

A patient care condition not being efficiently met:

Introduction:

Patients with neurological injuries like traumatic brain injury (TBI), acquired brain injury (ABI) and strokes; spinal cord injuries, torticollis; cerebral palsy; Parkinson's disease; multiple sclerosis; dementia and end stage Alzheimer's disease commonly develop an increased intensity of contractions of certain muscles that have been affected by damage somewhere in the Central Nervous System. These contractions are referred to as varying degrees of "tone" and "spasticity," which can begin within a few days of injury. These muscle contractions hold the tissue in a shortened length, encouraging an alteration to that length. This shortened length of tissue that prevents the full range of motion of that extremity becomes a physical deformity referred to as a "contracture." The longer this increased tone continues without being relaxed and it is holding the tissue in a shortened length, the more likely that other joint involvement will occur.

Historically splints were basically of one category, and that category has been used for any type of condition that was deemed to need bracing. The definition of a splint varies greatly. According to the Free English Dictionary is, "A rigid device used to prevent motion of a joint or of the ends of a fractured bone." Another definition is "a brace to hold something in place temporarily." Then from Merriam-Webster: "a device (such as a brace or splint) for supporting, immobilizing, or treating muscles, joints, or skeletal parts which are weak, ineffective, deformed, or injured."

There are no established industry recommendations of splint categories to be used for different patient conditions. Also, there is little mention of lost range of motion or contractures, if any, to be found on web searches of various neurological conditions. These sites discuss therapy and pharmaceutical products but not the life-altering deformities that cause pain and suffering, increasing morbidity, and the coinciding health expenses up to and including repeat hospitalizations, surgeries, and the need for long term care. The stress on caregivers is hard to quantify.

Because these contracture deformities tend to reach profound stages after the patient is discharged from acute therapy, those clinicians may not be aware of the long-term effects of increased muscle tone and spasticity, and how much it can adversely affect patients' lives.

The crucial factor of the big picture is the cost of not treating these problems efficiently and effectively, both in human suffering and in the cost to the healthcare system. We will further discuss the health implications later in this paper.

Working Toward a Solution:

Several areas need to be further discussed in order to make sure we are treating these conditions in the most effective manner.

- 1) What is the cause of the lost range?
 - Immobility
 - orthopedic injury or condition
 - burn
 - neurological injury or disease process.
- 2) Is this an acute injury or a chronic condition?

Immobility:

Any tissue can shorten when it is not stretched to full length often enough each day. Persons who are immobile, whether forced from some condition like: chronic obstructive pulmonary disease (COPD); obesity; lower extremity amputations; and depression; or simply sitting for too long each day, adaptive tissue will likely shorten to the length to which it is maintained or allowed to rest. The process to relengthen this tissue requires prolonged low load passive strength (LLPS) over long periods of time to realign the proteins in the muscle to prepare it to be relengthened. According to the condition of the patient and the degree of severity, total alignment of the body part may never be achieved, and the goal may be to maintain current status to prevent worsening. This prolonged LLPS requires the use of some type of an orthotic or stretching device.

Orthopedic injuries:

“Most nurses do not recognize a contracture until it limits joint movement to 45 degrees. Reversing a contracture at this point often takes months but can take years. Most contractures can be reversed if detected before the joint is immobilized completely.”

The Long-Term Care Nursing Desk Reference, Second Edition, by Barbara Acello, MS, RN.

An orthopedic contracture may be related to a surgery or blunt trauma to a joint. Thick collagen fibers and adhesions that restrict movement can develop. If these fibers are present, it is common for therapy to aggressively extend joints to loosen and break through these adhesions. The orthotic devices used can be comfortably padded rigid splints in combination with therapy and continued to be used after therapy has ended to maintain the achieved range.

Caution should be used if applying rigid splints to any patient who may have or may develop increased muscle tone or spasticity as indicated by a neurological diagnosis.

Burns:

Burn scar contracture is the tightening of the skin after a second or third degree burn. If this occurs around or near a joint, it will limit range of motion. Ideally, a well-padded splint to maintain the muscle length, or begin to bring an already contracted joint back toward normal alignment, will be used as soon as it is safe.

According to the National Institute of Health, “The shortening of deeper structures has great clinical significance. It may not be possible to release the contracture fully at the time of operation because the neurovascular structures and musculotendinous units may stand out as bowstrings, limiting any further release. Moreover, the vessels may also go into spasm with compromise of distal limb or digit circulation due to excessive stretch. The muscles/tendons may resist any lengthening by forceful pull even under general anesthesia. Such contractures need gradual release by sustained traction using various methods for complete correction.” [Indian J Plast Surg. 2010 Sep; 43\(Suppl\): S63–S71.](#)

Neurological injury or disease process:

“Spasticity is increased, involuntary, velocity-dependent muscle tone that causes resistance to movement. The condition is typically a result of insult to the central nervous system or motor neurons. It may occur as a primary condition such as in degenerative conditions or as a result of secondary causes such as spinal cord injury, trauma to the brain, or inflammatory conditions such as multiple sclerosis.” Mar 01, 2018 Author: Krupa Pandey, MD; Chief Editor: Stephen A Berman, MD, PhD, MBA

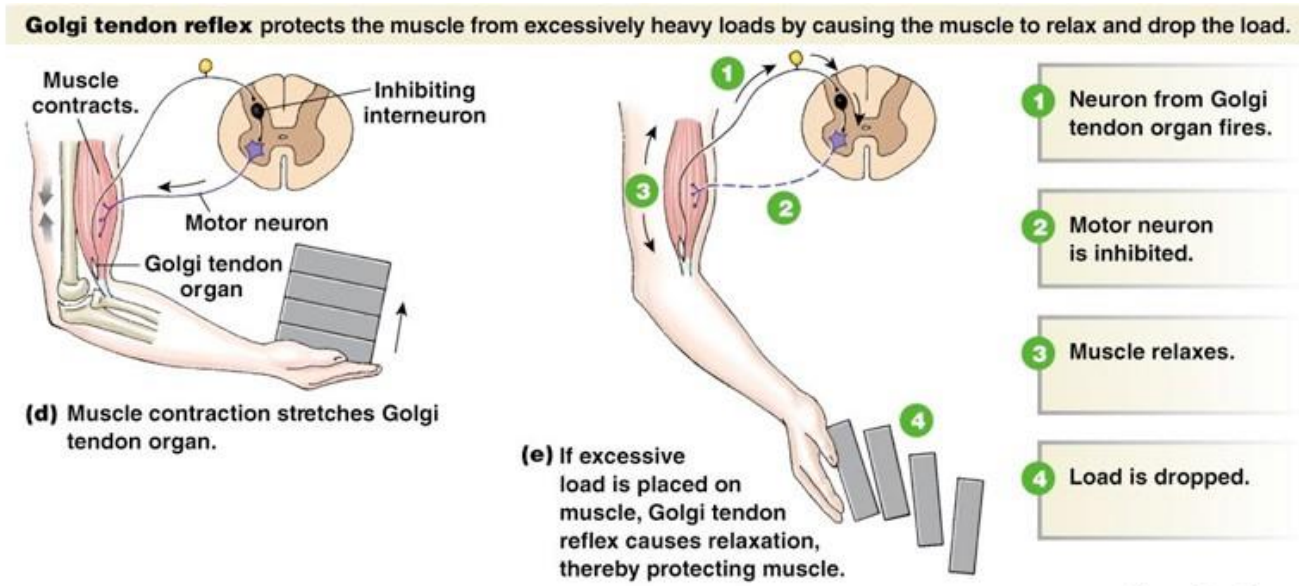
Casting and splinting techniques are extremely valuable to extend joint range diminished by hypertonicity. Katz Richard T. MD, Management of Spasticity, American Journal of Physical Medicine & Rehabilitation: [June 1988 - Volume 67 - Issue 3 - ppg 108-116](#)

Orthopedic splints are rigid and, by definition, are designed to hold a joint or body part in a specific plane to facilitate healing and function. If these splints are used on neurologically injured patients, the splint attempts to hold the muscle at a lengthened state and prevent the muscle from shortening. When the muscle exhibits with increased tone, it appears – with anecdotal observation – that this holding the muscle at its full length might increase the intensity and duration of the episode.

When a splint is applied to the body part that can move with the patient and allow the muscle to be able to shorten during the episode with slight flexible tension/resistance, and then the muscle be brought back to the predetermined submaximal length, typically in approximately 15 minutes some degree of relaxation is seen. This relaxation can be dramatic or subtle according to the origin of the damage and to what degree and if there is underlying tissue shortening. Other factors as simple as if the patient is well hydrated or not can have an affect on the relengthening of shortened tissue.

Hypertonicity: "Some authors suggest that the current definition for spasticity, the velocity-dependent over-activity of the stretch reflex, is not sufficient as it fails to take into account patients exhibiting increased muscle tone in the absence of stretch reflex over-activity. They instead suggest that "reversible hypertonia" is more appropriate and represents a treatable condition that is responsive to various therapy modalities like drug and/or physical therapy.^[4] Bakheit, AM; Fheodoroff, K; Molteni, F (2011). "Spasticity or reversible muscle hypertonia?". *Journal of Rehabilitation Medicine*. 43 (6): 556–7. doi:10.2340/16501977-0817. PMID 21491075.

Below is an illustration by Benjamin Cummings with Copyright by Pearson Education, Inc., showing the process to relax muscle tone. The appropriate splints and braces should mimic this action. Although the weight puts a stretch on the muscle, it does not hold the muscle rigidly in a stretched position, but allows it to move as needed until the relaxation is occurs.



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Fig. 13-6b

The former Chief of Brain Injury at Frazier Rehab in Louisville Kentucky, Kenneth Mook, MD, PhD, wrote: "I have found that a static, rigid splint is not effective in controlling spasticity because it provides a persistence of a spastic event by not allowing the muscle to shorten. A splint that has static properties with some dynamic "give" during a spastic event allows the muscle to shorten, thereby the spastic event regresses, and yet the splint maintains the proper positioning of the joint. "

As an example of a diagnosis that commonly results in increased muscle tone and spasticity, let's look at some facts in the USA of persons following a Traumatic Brain Injury.

Traumatic Brain Injury (TBI) is the leading cause of death and disability in children and adults from ages 1 to 44.

Brain injuries are most often caused by motor vehicle crashes, sports injuries, or simple falls on the playground, at work or in the home.

Every year, approximately 52,000 deaths occur from traumatic brain injury.

An estimated 1.5 million head injuries are seen every year in United States emergency rooms. ^a

An estimated 1.6 million to 3.8 million sports-related TBIs occur each year.

At least 5.3 million Americans, 2% of the U.S. population, currently live with disabilities resulting from TBI.

Moderate & severe head injury (respectively) is associated with a 2.3 and 4.5 times increased risk of Alzheimer's disease.

Males are about twice as likely as females to experience a TBI.

TBI hospitalization rates have increased from 79% per 100,000 in 2002 to 87.9% per 100,000 in 2003.

Exposures to blasts are a leading cause of TBI among active duty military personnel in war zones.

Veterans' advocates believe that between 10 and 20% of Iraq veterans, or 150,000 and 300,000 service members have some level of TBI.

30% of soldiers admitted to Walter Reed Army Medical Center have been diagnosed as having had a TBI.

^aLanglois, J. ScD, MPH; Rutland-Brown, W. MPH; Wald, M. MLS, MPH; *The Epidemiology and Impact of Traumatic Brain Injury: A Brief Overview; Journal of Head Trauma Rehabilitation, Vol. 21, No. 5, pp. 375378 2006*

^bMMWR Morb Mortal Wkly Rep. 2007; 56:167-170

^c*Iraq & Afganistan Veterans of America*

^dEmery, Erin; *Hidden wounds plague GIs, Denver Post; April 16, 2007*

Due to advanced medical treatments, many military persons who suffer Traumatic Brain Injuries today survive where in previous military conflicts they did not.

The cost of not effectively treating the lost range of motion in these persons does not only result in initial increased costs of care. The inappropriate muscle contractions (tone) continue to pull the muscles to shorter lengths, resulting in twisted, deformed joints and body parts that can involve from only one joint to more severe conditions that include the entire body. These deformities, especially those that affect body posture, can eventually adversely affect every system of the body. These patients tend to have decreased mobility, and require repeat hospitalizations for conditions that are not limited to but include:

- Urinary Tract Infections (if the bladder is unable to completely empty due to lack of the ability to achieve upright body positioning to allow the bladder to completely empty). CORRECTIVE MEASURE: improve posture by correcting hips/knees/postural curves to be able to position patient on commode and ideally for male patients to stand.
- Other infections. CORRECTIVE MEASURE: Correct lost range to have as close to full range as possible to prevent pressure sores and other skin issues. Decrease the time spent in hospitals for any reason – the longer a person is hospitalized, the greater the threat of infection.
- Increased blood sugar due to immobility. CORRECTIVE MEASURE: Correct body alignment and relax tone, of present, to increase mobility and the ability to stand or to sit upright. Exercise increases insulin receptors, therefore helping to increase the efficiency of sugar digestion. The American Diabetes Association (Association) released new research on March 22, 2018 estimating that the total costs of diagnosed diabetes have risen to \$327 billion in 2017 from \$245 billion in 2012, when the cost was last examined. April 30, 2018
- Pneumonia (if unable to have full lung expansion and lack of mobility), CORRECTIVE MEASURE: Correct head/neck/shoulders/spine posture, hips and knees to be able to sit upright or stand to encourage full lung expansion. The diaphragm must be able to expand the lungs to pull in enough oxygen and then expel carbon dioxide. The tidal

volume of the lungs shifts when the patient is in bed for prolonged periods of time. The torso must rotate or be rotated enough to keep fluids moving and prevent the alveoli from filling up with excess fluid. This excess fluid can prevent the exchange of oxygen and carbon dioxide resulting in difficulty breathing and poor blood oxygenation. And, any stagnant fluid presents a perfect breeding ground for bacteria.

- Dehydration, CORRECTIVE MEASURE: Correct head/neck/spine posture to be able improve the ability to take in adequate fluids.
- Dementia symptoms/confusion from lack of oxygen and lack of environmental stimulation, CORRECTIVE MEASURE: Correct posture of head/neck/spine, hips, knees and feet to be able to sit or stand upright to have adequate oxygen intake (to supply brain cells) and to be able to view their environment to receive adequate stimulation to help to remain oriented or improve current orientation.
- Fecal impactions, CORRECTIVE MEASURE: Correct body alignment to be able to take in adequate fluids and appropriate nutrition, and to increase mobility and bowel motility.
- Skin integrity. CORRECTIVE MEASURES: Relax increased muscle tone and spasticity to decrease sheering and friction to skin; correct contractures to decrease bony prominences that may increase potential for areas of pressure; increase range in all joints to allow oxygen to all areas of skin, and be able to keep all areas of their body clean and dry – especially in persons who lack control of bowel and bladder.
- These persons may require surgically implanted feeding tubes to take in enough nutrition and hydration due to lack of posture and/or lack of ability to swallow, CORRECTIVE MEASURE: Correct posture, especially head/neck and upper body posture to be able to take in adequate food and fluids to prevent the need for a feeding tube.
- Surgeries, including amputations, CORRECTIVE MEASURE: Correct posture and range of motion of all joints to increase blood flow to areas for health of cells, and to reduce the incidence of infections.

Every cell in the body requires adequate blood flow to remain healthy. Each red blood cell has the ability to bind with four molecules of oxygen. A concentration of oxygen molecules in the lungs is required to be able to cross the semi permeable membrane to reach the area where these molecules can be picked up by the blood stream. At the same time, the blood stream is bringing carbon dioxide to the lung area from all parts of the body and the oxygen/carbon dioxide exchange which can only occur with this concentration of oxygen molecules. This process allows the carbon dioxide to exit the body. If there is fluid and congestion in the lungs,
















it can slow and prevent this exchange. If there is inadequate upper body posture, full lung expansion and inspiration of adequate oxygen tends to be lacking. Lack of mobility and inadequate fluid intake can also lead to lung congestion and lack of oxygen intake.

This is only one example of the downward spiral of health that commonly results from less than appropriate posture of the torso and any joint of the body. These conditions can lead to expenses like: repeat hospitalizations; long term care; therapy; custom made wheel chairs; high end chair cushions; therapeutic beds and mattresses; custom vans; scooters and the vehicle attachments required to transport them; wound care up to and including debridement and amputations; feeding tube placements and the formula and additional nursing care for the rest of their lives; and oxygen.

Please see the spinal chart below that identifies the body area and vital organs fed by each spinal nerve. Also to the right, please see common health conditions that may occur due to lack of adequate nerve conduction to that area:

Spinal Nerve Function

Your brain controls every cell in your body through spinal nerves

	VERTEBRAL LEVEL	NERVE ROOT	INNERVATION	POSSIBLE SYMPTOMS
Cervical Vertebrae	C1	C1		Migraine Headaches
	C2	C2		Headaches Dizziness
	C3	C3		Sinus Problems Allergies
	C4	C4		Head Colds Fatigue
	C5	C5	Intracranial Blood Vessels Eyes Lacrimal Gland Parotid Gland Scalp Base of Skull	Vision Problems
	C6	C6	Neck Muscles Diaphragm	Runny Nose Sore Throat
	C7	C7		Stiff Neck Cough Croup
	C8	C8		Arm Pain Hand and Finger Numbness or Tingling Asthma
Thoracic Vertebrae	T1	T1		Heart Conditions
	T2	T2		High Blood Pressure
	T3	T3	Neck Muscles Shoulders Elbows Arms	
	T4	T4	Wrists Hands Fingers Esophagus Heart	
	T5	T5	Lungs Chest	
	T6	T6	Arms Esophagus Heart	
	T7	T7	Lungs Chest Larynx Trachea	
	T8	T8		
	T9	T9		Congestion Difficulty Breathing Asthma
	T10	T10		High Blood Pressure
	T11	T11		Heart Conditions
	T12	T12		Bronchitis Pneumonia
Lumbar Vertebrae	L1	L1		Gallbladder Conditions
	L2	L2		Jaundice Liver Conditions Stomach Problems
	L3	L3	Gallbladder Liver Diaphragm	
	L4	L4	Stomach Pancreas Spleen Kidneys	
	L5	L5	Small Intestine Appendix Adrenals	
Sacral Curve	S1	S1	Small Intestines Colon Uterus	Ulcers Gastritis
	S2	S2	Colon Uterus Buttocks	Kidney Problems
	S3	S3		
	S4	S4		Constipation Colitis
	S5	S5		Diarrhea Gas Pain
	SACRAL		Large Intestines Buttocks Groin	Irritable Bowel Bladder Problems Menstrual Problems Low Back Pain
	SACRAL		Reproductive Organs Colon Thighs	Pain or Numbness in Legs
	SACRAL		Knees Legs Feet	
	SACRAL			Constipation Diarrhea
	SACRAL			Bladder Problems
	SACRAL		Buttocks Reproductive Organs Bladder	Lower Back Pain Pain or Numbness in Legs
	SACRAL		Prostate Gland Legs Ankles Feet Toes	

Reference: Haines, DE, PhD, Neuroanatomy, 7th Edition, Lippincott Williams & Wilkins, 2007 ; Kandel, ER, et al, Principles of Neural Science, Appleton & Lange, 1991
Hoppenfeld, S, MD, Physical Examination of the Spine & Extremities, Appleton-Century-Crofts, 1976 ; Netter, FH, MD, Atlas of Human Anatomy, 4th Edition, Saunders, 2006

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Below is a male who suffered from a Traumatic Brain Injury (TBI) from a motor vehicle accident. He is very similar to many of our Wounded Warriors, and his pictures plainly illustrate what increased muscle tone and spasticity can do to the human body. Imagine the affects to each system of his body and the costs of his care for the rest of his life. Imagine the difficulty to meet his care needs and the hardship on his caregivers.

TBI – 3 years after auto accident

- Severe tone affecting all body functions and quality of life
- Splints will be adjusted in 3 months, will begin to address feet



The image contains three photographs of a man with severe spasticity and muscle tone issues. The first photo shows him lying in bed with his legs in splints. The second photo shows him sitting in a wheelchair with his right arm raised and hand in a splint. The third photo shows him sitting in a wheelchair with his hands in splints.

Abnormal Muscle Tone - especially upper body extensor tone that neurologists tell us can bombard the brain with so many messages the result is that the brain attempts to protect itself by (like a fuse breaker in a building) slowing its processing. This can mimic dementia. Once the tone is relaxed or decreased, the brain may appear to, over time, “wake up” and begin to function again at some level.

By treating these patients specifically as “neurological” rather than “orthopedic,” the costs can potentially be much lower, especially when factoring in the costs of their care for the rest of their lives.

The quality of life for these persons and for their entire family is not only measured in dollars and cents but may also be considered as a moral and ethical issue that we as fellow human beings are required to address.

The costs of care of any person who is prevented from requiring long term care placement is shown below and taken from the web site <http://www.payingforseniorcare.com/longtermcare/costs.html>. Notice the increase in costs of care with each level of care therefore providing a significant benefit to keep persons at their highest level of body alignment and appropriate range of motion.

Adult Day Care

The average daily rate for adult day care is less than 1/2 of assisted living, 1/3 of home care and almost 1/4 of nursing home care.

Adult day care centers provide the elderly with supervision and social activities in a structured setting during daytime hours. In 2015, the national average was \$69 / day with different state averages ranging from \$35 - \$124 / day.

Adult Day Medical Care provides the supervisory and social aspects of Adult Day Care and offers more intensive health and therapeutic services for individuals with severe medical problems and those at risk of requiring nursing home care. Families should expect to pay 5% - 15% more for adult day health / medical care than for regular adult day (social) care.

Assisted Living / Senior Living Costs

Assisted Living Residences provide help with activities of daily living including basic health services, recreational and Assisted Living Residences provide help with activities of daily living including basic health services, recreational and social activities. Cost is usually made up of monthly rent with additional fees based on the level of attention the resident requires. In 2015, the national average amount paid is \$3,600 / month and different state averages ranged from \$2,525 to \$5,745. Patients requiring Alzheimer's or dementia care paid an additional \$1,200 or approximately \$4,800 / month. [Find Assisted Living and Alzheimer's Care Communities](#) or see [residential care costs by state](#).

Nursing Homes

Skilled Nursing Residences offer 24/7 care by licensed health professionals including all housekeeping, medical and social needs. In 2015, the average amount being paid for a shared room is \$220 / day with different state averages ranging from \$140 - \$771 / day. A shared residence usually costs 80-90% of a private one. [Find affordable skilled nursing homes](#).

The chart below is from the website eCareDiary

2015 Average Senior Care Costs by Type and Duration				
Type of Senior Care	Hour	Day	Month	Year
Home Care Aide Cost	\$20	\$160 (8 hrs / day)	\$3,520 (22 work days / mo.)	\$40,000 (250 work days / yr.)
Home Health Aide Cost	\$20	\$160 (8 hrs / day)	\$3,520 (22 work days / mo.)	\$40,000 (250 work days / yr.)
Adult Day Care Cost	n/a	\$69	\$1,518 (22 work days / mo.)	\$17,250 (250 work days / yr.)
Assisted Living Cost	n/a	\$119	\$3,600	\$43,200
Skilled Nursing Home Cost	n/a	\$220	\$6,600	\$80,300

The new Genworth study found that the national median annual cost for a private room in a nursing home has climbed to \$92,378, up 1.2% from a year ago; a semi-private room runs **\$82,125**, which is 2.3% more than in 2015. May 10, 2016 Forbes.com

Conclusion:

Treating TBI and other neurological and lost range of motion patients with measures and products designed specific for their condition can not only be inexpensive, but they can also potentially save vast amounts of healthcare dollars for the rest of these patients’ lives by maintaining body alignment, posture and position, and decreasing the tone that can pull their body parts into profound, life-altering deformities.

Rigid, orthopedic splints were not designed with the intention to treat neurological patients. More study needs to be done to determine if they might have an adverse effect by not allowing the muscle to shorten during episodes of tone.

Because Flex Technology splints for lost range of motion are not expensive, these disabled patients who deserve the best, most appropriate treatment approach available can easily be fit with them. The American taxpayer deserves the best use of their tax money, therefore these patients should receive the most appropriate products and treatments for their specific condition.

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About Restorative Medical:

Restorative Medical (RM) is a global expert in the field of splints and braces for lost range of motion and other potentially disabling conditions. We have designed and manufactured custom made and off the shelf splints and braces for the past 27 years. These splints are made in the USA with the highest quality raw materials and workmanship. We also train clinicians and caregivers in our technology to help them to achieve the highest patient successes.