Cast Saw Burns: Evaluation of Simple Techniques for Reducing the Risk of Thermal Injury

Alan C. Puddy, MD, Jon A. Sunkin, MD,* James K. Aden, PhD,† Kristina S. Walick, MD,* and Joseph R. Hsu, MD‡*

Background: Although a routine practice in all orthopaedic clinics, the use of cast saws is not without risk of thermal and abrasive injury to patients. This study investigates the use of readily available supplies for reducing oscillating saw blade operating temperatures.

Methods: An oscillating cast saw blade and an adhesive thermocouple fixed to the blade were uniformly heated and subsequently cooled from 70°C to 45°C using 6 different methods. Variables tested included the use of water applied with cotton cast padding or gauze dressing, 70% isopropyl alcohol applied with cotton cast padding, gauze dressing, or commercially available alcohol pads, and ultrasound gel applied with gauze dressing. All methods were tested with either the cast saw off or the saw and vacuum running. Statistical analysis included a 2-way analysis of variance to compare conditions with the cast saw off versus on and Tukey-adjusted pairwise comparisons of individual variables within each group.

Results: Cast saw blade cooling in ambient air required 114.2 seconds, whereas oscillating the blade and using the vacuum reduced the time to 14.6 seconds. Applying 70% isopropyl alcohol with a commercially available pad or ultrasound gel on a gauze dressing only required 9.0 and 10.2 seconds, respectively. Cooling with water or 70% isopropyl alcohol applied with either gauze dressing or cotton cast padding ranged from 4.8 to 7.4 seconds.

Conclusions: At rest, the cast saw blade required almost 2 minutes to return to safe operating temperatures after being heated to 70°C. Running the saw and vacuum resulted in significantly faster cooling across all measured variables. Of all methods tested, cooling with 70% isopropyl alcohol using gauze or cast padding or cooling with water on gauze resulted in the fastest responses. As a result, this study suggests that the routine use of any of these 3 methods would significantly decrease the risk of patient discomfort and thermal injury during cast cutting.

Clinical Relevance: Provide simple method for decreasing risk of thermal injury when removing casts.

Key Words: cast saw burns, thermal injury, cast cutting

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Although the application and removal of casts in orthopaedic clinics is a routine practice, patients continue to be at risk of complications related to these procedures. The frequency of thermal and abrasive injuries related to cast saws has been evaluated in the literature previously and occurred with a frequency of 0.72% in a single clinical setting.[1] In addition to causing painful patient injury and permanent scarring, cast saw burns can also result in significant ligitation.[2]

In patients burned by cast saws, thermal injuries are the result of both the absolute temperature as well as the duration of the exposure to the blade.[3–5] Prior experimentation demonstrated a temperature of 49°C requires > 5 minutes to result in a burn, whereas 65°C needs < 1 second.[2] Earlier studies have also identified factors related to increased risk of thermal injury from cast saws.[2,6,7] Killian and colleagues compared multiple oscillating saws and saw blade modifications. Their study concluded that the Stryker Cast Vac generated the lowest operating temperatures, cutting fiberglass resulted in higher temperatures as compared with plaster, and saw blade temperatures increased 20°F to 40°F after 3 to 5 uses. Shuler and Grisafi assessed the effects of cast padding thickness, cast material, and removal technique. They found elevated temperatures with cutting fiberglass compared with plaster, using 2 layers of cast padding compared with 4, and cutting with poor technique. Taken together, these publications recommend an up-and-down cutting technique with sharp saw blades utilized by well-trained individuals. Conversely, no study has investigated specific methods for decreasing cast saw blade temperature during use.

This study aims to evaluate several simple and inexpensive methods of cast saw blade cooling by using readily available materials. We examined 6 methods of cooling, including the use of water applied to the blade with cotton cast padding or gauze dressing, 70% isopropyl alcohol applied with cotton cast padding, gauze dressing, or commercially available presaturated alcohol

From the *Department of Orthopaedics and Rehabilitation, San Antonio Military Medical Center, United States Air Force Medical Corps; †United States Army Institute of Surgical Research; and ‡Carolinas Medical Center Department of Orthopaedic Surgery, Charlotte, NC.

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Reprints: Alan C. Puddy, MD, Department of Orthopaedics and Rehabilitation, San Antonio Military Medical Center, United States Air Force Medical Corps, 3551 Roger Brooke Dr, Ft. Sam Houston, TX 78234. E-mail: alan.c.puddy.mil@mail.mil.

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pads, and ultrasound gel applied with gauze dressing. Given prior literature suggesting that the vacuum attachment to the Stryker Cast Vac decreases the temperature of blades during cast cutting, each method was tested with either the cast saw off or the saw oscillating and vacuum running.[2] We hypothesized that the application of isopropyl alcohol to the blade would provide the fastest temperature reduction as evaporation could contribute to cooling.

METHODS

A K-type adhesive thermocouple (Omega Engineering, Stamford, CT) was fixed to the undersurface of a new Stryker stainless steel 940-023 cast saw cutter blade (Stryker Instruments, Kalamazoo, MI). The saw blade was placed on a Stryker 940 Cast Cutter with a Stryker 986 Cast Vac attachment (Stryker Instruments). Temperature data were collected and analyzed with a 4-channel Data Logger Thermometer (Omega Engineering) and provided software with temperature data points collected every second.

The oscillating saw blade was heated with a forced air convection heat source (Model RVDR5033; Revlon, New York, NY) until the temperature of the blade reached 70°C. At that point, either control conditions or one of several different cooling methods were utilized to evaluate the length of time required for blade cooling from 70°C to 45°C. These temperatures were chosen based on prior studies showing that 70°C resulted in skin burns in <1 second and 45°C required >5 minutes. Therefore, these tests evaluated a clinically relevant temperature range to return saw blades back to safe temperatures after heating them to a degree that would easily result in thermal injury.

As the experimental control, the blade was heated and allowed to cool with the instrument either at rest or with the blade oscillating and vacuum attachment running. Further variables tested included water applied with cotton cast padding (WEBRIL; Kendall, Manfield, MA) or a 4×4 inch gauze dressing (Versalon All-purpose Sponges; Kendall), 70% isopropyl alcohol (Mundelein, IL) applied with cotton cast padding, gauze dressing, or commercially available alcohol prep pads (WEBCOL 2-ply medium Alcohol Prep; Kendall), and ultrasound gel (Grafco Ultrasound Gel; GF Health Products Inc., Atlanta, GA) applied with gauze dressing. Solutions were applied to the padding or dressing until they were completely saturated. All of the conditions were tested by evenly applying the liquids or gel to the top surface of the blade in a back and forth direction under uniform speed by a single investigator with either the cast saw off or the saw and vacuum running. The back and forth application was continued at a rate of approximately one back and forth application per second until the blade temperatures decreased below 45°C. Temperatures were measured at 1-second intervals and recorded with an automated data logging software program. Each set of conditions were tested in 5 separate trials for a total of 70 trials performed. All of the materials were maintained at ambient temperature, which was found to be 23°C at the location of testing.

Statistical analysis of the data included a 2-way analysis of variance comparing conditions with the cast saw off versus the saw oscillating and vacuum running in conjunction with a comparison of mediums used to cool the cast saw, including ambient air, water, 70% alcohol, and

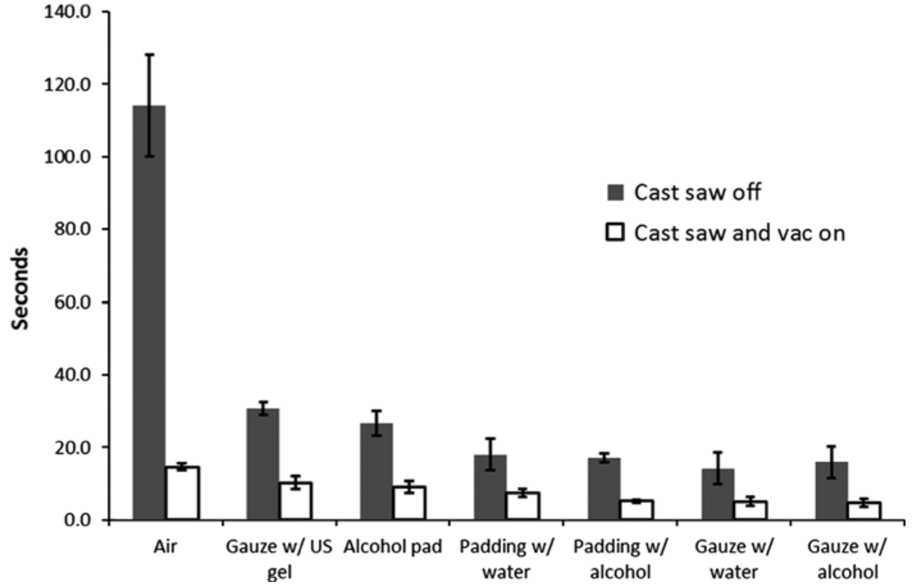

FIGURE 1. Mean time required for cooling of cast saw blade from 70°C to 45°C with cast saw at rest or cast saw blade oscillating and vacuum attachment running. Air indicates cooling in ambient air without additional intervention; gauze, 4×4 gauze dressing; padding, WEBRIL cotton cast padding; alcohol, 70% isopropyl alcohol; US gel, ultrasound gel; alcohol pad, commercially available 70% isopropyl alcohol presaturated pad. Error bars indicate the SEM.

ultrasound gel. Tukey-adjusted pairwise comparisons of individual variables within each group were performed. Statistical significance was determined utilizing a P-value of <0.05.

RESULTS

All treatment conditions were tested utilizing a single oscillating cast saw, saw blade, and thermocouple combination. Control conditions consisted of the cast saw blade simply cooling in ambient air from 70°C to 45°C after being heated, which required an average of 114.2 seconds (Fig. 1). A second group evaluated the cooling rate when the blade was oscillating and the vacuum on, which reduced the cooling time significantly to 14.6 seconds ($P < 0.05$, Fig. 2).

Using any of the 6 cooling methods described above resulted in further reduction in cooling time that was statistically significant as compared with cooling by blade oscillation and vacuum alone (Fig. 3). Cooling with ultrasound gel on a gauze dressing, 70% isopropyl alcohol on a presaturated pad, or water applied with cotton cast padding required 10.2, 9.0, and 7.4 seconds, respectively. Water applied with gauze dressing or 70% isopropyl alcohol applied with either gauze dressing or cotton cast padding generated the 3 fastest cooling times and statistically similar results with average cooling times ranging from 4.8 to 5.2 seconds. Subgroup analysis demonstrated that these 3 groups were statistically faster than all other methods with the exception of comparisons to cast padding with water, which only trended toward faster cooling times ($P < 0.05$, Fig. 3).

DISCUSSION

Thermal injuries related to cast saws continue to occur in orthopaedic clinics with cases of injured patients as well as the potential for ongoing litigation. The rate of thermal and abrasive injuries from cast saws has been reported in the literature previously at 0.72% in a single institution. Lawsuits in those cases resulted in settlements on the order of tens of thousands of dollars.[2] It is clear that improved methods for minimizing risk with the use of cast saws are needed. Anecdotally, the authors are aware of various saw blade cooling practices being performed at various institutions, but no direct comparison of cooling methods has been reported in the literature to date.

This study aimed to identify simple and affordable methods for cast saw blade cooling that can be applied easily and quickly. All of the methods evaluated in this study used materials that are readily available and, therefore, should have broad applicability to most orthopaedic clinics. In this study, we found that the saw blade required almost 2 minutes to return to safe operating temperatures after being heated to 70°C when the cast saw and vacuum were not running. Allowing the saw blade to oscillate with the vacuum device running resulted in significantly shorter cooling times across all measured variables, but required almost 15 seconds to return to 45°C. Applying 70% isopropyl alcohol, water, or ultrasound gel to the heated saw blade further increased the rate of cooling in a statistically significant manner. Of all cooling methods tested, the application of 70% isopropyl alcohol using gauze dressing or cotton cast padding or water applied with gauze dressing resulted in the fastest cooling profiles. These methods reduced the cooling time to approximately 5 seconds, which is about the amount of time required to apply the liquid and align the cast saw on the cast for continued cutting. From a practical standpoint, we feel that this reduction in cooling time is significant. Considering the likely situation of removing a cast and needing to stop 3 times to cool the blade, these cooling methods result in cast removal approximately 30 seconds faster. We feel that this is a significant time difference, especially for a fair number of our pediatric patients who are anxious about the removal process and the loudness of the cast saw itself.

Cast Saw	Cooling Time (s)	p-Value
Off	33.8	<.0001
On	8.0	

FIGURE 2. The effectiveness of cast saw oscillation and vacuum running on the average cooling time from 70°C to 45°C across all variables.

Condition 1	Condition 2	Difference (s)	p-Value
Air	Gauze w/ alcohol	9.8	<.0001*
	Gauze w/ water	9.6	<.0001*
	Padding w/ alcohol	9.4	<.0001*
	Padding w/ water	7.2	<.0001*
	Alcohol pad	5.6	<.0001*
	Gauze w/ US gel	4.4	<.0001*
Gauze w/ US gel	Gauze w/ alcohol	5.4	<.0001*
	Gauze w/ water	5.2	<.0001*
	Padding w/ alcohol	5	<.0001*
	Padding w/ water	2.8	0.0193*
	Alcohol pad	1.2	0.7224
Alcohol pad	Gauze w/ alcohol	4.2	0.0002*
	Gauze w/ water	4	0.0004*
	Padding w/ alcohol	3.8	0.0007*
	Padding w/ water	1.6	0.41
Padding w/ water	Gauze w/ alcohol	2.6	0.0353*
	Gauze w/ water	2.4	0.0628
	Padding w/ alcohol	2.2	0.1079
Padding w/ alcohol	Gauze w/ alcohol	0.4	0.9985
	Gauze w/ water	0.2	1
Gauze w/ water	Gauze w/ alcohol	0.2	1

FIGURE 3. Tukey pairwise comparisons with cast saw oscillating and vacuum attachment on. Differences between average cooling time as well as corresponding P-values are shown for each pair. Air indicates cooling in ambient air without additional intervention; gauze, 4×4 gauze dressing; padding, WEBRIL cotton cast padding; alcohol, 70% isopropyl alcohol; US gel, ultrasound gel; alcohol pad, commercially available 70% isopropyl alcohol presaturated pad. *Statistical significance.

Limitations in this study relate to the equipment utilized and method of testing. First, the K-type thermocouple and data logging software combination were limited to obtaining a single data point per second. Improving the frequency of data acquisition would possibly improve the quality of our data and potentially elucidate additional differences between the test groups. Second, this study used a forced air convection heat source to heat the saw blade to a desired temperature, which differs from the method of heating when cutting casts. We used this method, however, as it provided a consistent method of heating without altering the blade as would naturally occur from friction during cast cutting.

In conclusion, cooling solutions like water and isopropyl alcohol can cool saw blades almost 3-fold faster compared with simply oscillating the saw and running the vacuum and >20-fold faster than a saw blade cooling in ambient air. On the basis of the findings of this study, we feel that clinicians should utilize the application of 70% isopropyl alcohol using gauze dressings or cotton cast padding or water applied with gauze dressing when cutting casts. Combined with conclusions from other studies demonstrating increased saw blade temperatures after as little as 15 seconds of cast cutting, we recommend that cast removal be performed by well-trained individuals using sharp blades and an up-and-down technique where blade temperature is assessed every 15 seconds and cooled as described herein.[2]

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