Skin Temperatures Generated Following Plaster Splint Application

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**Abstract:** Heat is generated during the exothermic reaction associated with plaster splint application. The amount of heat generated is affected by the plaster thickness, dipping water temperature, and extremity elevation method. The authors assessed the effect of these variables on skin and plaster temperatures. Short-leg posterior splints were applied to noninjured extremities on a volunteer using 2 protocols. Following splint application, the splinted leg was elevated in 4 ways: on plastic-covered urethane pillows in cotton pillowcases, on cotton blankets, on ice packs (short-term cryotherapy) placed on top of cotton blankets, or with heel elevation to promote free air circulation. Skin and plaster temperatures were monitored at 1-minute intervals. The maximum skin temperature generated and the average time that skin temperature was 40°C or higher were recorded.

Heat is produced during the exothermic curing reaction generated during plaster cast and splint application. This heat can produce a thermal insult to the soft tissues being casted.1,7 For patients receiving splints, the skin can be compromised by open and closed fractures, soft tissue trauma (ie, sprains, contusions, and crush injuries), vascular compromise (ie, ischemia, diabetes mellitus, and vascular disease), neural compromise (ie, anesthesia, coma, and insensitivity), malnutrition (ie, decreased subdermal fat), infection (ie, cellulitis), and postoperative changes (ie, incision and suturing, swelling, and tourniquet use). These factors contribute to making the skin and soft tissues more susceptible to thermal injury.6

The exothermic curing reaction has been studied in circumferential casting in vitro in glass and polyvinyl chloride surrogate testing models. Key variables that affect heat production are the number of plaster plies (ie, cast thickness) and dipping water temperature.5,8 These variables are frequently changed from the manufacturer’s protocol in clinical practice by increasing the cast or splint thickness for rigidity and decreasing water temperature.5,8 Cast padding thickness is also frequently altered. The effect of cast padding thickness on temperature increase beneath the casting material has been previously studied. Increased Webril (Kendall, Mansfield, Massachusetts) insulation, has little effect on fiberglass but traps heat and elevates temperatures under plaster casts.6,8 Cast padding should be considered as a way to reduce the pressure beneath splints and casts and to protect the skin from direct contact with casting material and the cast saw during removal. Choice of casting materials also affects the risk of thermal injury; fiberglass curing generates less heat than plaster curing, with faster-setting plasters generating more heat.7

Williamson and Scholtz2 reported the time and temperature threshold of normal skin thermal injury, with individual variations noted. They reported that skin blisters (second degree burns) occurred after direct skin contact with a heated probe after 4 minutes at 51°C (124°F) in normal volar forearm skin.2 Temperatures in this range have been reported in experimental casting surrogate studies; however, “thermal exposure over 40°C for an
extended period of time raises concern. For perspective, the water temperature of a “very hot” bath is 42.5°C (discomfort is noted at 43°C; eg, jerking your hand away from a hot water faucet), with an average temperature of 40.5°C for bathing. Previous experiments on uninjured skin reported that “if an object is to be in contact with skin for any appreciable length of time, the temperature of the skin interface should not exceed 42°C and that damage should be anticipated with temperatures above 43.5°C.”

Few studies report the thermal insult generated following noncircumferential plaster splint immobilization. The purpose of the current study is to evaluate in vivo skin temperatures generated during plaster splint application using a nonsurrogate testing model. Variables tested were plaster thickness, dipping water temperature, and postsplint elevation method. The authors compared the manufacturer’s protocol with their own practice. Four postsplint elevation methods were tested for each protocol.

### MATERIALS AND METHODS

Short leg posterior JAJ101 Specialist plaster splints (5×30 inches; BSN Medical, Charlotte, North Carolina) were applied to a noninjured extremity in a healthy volunteer (F.D.S.) in a room regulated at 23°C with a uniform relative humidity of 32%. Two splinting techniques were tested and evaluated. One technique was based on the manufacturer’s protocol of using 8 plaster plies and a cool dipping water temperature of 23.9°C. The current practice involves using 10 plies for increased splint rigidity and increasing the dipping water temperature to 35°C. Splints were applied to alternating legs, with a total of 7 splints applied for each protocol (splint applications total 70 with 35 applications for each splinting technique).

Clean water was used for each splint application because plaster residue in dipping water elevates the splint temperature and temperature curve. Each splint had 4 layers of Webril separating the splint material from the skin surface. A calibrated monotherm thermistor (Omega Engineering, Stanford, Connecticut) with 60.1°C sensitivity was affixed to the posterior calf at the myotendinous junction of the gastrocsoleus complex using Webril. An additional calibrated monotherm thermistor was placed in the splinting material. Baseline skin temperature was recorded (average, 31°C), and splints were not applied to extremities that were prewarmed from previous splint applications.

The splinted extremity was elevated in 4 ways: on shredded urethane pillows covered in plastic with a cotton pillowcase; on cotton blankets; on ice packs placed on top of cotton blankets and applied to the posterior splint surface for 30 minutes (short-term cryotherapy); or with the heel elevated on the corner of a wooden bed to permit free air circulation. Skin and plaster temperatures were recorded at 1-minute intervals until returning to the baseline skin temperature (approximately 90 minutes, with the maximum skin temperature achieved approximately 15 minutes after splint application). Seven splint applications were used to test each protocol.

Results are reported as mean±SE. Statistical testing with analysis of variance was used to determine the differences between the 2 splinting protocols and 4 elevation techniques, with a 2-tailed P value of .05 considered statistically significant. P values for multiple comparisons were corrected using the Bonferroni method. The maximum skin temperature achieved and the average time that skin temperature was 40°C or higher are reported (which corresponded with the initial onset of discomfort).

### RESULTS

Using the manufacturer’s protocol, the mean plaster temperature was 42.7°C±0.4°C and the mean time the plaster temperature was 40°C or higher was 22.3±0.7 minutes. Using the current practice, the mean plaster temperature was 47.4°C±0.4°C, and the mean time the plaster temperature was 40°C or higher was 24.9±0.5 minutes. Maximum plaster temperature was 44°C when using the current practice and 42°C when using the manufacturer’s protocol (Table).

Elevating the splinted extremity using pillows and blankets resulted in the highest skin temperatures for both protocols, with skin temperatures of 40°C or higher for an average of 19±1 minutes in both groups (Figures 1, 2). When pillow elevation was used, skin temperatures were higher using the current practice than the manufacturer’s protocol (44.4°C±0.4°C vs 42.1°C±0.3°C, respectively). Blanket elevation also resulted in higher skin temperatures for the current practice than the manufacturer’s protocol (45.4±0.5°C vs 41.0±0.3°C, respectively). A significant decrease in maximum skin temperature and time of skin temperature at 40°C or higher was achieved when the heel was elevated to allow free air circulation (manufacturer’s protocol group, 38.0±0.3°C and 9 minutes at 40°C or higher; current practice, 40.9±0.3°C and 9 minutes at 40°C or higher). Short-term cryotherapy produced a significant decrease in skin temperatures (10°C decrease in the current practice group), with maximum skin temperature only slightly above the starting skin temperature of 31°C.

### DISCUSSION

A statistically significant increase in maximum skin temperature was generated for all elevation techniques using the current practice. No burns were noted on clinical examination in the current study population, but temperatures between 40°C and 42°C were associated with the start of discomfort, with the maximal...
skin temperature of 47°C (Table) producing discomfort and skin erythema without blistering. Statistically significant differences in the time skin temperatures were 40°C or higher were noted when comparing blanket and pillow elevation vs free air circulation and short-term cryotherapy between the protocols (Figure 2).

Many physicians in the acute setting use higher dipping water temperatures and faster-setting plasters to decrease splint-setting time. This should be discouraged due to the increased thermal insult. It is important to note that the temperature and exposure studies for thermal injury were performed in nontraumatized soft tissues. For patients requiring splints, soft tissue trauma increases the risk of thermal injury because of a shift in the temperature and exposure relationship. Traumatized tissues require lower temperatures and shorter exposure times to produce a thermal injury to skin.

Hutchinson and Hutchinson reported that “thermal exposure over 40°C for an extended period of time raises concern.” Thus, using blankets and pillows for extremity elevation after splint application should be discouraged. The only method that decreased skin temperatures to below the 40°C threshold in both protocols in the current article was the application of short-term cryotherapy (Figure 2). Although free air circulation produced a statistically significant decrease in the time that the skin was warmer than 40°C when compared with ex-

<table>
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<tr>
<th>Variable</th>
<th>Temperature Measurement in Plaster Splint</th>
<th>Temperature Measurement at Skin Surface, °C</th>
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<tbody>
<tr>
<td></td>
<td>Manufacturer protocol</td>
<td>Current practice</td>
</tr>
<tr>
<td>Maximum temperature, °C</td>
<td>42.7±0.4</td>
<td>47.4±0.4</td>
</tr>
<tr>
<td>Time temperature was 40°C or higher, min</td>
<td>22.3±0.7</td>
<td>24.9±0.5</td>
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Data are reported as mean±SE. Average baseline skin temperature was 31.3°C±0.3°C.

Figure 1: Graph showing the maximum plaster and skin temperatures. Data are reported as mean±SE for 7 splint applications. The current practice of increased plaster plies with warmer dipping water temperatures generated statistically significant increases in temperature of the splint material and at the skin surface.

Table

<table>
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<tr>
<th>Maximum Temperature and Time Temperature was Higher Than 40°C for the 2 Splinting Methods and 4 Splint Elevation Techniques*</th>
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<tr>
<td>Variable</td>
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*Data are reported as mean±SE. Average baseline skin temperature was 31.3°C±0.3°C.

bHighest skin temperature achieved in 2 trials (47°C).
tremity elevation using blankets and pillows, this method was not beneficial if the splint thickness was increased by 2 plaster plies. The average decrease in skin temperature achieved correlates with a previous report of a 10.8°C decrease in skin temperature achieved with cryotherapy in casts.

In addition, because a subjective maximal pain threshold was realized with the current practice when elevation on blankets occurred, which generated a maximum temperature of 47°C (Table), no testing of additional plaster thicknesses was performed. The authors’ initial intention was to observe the effect of doubling the plaster plies with both techniques because folding over extra splinting material is common. Therefore, the authors recommend careful sizing of the splint material to prevent doubling the splint thickness, which increases the thermal insult generated.

**CONCLUSION**

Plaster splints should be applied following the manufacturer’s protocol with cool dipping water in conjunction with elevation to permit air circulation or splints should be elevated with short-term cryotherapy. Splint modification to increase thickness and rigidity, and the use of lukewarm water increase the thermal insult. Splint elevation on blankets and pillows should be avoided due to the generation of higher skin temperatures.

**REFERENCES**


