PREVENTING THERMAL INJURY IN THE PLASTER ROOM.

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The Plaster Cast remains the most widely used immobilization technique in Orthopaedics. Plaster of Paris has been used since its inception in 1978. The casting materials have changed over time and new synthetic products have been developed; yet the risk as well as cases of thermal injury continue to be reported (Becker, 1978), (Kaplan, 1981), (Unal, 2004), Grazer, 1979). Gannaway & Hunter (1983) suggest that subclinical burns may be present more often than is documented; with thermal injury possibly being mistaken for cast allergies, fracture blisters, pressure sores, erythema of the skin or similar.

Although burns under casts are fairly rare, they can be a very devastating cast complication and so the education of new technicians and medical staff continues to be vital to cast safety. It is important that all casting technicians are aware of thermal injury as it relates to cast application in order for them to make informed decisions relating to best practice. To fully understand the risks it is important to understand the functions of skin, how burns to the skin occur and the relationship between time and temperature in burns.

THE SKIN

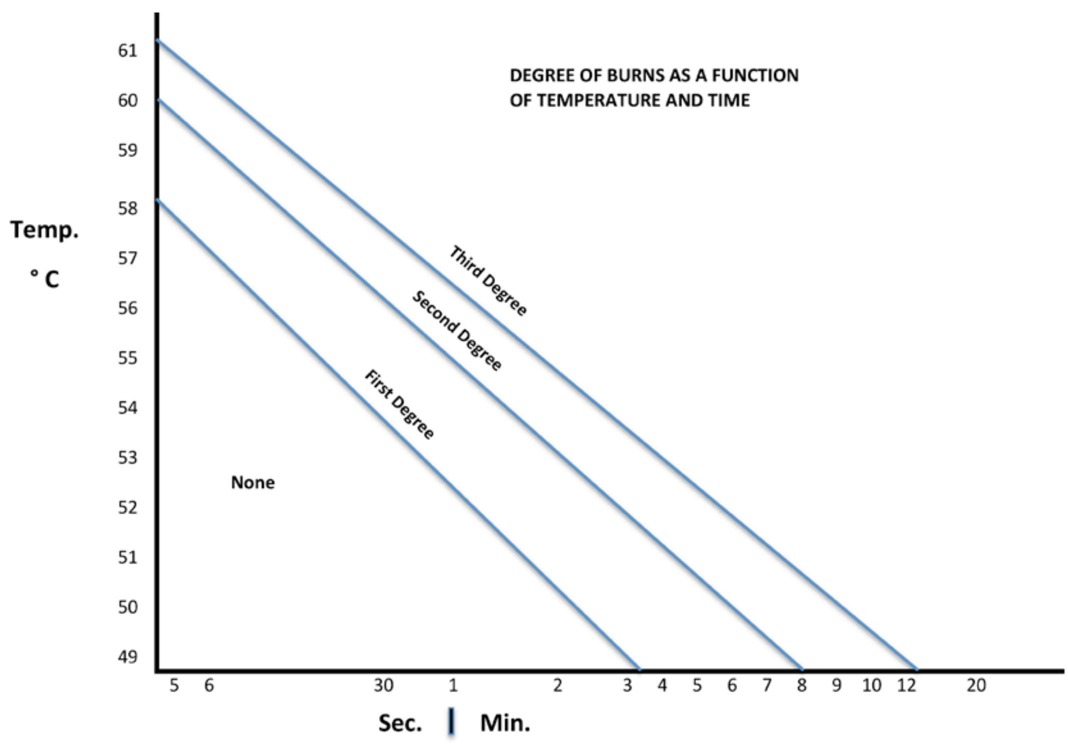
The skin protects the body from the environment. It provides a mechanical defence, as collagen protects the skin from bumps and knocks by providing the skin with strength and elasticity. The skin both allows and protects against water loss; our bodies naturally lose water through evaporation from the skin. The closer to the surface, the less water the layers contain. The basal layer of the skin contains 70-75% of water while the stratum corneum contains only 10-15%. The skins hydration has a direct effect on the vulnerability of the skin to cellular damage. The skin regulates body heat through the control of sweating and blood flow. Sweating controls temperature through evaporation. Blood flow controls temperature by vasoconstriction and vasodilation. When the external temperature is cold the blood vessels in the dermis constrict so that there is less heat taken to the surface where it can be lost to the atmosphere, when the temperature is hot the vessels dilate so it is closer to the surface and heat can escape via convection and radiation. These two processes are important to understanding the bodies' ability to diffuse and dissipate heat. While the body has an excellent capacity to diffuse and dissipate heat; if the absorption of heat exceeds the rate of dissipation then damage to cells will occur (Artz, Moncrief and Pruitt, 1979).

The above information is crucial to understanding that pts with compromised skin and/or comorbidities are at higher risk of thermal injury. The technician must take into account factors such as oedema, ischaemia, tourniquet use, anaesthesia, low body fat, dehydration, diabetes, peripheral vascular disease amongst others as these conditions may produce an atmosphere where thermal injury is produced at lower temperatures.

THE TIME – TEMPERATURE EFFECT

There is a limited thermal range the internal body must maintain in order to prevent cellular damage, so thermoregulation is critical to life. The surface temperature of the human body on the other hand can withstand extreme temperature changes without permanent damage. This however is directly dependant on the length of time of the exposure. The Time-temperature effect is critical to understanding the risks of thermal burns in cast application. Temperatures below 44 degrees will not cause permanent skin damage, we know this because people are known to lie in baths of this temperature. At 44 degrees the skin will maintain equilibrium for up to 6 hours. Longer than this and irreversible damage can occur. In temperatures from 44 degrees to 51 degrees Celsius the rate of cellular damage doubles and only limited exposure is needed. 51 degrees and higher will rapidly overwhelm the skins compensatory processes and cell damage will be rapid, permanent and irreversible (Artz, Moncrief and Pruitt, 1979), (Moritz and Hendriques, 1947)

So the length of time required for contact with heat to produce burn is directly affected by the degree of temperature. And the ability of temperature to produce burn is directly affected by the length of time of exposure. This is demonstrated in the following graph (Moritz and Hendriques , 1947)



When the external temperature is increased, the body's response is to regulate absorption and dissipation of heat from the body surface. This involves a change in the body's circulation. The blood vessels in the immediate area will vasodilate and there is increase in capillary permeability; sending a higher amount of blood to the subsurface of the skin in an attempt to dissipate heat and equilibrate to the outside temperature. When the limb is in a cast, the body cannot use these heat regulation functions efficiently, particularly when the limb is in a full circumference cast. Dissipation and evaporation iin the immediate area is limited and so the limb is at higher risk of damage in adverse conditions.
Once thermal injury has occurred and cellular damage has begun, the increase in capillary permeability along with an increase in hydrostatic pressure causes fluid to leak into the wound bed and into the surrounding tissues causing wet, weepy wounds, blisters and swelling to the direct area.

TECHNICAL VARIABLES

It takes a combination of factors to produce a burn under a cast. One factor alone will not be likely to produce a burn; However, a combination of factors together and the risks will significantly rise.

<u>DIP WATER TEMPERATURE</u>: Plaster of Paris is made by coating bandages with Calcium Sulphate, which is dipped in water at time of application. The Calcium Sulphate reacts with the water and an exothermic (heat producing) reaction occurs that enables the cast to set. Modern synthetic products rely on this same reaction. The warmer the dip water the faster the setting time. If the dip water temperature is hot rather than cold the heat generated by the exothermic reaction will be greater and will extend the length of time the skin is exposed to a dangerous temperature. BSN Medical; the manufacturers of Gypsona recommend a dip water temperature of 20-25 degrees for their Plaster of Paris (BSN Medical, 2007) and 3M suggest a temperature of 21-24 degrees (3M, 2006); in the writers experience many practitioners use warm or even hot water due to the fact that the setting time can be reduced. This is perhaps with a lack of understanding of the associated risk.

<u>CAST THICKNESS</u>: The thickness of the cast is another important variable. The thicker the cast, the more heat generated and the longer it will be maintained. "The temperature of the skin is strongly affected by the number of plies and dangerous conditions (high enough for a sufficient time) are more likely to occur if the cast is thicker" (R Lavalette, MH Pope and H Dickstein). A study by R. Lavalette et al showed that a cast of 8 plies dipped in 32 degree water could reach a temperature of 42.6 degrees and a cast of 16 plies in the same dip water reached a temperature of 45.2 degrees. The same ply casts dipped in 40 degree water reached temperatures of 48.9 degrees and 63.2 degrees which demonstrates a temperature capable of causing a 3rd degree burn! If a backslab or splint has not been accurately measured, it is important for the practitioner to remember this point as if the plaster is folded back on itself rather than trimmed

to size, the thickness of the cast will instantly double and the exotherm greatly increases!

CAST PADDING: A cast being placed on a pillow and/or covered by a blanket while it sets is at significant risk, the pillow will stop the dissipation of heat and reduces ventilation which in turn increases the heat and interferes with the cooling process, extending the time taken to cool. Many well meaning practitioners add extra padding inside the cast in an attempt to keep the plaster away from the skin and reduce risk of burn however over padding the cast will increase the peak temperature as it acts as an insulator (Hutchinson and Hutchinson. 2008).

WETTING PLASTER: Another interesting variable is the wetting of the plaster; Kaplan (1981) reported that if plaster is not sufficiently wet through, intense heat can be produced as it tries to set, water is needed to allow the absorption of heat and evaporation to occur. Once plaster has been dipped in water, if too much water is squeezed out prior to application the same increase in heat will occur; in a very wet plaster evaporation will dissipate the heat and temperatures will reduce more efficiently. (cited by R. Lavalette, MH Pope and H Dickstein, 1982) If the outer layer of the cast dries faster than the inner layers eg if little water used, the outer layer will insulate the inner layer which will in turn increase the resulting heat and exposure time. It is common practice for some technicians to apply a "dry" (undipped) layer of synthetic tape when moulding is required and a longer setting time desirable, the top layer is then wet and applied overtop to complete the plaster and to start the curing process. The outer wet layer will dry far more rapidly than the inner layer, trapping the heat inside and significantly extending the time held at maximum temperature. It highlights the importance of technicians understanding these processes and the possible implications of their choices and practices on their patients.

OTHER FACTORS: High room temperature and humidity will not effect the setting temperatures reached however will lengthen the time high temperatures are maintained.
Used dip water with residue from previous plaster is suggested to also lengthen the exposure to high temperature due to residual chemical accelerators being present in the dip water (Gannaway and Hunter, 1983).
Placing a setting cast on a pillow and/or covering it with a blanket places the limb at significant risk; the pillow will stop the dissipation of heat and reduces ventilation which in turn increases the heat and interferes with the cooling process.

CONCLUSION

It is important for cast technicians to understand that thermal injury is possible under certain circumstances. Warm water is commonly used to intentionaly speed up the setting process of casts for various reasons, possibly with little knowledge of the potential implications for patients. There is little published information available on this subject and clinical trials are inappropriate. However, the literature that can be found covering decades differs very little in their basic conclusions. It is widely agreed that the use of cool water reduces the risk of thermal injury. It is important for casting technicians to note that under the right combination of conditions thermal injury is possible. Cast burns are caused from a combination of factors with hot dip water rarely being the sole cause; however with all contributing factors being present but cool dip water being used it is impossible to yield a temperature high enough and for long enough to cause a thermal burn. It is for this reason that the writer concludes that cool dip water should be the standard intervention and considered best practice when applying a cast in any setting.

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