Comparison of Temperature Time Characteristics of Two Indirect Moxibustion Products

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Available online Aug 16, 2012

Abstract
The aim of this experiment was to investigate the thermal properties of a new indirect ceramic moxibustion (ICM) in comparison with conventional indirect stick moxibustion (ISM) and to interpret the clinical implications of the data. A thermocouple was installed underneath each moxibustion unit to record temperature, and 10 units were burned for each moxibustion trial. The procedure began when the unit temperature reached 27 ± 1°C and finished when the temperature had returned to 27 ± 1°C. The maximum unit temperature, time to reach maximum temperature, and duration of combustion were measured for each moxibustion modality. The maximum temperatures for ISM and ICM were 62.5 ± 2.59°C and 50.2 ± 2.53°C, respectively. The times to reach maximum temperature for ISM and ICM were 5.6 and 16.8 minutes, respectively. The two modalities exhibit different thermal properties as ISM showed a higher maximum temperature (p < 0.0001), which can immediately cause third-degree burns, and a steeper slope of temperature change. ICM, however, showed a lower maximum temperature, more slowly reached the maximum temperature (p < 0.0001), and had a longer and stable duration of combustion. This study suggests that ISM and ICM have statistically different thermal properties, and ICM showed safer thermal...
1. Introduction

Moxibustion is a major treatment method in Traditional Korean Medicine and creates a therapeutic effect from the heat emitted by burning *Artemisia vulgaris* (also called moxa) [1]. Moxibustion is practiced in two ways: direct moxibustion, which attaches the moxa directly to the skin, and indirect moxibustion, which uses buffering materials between the skin and the moxa [2] to avoid the adverse effects of burns.

Due to its use of heat stimulation, moxibustion can damage patients’ skin. Direct moxibustion is thought to generate more burns than indirect moxibustion; however, Park et al reported more adverse events (such as allergic reactions and burns) associated with indirect moxibustion, and attributed this observation to the fact that indirect moxibustion is in wider use than direct moxibustion [3].

The thermal properties of moxibustion should be measured to prevent unintentional skin burns and ensure its adequate application. Even though recent studies have reported the thermal properties of a variety of moxibustion techniques [4–9], comparative studies of indirect moxibustion using a ceramic container as a buffer, and stick moxibustion, have not yet been published. We therefore conducted this experiment to assess and compare the thermal properties of two different types of indirect moxibustion modality.

2. Materials and methods

2.1. Indirect stick moxibustion

We used indirect stick moxibustion (ISM) (Goyang, Gyunggido, Korea) made from mugwort (*A. vulgaris*) that had been cultivated in Dangjin, Chungcheongnamdo. The average unit diameter, length, and weight were 0.6 cm, 1.9 cm, and 0.467 g, respectively. Each stick was covered in a paper cylinder that would not adhere directly to patients’ skin, thus creating a void (buffer) between the moxa and the patient’s skin (Fig. 1).

2.2. Indirect ceramic moxibustion

We also tested indirect ceramic moxibustion (ICM) units comprising three parts: a cone-shaped moxa, a ceramic container for the moxa, and a netted safety cover. The diameter, height, and weight of the unit were 2.1 cm, 1.9 cm, and 3.2 g, respectively. The container was made of traditional red clay, with a void under the moxa to prevent patients from being burned, which stored and steadily emitted heat (Fig. 2).

2.3. Experimental set-up

Each moxibustion unit was positioned on a single glass plate 0.5 cm thick with a heat conductivity of 0.67 kcal/m/hr/°C. A thermometer (Giltron GT309; Gilwoo Trading Co.; Seoul, Republic of Korea) was used to record the temperature of moxibustion. A thermometer thermocouple was installed underneath each moxibustion unit 3 mm above from the plate surface. The recorded data were sent to a computer to be analyzed. Room temperature was maintained at 27 ± 1°C, and all windows and doors were closed.

2.4. Procedure

The procedure of recording the temperature began when the moxibustion unit temperature reached 27 ± 1°C and was performed until the temperature had fallen to 27°C for ISM, and for a duration of 50 minutes for ICM. We tested 10 moxibustion units of each type. To analyze the thermal properties of each type of moxibustion, we calculated the duration of combustion, maximum temperature, and time to reach maximum temperature. In addition, we calculated the duration of temperature from which patients could receive third-degree burns.

3. Results

3.1. Temperature curves for each moxibustion type

Fig. 3 shows the temperature curves for 10 ISMs and ICMS. The graph for ISM shows an immediate initial increase and a steeper slope than the graph for ICM. Differences in the two modalities, such as duration of combustion, maximum
temperature, and time to reach maximum temperature, are also shown and are discussed below.

3.2. Arithmetical thermal properties

We computed the mean value for each criterion; Table 1 summarizes the arithmetical thermal properties of each moxibustion.

3.2.1. Maximum temperature

The mean maximum temperatures for the ISM and ICM were $62.5 \pm 2.6 \degree C$ and $50.2 \pm 2.5 \degree C$ respectively. Fig. 4 shows that two maximum temperatures are significantly different ($p < 0.001$).

3.2.2. Time to reach maximum temperature

The times to reach maximum temperature from the onset of combustion for the ISM and ICM were 5.6 and 16.8 minutes, respectively.

3.2.3. Duration of combustion

We defined the duration of combustion as the time elapsed from the start of each moxibustion until the unit returned to its initial temperature. We considered that, in practice, most moxibustion treatments do not exceed 30 minutes, and we proceeded with an experiment during which we recorded the ICM temperature for 50 minutes. The duration of combustion for ICM was more than 50 minutes, and the mean value of the duration of combustion for ISM was 22.0 minutes.

3.2.4. Exposure time to receive third-degree burns

In order to consider clinical applications, we calculated the duration of each temperature from which patients could receive third-degree burns. The data of Moritz and Henriques in 1947, and Katcher in 1981 [10,11], were used as criteria. ISM was calculated to have a danger of producing a burn when it reached more than $50 \degree C$. ICM, however, was shown to have a danger of a burn when it reached $52.8 \degree C$, although the duration of other temperature implied less of a hazard of burn. The data are summarized in Table 2.

4. Discussion

Moxibustion treatment is increasingly used in clinical trials [12], and some systematic reviews have evaluated the effectiveness of moxibustion for certain diseases or symptoms. However, Kim et al and Lee et al have argued that more clinical trials are needed to clarify the effectiveness of moxibustion [13,14]. This raises the question of the type of moxibustion that is most appropriate for treating certain diseases, and consequently the thermal properties of

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Arithmetical thermal properties of indirect stick and ceramic moxibustion.</th>
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<tbody>
<tr>
<td>Criteria</td>
<td>Indirect stick moxibustion</td>
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<tr>
<td>Maximum temperature ($\degree C$, mean $\pm$ SD)</td>
<td>$62.5 \pm 2.6$</td>
</tr>
<tr>
<td>Time to reach maximum temperature (min), mean $\pm$ SD</td>
<td>$5.6 \pm 0.4$</td>
</tr>
<tr>
<td>Duration of combustion (min), mean $\pm$ SD</td>
<td>$22.0 \pm 1.1$</td>
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SD = standard deviation.
moxibustion are a significant factor in choosing a moxibustion modality.

In this experiment, we measured the thermal properties of two types of indirect moxibustion. Even though these types are similar in that they stimulate the skin indirectly, the thermal properties suggest that they should be used differently. The duration of combustion and time to reach maximum temperature were greater for ICM, and the maximum temperature was statistically higher for ISM ($p < 0.001$). This suggests that the two types of moxibustion have distinct thermal properties and different heating potentials. These characteristics determine where individual units should be used depending on the patient’s condition, and also whether a patient needs a high temperature with a short duration or a mild temperature of long duration.

Additionally, risks for a burn should be defined. As for time–surface temperature thresholds, it is known that hot water can cause full-thickness epidermal burns at 65.6°C within only 2 seconds, in comparison with 10 minutes at 49°C [10,11]. In the present study, ISM showed a high risk for burn when it reached over 50°C. Furthermore, the duration of treatment was four times as long as the exposure duration from which patients can receive a severe burn at above 50°C. IDM showed risks for producing a burn as well; however, the duration over 52.8°C (1.2 minutes) implies that IDM is safer than ISM. In particular, great caution is required when treating patients who are sensitive to thermal stimulation or who have disorders of peripheral blood circulation [15]. Therefore, ISM requires stricter conditions to prevent burns, and ICM can provide wider clinical applications with lower risks for a burn.

The limitations of our study are that we measured thermal properties not on human skin, but on glass. For safety issues, much thermal property research has been performed using various antiheating plates, or copper, aluminum, or pork, instead of human skin, except in some lower temperature moxibustion studies. In addition, our thermometer thermocouple was installed 3 mm above the plate surface and did not have direct contact with the glass, which minimized the effects of the plate. This is preliminary research to investigate thermal properties, and not clinical research. To better understand the thermal properties of moxibustion in practice, further rigorous clinical trials should be conducted to examine the correlation between the thermal properties of moxibustion and its clinical effects.

In conclusion, this study suggests that ISM and ICM have statistically different thermal properties, and ICM showed safer thermal properties and more stable heating pattern.

### Acknowledgments

This work was supported by the Undergraduate Research Program (URP) grant funded by Kyung Hee University College of Korean Medicine and by the National Research Foundation of Korea (NRF) grant funded by the Korean government (MEST; No. 20110-028968).

### References


