited a jump sign or verbal response to pain when the trigger point was located. All subjects reported referred pain with prolonged (5-20 sec) digital pressure applied to the TrP, and most subjects reported referred pain to the posterior neck. However, there was some variation in the areas of referred pain among individuals and from one extremity to the other (see Table 1). Other findings included a palpable nodule or taut band in the underlying tissues of the TrP in subjects who had referred pain. A local twitch response in the upper trapezius could be identified in only 8 subjects.

With prolonged pinching (5-20 sec) of the skin in the identified TrP, only one subject reported no referral of pain; however, this subject had minimal primary
complaint of neck pain, and prolonged digital palpation produced referred pain only to the posterior neck. All other subjects who reported referred pain with prolonged digital pressure also reported referred pain with pinching of the skin, but not all areas of referred pain revealed by pinch corresponded directly to areas described for the digital method or to areas of primary pain complaint (see Table 1).

TABLE 1
AREAS OF REFERRED PAIN

<table>
<thead>
<tr>
<th></th>
<th>Posterior Neck</th>
<th>Mastoid Process</th>
<th>Occiput</th>
<th>Temple or Orbit</th>
<th>Jaw Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary complaint</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Bilateral</td>
<td>8</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>1</td>
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<tr>
<td>Left</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Right</td>
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<tr>
<td>Digital pressure</td>
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</tr>
<tr>
<td>Bilateral</td>
<td>8</td>
<td>5</td>
<td>3</td>
<td>1</td>
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</tr>
<tr>
<td>Left</td>
<td>0</td>
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<td>1</td>
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<tr>
<td>Right</td>
<td>3</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>1</td>
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<tr>
<td>Skin pinch</td>
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<tr>
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<td>4</td>
<td>4</td>
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<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

Subjects (n=17) reporting areas of pain prior to testing as primary complaint, referred pain in response to prolonged digital pressure over TrP1, or referred pain in response to prolonged pinching of the skin encompassing TrP1.

The location of TrP1 of the upper trapezius was recorded as a ratio of the distance from the spinous process of C7 to TrP1/spinous process of C7 to the acromion process of the scapula. There was significant inter-rater reliability with both the first (r= 0.706, p< 0.05) and repeat (r= 0.552, p< 0.05) measurements identifying TrP1 of the upper trapezius. There was significant intra-rater reliability for rater 1 (r= 0.615, p< 0.05); however, intra-rater reliability for rater 2 did not reach significance (r= 0.467, p> 0.05) (Fig. 4). The point identified as TrP1 of the upper trapezius was
0.45 ± 0.04 (mean ± SD) of the distance from the spinous process of the 7th cervical vertebra (C7) to the acromion process. There was a significant linear relationship ($\alpha \leq 0.05$) between the distance from spinous process of C7 to TrP1 and the total distance of spinous process of C7 to the acromion process (shoulder width) in the left ($r^2 = 0.45$, n=60) and right ($r^2 = 0.53$, n=60) extremities of subjects (Fig. 5).

Figure 4. The location of TrP1 of the upper trapezius was identified in subjects by digital palpation and recorded as a ratio of the spinous process of C7 to TrP1/spinous process of C7 to the acromion process distance. This point was measured at the initial visit (exam 1) by rater 1 and rater 2 with repeat measurements on a second visit (exam 2) by rater 1 and rater 2. Each column and short bar show the mean and SD.
Figure 5. The location of TrP1 of the upper trapezius was determined by the ratio of the distance from the spinous process of C7 to TrP1/spinous process of C7 to acromion process (shoulder width). A significant linear relationship ($\alpha$=0.05) was shown between the distance from C7 to TrP1 and C7 to acromion process. Lines represent regression and 95% confidence intervals. A: shows relationship for the left extremity ($y = 0.554x +(-2.20)$). B: shows relationship for the right extremity ($y = 0.543x +(-1.89)$).
Additionally, there was no significant difference ($p<0.05$) in the location of this point from one extremity to the other in all subjects (Fig. 6). Furthermore, there was no significant difference ($p<0.05$) between subjects with no referred pain in response to digital pressure (controls) and subjects with referred pain with digital pressure (Fig. 7). None of the control subjects complained of referred pain with digital pressure, but they did have point tenderness as exhibited by the jump sign or verbal response to pain.

**Pressure Sensitivity**

Measurements taken with the pressure algometer clearly showed an increase in pressure sensitivity over the TrP1 compared to areas one centimeter to either side of the TrP1 when pressure was applied both perpendicular to the surface of the skin and in pinching the skin (Figs. 8, 9, 10, 11). There was, however, greater sensitivity to pinching of the TrP ($2.7 \text{ kg/cm}^2 \pm 1.1$; mean $\pm$ SD) than to applying pressure perpendicular to the surface of the skin ($3.6 \text{ kg/cm}^2 \pm 1.2$; mean $\pm$ SD).

**TrP1 in Relation to Upper and Middle Trapezius**

When performing isolated muscle contractions of the upper and middle fibers of the trapezius in manual muscle testing procedures, several subjects had difficulty contracting one portion of the muscle (upper fibers) while maintaining relaxation of the other portion (middle fibers). Better discrimination was produced when scapular abduction was performed in conjunction with the test motion for the upper trapezius, and the initial rater was able to distinguish between the two fiber groups when palpating the muscle fibers during isolated muscle contraction. Subjects who had difficulty isolating the individual muscle actions when performing the test for the upper or middle trapezius were given several practice trials before measurements were taken.

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Figure 6. The location of TrP1 was identified in subjects by digital palpation and recorded as a ratio of the spinous process of C7 to TrP1/spinous process of C7 to acromion process distance. Measurements were made on both left and right extremities. Measurements represent means and SD (column and short bar) for the left and right extremities.
Figure 7. Location of TrP1
Subjects who had a palpable tender point but no complaint of referred pain with digital pressure over the point were treated as controls for that extremity. The tender point and TrP1 were identified as a ratio of the spinous process of C7 to TrP1 (tender point)/spinous process of C7 to acromion distance. The columns and short bars show the mean and SD.
Figure 8. Perpendicular Pressure Right Extremity
Pressure was applied perpendicular to the surface of the skin with a pressure algometer at the rate of 1 kg/sec until the subject gave a verbal response to pain at which time pressure was immediately stopped. The applied pressure was recorded as kg/cm². A: pressure sensitivity is shown for the right extremity in each individual when pressure was applied to the left of the TrP (open circle), over the TrP (filled circle) and to the right of the TrP (open triangle). Data is presented in ascending order for pressure readings of TrP. B: same data represented as means and SD (column and short bar) for pressure pain to the left of TrP, over the TrP, and to the right of the TrP.

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Figure 9. Pinch Pressure Right Extremity
Pressure was applied to the skin in a pinching manner using a finger and the pressure algometer at the rate of 1 kg/sec until the subject gave a verbal response to pain at which time pressure was immediately stopped. The pressure was recorded as kg/cm². A: pressure sensitivity is shown for the right extremity in each individual when pressure was applied to the left of the TrP (open circle), encompassing the TrP (filled circle), and to the right of the TrP (open triangle). Data is presented in ascending order for pressure readings over TrP1. B: same data represented as means and SD (column and short bar) for pressure pain to the left of the TrP, over the TrP, and to the right of the TrP.
Figure 10. Perpendicular Pressure Left Extremity
Pressure was applied perpendicular to the surface of the skin with a pressure algometer at the rate of 1kg/sec until the subject gave a verbal response to pain at which time pressure was immediately stopped. The applied pressure was recorded as kg/cm². A: pressure sensitivity is shown for the left extremity in each individual when pressure was applied to the left of the TrP (open circle), over the TrP (filled circle) and to the right of the TrP (open triangle). Data is presented in ascending order for pressure readings over TrP1. B: same data represented as means and SD (column and short bar) for pressure pain to the left of the TrP, over the TrP, and to the right of the TrP.
Figure 11. Pinch Pressure Left Extremity
Pressure was applied to the skin in a pinching manner using a finger and the pressure algometer at the rate of 1 kg/sec until the subject gave a verbal response to pain at which time pressure was immediately stopped. The pressure was recorded as kg/cm².
A: pressure sensitivity is shown for the left extremity in each individual when pressure was applied to the left of the TrP (open circle), encompassing the TrP (filled circle) and to the right of the TrP (open triangle). Data is presented in ascending order for pressure readings over TrP. B: same data represented as means and SD (column and short bar) for pressure pain to the left of the TrP, over the TrP, and to the right of the TrP.
The TrPl was determined to be in the upper fibers of the trapezius and within one centimeter of the upper and middle trapezius interface. For the subject with the loss of motor function of the trapezius muscle, it was not possible to determine the location of the TrPl based on muscle contraction. The position of the TrPl was estimated based on the distance from a line from the spinous process of C7 to the acromion process adjacent to the acromioclavicular joint.

**EMG Recordings**

With channel A electrode placed over the marked TrP and channel B electrode one centimeter directly inferior to A, a higher electrical activity was recorded for channel A than for channel B during contraction of the upper fibers of the trapezius muscle. Conversely, channel B displayed a higher electrical activity than channel A during contraction of the middle trapezius (Fig. 12). This would indicate that the TrP (electrode A) was located within the upper trapezius and within one centimeter of the middle trapezius (electrode B). This finding was consistent for both extremities in all subjects but one, who had difficulty performing isolated muscle contractions of the upper and middle trapezius.

**Gross Anatomical and Histological Results**

**Cutaneous Neurovascular Supply Overlying the Upper Trapezius**

Examination of the grossly dissected cadavers revealed nerves and blood vessels (NAV) emerging from the upper trapezius to supply the structures of the skin at 0.50 ± 0.05 (mean ± SD) of the distance from the spinous process of C7 to the acromion process of the scapula and within one centimeter of the interface between the upper and middle fibers of the trapezius (Fig. 13). There were no other NAVs in the upper trapezius within 1 1/2 cm from this NAV (Figs. 13, 14); however, there were
Figure 12. Surface EMG recordings were made showing muscle activity during contraction of the upper and the middle trapezius. A: With contraction of the upper trapezius, there was a higher recording for channel A (white arrow) electrode overlying the TrP1. B: With contraction of the middle trapezius, there was a higher recording for channel B (white arrow) electrode placed 1 cm inferior to channel A electrode.
Figure 13. Left extremity of a cadaver with the skin grossly dissected to show the underlying trapezius muscle. The black line indicates the interface between the upper and middle fibers of the muscle which extends from the spinous process of C7 (c) to the acromion process (a). The white arrow indicates a neurovascular supply (NAV) located approximately midway between a and c.

Figure 14. Right extremity of a cadaver as described above showing a NAV (arrow) located approximately midway between the spinous process of C7 (c) and the acromion process (a).
NAVs emerging from the middle fibers of the muscle within one to two centimeters of the upper and middle trapezius interface. There was a significant linear relationship ($\alpha < 0.05$) between the distance from the spinous process of C7 to the NAV and the total distance of C7 to the acromion process (shoulder width) in the left ($r^2 = 0.446$, $n=33$) and right ($r^2 = 0.425$, $n=44$) extremities of cadavers (Fig. 15). In addition, there was no significant difference from left to right extremities ($p>0.05$) in the location of the upper trapezius NAV (Fig. 16). In the left extremity of 5 cadavers, there were two NAVs in close proximity (within 2 cm) to the TrP in the upper trapezius.

Retrograde dissection of these cutaneous nerves emanating from the upper trapezius revealed that these fibers received contributions from the cervical plexus, spinal cord segments C3 and C4, and combinations thereof. Some of these cutaneous nerves also received contributions of fibers traveling with the spinal accessory nerve.

**Histology**

Examination of tissue sections, which contained the NAV, taken from 5 cadavers at the level of the most superficial muscle layer showed small nerve fascicles surrounded by connective tissue and in close proximity to blood vessels (Fig. 17). Measurements of red blood cells in the area showed no difference from normal in size (approximately 7-8 $\mu$m in diameter). Nerve fascicles contained fibers whose diameters were consistent with C or A$\delta$ fibers. The smallest of the fibers often appear to be in clusters within the fascicles (Fig. 18). There was a large variability in the size of the fascicles and the distribution of fiber types within the fascicles (Fig. 19). There were several fascicles which contained a large proportion of C fibers. Nerve fascicles were not observed in the superficial muscle layer in tissue sections taken from tissue plugs 1 cm to either side of the identified NAV.
Figure 15. The location of the identified NAV of the upper trapezius was determined by the ratio of the distance from the spinous process of C7 to the NAV/spinous process of C7 to acromion process (shoulder width). A significant linear relationship ($\alpha < 0.05$) was shown between the distance from C7 to NAV and C7 to acromion process. Lines represent regression and 95% confidence intervals. A: shows relationship for the left extremity ($y = 0.446x + (-2.20)$). B: shows relationship for the right extremity ($y = 0.424x + (-1.89)$).
Figure 16. Cadavers were grossly dissected to reveal nerves and blood vessels (NAV) emerging from the muscle to supply the overlying skin. One NAV corresponded to the approximate location of the TrP in living subjects. The location of this NAV was determined to be the ratio of the distance of the spinous process of C7 to NAV/spinous process of C7 to acromion process. Measurements were made on both left and right extremities. Data are represented as means and SD (column and short bar) for the left and right extremities.
Figure 17. Tissue section from the most superficial layer of muscle (m) in the upper trapezius containing a neurovascular supply. Small nerve fascicles (n) are in close proximity to blood vessels (bv).
Figure 18  Nerve fascicle containing C (open arrow) and A\(\delta\) (closed arrow) fibers. The smaller C fibers frequently appeared in clusters.
Figure 19. Histological examination of the identified NAV at the level of the superficial muscle layer showed nerve fascicles containing C and A\(\delta\) fibers. There was variability in the number of fibers in each fascicle as well as the distribution of C and A\(\delta\) fibers within the fascicles. Based on measurements of diameters, fibers were determined to be C, A\(\delta\), or C or A\(\delta\) fibers. Data represent means and SD (column and short bar) for the numbers of C, A\(\delta\) and C or A\(\delta\) fibers/fascicle.
Trigger Point to NAV Relationship

A comparison of the location of the TrP1 of the upper trapezius in living subjects (n=17) (0.45 ± 0.04 of the distance from the spinous process of C7 to the acromion process; mean ± SD) to the NAV in the upper trapezius in cadavers (n=44) (0.50 ± 0.05 of the distance from the spinous process of C7 to the acromion process; mean ± SD) showed a significant difference (p<0.05) (Fig. 20). Because of the difference noted in the location of the TrP in living subjects and the NAV in cadavers, measurements of shoulder widths (spinous process of C7 to the acromion process) in the two groups were compared. Since only two males were included in the TrP study, comparisons of shoulder width measurements were made only on female living subjects and female cadavers. There was a significant difference (p<0.05) in the shoulder widths between the living subjects (20.0 cm ± 1.07; mean ± SD) and cadavers (16.8 cm ± 1.3; mean ± SD) (Fig. 21).
Figure 20. A comparison of the location of the TrP1 of the upper trapezius in living humans (subjects) to the location of a NAV in the upper trapezius in cadavers using the same measurement parameters showed a significant difference (*p<0.05) in the two populations. Means and SD (column and short bar) of TrP1 in living subjects represents the ratio of the distance from the spinous process of C7 to TrP1/spinous process of C7 to the acromion process and NAV in cadavers represents the ratio of the distance from the spinous process of C7 to NAV/spinous process of C7 to the acromion process.
Figure 21. A comparison of shoulder widths (spinous process of C7 to acromion process) in cadavers and living humans (subjects) showed a significant difference (*p<0.05) between the two populations. The spinous process of C7 to acromion process distance was measured in centimeters, and the distance is represented in means and SD (column and short bar) for cadavers and living subjects.
CHAPTER 4
DISCUSSION AND CONCLUSIONS

Head and neck pain is a problem affecting a large portion of today’s workforce resulting not only in monetary costs to industry but also to a diminished quality of life for the individuals afflicted (Rasmussen and others 1991; Harris and others 1995). Myofascial trigger points appear to be a precipitating factor associated with acute and chronic pain syndromes that include myofascial pain, fibromyalgia, repetitive motion injuries, Reflex Sympathetic Dystrophy (RSD), and tension headaches (Travell and Simons 1983; Lin and others 1995). One of the most common trigger points is TrP1 of the upper trapezius that refers pain to the neck, occiput, mastoid process, angle of the jaw, temple, and orbit (Travell and Simons, 1983). Although this point has been identified as the approximate middle of the upper portion of the trapezius muscle, its precise location within or over the muscle has, as yet, not been identified. Additionally, it has not been determined if the TrP lies within the muscle or is located superficial to the muscle, possibly within the muscle’s fascia. The ability to precisely identify the location of a trigger point and some of the tissues associated with it may aid in identifying structures and/or mechanisms associated with the activation of a trigger point and referred pain.

Localization of TrP1 of the Upper Trapezius

Previous studies have shown that there is little variability in eliciting referred pain with digital pressure between subjects reporting pain and pain-free subjects, who serve as controls, for a trigger point or tender point (Sola and others 1955; Sola and Williams 1956; Scudds and others 1995). No studies to date, however, have precisely located a TrP in living humans. The estimated location for TrP1 of the upper trapezius has been described as the approximate midpoint of the length of the muscle, and the mechanism of activation
has been described in association with muscle (Travell and Simons 1983). However, no studies to date have shown that a TrP is located within the substance of the muscle; therefore, a cutaneous location should also be considered. Additionally, studies describing treatment of a TrP by needle insertion or needle injection have shown needle insertion into the skin (acupuncture) is as effective as insertion into the muscle (Baldry 1995). Furthermore, deep pain thresholds over trigger points have been shown to be over or on the muscle fascia (Kawakita and others 1991).

The conclusion drawn from the data collected in this study is that trigger point 1 in the upper trapezius may be precisely located in living humans with no significant difference among individuals or from one extremity to the other. This TrP refers pain to the head and neck, but the location of this TrP did not differ significantly among subjects who reported referred pain and subjects who had a tender point but no referral of pain in response to digital pressure. The preponderance of the data support this conclusion as there was significant inter-rater reliability in localizing this TrP. However, it should be noted that there was variation in the intra-rater reliability. There was lack of significance for the intra-rater reliability of the second rater. This may have been due to insufficient time spent in the training of this examiner prior to beginning the study.

Techniques for identifying a TrP with the use of a pressure meter (algometer) have shown to be reliable (Mersky and Spear 1964; Reeves and others 1986; Fischer 1987; Airaksinen and Pontinen 1989; Scudds and others 1989; Smythe and others 1991; Delaney and McKee 1993; Tunks and others 1995). Use of the pressure algometer applied perpendicular to the surface of the skin demonstrated that the identified TrP1 was more sensitive than points one centimeter to either side. This indicates that the TrP can be localized to an area of approximately 1 cm² (surface area of the algometer tip). This is a novel approach to using the pressure algometer that not only measures the sensitivity of
the identified TrP, but also helps to delineate the most sensitive area. This procedure may aid clinicians in more precisely locating the area for injection or application of needle stimulation.

Methods for use of the pressure meter (algometer) (Airaksinen and Pontinen 1989; Tunks and others 1995) indicate pressure is applied perpendicular to the surface of the skin to measure sensitivity of the underlying muscle, but this pressure is first transmitted to the structures of the skin and subcutaneous tissues. This fact presents an obvious confounding variable for those who wish to localize a TrP to muscle using superficial pressure. Some studies have used topical anesthetics in an attempt to minimize effects on cutaneous receptors when measuring pressure sensitivity, but depths of penetration of the anesthetic have not been determined (Kosek and Ekholm 1995). Consequently, the applied pressures may still be stimulating the skin and/or fascial structures.

Although subjects did not report referred pain to the same areas or to the same number of areas with pinching of the skin as with digital pressure, the presence of referred pain to pinch indicates that structures of the skin most likely play a part in the trigger point mechanism. One possible explanation is that both muscle and skin receptors play a role in the TrP mechanism. However, another explanation is that penetration to the deepest layers of the skin and/or muscle fascia was not achieved with pinching the skin, whereas digital pressure penetrated skin, fascia and muscle. Furthermore, support for the importance of structures of the skin in the trigger point mechanism was provided by the subject with loss of motor function to the right trapezius muscle who still exhibited features of an active trigger point including a palpable nodule, jump sign, and an appropriate pattern of referred pain for TrP1 of the upper trapezius. Increased sensitivity of the skin at TrP1 was shown for pinch pressure in this subject and this paralleled the findings for perpendicular pressures. This is the first time that pressure thresholds for the skin over trigger points
have been measured, and the results show that skin sensitivity may be localized to a small area (1cm²) as was shown for conventional pain pressure measurements.

Results of manual muscle testing and surface EMG recordings showed that TrP1 was located within the upper fibers of the trapezius approximately 1 cm superior to the interface between the upper and middle fibers. Thus, the medial to lateral and superior to inferior demarcation of TrP1 was well defined. There was often, however, not a large difference in motor activity recorded when attempting to isolate the actions of the upper and middle portions of the muscle. There are several factors which could influence these results. First, some subjects had difficulty isolating individual muscle activity in performing the discrete motions for testing the upper and middle portions of the trapezius. Secondly, cadaver dissection of this portion of the trapezius showed an overlap of the upper and middle fibers of the muscle, particularly at the medial and lateral attachments. Lastly, the surface electrodes were placed close together (1 cm separation) which could allow for spread of the signal.

**Localization of a Neurovascular Supply Associated with the Upper Trapezius**

The skin is the largest organ of the body and yet cutaneous innervation to the skin is described much less precisely than innervation to the skeletal muscles. Sensory innervation to muscles (myotomes) can be defined by each particular muscle, but sensory areas of the skin are not limited to structures with well defined borders such as muscle. Instead, sensory innervation to the skin occurs in bands (dermatomes) which may overlie several muscles and may receive innervation from branches of spinal nerves different from the underlying muscle as in the innervation for the trapezius muscle and the skin which overlies it (Williams and others 1989). Considering the vast sensory and sympathetic network of nerves that supply structures of the skin, it may add to the understanding of pain mechanisms to have a more detailed knowledge of the peripheral network of nerves that
appear to influence pain mechanisms.

This study showed that a particular neurovascular supply (NAV) emerging from the upper trapezius to supply structures of the skin could be precisely and consistently located on cadavers with no significant difference in its relationship to surrounding structures. It was shown to be within 1 cm of the upper and middle trapezius interface and 0.50 ± 0.05 (mean ± SD) of the distance from the spinous process of C7 to the acromion process of the scapula. There was also no significant difference between right and left extremities. This provides a reliable marker for the location of a particular NAV associated with the upper trapezius and that supplies structures of the skin overlying the trapezius.

In 5 cadavers used in this study, the cutaneous nerves traced from termination to origin had contributions from cervical spinal levels C2-4 which are the same spinal levels supplying sensory innervation to the posterior neck, and may provide sensory innervation to the jaw, temple and orbit via connections with the facial and trigeminal nerves (Williams and others 1989). These are the same potential areas of referred pain from TrP1 of the upper trapezius. Thus there may be a convergence of nerves from this TrP with those supplying the areas of referred pain associated with this TrP.

Histological findings indicating the cutaneous nerve fascicles in the vicinity of the identified NAV at the level of the superficial muscle layer contained C and Aδ nerve fibers. In addition to C fibers providing nociceptive receptors, postganglionic sympathetic axons supplying blood vessels and other structures of the skin also consist of unmyelinated C fibers (Guyton and Hall 1996). Therefore, a large number of C fibers would be expected to be found in these fascicles, but the function of these fibers cannot be determined by anatomical description. Thus, the proportion of nociceptive fibers within these NAVs cannot be estimated from the results of this study.
Relationship of TrP to NAV of the Upper Trapezius

Although there are several findings that implicate a close relationship between the location of TrP1 of the upper trapezius and a neurovascular supply to the structures of the skin overlying the upper trapezius, there are significant differences that preclude one from drawing the conclusion that they are one and the same. The study showed there was no significant difference in the location of TrP1 in living humans and no significant difference in the location of the NAV overlying the upper trapezius in cadavers, and that both the TrP1 and NAV were within approximately 1 cm of the upper and middle trapezius interface. However, there was a significant difference in the medial to lateral location of the TrP1 in living human and the NAV in cadavers as indicated by the difference in the ratio of the distance of spinous process of C7 to TrP1 (0.45 ± 0.04; mean ± SD) or NAV (0.50 ± 0.05; mean ± SD)/ spinous process of C7 to acromion process. A possible explanation for this variation might be the significant difference in shoulder widths (spinous process of C7 to acromion process of the scapula) between living humans and cadavers. Since rigor mortis occurs immediately after death causing muscle contraction and rigidity (Guyton and Hall 1996), this could account for differences in shoulder width. However, a disproportionate shortening of the length of the muscle with rigor mortis could account for a difference in the relative position of the NAV in relation to the overall shoulder width.

Furthermore, there were differences in measuring positions in determining the location of TrP1 (NAV) and shoulder widths. Living humans were measured in a sitting position while cadavers were measured in a prone position. To account for variations due to position, 4 of the subjects included in the study were measured in both a sitting and a prone position. Results showed there was no significant difference (p>0.05) in the location of the TrP1 for sitting (0.44 ± 0.04; mean ± SD) or prone (0.44 ± 0.03; mean ± SD), and there was no significant difference in shoulder widths between sitting (21.8 cm ± 1.9; mean ± SD) and prone (21.2 cm ± 1.8; mean ± SD) (Fig. 22).
Figure 22. A comparison between sitting and prone positions was made to determine the location of the TrP1 and shoulder width measurements in 4 subjects. A: shows means and SD for shoulder width (spinous process of C7 to acromion process) in cm. B: shows means and SD for location of TrP1 (ratio of the distance of spinous process of C7 to TrP1/spinous process of C7 to acromion).
Conclusions

Trigger point 1 (TrP1) associated with the upper trapezius, which causes referred pain to the head and neck, can be located precisely in living humans. There is little variability among individuals or from one extremity to the other. Results show that pinching of the skin encompassing TrP1 produces similar patterns of referred pain as with digital pressure; therefore, tissues that overlie the muscle are likely to be involved with the trigger point mechanisms. Although there is a close relationship in the location of the TrP1 in living humans and a neurovascular supply to the skin in cadavers, it cannot be concluded from this study that the TrP1 overlies the emergence of these nerves and blood vessels. Future studies should include identification of other common trigger points that may be studied in a similar manner; however, points which would not be affected by joint movement would be easier to compare to the cadaver model and help to minimize differences in muscle tissue due to rigor mortis.
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