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Does EMG (dry needling) reduce myofascial pain symptoms due to cervical nerve root irritation?

J. Chu

Abstract

Objective: *EMG examination at tender points affects myofascial pain symptoms related to cervical nerve root irritation.*

Methods: *Consecutive patients with neck and arm pain had physical examinations immediately before and after having EMGs of bilateral C3-C8 myotomes. Patients were randomly chosen for EMG either at the most tender point along the palpated myofascial band* [1] *or at a nonselected site* [2]*. The myotomal presence of* $\geq 30\%$ *incidence of normal duration and amplitude, and polyphasic motor unit potentials confirm the diagnosis of cervical nerve root irritation.*

Results: *52% returned patient questionnaires 2 weeks post EMG examination. Group 1 (82/122 patients [67.2%]), averaged pain relief of* $51.8 \pm 21.9\%$*, a mean of* 10.2 ± 8 *days; 14% had* $\geq 75\%$ *relief. The number of days of pain relief correlated positively with the percentage of pain relief (*$p < 0.005$*), but negatively with the number of nerve roots involved on EMG (*$p < 0.05$*). Group 2 (23/42 patients [54.8%]), averaged relief of* $39.0 \pm 18.7\%$*, lasting* 8.8 ± 11.2 *days. None had* $\geq 75\%$ *pain relief. Both groups' duration of pain symptoms affected onset of relief. Evidence of bilateral multiple-level cervical nerve root irritation, especially noted at bilateral C6 and C7 levels.*

Conclusion: *EMG at tender points on myofascial bands tends to improve symptoms. Needling these points elicits motor endplate activity and twitches, and induces more relief than when needling random points.*

Introduction

Dry needling relieves pain of myofascial origin (2, 8, 9, 10, 18). The EMG examination itself is a form of dry needling and is a non-electrical, non-chemical stimulation of muscle. The pin moves in different directions during the EMG to examine electrical activity of the muscle at rest and minimal and maximal contraction. These movements at the tender points had an effect on reducing the original lumbosacral pain symptoms due to lumbosacral nerve root irritation. Such points, when needled, evoke potentials including miniature endplate spikes, endplate potentials and/or fasciculations, myokymia and twitch responses (2). This present study in patients with neck and arm pain is to determine the following concerns: (1) Does EMG at tender points reduce the original pain symptoms?; and, (2) What are the clinical or electromyographical indicators in those patients who will or will not achieve pain relief with the needling of tender points in the muscles?

[1] Group 1, test group.
[2] Group 2, control group.

Methods and materials

Patients referred to the author's electrodiagnostic laboratory for diagnosis of neck and upper-extremity pain had electrodiagnostic studies. The period of study was between June of 1994 and March of 1995. The electrodiagnostic studies included nerve conduction studies of the bilateral motor and sensory median and ulnar nerves, F responses, and the bilateral radial sensory nerves.

The EMG portion of the test was done bilaterally on the following muscles: levator scapulae (C3), trapezius (C4), anterior deltoid (C5), rhomboid major (C5), supraspinatus (C5), infraspinatus (C5), posterior deltoid (C6), biceps brachii-short head (C6), brachialis (C6), teres major (C6), triceps (C7), extensor digitorum communis (C7), flexor carpi radialis (C7), flexor digitorum superficialis (C8), flexor carpi ulnaris (C8), abductor pollicis brevis (C8), first dorsal interosseous muscle (T1), and the cervical paraspinal muscles at C3-C7 level.

The patients underwent a physical examination prior to and immediately following the EMG examination, which included the following: goniometric measurements obtained in degrees of cervical spine flexion and extension; shoulder abduction; flexion; and, extension. The vertical distance in centimeters between the ear and the angle of the neck measures the lateral flexion of the neck while the patient attempts to bend his head sideways to the best of his ability. The distance in centimeters between the middle of the chin and the ipsilateral acromioclavicular joint measures the lateral rotation of the neck while the patient attempts to turn his face to the same side. Measurement of the external rotation of the shoulders requires the patient to flex fully at the test shoulder with the elbow flexed and the supinated forearm wrapped behind the neck. The distance in centimeters between the tip of the middle finger (test side) and the corner of the contralateral angle of the mouth measures the ability of the examined shoulder to externally rotate. Internal rotation of the shoulder is measured by asking the patient to extend the test shoulder with the elbow flexed behind the back while attempting to reach the contralateral scapula spine with the forearm in supination. The distance between the tip of the pulp of the middle finger of the examined arm and the middle of the contralateral scapula spine measured in centimeters allows the examined shoulder to rotate internally. A metal tape measures the distance changes in centimeters for comparison of before and after measurements.

The blunt end of a PaperMate ballpen was pressed into the motor points of the representative muscles of the upper limb, and the score (0-3) obtained measures the tenderness at the motor points. The total motor point tenderness obtained by adding the motor point scores given for each representative muscle elicited the total motor point tenderness score. The muscles examined for this purpose from different myotomes are as listed: sternocleidomastoid (C2), levator scapulae (C3), trapezius (C4), rhomboid major (C5), biceps brachii (C6), extensor carpi radialis longus (C6), triceps brachii (C7), flexor digitorum superficialis (C8), and the cervical paraspinal muscles. The highest pain scale in the paraspinal muscles was recorded, despite the level noted. The tenderness scale used was from 0 to 3, as described by Gunn (6). Totaling the scales elicited a grading of "0" as the lowest score and "27" as the highest.

The bilateral nerve conduction studies and EMG are done as described in Chu-Andrews and Johnson (3). The EMG done in one group of consecutive patients was without palpation immediately before the EMG, whereas in the second group of consecutive patients, palpation for a tender myofascial band preceded the pin insertion. The examinations of the cervical paraspinal muscles were done one-half inch from the spinous process. The EMG included examination of the muscle at two skin insertion sites, with the examination done in different directions and at different depths for electrical activity at rest and at minimal and maximal contraction. The MUAP study used the method of triggering and delaying the MUAP activity at a sweep speed of 5 ms/division (3). The filter used was 20 Hz-10 KHz. Twenty MUAPs were semi-quantitatively analyzed at each skin insertion site by examination at different quadrants of the muscle, with the recording done from twenty different positions within the muscle and separated by at least 3 mm (3). The decision for the morphology of the MUAPs for amplitude, duration, number of phases, and percentage of polyphasia came from MUAPs selected to have the sharpest rise time. The duration was assessed at a standard gain of 200 uV to 250 uV/division, with averaging when needed. The equipment used consisted of the TD 20 EMG machine [1], and disposable TECA monopolar MG 37 needles provided the necessary EMG recordings.

The diagnosis of recent onset and current radiculopathy was formulated primarily from the presence of the increase in the percentage of polyphasic potentials (>30%), with normal duration (<15 ms) and normal amplitude (<4 mV).

[1] TECA Corporation, White Plains, New York.

The diagnosis of chronic partial radiculopathy came from the presence of increase in the percentage (> 10%) of long-duration triphasic potentials (> 20 ms) with large amplitude (> 4 mV) (11). The presence of these potentials in a myotomal pattern, including the paraspinal muscles, confirmed the diagnosis of recent or chronic cervical nerve root irritation, respectively. Excluded from this study were all patients having evidence – by nerve conduction study – of peripheral neuropathy.

The grading of the degree of severity of recent-onset involvement included the following: *Grade 1*, when normal duration, normal amplitude polyphasic MUAPs percentage increased to ≥30% and ≤50%; *Grade 2*, when the increase in polyphasia is > 50% and ≤75%; *Grade 3*, when the increase in polyphasia is > 75%; and, *Grade 4*, when any of the above occurs with spontaneous activity.

Immediately after the EMG, the patients received both a reexamination of the same physical parameters as before the EMG, and a questionnaire that was to be returned two weeks after the EMG examination. The questionnaire concerned the following: (1) whether they had pain relief; and, (2) whether the average pain level could be rated on a scale of 0 to 10, using a visual analog scale. Comparison with the scale filled before the EMG examination provided for the percentage changes in pain symptoms. Changes in physical examination of ≥5 degrees for neck flexion and neck extension; ≥10 degrees for a change in shoulder flexion, shoulder abduction, and shoulder extension; and, ≥2 cm changes for the lateral flexion, lateral rotation of the neck, and external and internal rotation of the shoulders, provided a basis for improvement for these ranges. A change in the total sum of the motor points by more than 3 points provided information for an improvement for total motor point tenderness.

Treatment of data

Data analysis was performed using Statistica software [1]. Relationships between variables was determined using Pearson product moment correlation analyses and multiple regression. Differences in mean scores of variables were compared using paired t-tests and group differences with chi square and logistic regression, with significance set at a probability of 0.05.

[1] Tulsa, OK, USA.

Results

There was a 52% (154/296) return of questionnaires among the patients examined in this laboratory during the test period. The return pattern of the questionnaires was equally distributed between the test group and the control group. *Group 1* (test group) included 82/122 patients having an EMG at tender points along the myofascial bands and having pain relief. The test group was subdivided into pain relief and non-pain relief groups in order to understand the differences, if any, in the clinical and electromyographic characteristics of the patients who fit into these subgroupings. The subdivisions of this group included *Group 1.1* and *Group 1.2*. *Group 1.1* consisted of patients having ≥50% pain relief, while patients in *Group 1.2* were those having < 50% pain relief. *Group 1.3* included those patients having a similar EMG done, but having no pain relief.

Similarly, *Group 2* (control group) classifies those 42 patients having an EMG at random points who replied to the questionnaires. The subdivisions of this group were *Group 2.1* and *Group 2.2* and included those patients having ≥50% pain relief, and < 50% pain relief, respectively. *Group 2.3* included patients having a similar EMG, but having no pain relief.

Arbitrary criteria were then set for significant range-of-motion improvement of the neck and shoulders. This was done in order to understand whether there was a pattern between the different range-of-motion changes and the changes in pain symptoms. The range-of-motion changes listed are those in which improvement was noted in ≥20% of patients in each group.

Results related to Table 1

Gender

Females were more noted in all groups ($p < 0.05$), except in Group 1.3 (test group without pain relief).

Table 1. – *General characteristics of patients studied*

	MPEMG PAIN RELIEF Group 1.1 Group 1.2	MPEMG NO RELIEF Group 1.3	CONTROL PAIN RELIEF Group 2.1 Group 2.2	CONTROL NO RELIEF Group 2.3
F/M	50/32	22/18	16/7	14/5
Auto acc	60	30	16	12
Work acc	12	8	4	6
Other	10	2	3	1
Auto acc (< 6 mo pain)	40	20	13	6
Auto acc (≥6 mo pain)	20	10	3	6
Uni sym (%)	43(52)	13(32)	3(13)	3(16)
Bilat sym (%)	39(48)	27(68)	20(87)	16(84)
Pain relief	82(67)	40(33)	23(55)	19(45)
< 50% relief(%)	44(54)		16(70)	
≥50% relief(%)	38(46)		7(30)	
≥75% relief(%)	16(13)		0(0)	

Abbreviation: *MPEMG* = motor point EMG.

Trauma

Automobile accident cases were more common than were other types of trauma ($p < 0.0001$) in Group 1 (with or without pain relief). In the control group with pain relief there were more patients with automobile accidents; no difference was noted in the control group without pain relief.

The auto accident cases were present more significantly in patients with < 6 months of pain duration than in patients with ≥6 months of pain in the test group with pain relief ($p < 0.005$) and without pain relief ($p < 0.05$), as well as in the control group with pain relief ($p < 0.001$). No differences were noted in the control group without pain relief.

Symptoms

Combined Group 1.1 and Group 1.2 (test group with pain relief) showed a lesser percentage of patients with bilateral symptoms ($p < 0.05$) than did Group 1.3 (test group with no pain relief). The combined Group 1.1 and Group 1.2 also had a lesser percentage of patients having bilateral symptoms ($p < 0.001$) than did combined Group 2.1 and Group 2.2 (control patients having pain relief) and Group 2.3 (control patients with no pain relief). There were no differences in the percentage of patients with bilateral symptoms between the test and control groups of patients having no pain relief.

Pain relief

In Group 1 (test group), there was a greater percentage of patients with pain relief ($p < 0.0001$) than without pain relief. Group 2 (control group) showed no differences in the percentage of patients having pain relief and those having no pain relief.

Percentage of patients with pain relief

In Group 1 (test group), no significant differences were noted between the percentage of patients having < 50% pain relief and those having ≥50% pain relief. However, in Group 2 (control group) the percentage of patients having ≥50% pain relief was less than in those having < 50% pain relief ($p < 0.005$). Thirteen percent of Group 1 patients having ≥75% pain relief, but no patients in Group 2 were in that category.

Results related to Table 2

Pain duration

No differences were noted among all groups tested.

Age

There were no differences in ages among all groups.

Table 2. – *Specific characteristics of patients studied*

	MPEMG PAIN RELIEF Group 1.1 Group 1.2	MPEMG NO RELIEF Group 1.3	CONTROL PAIN RELIEF Group 2.1 Group 2.2	CONTROL NO RELIEF Group 2.3
Number	82	40	23	19
Pain dur (mo)	10.9±12.2	13.9±17.6	11.3±13.3	17.1±20.4
Age (yrs)	44.2±14.0	40.1±11.5	40.5±13.7	40.9±12.8
Sym m.p.(total sum)	15.4±6.5	17.8±5.3	13.8±5.7	17.6±6.4
Asym m.p.(total sum)	13.2±6.9	15.9±5.4	14.7±5.7	14.8±7.5
Pain relief (days)	8.0±7.6	—	8.8±11.2	
When relief (days)	1.6±2.0	—	3.2±4.4	
Pain days (days)	1.6±2.0	4.8±3.8	2.9±4.4	5.0±3.7
Total m.p. impr sym (no)	6.3±3.3	4.4±1.6	4.4±1.9	4.0±1.7
Total m.p. impr asym (no)	5.7±2.9	4.4±1.6	4.4±1.9	4.4±1.0
Quan. relief (%)	51.8±21.9	6.5±22.5	39.0±18.7	33.8±16.3
Imm. relief (% of pat's.)	49.4		26.1	

Abbreviations: *MPEMG* = motor point EMG; *sym* = symptomatic; *asym* = asymptomatic; *m.p.* = motor point; *impr* = improvement; *quan* = quantitative; *imm* = immediate; *pat's* = patients.

Total sum of tender motor points in the symptomatic side

Group 1.3 patients (test patients with no pain relief) had a significantly higher sum of tender motor points than did combined Group 1.1 and Group 1.2 (test patients with pain relief). Similarly, Group 2.3 (control patient with no pain relief) had a higher sum of tender motor points than did combined Group 2.1 and Group 2.2 (control patients with pain relief).

Total sum of tender motor points in the asymptomatic side

The Group 1.3 patients (test patients with no pain relief) had a significantly higher sum of tender motor points than did combined Group 1.1 and Group 1.2 (test patients with pain relief). No differences were noted for the values of Group 2 patients with pain relief and those not having pain relief.

Days of pain relief

No differences were noted between Group 1 (test patients with pain relief) and Group 2 (control patients with pain relief).

When pain relief occurred

The Group 1 patients having pain relief noted pain relief sooner after the EMG than did the control Group 2 patients having pain relief ($p < 0.05$). Pain duration has a direct effect on when pain relief will occur.

Days of pain after the EMG

The Group 1 patients having pain relief had shorter duration of pain after the EMG when compared to the Group 1.3 patients ($p < 0.0001$). This pattern also was noted for the control patients having pain relief and for those not having pain relief ($p < 0.05$). Pain duration has a direct effect on the number of days in pain after EMG.

Total of improvement scores in motor point tenderness in the symptomatic side

The Group 1 patients having pain relief had more improvements in this category than did those not having pain relief.

Group 1 patients having pain relief also had more improvement in this category than did the control patients having pain relief ($p < 0.05$). No significant difference was noted between the Group 2 patients having pain relief and those not having pain relief.

Total of improvement scores in motor point tenderness in the asymptomatic side

The pattern was similar to that described for the symptomatic side.

Quantitative pain relief

Test Group 1 patients having pain relief had more pain relief than did the control Group 2 patients having pain relief ($p < 0.05$). The intensity of pain in test Group 1.3 patients, who complained of more pain after the EMG testing, also was less than that of Group 2.3 patients ($p < 0.0001$).

Immediate relief

The percentage of patients in Group 1 having immediate relief was greater than that noted in Group 2 ($p < 0.05$).

Results related to Table 3

Group 1.1 (≥50% pain relief) showed a higher percentage of patients having an improvement in all categories listed in Table 3, when compared with Group 1.3 (no pain relief).

Results related to Table 4

No significant differences were noted for the percentage of patients in Group 2 (pain relief) and Group 2.3 (no pain relief) who showed an improvement in all listed categories.

Comparisons of categories listed in Table 3 and Table 4

No significant differences were noted in the percentage of patients for listed categories between Group 1 and Group 2.

Results related to Table 5

No significant differences were noted in Table 5 between the number of patients having < 4 roots involved and those having ≥ 4 roots involved (symptomatic and/or asymptomatic sides) for Group 1.1, Group 1.2, and Group 1.3.

Table 3. – *Ranges-of-motion improvement for test group of patients having EMG at tender points in the muscles*

	PAIN RELIEF Group 1.1 ≥50% PR	PAIN RELIEF Group 1.2 <50% PR	NO PAIN RELIEF Group 1.3 No PR
Number	63	19	40
Neck flexion (degrees)	11.0±3.7	9.9±4.2	9.8±3.7
No. of patients (%)	24(19.7)	19(15.5)	9(7.4)
Lat. rot. (sym) (cm)	2.8±0.9	2.6±0.8	2.5±0.6
No. of patients (%)	22(18)	4(3.3)	13(10.7)
Sh. abd. (sym) (degrees)	25.7±16.7	21.1±15.6	25.7±24.9
No. of patients (%)	29(23.8)	9(7.4)	13(10.7)
Sh. flex. (sym) (degrees)	15.2±9.6	13.8±4.8	17.8±9.2
No. of patients (%)	24(19.7)	7(5.7)	12(9.8)
Sh. ext. (sym) (cm)	14.4±5.9	14.4±4.2	16.0±7.4
No. of patients (%)	34(27.9)	8(6.6)	15(12.3)
Sh. ext. (asym) (cm)	15.9±5.9	12.1±2.7	13.9±4.9
No. of patients (%)	34(27.9)	7(5.7)	14(11.4)
Sh. extl. rot. (sym) (cm)	5.3±4.0	3.7±2.9	3.3±1.8
No. of patients (%)	22(18.0)	7(5.7)	9(7.4)
Sh. int. rot. (sym) (cm)	6.7±4.7	4.3±2.1	6.7±5.7
No. of patients (%)	28(22.9)	4(3.3)	15(12.3)
Sh. int. rot. (asym)(cm)	7.3±5.0	4.3±2.1	4.5±3.2
No. of patients (%)	23(18.9)	4(3.3)	16(13.1)

Abbreviations: *PR* = pain relief; *lat* = lateral; *rot* = rotation; *sh* = shoulder; *abd* = abduction; *flex* = flexion; *ext* = extension; *extl* = external; *int* = internal; *sym* = symptomatic; *asym* = asymptomatic; *cm* = centimeters.

Table 4. – *Improvement of ranges-of-motion in control patients having EMG at random points in the muscles*

	PAIN RELIEF Control Group 2.1 Group 2.2	NO RELIEF Control Group 2.3
Number	23	19
Neck flexion (degrees)	9.3±3.6	8.9±2.4
No. of patients (%)	9(21.4)	8(19.0)
Sh.abd.(sym)(degrees)	23.9±26.7	23.3±25.8
No. of patients (%)	9(21.4)	3(7.1)
Sh.int.rot.(sym)(cm)	8.1±5.9	5.9±6.5
No. of patients (%)	10(23.8)	6(14.3)
Sh.int.rot.(asym)(cm)	7.4±4.7	5.9±5.9
No. of patients (%)	10(23.8)	6(14.3)

Table 5. – *EMG profile of all patients*

	Group 1.1	Group 1.2	Group 1.3
Number	38	44	40
EMG < 4 roots inv. C5,C6,C7 (sym) or C6,C7 (sym) or C5,C6 (sym)	7(5.7)	3(2.5)	4(3.3)
EMG≥4 roots inv. C4,C5,C6,C7 or C3,C4,C5,C6,C7 (sym)	31(25.4)	41(33.6)	36(29.5)
EMG < 4 roots inv. C5,C6,C7 (asym) or C6,C7 (asym) or C5,C6 (asym)	17(13.9)	14(11.5)	10(8.2)
EMG≥4 roots inv. C4,C5,C6,C7 or C3,C4,C5,C6,C7 (asym)	21(17.2)	30(24.5)	30(24.5)
	Group 2.1	**Group 2.2**	**Group 2.3**
Number	7	16	19
EMG≤3 roots inv. C5,C6,C7 (sym) or C6,C7 (sym) or C5,C6 (sym)	3(7.1)	3(7.1)	4(9.5)
EMG≥4 roots inv. C4,C5,C6,C7 (sym) or C3,C4,C5,C6,C7 (sym)	4(9.5)	13(31.0)	15(35.9)
EMG≤3 roots inv. C5,C6,C7 (asym) or C6,C7 (asym) or C5,C6 (asym)	3(7.1)	5(11.9)	7(16.7)
EMG≥4 roots inv. C4,C5,C6,C7 (asym) or C3,C4,C5,C6,C7 (asym)	4(9.5)	11(26.2)	12(28.5)

Abbreviations: *inv* = involved; *sym* = symptomatic; *asym* = asymptomatic.

In Group 2, however, there were more patients, with Group 2.2 and Group 2.3 having ≥4 roots involved than in Group 2.1 for both the symptomatic and asymptomatic sides.

Discussion

Relating to the intramuscular stimulation (IMS) effect of the EMG on clinical findings

Questionnaire survey response was at 52% of patients examined. Among patients who replied, there may be a bias by those having pain relief to feel obligated or motivated to return the questionnaire, explaining why test Group 1, rather than control Group 2, had more patients with pain relief. This pattern appeared to be similar to that previously noted in an earlier study of patients with pain related to lumbosacral radiculopathies (3). The obligation to return questionairres may be stronger in females than in males and may explain why there were more females in this study. Thus, even if those patients not returning the questionnaires had no pain relief, it can be inferred from those returning questionnaires that the EMG examination does affect a patient's original pain symptoms. EMG examination reduced the original pain symptoms for approximately one week or increase the original pain symptoms for an average of two days, with less exacerbation of pain symptoms when the EMG examination was performed at the tender motor points.

Pain and spasm of the muscles supplied by the involved nerve roots would lead to a higher total score for tenderness of motor points (6). This pain is present not only in the palpated representative muscles, but also in other muscles supplied by the involved nerve root(s) and belonging to the same myotome. The probability of the presence of multifocal tender areas in the muscles examined also may explain why a single EMG at the tender points was unable to relieve pain, especially in those patients having a high total motor point score or bilaterality of symptoms (see Tables 1 and 2). The presence of multiple-level cervical nerve root irritation is the cause of these patients' bilateral symptoms.

There may be a subgroup of patients who will not respond with pain relief to the method of needling associated with a routine EMG, even when performed at the tender motor points. The present work underscores the need for further outcome studies of these patients with high motor point scores or bilateral myofascial pain symptoms. The patients with bilateral symptoms tended to respond less effectively with the simplified form of dry needling associated with an EMG. These patients may have more multifocal areas of pain and muscle spasm and may need a different type of needling, as in that described in a previous work on lumbosacral radiculopathy, in which twitch responses were specifically evoked at multiple sites in multiple muscles of all involved myotomes.

There was a significantly higher number of automobile accident cases in the test and control groups of patients who had pain relief, but whose duration of symptoms was less than six months. This pattern of stretch injuries was not noted in the patients with more than six months of pain duration, since trauma was equally distributed with other type of injuries, including work injuries. The mechanism of trauma to the nerve roots is different in automobile cases where a sudden onset tensile stretch injuries to the nerve roots is common due to hyper-extension and hyperflexion to the cervical spine. Work-related injuries may have a more insiduous onset of of trauma and the mechanism of trauma may be different from motor vehicle accidents. This, when combined with a shorter duration of symptoms, gave the better results for pain relief. However, in spite of the importance of the mechanism of trauma and duration of symptoms, the fact still remains that there is a precise need for locating and needling the motor endplate zones as the most crucial factor for inducing pain relief, since patients with very chronic symptoms and various types of trauma were able to appreciate pain relief also, especially those in Group 1.1.

Assessment of improvement in motor point tenderness was a useful criterion for assessment of pain relief, since patients having pain relief did show a reduction in the total motor point tenderness scores post EMG. However, the nociceptive pain from the EMG examination precludes a meaningful interpretation of the changes in the motor point tenderness post EMG examination. The presence of tenderness at the motor points post

EMG is not conclusive for the completeness or incompleteness of desensitization at that point.

Relating to the EMG findings

The principal sign used in electromyography to diagnose root-level involvement is the finding of spontaneous activity in a myotomal distribution. However, the spontaneous activity may not be present, depending on the degree or extent of nerve injury and the timing of the EMG study. When there is a sudden and isolated tensile stretch injury to the nerve roots, the EMG examination at rest may not reveal spontaneous activity. These tensile stretch injuries are partial axonal injuries and are less severe than are the axonal injuries encountered; for example, a situation in which there is a progressive and unrelenting extrinsic nerve root compression, as from a herniated disc or bony lesions, such as spinal stenosis. Most of the patients in this study were those predominantly involved in motor vehicle accidents and work-related injuries, primarily those involved with lifting or twisting injuries (see Table 1). Tensile stretch injuries easily can damage bilateral cervical nerve roots at multiple levels, since the spinal nerve roots are the sites most vulnerable to injury. They lack epineural and perineural tissue, have fewer and finer collagen fibers in endoneural tissue, and have the nerve fibers arranged in parallel nonplexiform bundles (31).

The EMG findings in this study consisted of increased incidence of normal duration and normal amplitude polyphasic MUAPs in the distribution of bilateral C3 through C7 nerve roots, especially involving the bilateral C6 and C7 myotomes. These findings suggest the mechanism of injury to the roots to be that of tensile stretch or distortion-type injuries. With tensile stretch or distortion injuries, the denervation may be partial and random and, thus, can be re-innervated readily by neighboring healthy axons. This explains the absence of spontaneous activity and the presence of increased incidence of polyphasia. Many patients in this study were patients whose original injury occurred many months prior to electrodiagnostic study. Thus, even if the spontaneous activity had been present earlier, due to the original injury, the spontaneous potentials may not have been detectable at the time of the EMG examination, since the denervated muscle fibers already would have been re-innervated.

There is still debate about the usefulness (4, 5, 13, 16, 17), or the lack of clinical significance of polyphasic potentials in the diagnosis of radiculopathy (15, 34). However, the author has found that these polyphasic potentials are very useful in confirming the neuropathic origin of chronic pain due to partial injuries to the nerve roots, with subsequent partial denervation and reinnervation (2). These potentials are significantly different in numbers and complexities among the involved nerve roots, being most simple in shape - usually five phases or turns (see Figs. 1 & 2) - in the more involved roots of the symptomatic or asymptomatic side. They are highest in numbers in the most involved nerve roots, usually at the C5, C6, and C7 nerve root levels. These potentials are more complex in shape and fewer in number in the less

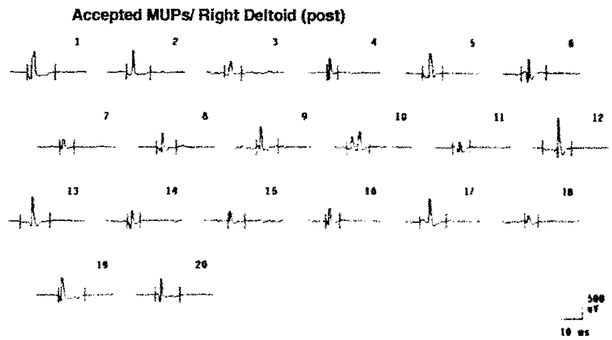

Fig. 1. – A series of normal MUAPs recorded from the deltoid muscle of a control subject.

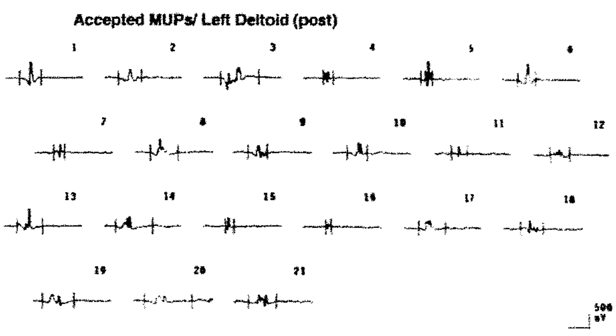

Fig. 2. – A series of MUAPs recorded from the deltoid muscle of an age-matched test subject showing excessive normal duration, normal amplitude polyphasic MUAPs.

involved nerve roots of the symptomatic side or asymptomatic side. The physical findings of joint limitation in the neck and shoulders, with tenderness of the motor points of the involved myotomes as objective findings of muscle pain and spasm, complemented the EMG findings of multiple-level cervical nerve root irritation.

The usefulness of quantitation of the polyphasic MUAPs for presence of nerve root irritation and their relation to pain symptoms was evidenced in this study by the fact that the degree of pain relief had a negative correlation with the number of nerve roots involved as in Group 1, or that little or no pain relief occurred in the patients who had at least four nerve roots involved, as in Group 2.

The patients in the control group had pain relief due to random and unintentional needling of tender points along myofascial bands (see Fig. 3), since the control group also had evidence of multiple-level bilateral nerve root involvement. However, due to the lack of identification of the most tender point along the myofascial band and, hence, lesser specificity in locating the endplate zone (see later in EMG section of "Discussion"), the random needling-type EMG gave less significant pain relief. This was evidenced in the control group by a larger percentage of patients having less than 50% pain relief; moreover, onset of pain relief was later than in the test group and less numbers of patients felt immediate reduction in pain after the EMG.

The muscles innervated by several involved nerve roots will have more focal areas of muscle spasm and a more scattered and widespread presence of tender myofascial bands than in muscles with fewer involved nerve roots. In the former type of situation, the muscles are not likely to be relieved of pain adequately with the one-to-two skin penetrations of a muscle associated with a single EMG examination. Therefore, the pain-relief effect would not have been appreciated if the muscles that were not examined were the muscles causing the patient more pain than the examined muscles. It is possible that the muscles of the patients presenting with more involved symptoms may have fibrosis in addition to muscle spasm and, therefore, are not responsive to the needling associated with an EMG (11). The changes in the inherent properties of muscle elasticity due to chronic nerve root irritation may play a significant role in maintaining pain.

The author documented that there were EMG abnormalities in multiple bilateral root distributions in patients with myofascial pain syndrome due to lumbosacral radiculopathy, despite the side of symptoms and, pain relief was obtained in those patients by the dry needling of multiple muscles of

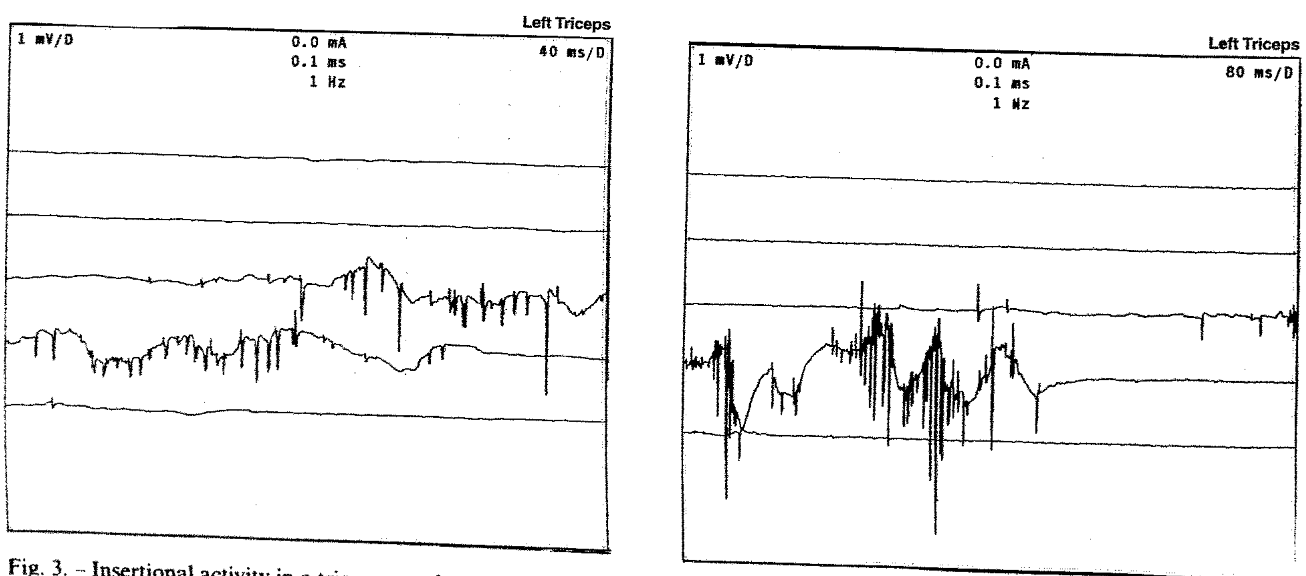

Fig. 3. – Insertional activity in a triceps muscle recorded at a random point within the muscle without prior palpation for a myofascial band. *Trace A* shows sparse insertional activity consisting of positive spikes and endplate spikes (negative or negative-positive spike form). *Trace B* shows grouped insertional activity culminating in a small twitch. Sweep speed 40 ms/division for Trace A and 80 ms/division for Trace B. Both traces recorded at a sensitivity of 1 mV/division.

the involved myotomes (2). Thus, in order to relieve myofascial pain symptoms due to multiple cervical radiculopathy, desensitization should include dry needling to multiple muscles in multiple myotomes.

Relating to EMG (IMS) and effects on pain

During EMG at the tender points, the presence of miniature endplate potentials (MEPPs) and endplate potentials (EPPs) discharges identified the location of the endplate zones. Upon needling the irritable motor endplate zones, the electrical phenomena evoked by mechanical stimulation would range from MEPPs, EPPs, grouped single-fiber discharges, fasciculations, and myokymic discharges to twitch responses (see Figs. 3 & 4) (2). Clinically, large twitch responses are seen or palpated. Spontaneous electrical activity has been found in trigger points (12, 14, 27, 28, 29). The author would define the points with the mechanically evoked electrical phenomenon consisting of MEPPs, EPPs, fasciculations, myokymic discharges, and twitches – as grouped single-fiber discharges, positive, negative, or negative-positive form – as *minor trigger points.* The *major trigger points* are defined when clinical twitches are obtained (2).

The force produced from the discharge of these potentials, especially that of the twitch responses, can produce alteration of muscle fiber length and tension. This can occur through stimulation of large-diameter muscle afferent fibers such as Group Ia, Ib, and Group II, producing a pain-relieving effect by activating the gating mechanism as described by Melzack and Wall (21, 22). Dispersion of nociceptors or a desensitization effect on the sympathetic afferent fibers, especially those in blood vessel walls, may occur from the lengthening of the muscle fibers associated with a fasciculation or a twitch. In addition, muscle contractions under ischemic conditions are prevented, and a vicious cycle maintaining the spasm or physiologic contracture is eliminated (31, 32).

Cannon and Rosenblueth described denervation supersensitivity (1). Any measure that blocks the flow of motor impulses and deprives the effector organ of excitatory input for some time causes "disuse supersensitivity" in that organ and in associated spinal reflexes (26). With supersensitivity, the nerves and muscles become hypersensitive and react abnormally to stimuli (1, 7, 35). The presence of denervation supersensitivity and disuse supersensitivity may have caused mechanical provocation by the needle to easily cause discharge of endplate spikes, grouped single muscle fiber dis-

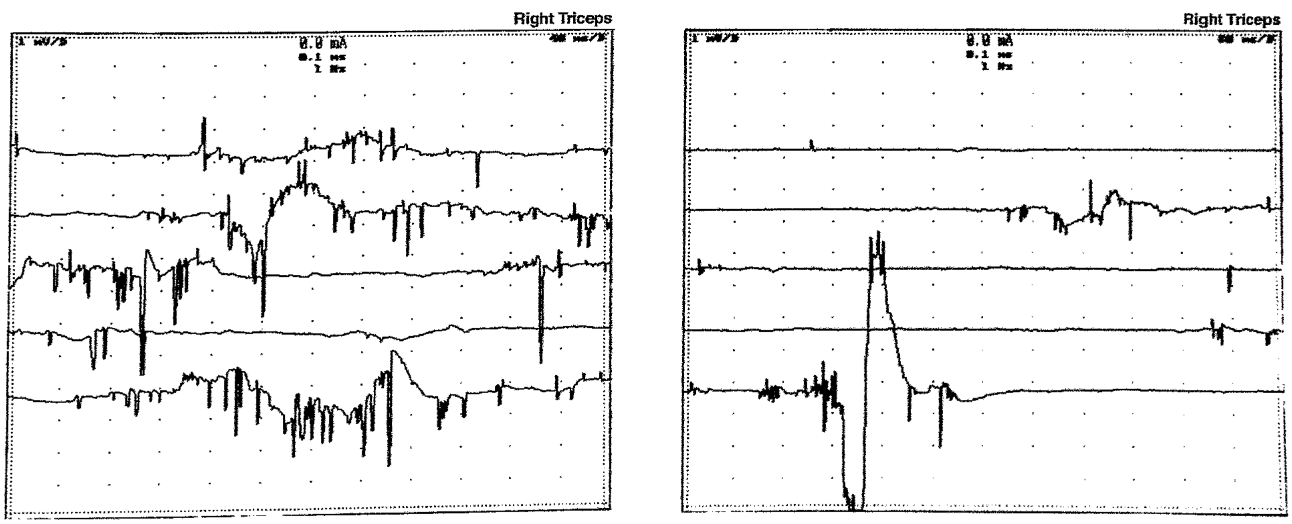

Fig. 4. – Insertional activity in a triceps muscle at a tender point within a myofascial band showing (*A*) increased insertional activity consisting of grouped endplate spikes (negative or negative-positive form) and positive spikes, and Trace (*B*) showing a grouped insertional activity culminating into a large twitch response. Sensitivity in both traces was set at 1 mV/division Sweep speed was set at 40 ms/division for Trace A and 80 ms/division for Trace B.

[*Note*: Tracings recorded with Keypoint Electromyograph, DANTEC Corp., Allendale, NJ, USA.]

charges, fasciculations, myokymic discharges, and twitch responses. Presence of visible or palpable twitch responses was noted in many muscles while performing the EMG, especially at the tender points. Occasionally, the twitch may be strong enough to cause a sudden movement of the joint, especially at the elbow, due to a sudden twitch of the triceps muscle, usually catching the patient and examiner by surprise. The author believes that the presence of discharges of sustained or grouped endplate potentials and twitch responses (see Figs. 3 & 4) are gradations of the same phenomenon of achieving focal muscle contraction of varying forces at a physiological level. Stretching occurs at the myofibrillar level with breaking of the actin-myosin bonds responsible for sarcomere shortening and stiffness. This, in turn, reduces the pain associated with mechanical manifestations due to muscle shortening. Occurrence of the pain relief is due to an effect on the alpha or gamma activity (19). An increase in gamma activity may occur if the site of the lesion is outside the muscle; for example, in a neighboring joint (20, 24). Relaxation of the treated muscles by obtaining twitch responses could lead to a lesser tension on the bones and joints onto which the tendons attach, thus having an effect on gamma motor neuron activity.

The twitches would cause sarcomere lengthening and release the energy-consuming contracture that led to tissue ischemia, metabolic deficiency, and energy crisis as described by Travell and Simons (32, 33). Large muscle fibers have a poor capillary supply, which can be impaired further by muscle spasm. An improvement in microcirculation previously restricted by focalized muscle spasm also occurs.

Patients who had EMG done at random points within the muscle had pain relief that was significantly less than that experienced by patients who had the EMG examination done at the tender points along the myofascial bands. Even with random pin penetration within the muscle, MEPP, EPP, and twitches as single-fiber grouped discharges (positive, negative, or negative-positive forms) occurred easily during EMG in those patients with pain symptoms (see Fig. 3). These discharges may occur without the fasciculations, myokymia, and twitch responses, indicating that these areas consist of more normal endplates or less irritable endplates and muscle fiber membranes. However, alteration of single muscle fiber lengths also may occur and may be the cause of the pain relief. This may be the physiologic explanation for pain relief in dry needling associated with body acupuncture using the meridian system (25). The acupuncture points have been shown previously to coincide with trigger points (22, 23). It is the author's opinion that the trigger points represent abnormally irritable motor endplate zones. These motor endplate zones (trigger points) can be randomly coincident with the acupuncture points.

When acupuncture points are identified by palpation for a tender point on the meridians immediately prior to the needling, there will be a better pain-relief response in acupuncture. The acupuncture effect using the body meridian could be due to the effect of the dry needling, which causes electrical discharges such as MEPPs, EPPs, fasciculations, myokymic discharges, and twitches. These electrical phenomena cause lengthening of the individual and groups of muscle fibers, thereby effecting pain relief by reducing the mechanical tension on the blood vessels, tendons, bones and joints. The mechanical tension is created by the shortening of muscle fibers secondary to nerve root irritation (9, 11). The efficacy of acupuncture thus would be proportional to the ability of the acupuncture needle to discharge the electrical potentials described when the needle is precisely located at the tender points; that is, the motor endplate zones.

Increase in pain or longer duration of pain post EMG usually can occur in patients with a high motor point tenderness score and in patients who do not attain pain relief. This could result from direct mechanical activation of the nociceptors. Sensitization of the nociceptors by neurovasoactive substances and other substances released from damaged tissues and/or blood constituents also could occur, resulting in muscle tenderness. When the needling misses the very active trigger points in which twitches can be elicited, inadequate desensitization occurs, since muscle contraction and subsequent relaxation cannot be achieved. The randomly inserted EMG pin that misses the tender points and, therefore, the irritable motor endplate zones, can cause more muscle fiber tightness from the inability to depolarize the more normal endplates of muscle fibers or the muscle membranes at that region. A microscopic area of bleeding and inflammation from needle-induced tissue trauma may have acted as an irritant, thereby causing a physiologic contracture of the muscle fibers and aggravating the underlying local spasm or local contracture at these points. Any increase in the shortening of the muscle fibers at the examined points thus would exacerbate the underlying pain from the increase in the mechanical effects associated with muscle fiber shortening (9, 11). In the presence of neuropathic involvement, a stimulus could trigger a response greater than normally expected due to the presence of denervation supersensitivity (1). In such situations, the EMG needle would be an irritant and would cause an unintentional increase in local muscle spasm or physiologic contracture in many examined muscles, even in the muscles that were not examined, due to a mechanical disturbance in the balance of pull of the adjoining muscles.

Conclusion

The EMG examination did reduce the underlying myofascial pain in patients with neck and arm pain symptoms related to cervical nerve root irritation. The irritation involved many nerve roots bilaterally, especially at the C6 and C7 levels. The original pain symptoms may be reduced on an average of about eight to ten days. Patients with the most pain relief were those who had the EMG examination done at the tender points along the myofascial bands. Pain relief had an inverse association with the number of nerve roots involved on the EMG. The number of days of pain relief was influenced by the percentage of pain relief obtained. Patients who had pain relief tended to have less bilateral symptoms and a lesser total score for tender motor points; moreover, they tended to have immediate pain relief. However, the duration of pain symptoms affected the onset of pain relief. Most of these patients also showed an associated improvement in the range of motion of the neck and shoulders. Pain may be exacerbated after an EMG. This is more common in patients who had random needling of the muscles. Improvement in range of motion was uncommon in patients who had an increase in pain or who had no pain relief after the EMG. These patients tended to have at least four cervical nerve roots involved. The pain relief was associated with the needling to the motor endplate zones, with the occurrence of twitch responses noted at the EMG or clinical level.

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