The Optimal Conditions for Microcatheter Shaping

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Objectives: Manual shaping of a straight microcatheter is required when guiding or retention of a microcatheter with a pre-shaped tip is difficult. According to the manufacturer’s instructions, it is recommended that the microcatheter be shaped by steaming “for 30s” and “25 mm away from the steam source”. However, insufficient shaping and blunting can occasionally occur during the procedure. In this technical note, we present the optimal conditions of shaping for a microcatheter system.

Methods: In this study, we used a hot air gun (BOSCH, Gerlingen, Germany) as the shaping source and a Headway microcatheter (Microvention, CA, USA; Terumo, Tokyo, Japan). After measuring the difference between the preset and the actual temperature value, shaping was performed at different temperatures (preset temperature of 110°C–140°C) and time intervals (30s–120s).

Results: The actual temperature was constant at 20°C below the preset temperature, at a distance of 2.5 cm from the hot air outlet. We performed shaping at a preset temperature of 110°C–140°C (i.e., 90°C–120°C actual temperature) for 30s–120s. Because the Headway microcatheter could not tolerate preset temperature higher than 130°C (i.e., actual temperature of 110°C), the distal tip fluffed, bubbled, and perforated. We examined the durability under each condition, comparing the shape just after mandrel removal, after micro-guidewire manipulation, and after stretching in a vascular model. The highest moldability and durability were achieved at a time interval of 90s–120s, and a preset temperature of 120°C (i.e., 100°C actual temperature).

Conclusion: The Headway microcatheter showed the best performance at a heating time of 90s and a preset temperature of 120°C (i.e., 100°C actual temperature) in hot air gun shaping, although the optimal temperature and time interval may vary with the used microcatheter, depending on each instrument structure and materials.

Keywords ➤ microcatheter, catheter shaping, hot air gun

Introduction

A microcatheter must be shaped before placement for aneurysmal coil embolization when microcatheter guiding or coil insertion is difficult with its pre-shaped tip. According to the manufacturer’s instructions, the catheter tip should be shaped by applying steam from a steam source 25 mm away for about 30s. By this method, however, shaping is often insufficient, and the angle is blunted during the catheterization procedure, and other conditions such as heating for 1 min–2 min1) may be recommended. There is also a book recommending shaping at 100°C–120°C,2) and, in Europe and some domestic facilities, shaping is performed using a hot air gun (BOSCH, Gerlingen, Germany) instead of steam. In this study, we evaluated the optimal conditions for macrocatheter shaping using Headway microcatheter (Microvention, CA, USA; Terumo, Tokyo, Japan).

Materials and Methods

Using a hot plate + kettle (Fig. 1A), electric kettle (T-fal, Groupe SEB, Lyon, France: Fig. 1B), steamer (IR-SSCP3, Towser, Fukushima, Japan: Fig. 1C), and hot
air gun (GHG660LCD, Fig. 1D), which are instruments commonly used in the field for catheter shaping, the actual temperatures of the instrument, steam, and hot air were measured (Figs. 1–3), and the optimal conditions for shaping using a hot air gun were evaluated. In the electric kettle (T-fal), the thermostat was disabled by taping the switch with vinyl tape (or by closing the hole leading to the thermostat with an eraser). In Fig. 3, the nosepiece is attached to the hot air gun, but it was used in the experiment by removing the nosepiece as in Fig. 1D, because the actual air temperature deviated widely from the preset temperature (the force of hot air increases, but the temperature decreases [data not shown]) with the nosepiece on, and setting the wind velocity at the minimum level (0.25 m/s/min). The temperatures were measured using a contact type digital thermometer (V-day, Pearl Metal Co., Ltd., Niigata, Japan) and a non-contact type infrared thermometer (Seek Compact, Seek Thermal, Inc. Santa Barbara, CA, USA), which were confirmed to be in agreement with a mercury thermometer.

Headway, which has been reported to be optimal for shaping, was used as an example of microcatheter in this study. Concerning the tip morphology, a shape consisting of a semi-circle 5 mm in diameter and a right angle (Fig. 4a) was prepared by stretching the usually unused end of the accompanying mandrel (Fig. 3A), and the enlargement of the diameter of the circle and blunting of the tip angle (Figs. 4b–4d) were used as indices of shape retention under various conditions.

### Results

The steam temperature was relatively low: about 60°C in the steamer, about 95°C in the electric kettle (T-fal), and 80°C in the hot plate + kettle. In the hot air gun, the air temperature was stable near the preset temperature at the nozzle and at the preset temperature minus 20°C 25 mm from the nozzle. The increase in the temperature was sharpest in hot air gun (Fig. 2).

While parts other than the nozzle such as the lower base were also heated in the other three steam-emitting instruments (Figs. 1A–1C), only the nozzle was heated, and the handle, on which the instrument can be stood for hands-free use, was not, in the hot air gun. Thus, as the air gun was considered to be the safest, it was used in this experiment.

When shaping was performed in a preset temperature range of 110°C–140°C (measured temperature range: 90°C–120°C) for 30s–90s, the tip of Headway was roughened at preset temperatures of 130°C or above (measured temperatures: 110°C or above) (Figs. 5A–5D). At a preset temperature of 130°C (measured temperature: 110°C), no change was observed under a magnifying lens until after 60s, but wave-like changes (Fig. 5D) and bubbles (Fig. 5C), which could be perceived even grossly, appeared after 90s. At 140°C (measured temperature: 120°C), fluffing, bubbling, and perforation occurred even after 30s (Fig. 5B). However, no change was observed on the surface of the catheter at a preset temperature of 120°C (measured temperature: 100°C, Figs. 5E and 5F; both were actual clinical cases) even after 90 (Fig. 5F) or 120 (Fig. 5E) s, or when the catheter was shaped at a sharp angle (Fig. 5F).

Moreover, when the shape retention was evaluated by to-and-fro sliding of a guide wire (15 strokes of insertion and withdrawal) and subsequent incubation in a vessel model (EVE, FAIN-Biomedical, Nagoya, Japan) connected to a thermostatic bath pump at 37°C (Fig. 3C), shaping at a preset temperature of 120°C (measured temperature: 100°C) for 90s was found to provide the highest degree of shape retention and to be safe (Figs. 6 and 7). At a preset temperature of 120°C (measured temperature: 100°C), no problem was observed in the surface structure, and shape retention
Fig. 2  Changes in the hot air or steam temperature according to the apparatus.

Fig. 3  We used a part of a ready-made shape of the attached mandrel for shaping (A). The durability under each condition was examined, comparing the obtained forms immediately after shaping using each apparatus (B), after micro-guidewire manipulation (to-and-fro sliding), and after stretching in a vascular model (C) under each condition.
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Fig. 4 Blunting of the right-angled bend (A) and changes in the half-circular arc diameter (B). An example of the dimensions of a Headway microcatheter shaped by a steamer at an actual temperature of 60°C. (a) The microcatheter was shaped using a mandrel. (b) Immediately after mandrel removal. (c) After guidewire sliding. (d) After retention in the vascular model.

Fig. 5 (A, B) The Headway microcatheter could not tolerate hot air above a preset temperature of 140°C (i.e., an actual temperature of 120°C) on a hot air gun; the distal tip fluffed (arrow), bubbled, and perforated (double arrowhead). (C, D) Even at a preset temperature of 130°C on the hot air gun (i.e., actual temperature of 110°C), surface bubbling (arrow) and waving was observed (arrowhead). (E, F) The safest shaping was achieved at a time interval of 90s–120s, at a preset temperature of 120°C (i.e., an actual temperature of 100°C).
Fig. 6 Blunting of the right-angled bend (A) and changes in the half-circular arc diameter (B). Differences according to the temperature. All data correspond to the hot air gun shaping with heating duration of 90s.

Fig. 7 Blunting of the right-angled bend (A) and changes in the half-circular arc diameter (B) shaped by the hot air gun at a preset temperature of 120°C (i.e., an actual temperature of 100°C): differences according to the heating duration.
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SL-10 was deformed at a preset temperature of 160°C (measured temperature: 137°C). Headway showed waving and bubbling of the surface at 130°C (measured temperature: 110°C) and perforation and fluffing at 140°C (measured temperature: 120°C), suggesting that shaping at a preset temperature of 140°C (measured temperature: 120°C) even over a short duration is considered to be risky. Shaping at a preset temperature of 130°C (measured temperature: 110°C) for 60s is not considered recommendable for the following two reasons although no change was observed in the surface structure. First, the shape retaining ability was lower than by shaping at 120°C (measured temperature: 100°C) for 90s. Second, the temperature readily reaches the risk zone if shaping is performed for a slightly longer duration (at a preset temperature of 130°C, waving of the surface begins from 90s) or at a slightly closer distance (at a preset temperature of 130°C, the measured temperature decreases to 110°C at 2.5 cm from the nozzle but remains at 130°C near the nozzle).

Although the manufacturer’s instruction for Headway recommends bending 1.3 times the intended angle and steaming for 30s, actual shaping of a curve of 1/1.3 (69° = 90°/1.3) at a distance of 2.5 cm from the nozzle required application of air at 100°C (hot air gun set at 120°C) for 90s (Green line in Figs. 6–8). Basically, while Headway also showed blunting of the shaped angle during various maneuvers, blunting was less notable under favorable conditions (90s–120s at a preset temperature of 120°C, thus an actual temperature of 100°C, green and orange).

Discussion

Steam shaping and shape retaining ability of the microcatheter were carefully examined using various microcatheters about 10 years ago, and, basically, bending to twice the intended angle was recommended, in principle, and described as such also in the manufacturer’s instruction. However, as treatment with steam alone was insufficient for durable shaping, shaping using a hot air gun has been performed in Europe and some domestic facilities. In addition, as a result of improvements in the manufacturing technology of microcatheters, Headway was introduced into the market as a microcatheter that, despite the presence of a blade, the manufacturer’s instruction recommend to be shaped by bending to 1.3 times instead of 2 times the intended angle as a result of thickening of the plastic layer at distal side. Since, at present, only data about shaping of SL-10 microcatheter, which required bending to twice the intended angle, using a hot air gun are available, shaping conditions were evaluated in this study using Headway.

While the optimal preset temperature was 150°C (measured temperature: 121°C) for SL-10, it was lower at 120°C (measured temperature: 100°C) for Headway. Also, while SL-10 was deformed at a preset temperature of 160°C (measured temperature: 137°C), Headway showed waving and bubbling of the surface at 130°C (measured temperature: 110°C) and perforation and fluffing at 140°C (measured temperature: 120°C), suggesting that shaping at a preset temperature of 140°C (measured temperature: 120°C) even over a short duration is considered to be risky. Shaping at a preset temperature of 130°C (measured temperature: 110°C) for 60s is not considered recommendable for the following two reasons although no change was observed in the surface structure. First, the shape retaining ability was lower than by shaping at 120°C (measured temperature: 100°C) for 90s. Second, the temperature readily reaches the risk zone if shaping is performed for a slightly longer duration (at a preset temperature of 130°C, waving of the surface begins from 90s) or at a slightly closer distance (at a preset temperature of 130°C, the measured temperature decreases to 110°C at 2.5 cm from the nozzle but remains at 130°C near the nozzle).

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conditions, confirming that it can be shaped by 1.3-time bending unlike SL-10. However, shaping was insufficient with a steamer by 90-s heating even by bending to twice the intended angle (90°/32° = 2.8) (Fig. 4).

When 30-s additional heating was applied following 60-s heating plus cooling with water, the shape change was similar to that after shaping for 90s once, and the tempering effect of 2-step heating was not evident (data not shown). Also, the rectangular part near the tip and the semicircular part proximal to it showed different morphological changes in the vessel model, presumably because the rectangular part near the tip is relatively free in the tube (Fig. 3C) and recovers the shaped form (Figs. 4A, 6A, 7A, and 8A) as in previous studies,3,4,5 but the large semicircular part is placed under stress working to stretch it (Fig. 3C) and is blunt further (Figs. 4B, 6B, 7B, and 8B).

## Conclusion

The optimal temperature may vary with the structure and material of the microcatheter, but, in Headway, shaping using a hot air gun at a preset temperature of 120°C (measured temperature: 100°C) for 90s exhibited the best performance and was effective.

## Disclosure Statement

The first author or any of the co-authors has no direct economic conflict of interest concerning the contents of this paper.

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