ORIGINAL RESEARCH

Evaluation of the Optimal Duration of Thumb Cupping Therapy for Frozen Shoulder by Thermal Metabolic Imaging

Yan Liu, MM; Yanli Xia, MM; Hongwei Chen, MM; Yuanyuan Zhu, MM; Chaoju Zhang, MD

ABSTRACT

Objective • To evaluate the optimal duration of thumb cupping therapy for frozen shoulder (FS) by thermal metabolic imaging (TMI) and to provide clinical evidence.
Methods • From April 2022 to August 2023, 120 patients with FS who received thumb cupping therapy at our hospital were randomized into groups A, B, and C for 5, 10, and 15 minutes of cupping, respectively. The clinical efficacy, Visual Analogue Scale (VAS) score, and shoulder range of motion (ROM) of the three groups were compared, and the skin blood flow and the incidence of adverse reactions during treatment were analyzed. Finally, the temperature difference improvement efficiency (i.e., higher TMI after treatment than before treatment) was compared among the three groups.
Results • Groups B and C showed higher overall clinical efficacy than group A ($P < .05$). After treatment, lower VAS scores were determined in groups B and C compared with group A, whereas the ROM values of groups A and C were smaller than those of group B Group C had the greatest skin blood flow and the highest incidence of adverse reactions ($P < .05$), while group B had the highest temperature difference improvement efficiency ($P < .05$).
Conclusions • Through TMI, it is confirmed that thumb cupping therapy with a duration of 10 min contributes to the highest efficacy and safety for patients with FS. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Frozen shoulder (FS) is an unexplained, self-limiting, aseptic inflammation of the soft tissue surrounding the shoulder, characterized by progressive shoulder pain, most pronounced at night, resulting in significant limitation of joint function.[1] The incidence of FS is extremely high in middle-aged and elderly people aged 40-70 and in long-term manual workers, with a global incidence of about 2-7%.[2] Although FS resolves spontaneously when it progresses to a certain extent, the resulting pain and influence on joint function can even reach 2-3 years, seriously affecting patients' normal life and work.[3] Therefore, patients should pay attention to the clinical intervention of FS to reduce its adverse threat.

In modern clinical medical treatment, traditional Chinese medicine (TCM) therapy is the most common treatment for FS, including acupuncture and oral or topical TCM, which has been shown to be effective in treating FS.[4,5] Among them, cupping therapy is a classic therapy with more than two thousand years of history in TCM, which mainly produces benign stimulation through negative pressure adsorption on the skin, thus achieving the purpose of treating diseases.[6] The thumb cupping therapy, which combines acupuncture and moxibustion, TCM, and external treatment, covers the three guiding treatment methods in the national standard version. This therapy has been used till today with reliable efficacy, simplicity, and cost-effectiveness and has now become one of the major FS treatment means recommended by the National Administration of TCM.[7] However, the current clinical cupping therapy guidelines mostly guide the standardized operation and treatment plan, lacking reliable references for the duration of cupping. Because of this, the selection of the duration of cupping has become the key dispute in modern cupping therapy. How to choose a duration of cupping that can achieve the goal of treating diseases without damaging the skin or causing other complications due to prolonged time is a difficulty in modern research.

As modern science and technology advance, human thermal metabolic imaging (TMI) is increasingly used in the medical field.[8] According to the thermal radiation generated by human cell metabolism, TMI comprehensively, intuitively,

and dynamically reflects the overall health status expressed by human metabolic heat, which can be used to observe the early pathological changes of various diseases and provide treatment guidance.[9] In FS, TMI has also been shown to accurately and effectively reflect the pathological changes of patients.[10]

Therefore, we believe that TMI can also be used to evaluate cell and tissue changes in FS patients during cupping to assist in clinical confirmation of the duration of cupping. However, there is no research to confirm our view. Accordingly, this study evaluates the optimal duration of thumb cupping therapy for FS through TMI, providing reference and guidance for future treatment of FS.

MATERIALS AND METHODS

Study participants

This is a randomized controlled trial of 120 patients with FS admitted to our hospital between April 2022 and August 2023. All of them received thumb cupping therapy in our hospital and underwent TMI testing. This study was strictly approved by the Ethics Committee of JingZhou Traditional Chinese Medicine Hospital (NO.2022113). It was carried out in strict accordance with the Declaration of Helsinki, with informed consent obtained from all participants. All patients were numbered in the order of admission (1-120), and then 40 of these numbers were randomly screened using a computer, and those corresponding to them were divided into groups (repeated 3 times). Using a table of random numbers, the patients were divided into three groups (n=40): group A, group B, and group C, with a cupping duration of 5 min, 10 min, and 15 min, respectively. All patients were unaware of their number as well as their grouping. Comparing patients' age, sex, course of disease, and other clinical data, we found no statistical significance among the three groups ($P > .05$) (Table 1).

Table 1. Comparison of clinical data

Group	Age	Course of disease (months)	Sex Male/Female	Location of pain Left/Right
Group A (n=40)	56.38±11.61	6.28±2.15	26 (65.00)/14 (35.00)	16 (40.00)/24 (60.00)
Group B (n=40)	57.28±9.51	6.55±2.09	22 (55.00)/18 (45.00)	20 (50.00)/20 (50.00)
Group C (n=40)	56.20±10.26	6.45±2.26	25 (62.50)/15 (37.50)	17 (42.50)/23 (57.50)
t (or χ^2)	0.121	0.165	0.909	0.879
P value	.886	.848	.635	.645

Note: Group A has a cupping duration of 5 min, group B has a cupping duration of 10 min, and group C has a cupping duration of 15 min.

Criteria for patient enrollment and exclusion

Inclusion criteria: All the enrolled patients (age: 18-65 years) presented with gradually worsening shoulder pain and shoulder limited range of motion (ROM), with no history of trauma, obvious pain at night, anterolateral shoulder pain that can radiate to elbow, hand and scapular area, and the most obvious tenderness at the intertubercular groove.[11] Auxiliary X-rays showed no obvious abnormality of the bone structure, and magnetic resonance imaging (MRI) revealed shrinkage and hypertrophy of the joint capsule, excluding rotator cuff injury and calcific tendinitis. In addition, the patients had not taken any medication or treatment for the disease for at least 15 days prior to treatment, nor had they participated in other clinical studies. Exclusion criteria: Patients with shoulder skin disease that cannot be cupped, severe heart disease, hemorrhagic disorders, tumors, or active pulmonary tuberculosis were excluded, as well as pregnant or lactating women and those with hyperthermia-induced convulsions.

Cupping therapy

Bamboo cups 6-8cm long made of sturdy and undamaged bamboo with a diameter of 3cm, one end of which was left as a bottom and the other as a cup mouth. The green husk and inner membrane of the bamboo cup were scraped off with a knife to make it a cylinder like a waist drum. Then, it was polished, and the cap mouth was made smooth and flat with sandpaper. Next, Chinese herbs, including Cortex Erythrinae, Garden Balsam Stem, Herba Scutellariae Barbatae, Radix Angelicae Sinensis, Fructus Zanthoxyli, Rhizoma Ligustici Chuanxiong, Radix Saposhnikoviae, Radix Angelicae Dahuricae, Ramulus Cinnamomi, Radix Clematidis, Flos Carthami and Rhizoma Corydalis, each with 15g, were put into a cloth bag and sealed for decoction with 3000mL of water. When the water boiled, the thumb bamboo cups were put into the water for another 3-5min of boiling. Cupping site: The cupping site was selected according to the diagnosis and treatment norms, with the optional acupoints including Jianjing, Jugu, Jianliao, Jianyu, Jianzhen, Tianzong, Jianzhong, Jianwai, Bingfeng, and Tianliao acupoints. The boiled bamboo cups were removed from the medicine pot, and the medicine juice inside the cups was shaken off. Then, the bamboo cups were applied to specific acupoints, and the air was discharged by the heat of boiling water or liquid medicine, resulting in negative pressure, so that they could be absorbed on the acupoints to produce stimulation. Before cupping, the temperature of the bamboo cups was measured by an infrared thermometer, and 80°C was selected as the instant temperature of cupping. The treatment was performed once a day for 7 days.

TMI testing

TMI testing was performed before and after cupping. The examinee stood 1.5m from the infrared camera lens and kept quiet, with the hands placed naturally vertical. The front, back, and affected side views were collected, with the temperature maintained at (27±1)°C. The dynamic changes of infrared radiation of the affected side, such as Quyuan, Jugu, Jianliao, Jianyu, Jianzhen, Tianzong, Jianzhong, Jianwai, Bingfeng, and Tianliao acupoints were observed—a higher temperature after treatment than before treatment was considered an improvement in temperature difference.

Efficacy evaluation

The curative effect was evaluated with reference to the FS treatment guidelines.[12] Cure: There is no shoulder pain or tenderness, and the joint function is normal. Markedly effective: There is significant relief in shoulder pain and tenderness, with joint functional activities close to normal. Effective: Shoulder pain and tenderness are relieved, and joint functional activities have improved compared with the baseline (before treatment). Ineffective: No improvement in

symptoms after treatment as before. Total effective rate = (cured + markedly effective + effective)/total cases × 100%.

Scoring standards

Patients' pain severity was assessed before and after cupping using the Visual Analogue Scale (VAS; score range: 0-10 points),[13] with higher scores indicating more pronounced pain. In addition, the shoulder joint ROM, assessed from antiflexion, abduction, and retroextension, was measured with a protractor (score range: 0-15 points);[14] the greater the ROM, the higher the score, and the better the mobility of the shoulder joint.

Outcome measures

The clinical efficacy, VAS, ROM before and after cupping, and the skin blood flow and incidence of adverse reactions (skin ecchymosis, redness, blisters, etc.) during treatment were counted. Finally, the temperature difference improvement efficiency was compared among the three groups.

Statistical analysis

This study employed SPSS software for statistical analysis. Counting and measurement data were described as [n(%)] and ($\bar{x} \pm s$), respectively; for comparative analyses of the former, chi-square tests were used, while the latter was compared between groups using independent sample *t* tests and within groups before and after treatment with paired *t* tests. $P < .05$ was the significance threshold.

RESULTS

Comparison of clinical efficacy

Groups B and C showed no marked difference in the total effective rate ($P > .05$), higher than that of group A ($P < .05$) (Table 2).

Comparison of pain and joint function

No statistical significance was identified in VAS scores and ROM among the three groups before cupping ($P > .05$). VAS decreased in all three groups, with no difference between groups B and C ($P > .05$), lower than group A ($P < .05$). However, an increase in ROM was observed in groups A, B, and C after treatment; groups A and C showed similar ROM ($P > .05$), which was lower compared with group B ($P < .05$) (Figure 1).

Comparison of skin blood flow

The skin blood flow of groups A, B, and C were (1.78±0.62) mL, (1.98±0.58)mL, and (3.70±0.79)mL, respectively. The skin blood flow was the highest in group C ($P < .05$) but was similar between groups A and B ($P > .05$) (Figure 2).

Comparison of safety

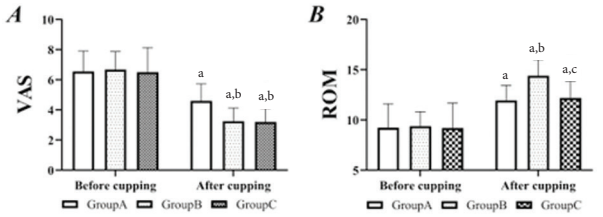
The incidence of adverse reactions in groups A and B were 7.50% and 12.50%, respectively, with no notable difference ($P > .05$). The incidence of adverse reactions in group C was 32.50%, which was elevated compared with groups A and B ($P < .05$) (Table 3).

Table 2. Comparison of clinical efficacy

Group	Cured	Markedly effective	Effective	Ineffective	Total effective rate
Group A (n=40)	2 (5.00)	10 (25.00)	14 (35.00)	14 (35.00)	65.00
Group B (n=40)	5 (12.50)	18 (45.00)	12 (30.00)	5 (12.50)	87.50[a]
Group C (n=40)	6 (15.00)	17 (42.50)	11 (27.50)	6 (15.00)	85.00[a]
χ^2					7.377
P value					.025

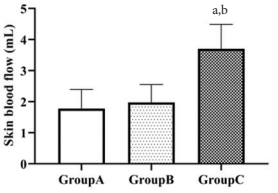
[a]indicates a statistically significant difference from Group A ($P < .05$). Group A had a cupping duration of 5 min, group B had a cupping duration of 10 min, group C had a cupping duration of 15 min.

Figure 1. Comparison of pain and joint function. (A) Comparison of VAS, (B) Comparison of ROM.



[a]indicates a statistically significant difference from before cupping ($P < .05$). After cupping, Group B had the lowest VAS and the highest ROM.
[b]indicates a statistically significant difference from Group A ($P < .05$)
[c]indicates a statistically significant difference from Group B ($P < .05$).

Figure 2. Comparison of skin blood flow. The skin blood flow was the highest in group C.



[a]indicates a statistically significant difference from Group A ($P < .05$)
[b]indicates a statistically significant difference from Group B ($P < .05$)

Table 3. Comparison of safety

Group	Blisters	Petechiae	Erythema	Allergy	Skin lesions	Total incidence
Group A (n=40)	1 (2.50)	1 (2.50)	1 (2.50)	0 (0.0)	0 (0.0)	7.50
Group B (n=40)	1 (2.50)	1 (2.50)	2 (5.00)	0 (0.0)	1 (2.50)	12.50
Group C (n=40)	2 (5.00)	3 (7.50)	4 (10.00)	1 (2.50)	3 (7.50)	32.50[a,b]
χ^2						9.697
P value						.008

[a]indicates a statistically significant difference from Group A ($P < .05$)
[b]indicates a statistically significant difference from Group B ($P < .05$). Group A had a cupping duration of 5 min, group B had a cupping duration of 10 min, group C had a cupping duration of 15 min.

Table 4. Comparison of TMI examination results

Group	Quyuan	Jugu	Jianliao	Jianyu	Jianzhen	Tianzong
Group A (n=40)	24 (60.00)	26 (65.00)	25 (62.50)	26 (65.00)	22 (55.00)	20 (50.00)
Group B (n=40)	40 (100.0)[a]	37 (92.50)[a]	35 (87.50)[a]	36 (90.00)[a]	36 (90.00)[a]	35 (87.50)[a]
Group C (n=40)	38 (95.00)[a]	37 (92.20)[a]	37 (92.50)[a]	34 (85.00)[a]	30 (75.00)	35 (87.50)[a]
χ^2	29.800	14.520	13.340	8.750	12.610	20.000
P value	<.001	<.001	<.001	.013	.002	<.001

Group	Jianzhong	Jianwai	Bingfeng	Tianliao
Group A (n=40)	18 (45.00)	17 (42.50)	21 (52.50)	20 (50.00)
Group B (n=40)	34 (85.00)[a]	32 (80.00)[a]	35 (87.50)[a]	32 (80.00)[a]
Group C (n=40)	32 (80.00)[a]	33 (82.50)[a]	32 (80.00)[a]	33 (82.50)[a]
χ^2	18.100	18.560	13.890	12.670
P value	<.001	<.001	.001	.002

[a]indicates a statistically significant difference from Group A ($P < .05$). Group A with a cupping duration of 5 min, group B with a cupping duration of 10 min, and group C with a cupping duration of 15 min.

Comparison of TMI examination results

The results of the TMI examination showed that the temperature improvement efficiency of all acupoints in group B was higher than that of group A ($P < .05$), the temperature improvement efficiency of Jianzhen in group C was not different from that of group A ($P > .05$), and the temperature improvement efficiency of all other acupoints was likewise higher than that of group A ($P < .05$). There was no difference in the temperature improvement efficiency of groups B and C ($P > .05$) (Table 4).

DISCUSSION

FS, as a common clinical disease, will gradually limit shoulder joint ROM as the disease progresses, seriously affecting patients' activities of daily living and work quality.[15] In virtue of high safety and stable effect, TCM cupping therapy is a commonly used treatment scheme for most FS patients.[16] At present, although international organizations have released a total of 13 standards related to cupping, there is still a lack of specific technical and operational standards for cupping, as well as a controversy throughout cupping. In this study, we analyzed the optimal duration of thumb cupping therapy for FS through TMI, which is of guiding significance for future standardized operations in clinical practice.

First, we compared the clinical efficacy among the three groups of patients. We found higher therapeutic effects in groups B and C compared with group A, suggesting that cupping for 10 or 15min is more effective than for 5min (Table 2). FS belongs to the arthralgia syndrome" category in TCM, mainly including anemofrigid-damp arthralgia, deficiency of Qi and blood, Qi stagnation in meridians, and deficiency of liver and kidney syndromes.[17] According to *Huangdi Neijing*, "for some symptoms of Q and blood stagnation and evil in the blood, it is advisable to use acupuncture" and "relieving blood stasis through bleeding with acupuncture", suggesting that needling collaterals and cupping can dispel evil blood to "restore the vital Qi", which in turn contributes to "the blood to be in a normal and harmonious state and travels to the whole body through the meridians", achieving the effect of moistening the muscles and bones and smoothing the joints. The mechanism of cupping therapy is to promote local vascular dilation and improve blood circulation and metabolism through negative pressure and warming, thereby playing a role in warming meridians to dissipate cold, promoting Qi circulation, and relieving pain. The two actions work synergistically to promote yin-yang balance to improve the shoulder joint function better.[18] However, too short a cupping duration can lead to the inability of negative pressure and warming effects to reach the dermis or even deeper tissues but only act on the surface layer of the patient's skin, resulting in no significant improvement. We speculate that this is also the main reason why the clinical efficacy of patients in group A is not as significant as in groups B and C. In a previous study by Cao et al., a short cupping duration was also reported to lead to unsatisfactory treatment effects,[19] which can support our view. Subsequently, further investigation of pain and shoulder joint mobility also showed that the improvement effect was most significant in groups B and C, which again validates the above viewpoint and confirms that the improvement effect of FS is not ideal because of the short duration of cupping (Figure 1). However, in comparing skin blood flow and adverse reactions, group C showed poorer performance than groups A and B, indicating that cupping for 15min will increase the discomfort of patients and affect their treatment experience. According to Wood et al., the skin of patients who have capped too long is prone to blisters or skin ecchymosis with obvious redness and swelling of the skin, increasing the pain sensation of patients,[20] which is also in line with the results of this study. It can be seen that the cupping time of 10min is the most suitable for FS cupping therapy.

However, the above analysis is mostly based on subjective experience or scoring standards. Instead, the selection of the length of duration of the cupping needs a more effective and accurate objective index to judge. Using the infrared thermal radiation theory, TMI can non-destructively measure human body surface temperature and provide objective data to understand human body function and evaluate the diagnosis and treatment of diseases.[21] This technique is sensitive to temperature and can reflect internal pathological changes through surface temperature alterations, so the results are objective and credible.[22] Research has applied TMI to the observation of lumbar disc herniation, knee osteoarthritis, and other diseases and found that there are obvious temperature differences in the local area before and after treatment, indicating that TMI can reflect the alleviation of pain to a certain extent and assist clinical efficacy evaluation.[23] In this study, group B showed the most significant improvement in efficiency of temperature difference after cupping, consistent with the above analysis results, confirming that 10min of cupping is the most suitable treatment for FS (Table 4). These results also provide a new evaluation scheme for the future clinical treatment of FS. Similarly, Silvestri et al. pointed out that TMI is helpful in evaluating the progression of knee osteoarthritis,[24] which demonstrates that TMI has important potential application significance in various joint diseases in the future, including FS.

CONCLUSION

Through TMI, it can be seen that thumb cupping therapy with a duration of 10min is the best and safest treatment for patients with FS. In the future, TMI can be used to provide more scientific and reasonable treatment guidance for cupping therapyto improve the therapeutic effect and provide a better treatment experience for patients. However, there are still many limitations to be addressed in this study. For example, due to the small number of cases, it is possible that the results of this study are accidental. Besides, the lack of follow-up investigation makes it impossible to evaluate the prognostic significance of TMI for FS for the time being. Finally, we need to use different types of instruments to verify the test results of TMI. Subsequently, we need to conduct better studies and analyses to address these limitations to provide more reliable clinical references.

CONFLICTS OF INTEREST

The authors report no conflict of interest.

FUNDING

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AUTHOR CONTRIBUTIONS

Chaoju Zhang designed the study, Yan Liu and Yanli Xia wrote and revised the manuscript, Hongwei Chen and Yuanyuan Zhu collected and analyzed data, and Yan Liu and Yanli Xia contributed equallyto this work. All authors read and approved the final submitted manuscript.

AVAILABILITY OF DATA AND MATERIALS

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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