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Original article

Effects of dry needling at tender points for neck pain (Japanese: *katakori*): near-infrared spectroscopy for monitoring muscular oxygenation of the trapezius

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Abstract

Background. Neck pain *(katakori)* is a common symptom in adult Japanese people. However, the pathophysiological aspect of this condition has not been well documented to date. The purpose of this study was to investigate the effects of tender point dry needling to the trapezius muscles and the resultant changes in muscular hemodynamics.

Methods. "Neck pain" patients were defined as those complaining of dull pain or discomfort mainly along the trapezius muscles without serious spinal or shoulder disorders. We used near-infrared spectroscopy to monitor the changes of oxyhemoglobin (oxyHb) and deoxyhemoglobin (deoxyHb) of the trapezius muscles and a Visual Analogue Scale (VAS) to assess subjective neck pain intensity. Experiment I: Nine subjects with "neck pain" and four control subjects were recruited. Total hemoglobin (Hb) and SdO_2 [= oxyHb/(oxyHb + deoxyHb)] were measured before and immediately after needling for 15 min. We compared these parameters and VAS before and immediately after needling. Experiment II: Thirteen subjects with "neck pain" were instructed to perform isometric contraction of their trapezius muscles for 1 min; the half-recovery time of SdO_2 (defined as T_R) was measured. After that, all subjects underwent needling. On the next day, we repeated the measurements of T_R after the same voluntary contraction of the trapezius muscle in the same patients. We compared T_R and VAS before and on the day after needling.

Results. Experiment I: All subjects with "neck pain" reported significant pain relief ($P = 0.0147$) measured by VAS immediately after needling, but total Hb and SdO_2 exhibited no significant change after needling. Experiment II: T_R was shortened on the day after needling in 10 of 13 patients ($P = 0.0043$), and neck pain was decreased in 12 patients ($P = 0.0158$).

Conclusions. After dry needling, total Hb and SdO_2 did not change in real time, but T_R was shortened on the next day. These results showed that the shortening of T_R would provide a measure by which to assess the effectiveness of treatment for neck pain.

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Introduction

Neck pain (in Japanese: *katakori*) is a common symptom in adult Japanese people. There are several terms that express this symptom in English, including neck pain,[1,2] chronic neck pain,[3–7] stiff neck,[8] and trapezius myalgia.[9] Many articles have described these symptoms, but the definitions are not unified and *katakori* does not always reflect these symptoms. For convenience, we chose the term "neck pain" as the expression of Japanese *katakori* in this article.

In general, neck pain is felt as a dull pain or discomfort along the trapezius muscles and muscles around the scapulae. The pathology of neck pain has been widely discussed, but the main symptoms are located in the above-mentioned muscles. Therefore, there is a possibility that some changes arise in local muscular tissue itself contributing to the occurrence of this symptom. Hiraizumi[10] reported that the trapezius muscular blood flow of neck pain patients was lower than that of control subjects. Discussing the pathology of neck pain, changes of local muscular tissue, and especially the disturbance of local hemodynamics, is thought to be of importance.

Near-infrared spectroscopy (NIRS) is one method for evaluating muscular hemodynamics and is good for monitoring tissue oxygenation and hemodynamics in vivo and noninvasively. Some researchers have reported studies on neck pain evaluated with NIRS,[11–13] but only a few studies have detected objective changes in response to treatment of neck pain.[9,13] The purpose of this study was to investigate changes of intramuscular hemodynamics evaluated with noninvasive NIRS in response to tender point dry needling of the trapezius muscles as the treatment.

Materials and methods

In this study, "neck pain" patients were defined as those complaining of dull pain or discomfort mainly along the trapezius muscles without serious spinal or shoulder disorders. The neck pain patients were included in this study if they had experienced uncomplicated neck pain for a minimum of 2 weeks. Patients who had undergone surgery or those with dislocation, fracture, neurological deficits, or systemic disorders were excluded.

As the NIRS system, we used a noninvasive oxygenation monitor system (OM-200, No. P/N 101-40200; Shimadzu, Kyoto, Japan) for monitoring the hemodynamics of the trapezius muscles. This apparatus uses four wavelengths (690, 780, 805, and 830 nm) to measure changes in the optical density of oxyhemoglobin (oxyHb) and deoxyhemoglobin (deoxyHb). The optical density of oxyHb and deoxyHb were calculated with respect to an initial arbitrarily set value equal to zero and expressed in arbitrary units. From these two variables, we can obtain Total Hb and SdO_2 using the following formulas.

Total Hb = oxyHb + deoxyHb (arbitrary units)
SdO_2 (%) = oxyHb/(oxyHb + deoxyHb)

Total Hb reflects the amount of total hemoglobin in the muscular tissue of interest, whereas SdO_2 indicates the oxygenation rate.

We selected the left trapezius muscles to monitor the hemodynamics of intramuscular tissue for uniformity. In the NIRS system, the pattern of the light path detected from input to output follows a banana-shaped figure in which the penetration depth into the tissue is approximately equal to half the distance between the light and the detector.[14] Thus, the probe measures changes of tissue oxygenation at a depth of 2–3 cm from the skin surface. Therefore, the data obtained by this apparatus represented the changes of the muscular tissue of the trapezius.

In this study, a Visual Analogue Scale (VAS) was used to assess subjective pain intensity. The VAS pain scale consisted of a horizontal 10-cm line with the words "no pain" at one end and "pain as bad as it could be" at the other end.

This study was approved by the institutional review board of the Rishiri Island Central Hospital and met all guidelines for the ethical conduct of studies as delineated in the Declaration of Helsinki. All subjects were informed that data from this study would be submitted for publication and gave their consent.

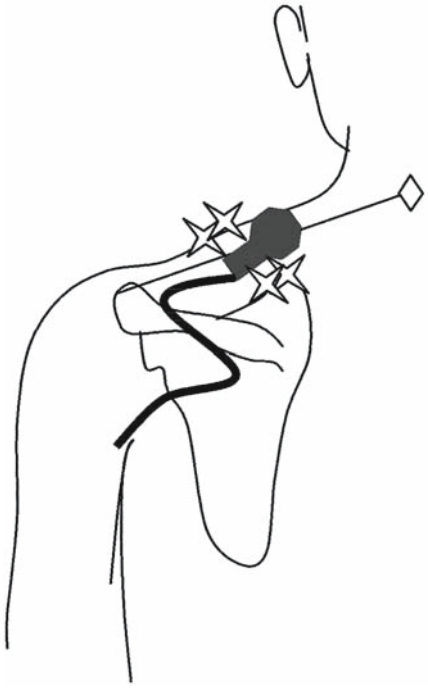

Fig. 1. Near-infrared spectroscopy (NIRS) probe was placed on the midpoint between the C7 spinous process and the acromion. *Four-pointed stars* indicate the points at which needling takes place

Experiment I

In experiment I, the study group consisted of nine subjects with neck pain (two men, seven women; ages 22–48 years, average 35.1 years) and four control subjects (four men; ages 25–27 years, average 26.0 years). They were recruited from the staff of the Asahikawa Medical College Hospital.

The NIRS probe was placed on the midpoint between the C7 spinous process and the acromion (Fig. 1) with an elastic bandage. This point is located on the trapezius muscles, and the tender points of neck pain often lie near this point. Six disposable needles (J type, No. 3; Seirin, Shizuoka, Japan) of the dimensions 0.2×40 mm were inserted through the skin around the NIRS probe (obliquely pointed about 20 mm under the center of the probe) and penetrated the fascia of the trapezius muscle. These needles were left in situ for 15 min without further manipulation. Total Hb and SdO_2 of the trapezius muscle just under the probe were measured continuously from about 5 min before insertion until 5 min after withdrawal of the needles.

We compared total Hb and SdO_2 before and immediately after needling. All subjects were also assessed for degree of the neck pain using a Visual Analogue Scale (VAS) before and immediately after needling.

Experiment II

In experiment II, the study group consisted of 13 subjects with neck pain (five men, eight women; ages 24–48

years, average 36.5 years). They were recruited from the staff of the Asahikawa Medical College Hospital and the inhabitants of Rishiri Island and Yagishiri Island. Three subjects participated in both experiments I and II.

At first, all subjects were assessed for degree of the neck pain using VAS. The NIRS probe was then placed on the midpoint between the C7 spinous process and the acromion with an elastic bandage. All subjects were instructed to perform isometric exercise; they held two dumbbells (2 kg × 2) and contracted their trapezius muscles with maximum effort for 1 min. Throughout this isometric exercise, the change of SdO_2 was measured.

Generally, the line graph of SdO_2 shows a linear decrease pattern during the early phase of exercise, and during the late phase of exercise the SdO_2 value may maintain a constant value or may slightly increase or decrease (Fig. 2). In the case of healthy muscle, the value of SdO_2 recovers immediately to the level of the rest phase after the cessation of exercise; if the aerobic capacity of the muscle is impaired, the recovery time of SdO_2 is prolonged. The half-time from the cessation of exercise until the maximum recovery of SdO_2 is defined as T_R, which has been used to evaluate the aerobic capacity of muscles.[14,15] We measured T_R in this study in relation to oxygen delivery and demand of local tissue (Fig. 2).

After the measurement of T_R was finished, all subjects underwent tender points dry needling therapy. Six to ten disposable needles (J type, No. 3; Seirin) of the dimensions 0.2 × 40 mm were inserted perpendicularly at the tender points of the trapezius muscle as treatment. These needles were left in situ for 15 min without further manipulation. On the day after needling (at the same time and in the same room as the first day, with no significant change of room temperature), all subjects were again assessed for degree of neck pain using VAS. They then repeated the same exercise as the day before; and the T_R on the day after needling was measured. The same examiner measured T_R on the first and second days. We compared T_R and VAS values for before and on the day after needling.

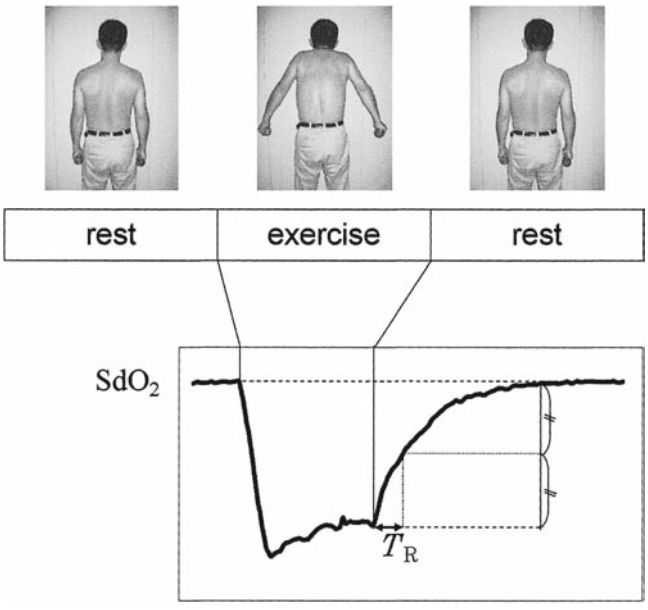

Fig. 2. Subjects were instructed to perform isometric exercise. They held two dumbbells (2 kg × 2) and contracted their trapezius muscles with maximum effort for 1 min. T_R is defined as the half-recovery time of SdO_2

Statistical analysis

The nonparametric Wilcoxon signed rank (two-tail) test and Spearman's correlation coefficient by rank (two-tail) test were used for analysis. P values were calculated using the plug-in software Statcel version 10 (OMS, Saitama, Japan). For all tests, $P < 0.05$ was regarded as statistically significant.

Results

Experiment I

All the subjects reported some degree of pain relief immediately after needling in the neck pain group. The average VAS score changed from 7.4 (before needling) to 3.3 (immediately after needling) with statistical significance ($P = 0.0147$) (Table 1). In contrast, the average total Hb in the muscle treated by dry needling exhibited no significant difference; before needling it was 33.6 (arbitrary unit) and immediately after needling it was 33.9 (Table 2). There was also no significant difference between before needling and immediately after needling in the control group (Table 2). The average SdO_2 also showed no significant difference; before needling it was 74.1 (arbitrary unit) and immediately after needling it was 70.7 (Table 3).

Table 1. Average VAS score in the neck pain group (experiment I)

Condition	VAS score (cm)	P
Before needling[a]	7.4 ± 1.9	
Immediately after needling	3.3 ± 1.7	
Before vs. after needling		0.0147*

Results are the mean ± SD
VAS, Visual Analogue Scale
* Wilcoxon signed rank test

Table 2. Average total hemoglobin (arbitrary units) (experiment I)

	Condition		
	Before needling[a]	Immediately after needling[a]	Significance
Neck pain(+)	33.6 ± 18.0	33.9 ± 18.2	NS
Neck pain(−)	47.9 ± 20.8	48.4 ± 21.4	NS

[a] Mean ± SD

Table 3. Average SdO_2 (%) (experiment I)

	Condition		
	Before needling[a]	Immediately after needling[a]	Significance
Neck pain(+)	74.1 ± 9.0	70.7 ± 10.2	NS
Neck pain(−)	75.1 ± 1.8	74.2 ± 3.8	NS

[a] Mean ± SD

Table 4. Average VAS score and T_R (experiment II)

	Parameter		
	Before needling[a]	Day after needling[a]	P*
Average VAS (cm)	5.2 ± 2.4	3.6 ± 2.3	0.0158
Average T_R (s)	12.5 ± 5.2	6.8 ± 3.9	0.0043

[a] Mean ± SD
* Wilcoxon signed rank test

Experiment II

The average VAS score decreased on the day after needling in 12 of 13 subjects. The average VAS score changed from 5.2 (before needling) to 3.6 (the day after needling) with statistical significance (P = 0.0158) (Table 4). T_R decreased on the day after needling in 10 of 13 patients (≥2 s decrease was defined as a significant change). The average T_R changed from 12.5 s (before needling) to 6.8 s (the day after needling) with statistical significance (P = 0.0043).

There was only one subject whose VAS increased on the day after needling and whose T_R also increased. Statistically, the correlation between the decrease of VAS and the decrease of T_R was not significant (correlation was 0.2, P = 0.5).

Discussion

Near-infrared spectroscopy is a well-established technique for monitoring tissue oxygenation in vivo. The advantages of NIRS are (1) it is noninvasive; (2) it is compact, inexpensive, and easy to operate; (3) it requires only a short measurement time; and (4) repeated measurements are allowed.[14] In our study, we used the half-recovery time of SdO_2 (T_R) in relation to the oxygen delivery and demand of local tissue. T_R, which has been used to evaluate muscle aerobic capacity by many researchers, ranges from short to long and is interpreted as a measure of the time for revival of oxygen and energy deficits following exercise.[14,15]

Takakuwa and colleagues[11] found that the T_R of the trapezius muscles was longer in neck pain patients than in control subjects. From the viewpoint of hemodynamics, their results indicated that the trapezius muscles in neck pain patients had impaired delivery of oxygen. To investigate "neck pain" further using NIRS, we designed a study comparing the degree of the neck pain and the T_R of the trapezius muscles in the same subjects before and after treatment of their neck pain.

With this study design, the same examiner treated subjects with needles and assessed the degree of pain with VAS; sham treatment was not performed. There was thus a possibility that there were some bias and placebo effects in our subjective assessment data.

We chose dry needling of tender points as the treatment for the neck pain. At first, in experiment I, we found that there was no significant change in the total Hb or SdO_2 in local muscle in real time, although the neck pain decreased immediately after needling. This result showed that the amount of tissue hemoglobin or the oxygenation rate had no relation with improvement of the neck pain. This may suggest that the amount of

tissue hemoglobin or the oxygenation rate make little contribution to neck pain. Sandberg et al.[9] reported that blood flow of the trapezius muscle increased only for the first 5 min of needle stimulation in patients with trapezius myalgia. They speculated that disturbances in the regulation of the microcirculation might have contributed to the small changes in blood flow in response to needling.

We then demonstrated in experiment II that in the same neck pain patients T_R was shortened on the day after needling with statistical significance. The degree of neck pain was also decreased on the day after needling. It was possible that needling stimulated the nociceptors in the trapezius muscle, thereby improving the microcirculation of the muscular tissue. This result showed that the impaired muscle aerobic capacity was reversible in response to dry needling along with alleviation of the neck pain. From the viewpoint of hemodynamics, the results of these two experiments indicated that the pathology of the neck pain had a closer relation with the muscle aerobic capacity than the total volume of tissue hemoglobin or the oxygenation rate. Our results also indicated that the shortening of T_R of the trapezius muscle provides a marker by which to assess the effectiveness of treatments for neck pain.

Technically, dry needling of tender points used in this study is similar to acupuncture, which is a branch of traditional Chinese medicine. With our method the points of needling were simply those exhibiting "tenderness" upon palpation, whereas acupuncture points should be selected according to the theory of channels used in traditional Chinese medicine. In acupuncture there also exist "*ah shi* points," which have no fixed location and are found by eliciting tenderness or pain at the site of greatest sensitivity. *Ah shi* points could also be selected when treating neck pain. However, acupuncture treatment typically consists of not only *ah shi* points but also distant or regional acupuncture points localized on affected channels. Therefore, acupuncture differs from tender points dry needling in a precise sense.

Incidentally, dry needling or injection therapies based on the myofascial "trigger point" mechanism are widely performed. A trigger point is not simply a tender point. Characteristic features commonly associated with the diagnosis of trigger points include referred pain, taut muscle bands, local twitch response, and the jump sign.[16,17] In this study protocol, the target of dry needling was a tender point, not a trigger point. Some tender points in our study might also be trigger points by chance, but strictly speaking tender points and trigger points are not the same.

Many systematic reviews have included studies relating to the efficacy of acupuncture as a treatment for neck pain. White and Ernst[1] reported in their systematic review that there were equal numbers of positive and negative randomized controlled trials of acupuncture for neck pain. Smith et al.[18] concluded in their systematic review that acupuncture was no more effective than placebo. Thus the question of the efficacy of acupuncture for neck pain remains unanswered.[6]

From the viewpoint of biomedical engineering, many reports about thermography in combination with acupuncture can be found. Litscher[19] reported some studies concerning visualization of peripheral changes in perfusion during acupuncture with the use of thermography. Using photoplethysmography, Sandberg et al.[9] reported different patterns of blood flow response in the trapezius muscles following needle stimulation.

Despite the high prevalence of neck pain, our pathophysiological understanding of this symptom is insufficient. In this study, we have shown that dry needling shortened the T_R of trapezius muscles in neck pain patients along with alleviating symptoms. We chose dry needling as the treatment for neck pain; however, other treatments such as manipulation or injection therapy that would decrease neck pain might have yielded the same results, namely shortening the T_R along with diminishing the symptoms.

Conclusion

Three results were obtained from the present study. First, as measured by VAS, dry needling at local tender points decreased neck pain, not only immediately after needling but also on the day after. Second, dry needling did not change the SdO_2 or total Hb of the trapezius muscle immediately after needling. Third, dry needling shortened the T_R (i.e., muscular aerobic capacity improved) on the day after needling. These results indicated that shortening the T_R (of trapezius muscles) provides a marker by which to assess the effectiveness of treatments for neck pain *(katakori)*.

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