Clinical Validation of Pain Management Manipulative Therapy for Knee Osteoarthritis With the Squeeze-Hold Technique: A Case Series

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ABSTRACT

Objective: The purpose of this case series was to describe the short-term and long-term clinical effects of a manual technique for treating osteoarthritis (OA) knee pain.

Methods: This study measured of the immediate effect and long-term effect by using a case series of different groups of subjects. Knee OA and activity restriction in patients were evaluated by using the Kellgren-Lawrence (K/L) Grading Scale and the Japanese Knee Osteoarthritis Measure (JKOM) index. In the intervention, lower limb muscles were squeezed by hand for 20 seconds. Each squeeze was performed for both lower limbs. Passive range-of-motion (ROM) exercise was performed on the knee joint. In one set of cases, immediate effects were measured after a one-time treatment with pretreatment and posttreatment outcome measures. Eleven people with knee OA participated in the study. On a visual analogue scale (VAS) for pain, muscle stiffness, and muscular hemodynamics for estimation of muscle blood flow were recorded before and after the squeeze-hold treatment. In another set of cases, the treatment was given to all patients once a week for 6 months, and long-term effects were measured. Data on 5 subjects with knee OA were collected for 6 months after initial treatment. The VAS for pain and JKOM were recorded every month for 6 months.

Results: For immediate effects, the VAS was 69 ± 21 mm before treatment and 26 ± 22 mm after treatment. Muscle stiffness was 8.8 ± 3.6 (absolute number) before treatment and 3.5 ± 2.1 after treatment. Tissue (muscle) oxygen saturation was $60.1 \pm 5.7\%$ before treatment and $65.3 \pm 4.8\%$ after treatment. Total hemoglobin was 24.3 ± 3.3 (absolute number) before treatment and 25 ± 2.3 after treatment. A tendency for reduction in OA knee pain and muscle stiffness was observed, and a tendency for increase was observed in the blood flow in the muscle. For long-term effects in all 5 participants (any K/L grade, any JKOM score), OA knee pain and JKOM score improved gradually through 6 months.

Conclusions: The participants in this case series showed improvement in pain and function. These findings indicate the feasibility of a larger study on the squeeze-hold intervention for OA knee pain. (J Chiropr Med 2017;16:122-130)

Key Indexing Terms: *Osteoarthritis, Knee; Pain Management; Manipulative Therapy*

INTRODUCTION

Knee osteoarthritis (OA), a degenerative joint disease and a major cause of locomotor disability, is likely to affect over 250 million people worldwide.¹ Knee OA limits the movement of 80% of affected individuals, and 25% of

affected individuals are unable to perform their major activities of daily living. Moreover, 11% of individuals with knee OA require personal care.² The prevalence of radiographic knee OA is approximately 37.4% among Americans 60 years or older.³ In developed countries, the incidence of knee OA is rising as the population ages. The increasing number of older people with functional impairments is dramatically affecting the medical economy.⁴ For example, 9.3 million people in the United States have symptomatic knee OA, and the average discounted lifetime costs for people with a diagnosis of knee OA are estimated at \$140,300.⁵ Despite the high prevalence and the significant economic burden, OA of the knee remains incurable.^{6,7}

The main problem with OA of the knee, and the biggest factor in the disability of patients, is pain.^{8,9} Pain renders patients inactive, and decreased joint movement disturbs the repair capacity of the articular cartilage. Moreover, inactivity weakens the lower extremity muscles, and this accelerates the progression of OA.¹⁰ Thus, pain exacerbates

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Fig 1. Basic squeeze-hold procedure. Squeeze-hold was performed on front thigh muscles, front leg muscle, back thigh muscles, and back leg muscles in a single treatment (all muscles attached to the knee joint) (B1, B2, B3, B4). The muscles were squeezed and held for 20 seconds each time, proximally to distally in each section (A1-A3). Front thigh (B1): Gently compress over the femur with the right hand, on the hip adductor muscle (left hand) hard (at a strength of 2 to 8 approximately). The area on the bone is a high pressure-prone area. Be careful not to strain the femoral neck, especially in the patient with osteoporosis. Front leg (B2): Hold medial surface of leg with one hand (left hand) and squeeze tibialis anterior with the other hand (right hand). At that time, hold the knee in slight flexed position by use of cushions to prevent straining the knee joint. Back thigh (B3): Compress with your hand over the femur (right hand) gently, on the hip adductor muscle (left hand) hard (at a strength of 2 to 8 approximately) for the similar reason as in the case of the front thigh. Back leg (B4): Compress with both hands simultaneously. Use cushions to avoid pressure on the patella (patellofemoral joint) from the squeeze-hold. If the patella is strongly compressed on the bed, the patient feels pain in the knee. Use cushions to prevent straining the knee joint, especially in the case of knee flexion contracture. Measures of compression strength (C): The reference dose is 200–300 mm Hg when compressed with a blood pressure cuff. It has little effect if the compression is too weak and the squeeze of blood from muscles is inadequate. However, if a patient feels severe pain as a result of the compression, evident as excessive muscle tension early in the treatment, then perform the procedure twice, first gently and then firmly. Warning: If a patient holds the breath during treatment, blood pressure rises; therefore, the therapist must give instruction to the patient not to hold the breath. This is especially important in a patient with hypertension.

the disease pathology of OA in the knee. Pain relief is, thus, a key component of effective treatment.

Medication brings only temporary pain relief.¹¹ In conservative therapy, therapeutic exercises are considered an effective treatment for OA knee pain.^{12,13} However, sustained effort is required for the analgesic effect to be obtained, and patients find it difficult to remain motivated. Therefore, such treatments have not yet become a solution.¹⁴ More immediate and effective measures for OA knee pain are eagerly anticipated. Osteoarthritis knee pain is mostly associated with motion, not with rest. Many patients experience strong pain when they start to walk, but the pain subsides as they continue walking.¹⁵ In other words, pain develops when the periarticular muscles of the knee joint contract and is reduced by repeated contraction and relaxation. This gave rise to the idea that the muscles attached to the knee joint may be largely responsible for the development of pain. The hypothesis is that the pain is caused by muscle spasms and the retention of

pain-producing and pain-enhancing substances caused by poor blood flow in these muscles. The poor blood flow leads to local acidosis, and the acidosis produces pain-producing bradykinin and pain-enhancing prostaglandin.¹⁶ To flush the pain-causing substances out of the muscles, it is necessary to facilitate blood flow through the capillaries. Blood perfusion to capillaries is controlled by the smooth muscle precapillary sphincter. For this reason, to flush out the bradykinin and prostaglandin, it is necessary to dilate the precapillary sphincter. These precapillary sphincters dilate when there is an increase in carbon dioxide (CO₂) and a decrease in pH.¹⁷ CO₂ is increased, and pH is decreased by “squeezing and holding blood in the muscles” as the muscular cells metabolize. Squeezing and holding the leg muscles could theoretically relieve pain for people with knee OA.

Therefore, the purpose of this case series was to describe the squeeze-hold technique applied to people with knee OA and measure the immediate and long-term effects on pain and activities of daily living.

Table 1. Changes in Pain, Muscle Stiffness, Muscular Hemodynamics Before and After Treatment

Participant No.	Age	Sex	BMI	Side	K/L	JKOM	VAS (mm)		Muscle Stiffness		StO ₂ (%)		Total Hb	
							Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	78	F	26.5	Lt	II	55	66	15	4	2	67.4	76.1	23.5	23.3
2	71	F	25.7	Lt	II	67	80	50	5	1	61.7	67.1	20.6	22.1
3	81	M	22.0	Lt	III	44	35	11	7	2	66.8	71.7	24.2	26.9
4	82	F	23.5	Lt - Rt	IV - III	71	83	43	8	5	64.8	64.4	20.6	22.9
5	80	F	24.2	Lt	IV	33	39	1	16	6	61.5	64.3	25.6	25.9
6	72	F	22.2	Rt	II	31	80	21	10	2	50.0	62.7	20.0	25.8
7	72	F	22.5	Rt	III	56	57	9	9	1	59.0	62.8	26.1	24.9
8	78	F	23.1	Lt - Rt	II - III	81	96	64	14	7	59.9	65.2	23.5	23.8
9	87	M	21.0	Lt	I	44	80	49	7	4	58.7	62.6	31.4	29.8
10	78	M	24.2	Rt	II	22	52	11	6.5	4	50.6	59.0	26.2	26.5
11	75	F	22.8	Lt - Rt	III - II	60	93	10	10	5	60.8	62.7	23.0	22.9
Mean ± SD	77.6 ± 4.9		23.4 ± 1.6				69.2 ± 20.9	25.8 ± 21.5	8.8 ± 3.6	3.5 ± 2.1	60.1 ± 5.7	65.3 ± 4.8	24.1 ± 3.3	25.0 ± 2.3

BMI, body mass index; Hb, hemoglobin; JKOM, Japanese Knee Osteoarthritis Measure; K/L, Kellgren-Lawrence; Lt, left; Rt, right; SD, standard deviation; StO₂, tissue (muscle) oxygen saturation; VAS, visual analogue scale.

METHODS

This case series consisted of 2 groups of patients: 1 group to measure immediate effects and another to measure long-term effects. Each group included different types of subjects. All participants gave written informed consent, and the study was approved by the institutional review board of the Kibi International University research ethics committee.

Immediate Effects

Eleven patients with newly diagnosed OA of the knee (age range 71–87 years) participated in the study. They had been diagnosed by an orthopedic surgeon, and the diagnosis was based on radiograph analysis and physical assessment. The treatment, provided by a skilled physiotherapist, consisted of the squeeze-hold procedure on the lower limbs of the patients and passive range-of-motion (ROM) exercises. Passive ROM exercises were subsequently performed on the knee joint because all patients had limitation in ROM of the knee. This was performed 1 time, applying pretreatment and posttreatment outcome measures. The outcome measures were the visual analogue scale (VAS) for pain and muscle stiffness, as well as muscular hemodynamics. Furthermore, VAS for pain was evaluated with a self-administered questionnaire after the first week following initial therapy.

Long-Term Effects

This group comprised 5 patients (age range 65–79 years). The treatment, provided by a skilled physiotherapist, consisted of the squeeze-hold technique and passive ROM exercises. Because all patients had limitation in ROM of the knee, passive ROM exercises were performed for improvement of ROM. The treatment was performed on a weekly basis for 6 months, with outcome measures recorded once per month. The VAS for pain and the Japanese Knee Osteoarthritis Measure (JKOM) were recorded every month for 6 months after initial treatment.

Experimental Methodology

Squeeze-Hold. The lower limb muscles were squeezed hard by hand for 20 seconds. Each squeeze was performed to target the muscles in linear sequence through the lower limbs (Fig 1, A1-A3) but was not hard enough to cause pain in the patients. The therapist treated the front thigh muscles and front leg muscles (tibialis anterior) while the patient was in the supine position (Fig 1, B1, B2) and treated the back thigh muscles and back leg muscles with the patient in the prone position (Fig 1, B3, B4). The number of squeezes was 5 to 6 times in total, from the front to the back from the hip joint to the knee joint in both legs to ensure that no segment was left unsqueezed. These same 5 to 6 squeezes

Table 2. Change in VAS Score Over 1 Week

Participant No.	VAS (mm)								
	Pretreatment	Post-treatment	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
1	66	15	15	15	24	25	25	25	50
2	80	50	50	77	77	78	80	80	80
3	35	11	30	30	30	30	30	30	30
4	83	43	69	60	70	70	75	75	79
5	39	1	20	20	20	30	30	30	31
6	80	21	69	74	79	80	80	80	80
7	57	9	51	51	57	57	57	57	57
8	96	64	89	89	91	91	91	91	96
Mean $\pm$ SD	67.1 $\pm$ 20.0	21.4 $\pm$ 22.9	51.5 $\pm$ 23.9	53.8 $\pm$ 25.2	57.9 $\pm$ 25.6	59.2 $\pm$ 24.1	60.0 $\pm$ 24.6	60.2 $\pm$ 24.5	63.8 $\pm$ 22.5

The data were obtained by the self-completion method. Eight of the 11 participants submitted their data. SD, standard deviation; VAS, visual analogue scale.

were similarly applied to the area from the knee joint to the ankle joint. The squeezes were held for 20 seconds and kept tight. If the grip was loose, the procedure was repeated from the top.

Evaluation

Osteoarthritis. Osteoarthritis and activity restriction were evaluated by using the Kellgren-Lawrence (K/L) Grading Scale¹⁸ and the JKOM index.¹⁹ The K/L Grading Scale is a method of classification of radiographic OA and consists of normal, grade I, grade II, grade III, and grade IV (most severe). The JKOM index is a set of standardized questionnaires for evaluating patients with OA of the knee and is a modified Western Ontario and McMaster Osteoarthritis index,²⁰ which was developed for assessing activities of daily life among the Japanese. It measures 8 items for pain and stiffness in the knee joint (score range 0–32), 10 for influence of knee condition on daily life (score range 0–40), 5 for influence of knee pain on daily activity (score range 0–20), and 2 general health conditions (score range 0–8). The JKOM score assigns ranges from 0 (best) to 100 (worst).

Assessment of Treatment Effect. The VAS score was recorded to evaluate pain. The VAS for pain assigned values from 0 mm (best) to 100 mm (worst). Moreover, muscle stiffness and muscular hemodynamics, as well as oxygen saturation of the muscular tissue (StO₂) and total hemoglobin (Hb), were recorded before and after this therapy as the objective index associated with pain. The evaluated site for muscle stiffness and muscular hemodynamics was the gastrocnemius muscle. This site was chosen because of the absence of subcutaneous fat. A hardness gauge (durometer; Kobunshi Keiki Co Ltd, Kyoto, Japan) was used to measure muscle stiffness and a near infrared spectrometer (BOM-L1 TR; Omegawave, Inc, Tokyo, Japan) was used to measure muscular hemodynamics. The evaluated area of near infrared spectrometer was at a depth of 2 to 3 cm from the skin surface.

Statistical Analysis

Descriptive statistics were used to describe the features of the data and VAS for pain, muscle stiffness, and muscular hemodynamics in the immediate-effects group. Data were presented as mean $\pm$ standard deviation (SD), unless otherwise specified.

RESULTS

Immediate Effects

The VAS for pain was 69.2 $\pm$ 20.9 mm before treatment and 25.8 $\pm$ 21.5 mm after treatment. Muscle stiffness was 8.8 $\pm$ 3.6 (absolute number) before treatment and 3.5 $\pm$ 2.1 after treatment. StO₂ was 60.1 $\pm$ 5.7 % before treatment and 65.3 $\pm$ 4.8 % after treatment. Total Hb was 24.3 $\pm$ 3.3 (absolute number) before treatment and 25 $\pm$ 2.3 after treatment. Regardless of the condition of the knee OA (K/L grading, JKOM), these effects were similar (Table 1). The VAS scores for pain rose gradually day by day (Table 2).

Long-Term Effects

In all 5 participants (any K/L grade, any JKOM score), OA knee pain and the JKOM score improved gradually through sustained once-a-week treatment. In participant 1, participant 2, and participant 3 (who had good JKOM scores), the VAS score for pain decreased by half within 1 or 2 months after the initiation of treatment. In participant 4 and participant 5 (who had poor JKOM scores), it took more than 4 months for the VAS score for pain to decrease by nearly half (Fig 2).

DISCUSSION

This is the first study to assess the effects of the squeeze-hold technique on patients with knee OA. The

Fig 2. Long-term effect (5 participants). In participant 1 with minor disorder in JKOM, OA knee pain disappeared 2 months after the initiation of treatment. The Kellgren-Lawrence (K/L) grade was worse with a similar degree of the JKOM (participants 4 and 5), and it took longer to decrease the visual analogue scale (VAS) score for pain. The score of “influence on daily activity by knee-pain” in the JKOM improved in proportion to decreasing pain. In other words, it is suggested that pain decreased in proportion to increase in physical activity.

Fig 3. Pain deterioration chain. Some primary pain in the knee elicits secondary myogenic pain. The patient is drawn into a “Pain deterioration chain” and begins to suffer chronic pain.

preliminary results showed that muscle stiffness was reduced, and StO₂ increased on the unchanging total Hb before and after the squeeze-hold treatment. Increased StO₂ on the unchanging total Hb indicated improvement of blood flow. Osteoarthritis knee pain gradually improved and diminished substantially in several months by sustained, once-a-week treatment regardless of the OA condition (K/L, JKOM).

These findings could be interpreted to mean that OA knee pain is principally musculoskeletal in origin. Osteoarthritis knee pain has many causes and has been poorly understood. It arises from not only the periosteum and subchondral bone but also from the tendons, ligaments, and muscles surrounding the knee joint.²¹ The squeeze-hold technique can reduce OA knee pain and appears to be effective regardless of OA grade, suggesting that OA knee pain is principally myogenic. Some reports^{22,23} have confirmed that the severity of knee joint disease, as shown by radiography, is only weakly related to OA knee pain.

It may be possible that OA knee pain is myogenic. Possible mechanisms are as follows: The γ -motor neurons located in the spinal cord are responsible for controlling skeletal muscle with the α -motor neuron counterparts. Pain triggers γ -motor neuron activity in the muscle spindle afferents and increases muscle stiffness.²⁴ Increased muscle stiffness affects the state of chronic ischemia in the muscular capillaries and induces inflammatory mediators, such as pain-enhancing substances, to reduce the threshold of nociceptors. Moreover, lasting pain promotes muscle sympathetic nerve activity and peripheral vascular constriction to local hypoperfusion. The anoxic conditions from hypoperfusion set up the dysfunction of muscular relaxation by inhibiting the production of adenosine triphosphate.²⁴ Furthermore, pain induces reflex inhibition and early muscle atrophy.^{25,26} Weakness in the quadriceps muscles accelerates the progression of OA in the knee.¹⁰ It is possible that some primary pain in the knee, such as the pain of inflammation, induces muscle stiffness and

Fig 4. Presumed pain relief mechanism for the effect of squeeze-hold. Blood is squeezed in the area where squeeze-hold is performed (A). This condition raises carbon dioxide (CO₂) concentration, and vascular smooth muscle relaxation occurs in the area (B). By increasing the blood flow, pain-producing substances are flushed out, and pain is relieved (C).

muscular hypoperfusion and may generate greater myogenic pain. Thus, a vicious cycle of pain is formed, and the pain is exacerbated (Fig 3).

Stretching and massage may relieve muscle stiffness. However, these treatments are not believed to relieve the pain of OA of the knee. In this study, after the squeeze-hold technique was used, patients provided positive feedback, such as “It feels so comfortable on my legs” and “I have good blood flow in my legs.” Increased muscle blood flow was demonstrated in this study. The palliative effect of the squeeze-hold technique could be attributed to improved blood flow through the muscles.

The presumed mechanism for the effect of the squeeze-hold technique is shown in Figure 4. Increase of CO₂ and decrease in pH are known to produce vascular smooth muscle relaxation. Blood is squeezed from the muscle tissue, and blood flow is constricted to the muscle

tissue in the area where the squeeze-hold technique is applied. With continuing treatment, CO₂ accumulates and pH decreases as muscular cells metabolize. This results in the relaxation of the precapillary sphincter in the area, which, in turn, leads to vasodilatation. Therefore, through muscle sympathetic nerve hyperactivity, even inactive capillaries in the muscles could be allowing blood to flow and pain-producing substances to leave the muscles. This dovetails with the fact that a block of time is required to obtain the full effect of the squeeze-hold technique.

In our study patients, the pain, however, may have gradually returned (Table 2) because the vasodilating effect of the squeeze-hold technique is temporary. The reaccumulation of pain-producing substances must have been gradual. Although in our study, the palliative effect was temporary, knee pain gradually improved by sustained once-a-week treatment in spite of the VAS score, K/L grade, and JKOM score (Fig 2). This may be attributed to improvement in the cause of the initial pain that comes from an increase of physical activity. The patients became more physically active when they were in less pain. Joints, especially cartilage, are always placed under mechanical stress by joint movement, and joint movement is important in the preservation of cartilage metabolism. Constant immobilization produces OA-like degeneration.²⁷⁻³⁰ Marked decreases in joint movement because of pain lead to worsening of knee OA. Physical activity increases blood flow to the articular tissue.³¹ Mechanical stimuli inhibit the degeneration of articular cartilage and have a positive effect on articular metabolism. Cyclic compressive loading on articular cartilage enhances chondrocyte biosynthetic response and extracellular matrix production.³²⁻³⁷ Moreover, cyclic compressive loading has chondroprotective effects. It inhibits the release of matrix metalloproteinase and proinflammatory mediators, such as interleukin (IL)-1 β , IL-6, tumor necrosis factor- α , and monocyte chemoattractant protein-1.^{38,39} Additionally, it inhibits the release of shear stress-induced nitric oxide that induces chondrocyte apoptosis.⁴⁰ With regard to the repair of cartilage lesions, joint movement enhances the healing of defects in the articular cartilage.⁴¹⁻⁴³ Thus, primary pain relief may occur as the result of enhanced homeostatic capacity through improved blood flow and increased mechanical stimuli. The reduction of primary pain may lead to a decrease in secondary myogenic pain. In this study, the frequency of treatment was once a week. More frequent treatments might further enhance the effect of treatment, as we observed that pain relief did not last for a week (Table 2). Decrease in physical activity because of pain caused worsening of the disease state. If the pain relief is immediate and considerable, physical activity might well increase automatically, improving articular metabolism and inducing a chondroprotective effect. It also might increase lower limb muscle strength. All of these effects can work synergistically to strengthen the body's natural healing power

in the medium and long terms. The key is pain relief obtained through knee OA treatment. The squeeze-hold technique can thus be a breakthrough in the treatment of knee OA.

The squeeze-hold technique is similar to many other forms of skin-connective tissue-muscle massage, but it has a different purpose. The overriding aim of skin-connective tissue-muscle massage is the inhibition of motor neuron excitability, relaxation response, and shift to parasympathetic nervous system activation by mechanoreceptor stimuli with moderate pressure (light touch).⁴⁴⁻⁴⁶ In contrast, the aim of the squeeze-hold technique is the elimination of pain-producing substances in muscle through vasodilatation by increasing CO₂ concentration. The squeeze applied is as hard as possible so that it forces out blood until the patient does not feel intense pain.

We are not aware of another therapy for treating OA knee pain such as the squeeze-hold technique, which is based on the idea that pain-producing substances are washed out through relaxation of vascular smooth muscle by increasing CO₂ concentration. Because of the immediately noticeable effect of this treatment, patient satisfaction is fairly high from the first treatment. Pain relief brought about continuous improvement in knee OA, as expected. Additionally, the technique is simple, is easy to learn and perform, and requires no specialized equipment. This therapy could offer hope to those struggling with OA knee pain.

Limitations

Although these results are promising, the sample size was small. Further large-scale follow-up studies are required to confirm the pain relief effect of squeeze-hold technique on knee OA. Additionally, the palliative effect of the squeeze-hold technique should be compared with other common manipulative therapies used to treat patients with OA of the knee. It was also difficult to control for confounding factors, such as medication and joint fluid aspiration, in the long-term effects group. In terms of implementation, the adequacy of strength and holding time of the squeeze and the frequency of therapy (the number of times in a week) have not been established. Moreover, the mechanisms of pain reduction in squeeze-hold therapy remain unclear. Although improved blood flow through the muscles was confirmed, the content of pain-enhancing substances in muscles was not investigated. Future research is needed to identify the effectiveness of this method of therapy. This study is a first step toward testing a new manipulative technique (squeeze-hold) for treating OA knee pain.

CONCLUSIONS

This study has provided preliminary evidence on the clinical effects of the squeeze-hold technique for treating OA knee pain and indicates the feasibility of a large-scale study.

Practical Applications

- This case series measured the reduction of osteoarthritis pain with the use of a hands-on technique.
- This new treatment requires no equipment and may be applicable in both developed and developing countries.
- Further research is needed to test this method.

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CONTRIBUTORSHIP INFORMATION

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