“A Radical Improvement in Wheelchair Seat Design”

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Good Morning! On behalf of Marty Carlson and the entire Tamarack design team, we would like to thank the Conference planning committee for the opportunity to share the work we have been doing at Tamarack.

People who use wheelchairs for daily mobility and function, especially those with impaired sensation due to spinal cord injury, are at constant risk for developing serious sub-pelvic or sacral ulcerations. Those wounds destroy careers, marriages, quality of life and are one of the three leading causes of death among people living with spinal cord injury. The total costs of medical care directly related to that type of ulceration in North America is in the billions of dollars per year.

There are four physical conditions at the ulcer site which contribute to tissue trauma and which relate to seat materials and design. They are pressure; friction; heat; and moisture. The wheelchair cushion design we will show you today, passively addresses and minimizes all four of these factors.

When contact pressure is too great, usually in a bony area, blood cannot flow through those capillaries to bring oxygen and nutrients to the cells and metabolic byproducts are not carried away. If that high contact pressure persists too long, the cells begin to die. Until very recently, this ischemia model of ulcer generation has exclusively dominated the design of wheelchair seat cushion and other body support surface products to the near-exclusion of the other three tissue trauma factors.

The second factor on that list, and probably the most destructive is friction. Friction forces upon the skin surface cause shear stresses and strains within the skin and soft tissues. Shear deformations are very distortional. In fact Bennet, et. al. detected capillary occlusion at greatly reduced pressure (up to 50%) when shear loads are superimposed. There is also evidence that the friction-induced shear stress caused by short duration friction loading causes direct fracturing of sub-dermal biological micro-structures. This makes simple sense to Mechanics of Materials engineers.

There is a common misconception that friction loads can only cause surface damage such as abrasion and dermal blisters. That friction loads at the skin surface do result in shear stress and strain changes at deeper levels is an elementary assumption.

A second misconception is that friction loads and their damaging effects occur only as the patient is moving or being moved. Actually, very damaging levels of residual friction-induced shear distortion persist after a person settles into wheelchair or bed. Those damaging combinations of friction superimposed on high pressure can cause trauma in a variety of locations but bony areas are at very high risk because that is where the enabling pressure and shear strain magnitude will be greatest. (Ref. Bennett)

Heat/temperature comes in as a factor because a one degree Centigrade rise in temperature will increase cell metabolic rate by approximately 10%. So, an insulating cushion material will hasten the onset and rate of cell necrosis.

Moisture is the last on the list of the four local physical factors in ulcer generation, and is related to temperature, just mentioned. The outermost layer of skin, the Corneum, is physically weaker when soaked with moisture. The Corneum also, like many other materials, exhibits a higher coefficient of friction (COF) when moist than when dry. To the extent that a cushion avoids thermal insulation and allows free air circulation, it will of course, help maintain epidermal integrity and delay onset of tissue necrosis.

The FlexForm weight-bearing structure consists of a simple Tabby weave pattern of straps attached to a frame. The frame provides a firm area of support under the thighs.

The perimeter of the posterior section of the frame is contoured to provide clearances for bony areas (the Sacrum and Greater Trochanters). The woven straps crossing the sub-pelvic area are suspended from the perimeter of the frame in a way which allows the woven surface to assume the contours of any individual pelvis. Beyond that, the design allows a trained provider to easily reduce or remove weight-bearing loads from any wounded or at-risk areas beneath the pelvis.

The custom contouring process is accomplished by allowing one end of each of the woven sub-pelvic straps to “play-out”, responding to the sub-pelvic contours and pressures imposed during that custom forming process. The provider can then increase the length of the two or more straps which intersect that area. During the custom forming process a pressure mapping mat may be used. Since the undersides of the woven straps are exposed and palpable, a knowledgeable provider can easily identify areas requiring additional pressure relief while the patient remains seated, undisturbed. When the provider has made any necessary adjustments, the “play-out” ends of the straps are firmly anchored to the frame.

The FlexForm cushion design is completed by the addition of a novel fabric cover assembly. The upper surface of the cover is divided into two very contrasting friction zones. The entire thigh area is a relatively high friction zone.

The sub-pelvic area of the cover is made of a patented low-friction composite material panel exhibiting an ultra-low COF of less than 0.2. The low-friction interface area under the pelvis effectively isolates those at-risk sites from damaging levels of friction-induced shear. The ultra-low COF material is brand named GlideWear.

The lower, second cushion cover component, is made of a reticulated spacer fabric. The spacer fabric smoothes out pressure irregularities left by the woven strap gaps. The open nature of the spacer fabric and strap gaps allow air access for drying and cooling.

The wheelchair seating technology just described can be adapted to either an independent cushion or it may be integrated into the wheelchair frame design. An integrated approach reduces total equipment weight and eliminates one mobility system component.

Currently we have two individuals using FlexForm systems successfully – both have paraplegic level spinal cord injuries. One had multiple pressure ulcers, and the other had come to the point of needing to miss work and limit daily activities in order to reduce severe discomfort and erythema.

This custom, tissue friendly technology may also find application in hospital and long-term care bed surfaces and long-duration seating for the comfort of healthy individuals.

Thank you!

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