Phototherapy Applications — Part 2
Occupational Injuries

Doug Johnson, a certified athletic trainer and certified laser therapist published the first article of this two-part series in the previous issue. His first article dealt with the use of therapeutic lasers for the management of pain associated with sports-related injuries. In this issue, he is presenting an article about the use of therapeutic lasers for the management of pain associated with industrial and work-related injuries. For many of us with pain relief practices, this type of patient represents a fair percentage of our patient population.

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A great many of today's jobs tend to be highly specialized and require advanced technical skills, as well as greater time management skills. With these increased job demands, employees are at greater risk of occupational injury in virtually any employment setting.

In 2005, there were 135.7 of these injuries and illnesses per 10,000 full-time equivalent workers in private industry. Figure 1 presents injuries and illnesses data for five specific occupations.

More than 4 out of 10 of injuries and illnesses were sprains or strains, most involving overexertion or falls. More than a third of the sprains and strains occurred in the trade, transportation, and utilities industry. Three occupations—in particular, laborers and freight, stock, and material movers; heavy and tractor-trailer truck drivers; and nursing aides, orderlies, and attendants—accounted for 20 percent of all sprains and strains. These occupations also had the highest numbers of injuries and illnesses, accounting for 17 percent of the total days-away-from-work cases.[1]

The rate of workplace injuries and illnesses in private industry that required recuperation away from work declined 4 percent in 2005, according to the Bureau of Labor Statistics (BLS), U.S. Department of Labor (see Figure 2). There were a total of 1.2 million injuries and illnesses requiring days away from work in 2005, relatively unchanged from 2004. A two percent increase in the number of hours worked in 2005 contributed to the decline in the rate. Median days away from work—a key measure of the severity of the injury or illness—was 7 days for all cases in 2005, as it was in 2004.[1]

Some of the decrease in the number of injuries entailing days away from work and the cost of workers' compensation is very likely attributable to return-to-work efforts by employers. Twenty years ago, most employers felt that an injured worker should not return to work until he or she was fully recovered. Today, the most aggressive employers rarely leave workers at home for any period of time. As soon as the worker is able to do anything at all, they assign them jobs that are within their restrictions. In the BLS data, this trend is graphically evident by the decrease in injuries with full days away from work and the increase in the injuries with only restricted days (see Figure 2).

Treatment Approach

As in sports medicine, an aggressive treatment approach is more advantageous than passive approaches, especially since it's necessary to minimize the number of lost work days and costly claims. Primary focus needs to remain on the functional limitations that were noted in the initial evaluation of the injury. Since pain can be subjective in nature, it should not always be a determining factor in return-to-work status. Improvement of functional activities and a return to normal function needs to be addressed even if pain abates. So time or, more importantly, lost work time, needs to be used efficiently. A focus on objective functional limitations as they relate to job-specific tasks should be addressed. Industrial rehabilitation is commonly prescribed to

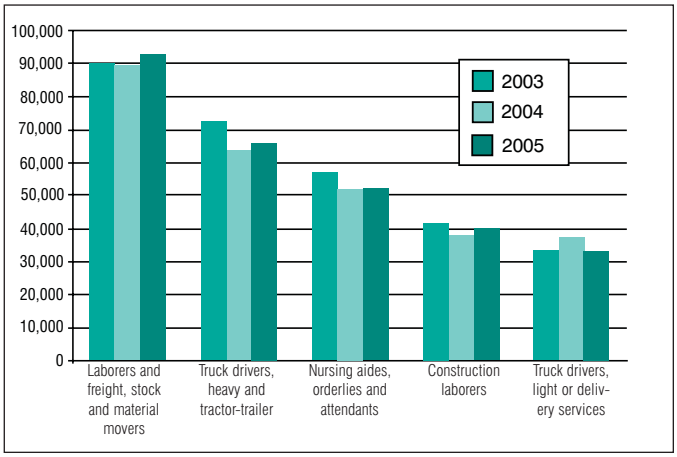

FIGURE 1. *Injuries and Illnesses for Five Occupations, 2003-2005 (Source: Department of Labor Bureau of Labor Statistics).*[1]

improve an injured employee's strength, range of motion, and endurance. The use of modalities should be aimed at restoring pre-injury function and selection of supportive modalities should be done carefully to suit the specific goals and restorative function desired.

Phototherapy As Therapeutic Modality

Phototherapy, a therapeutic physical modality using photons (light energy) from the visible and infrared spectrum for tissue healing and pain reduction,[3] is a relatively new option to address a wide variety of acute and chronic injuries associated with occupational injuries.

Phototherapy has been shown to be effective in the management of ankle sprains,[4] shoulder tendonitis,[5] medial and lateral epicondylitis,[6] cervical pain,[7] musculoskeletal back pain,[8] low back and radicular pain,[9] carpal tunnel syndrome,[10] and wounds/abrasions.[11] Additional evidence-based research is necessary to further validate the present findings and expand indicated uses. All future research studies should conform to the standards that have been established by the World Association of Laser Therapy (WALT).[12]

Dr. Mary Dyson has classified phototherapy and its effects on the body into primary, secondary, and tertiary effects.[13] It is the unique synergy between the three responses that create the phototherapeutic effect. The primary effects of phototherapy are created by direct photoreception of photons by cellular cytochromes resulting in increases in adenosine triphosphate (ATP) production and changes in cell membrane permeability. Photoreception is followed by transduction of light into cellular energy, amplification of the signal, and a photoresponse—the last of which can be classified as either secondary or tertiary.

Secondary effects include cell proliferation, protein synthesis, degranulation, growth factor secretion, myofibroblast contraction, and neurotransmitter modification—depending on the cell type and its sensitivity. Tertiary effects are the indirect responses of distant cells to changes in other cells that have interacted directly with photons. It is the summation of primary, secondary, and tertiary events that produce phototherapeutic activity.[13]

Occupational injuries are similar to those found in athletic participation. Both athletes and injured employees need to return to activity to minimize the amount of lost time on the field or lost work. Most workers' comp patients are able to identify causative factors and describe functional limitations they are experiencing. Occupational injuries typically involve soft and bony tissue with varying states of acute and chronic inflammation.

Contraindications

There are limited contraindications in the use of phototherapy for chronic and acute injuries. The stage of healing of the injury is the most important consideration. Acute injuries may respond best to third generation super-pulsed lasers (SPL). Higher-powered, continuous wave lasers (CWL) can generate substantial heat within injured tissues and so is contraindicated during the acute stages of healing. Phototherapy applications following steroid injections are contraindicated since anti-inflammatory medication is well documented to decrease the effectiveness of photobiostimulation.[14]

Trunk, Shoulders, and Back

The trunk, including the shoulders and back, suffers the most work incidents and accounts for 35 percent of all cases. Of those injuries or illnesses to the trunk, those involving the back accounted for 63 percent.[15]

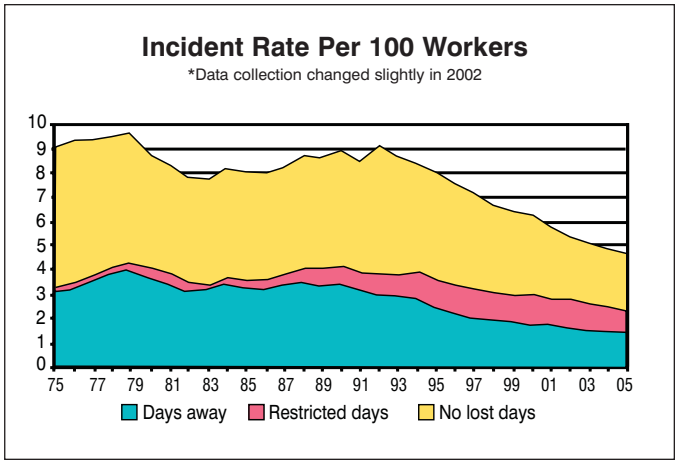

FIGURE 2. *Bureau of Labor Statistics Injury Survey of Lost Productivity.*[2]

Dr. Kneebone[16] has discussed the use of phototherapy for chronic back injuries. Additionally, it can be stated that the treatment of acute low back injuries can also benefit from the use of laser therapy—in particular, the pain associated with muscle spasm[17] and radicular pain (disc herniation).[18]

Two of the most common back injuries can be treated using phototherapy. In my last article, I discussed how to use light to treat a muscle spasm. The application in the low back would be the same. Continuous wave (CW) lasers of first and second generation use Pontinen's Principle to directly administer 6-8 J/cm^2 directly to the spasm. Super pulsed lasers (SPL) of the third generation need to deliver approximately 2-3 minutes of a frequency between 700 and 2500 Hz. Both techniques require a mild overpressure. Generally, results can be seen within 1 to 2 treatments. Chronic spasticity may require a treatment regimen consisting of 3-5 daily treatments for maximum effect.

Sacroiliac Joint Sprain

Common in the logistic and freight industries, sacroiliac sprain is generally caused by a combined kinetic movement of extension, rotation, and lateral flexion. SI sprains cause immediate pain and loss of function and can be implicated in the majority of low back pain—either as the prime cause or secondary effect.

The ligaments of the SI joint are innervated by eight anterior and posterior rami providing a vast potential for referred pain. With over 25 muscles controlling the action of the SI joint (SIJ), the patterns of trigger point and referred pain can also be very complex. Further, the superior aspect of each SIJ is almost contiguous with the L5 facet above, while the ilio-lumbar ligaments bind lower lumbar mechanics to SI function, another aspect of low back pain mechanisms. Even a minor joint sprain causes local muscles to splint around the joint. Supporting muscles, in constant contraction, become strained and will often become weakened and activate trigger points, (especially the gluteals and piriformis). It may also produce referred pain patterns and paresthesia into the buttock and leg.

Because of this complexity, treatment techniques need to vary and adapt to the clinical findings. Phototherapy treatments may

TABLE 1. CARPAL TUNNEL SYNDROME MIMICS

Vascular
- Thoracic Outlet Syndrome
- Venous Insufficiency
- Edema

Muscular
- Tendonitis
- Spasm
- Tenyosynovitis

Neurological
- Cubital Tunnel
- Neuritis
- Diabetic Neuropathy
- Nerve Root Compression

Soft Tissue
- Compression
- Swelling
- Direct Trauma

be divided into "zones." That is to say, it may be optimum to target both the primary target tissue (primary zone) together with surrounding tissues. These additional, surrounding zones can be used to maximize the tertiary or systemic effects of phototherapy treatments. They are generally larger areas and may require different dosages and/or frequencies.

The primary treatment zone is the SI joint itself. Direct irradiation into the SI joint is recommended to control pain and inflammation. Wavelength is an important consideration and, due to the nature of the joint structure and depth, infrared lasers are necessary to produce primary effects within the tissue. Note that red laser and light penetrate shallowly into tissue and may produce some tertiary effect within the tissues along with some temporary pain relief, however, it is best to use a laser in the infrared spectrum to achieve better results.

CW laser selection should include a second generation laser (higher power, continuous wave) with an adequate energy density. Be mindful of the heating effects of these higher powered diodes in the acute stages of injury. These devices are best suited to delivering the necessary amount of energy to target depths within clinically acceptable times, but can create some negative thermal effects within the tissues themselves. Dosages of 8-40 joules/cm^2 are not uncommon. This a considerable amount of energy and, since dose is time-dependent on the power output and mode of operation (continuous wave vs super-pulsed), first generation lasers lack the power and density to deliver these doses in acceptable time frames.

Third generation super-pulsed lasers require doses that are much smaller in comparison due to the very large energy densities created by the peak impulse. Because of the super-pulsing action of the laser, the duration of laser exposure is minimal, yet the tissue is irradiated with several thousand milliwatts and depth of penetration is achieved more rapidly. Accepted SPL doses are between 4 and 10 joules/cm^2. Frequency selection with a SPL is of considerable importance since it will determine the depth of penetration. Primary zone SIJ treatment should include frequencies between 5 Hz and 100 Hz and the probe should remain stationary during the application. Table 1 summarizes depth penetration dosimetry for super-pulsed and continuous wave lasers, respectively.

SI secondary zone treatments should be used to either induce tertiary effects of the laser or to treat the muscle guarding associated with the sprain. Secondary zone treatment may consist of scanning the affected area with higher frequencies (1000-3000 Hz) to produce anti-inflammatory effects or control pain. The other option is to treat the trigger points of the muscle around the joint. It would not be advisable to do both in the same session since the amount of radiated energy would likely reach a level causing photobioinhibition.

Carpal Tunnel Syndrome

With a growing population of computer and keyboard users, carpal tunnel syndrome (CTS) is of real concern to both employers and the health care professions. The U.S. Department of Labor has cited carpal tunnel syndrome, as well as other cumulative trauma disorders, as the cause of 48 percent of all industrial workplace illnesses. The disease affects more than five million Americans.[19] CTS's impact on American businesses is devastating. The average lifetime cost of carpal tunnel syndrome, including medical bills and lost time from work, is estimated to be about $30,000 for each injured worker.[20] The high cost of treatment for an employee with CTS, plus the lost productivity when that employee is absent for a long period of time, strains the company's ability to operate efficiently and can lead to morale problems when other employees have to take over the absent workers' responsibilities.[21]

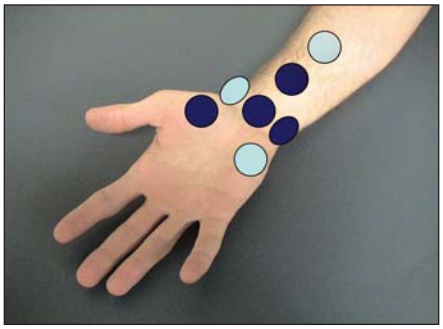

FIGURE 3. *Position of primary (blue) and secondary zones (light blue) of phototherapy for CTS.*

Carpal tunnel syndrome ranges in severity from a mild discomfort in the wrist, hand or lower arm to a completely disabling, constant pain enveloping everything between the fingertips and the neck. The etiology of CTS is multifactorial, with both local and systemic factors contributing to varying degrees. Direct pressure or a space-occupying lesion within the carpal canal can increase pressure on the median nerve and produce CTS. However, CTS symptoms can be attributed to fracture callus, osteophytes, anomalous muscle bodies, tumors, hypertrophic synovium, gout and other inflammatory conditions. In addition, infection can produce increased pressure within the carpal canal.[22]

Associated secondary trauma or root cause of the symptoms at a second site remote from the wrist—termed 'double crush syndrome'—can further lower the median nerve's pressure threshold for producing symptoms of CTS. First observed during the GM Flint CTS Double Blind Research Study of 1994, there can be many other precipitating factors that create or mimic CTS symptoms (see Table 1).

The primary zone treatment is the CT itself. CW laser dosage requires a minimum of 12j/cm^2. In Figure 3, the most common (primary) protocol is labeled with dark blue. However, in practice we have found that a modification of the standard protocol produces greater overall results. The light blue spots show the other locations that should be included when treating compression of the median nerve at the CT. SP laser dosimetry would use 1-2 minute per point at frequencies of 50-100 Hz.

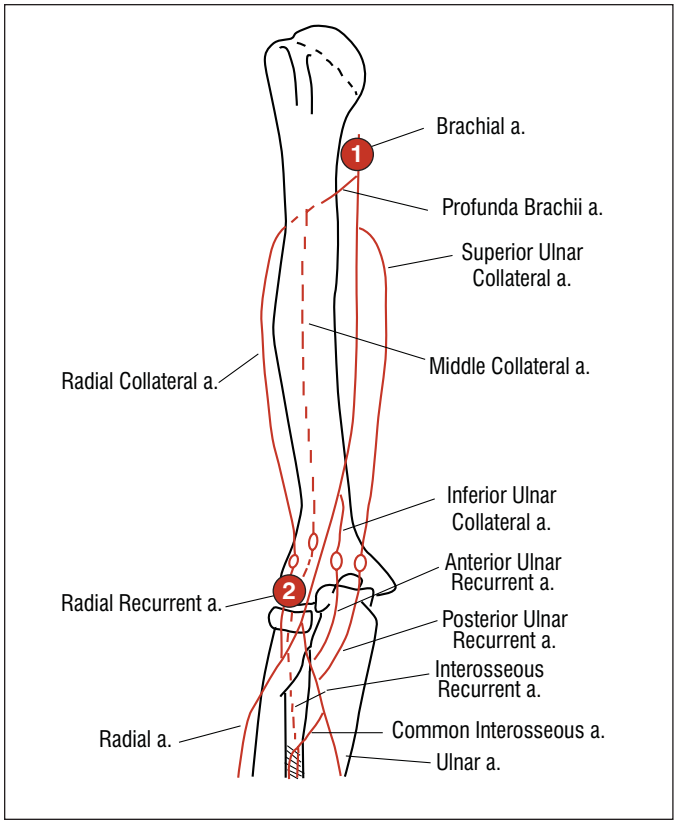

FIGURE 4. *Phototherapy secondary zones for upper extremity circulation (1-axilla and 2-anticubital fossa)*

Secondary zones need to specifically address the secondary causation of the symptoms. Clinical experience has shown that the majority of CTS symptoms can be related to vascular deficits, soft tissue injury within the upper extremity itself, musculoskeletal injury, and neurological dysfunction. This makes secondary zone selection of critical importance in successful management of CTS. Given the nature of the CTS, this can explain a great deal in the variation between research studies and clinical findings in the efficacy of phototherapy for this treatment.

Potential Vascular Component to CTS Symptoms

Special testing is necessary to rule out a vascular component. Tests such as Hyperabduction Test and Adson's Maneuver can be used when vascular compromise is suspected. If detected, treatment should focus on improvement of circulation through the upper extremity. Secondary zones should focus on the brachial artery, either at the axilla or anticubital fossa (see Figure 4). CW dosages would range between 8 and 12 j/cm^2

If symptoms are related to venous insufficiency, secondary zones should incorporate Oshiro's principle (as previously described in part one of this series) to treat the swelling prior to applying laser therapy directly to the CT. This would also include soft tissue inflammation or injury to the CT itself. Remember, it is prudent to treat proximal first, therefore opening and encouraging lymphatic flow from the distal area and to evacuate swelling at site. The use of larger cluster probes to stimulate the lymph vessels is highly recommended.

Tendonapathies of the flexor muscle group are relatively common as is those of the lateral elbow. There can be tenosynovitis at the CT, but also epicondylitis of either medial or lateral elbow. Specific details of tendon applications were covered in the last article.

Cervical Spine Neuropathies

A final consideration for secondary zone treatments is the cervical spine. CTS can often be confused with neuropathies. Nerve root compressions as well as disc herniations can mimic the radiating pain and numbness often associated with CTS. Second generation CW lasers are used to treat the cervical spine; affected levels should be treated at the spinous process as well as the nerve root and along the trunk and at levels above and below. Dosimetry can range from 6 to 15 j/cm^2.

The cervical epidural space lies at a depth of approximately 5-6 cm.[23] In cases of disc pathology, SP lasers have been shown to penetrate deeper than the CW counterparts. Dr. Jan Tuner, a leading expert in the laser therapy field has been quoted as saying, "The GaAs laser is most effective in the treatment of pain, inflammation, and functional disorders in muscles, tendons, and joints (e.g. epicondylitis, tendonitis, and myofascial pain, gonarthrosis, etc) and for deep lying disorder in general."[13]

It is therefore recommended to use a super-pulsed laser (SPL) to optimize the treatment outcome. A low frequency of 5-50 Hz at 3-4 minutes per point is recommended. For both methods, treatments may take anywhere from 12-16 treatments before results may be clinically significant. The use of ultrasound is commonplace in treating CTS. However, the use of ultrasound with laser therapy has shown little benefit and may actually counteract each other.[24] Selection of the most appropriate modality should be made based upon clinical findings.

Other Considerations for Successful Outcomes

Due to the nature of industrial work place injuries, there are far more acute injuries than chronic. As in athletics, injured workers are typically seen in the industrial therapy setting within hours of the initial injury. Dosage and duration of phototherapy during acute stages are smaller than those required for chronic injuries. Even an exacerbation of a chronic injury can be considered an acute injury. Keep initial doses toward the lower end of the given ranges, with a clear understanding that this dose may need adjustment upon subsequent visits.

Phototherapy devices need to follow dosimetry value curves in order to achieve beneficial therapeutic effects. This means that the initial dosage may need to be increased to elicit a treatment response and, as treatment progresses, may need to be decreased to avoid treatment reactions. After any phototherapy treatment, the patient should be reevaluated to monitor response to the therapy.

Clinicians need to be mindful of the stage of healing and to keep the "priority principle" in mind. Treating the injured tissues in order of significance is paramount to successful outcomes; these stages can be identified by the stage of healing the injury is in.

Employers, more so than the employees themselves, are anxious to see the injured worker return to full duty. Of course it is understandable in that there is a financial interest in a rapid return. However, it would be best for the injured worker to return to work only after a steady, well-monitored incremental increase in functional activities that demonstrate pain-free ranges of motion, strength, and endurance.[25] It is essential that the injured

Super-Pulsed Laser					
Depth	10 mW	25 mW	50 mW	100 mW	200 mW
.5 cm	2.5 min	1 min	30 sec	15 sec	10 sec
1 cm	5 min	2 min	1 min	30 sec	15 sec
2 cm	10 min	4 min	2 min	1 min	30 sec
3 cm	15 min	6 min	3 min	1.5 min	45 sec
4 cm	20 min	8 min	4 min	2 min	1 min

Continuous Wave Laser						
Depth	10 mW	25 mW	50 mW	100 mW	250 mW	500 mW
.5 cm	25 min	10 min	5 min	2 min	1 min	30 sec
1 cm	50 min	20 min	10 min	5 min	2 min	1 min
2 cm	*	40 min	20 min	10 min	4 min	2 min
3 cm	*	*	30 min	15 min	6 min	3 min
4 cm	*	*	40 min	20 min	8 min	4 min

Table 2. *Depth penetration dosimetry for super-pulsed and continuous wave lasers*

worker be allowed to recuperate and that training be resumed gradually. Return to work should be based on objective improvement in functional activities and not necessarily based on the presence, or absence, of pain. Treatment should not be interrupted just because pain is gone; pain abatement is only the first sign of progress toward recovery.[26]

Phototherapy treatments can modulate pain expression[27] and should allow patients to progress more rapidly in activities that return strength and range of motion and, as a result, ultimately reduce the number of lost work days.

Conclusion

It has become apparent, now more than ever, that successful phototherapy outcomes are based not just on appropriate dose but a correct assessment of the injury itself. Failing to address the root of the problem will provide mixed results and lackluster clinical outcomes. The concepts of phototherapy are learned in moments, yet optimum application can take years to master. It is the combination between wavelength, energy density, dose, and correct assessment that will produce the desired result. The negative results of many research projects can be traced to a failure by researchers to correctly take into account these parameters. Continued research is needed to assess how these parameters affect treatment outcomes. ■

Douglas Johnson, ATC, EES, CLS, is a certified athletic trainer with over 11 years of clinical/industrial experience. He attended Wayne State University and The University of Detroit Mercy where he earned a Summa Cum Lauds Bachelors of Science degree in Sports Medicine in 1994. He has worked extensively in the field of Occupation Medicine as the Assistant Regional Physical Therapy Director of Concentra Medical Centers Michigan Operations and as the therapy director of PrimeCare Medical Centers before co-founding a practice in 1996. Mr. Johnson is the co-owner of Sports and Industrial Rehab and founder of the Laser Center of Michigan. Working extensively with phototherapy technology, including the ML830 MedX Series 1100, PowerLaser 500, DuoLight 830, and the Solaris, he has been featured on FOX2 Healthworks, UPN50 Healthwatch, CBS WMEN5 Healthwatch, and ABC WXYZ7 Health Team Reports, and his articles that have appeared in NATA News, The Heritage Newspaper, and The Detroit News. He is the author of the article "Low Level Laser Therapy in the Treatment of Carpal Tunnel Syndrome" published in Athletic Therapy Today. His focus on phototherapy includes lectures throughout the Midwest, articles, and working on a phototherapy home study course.

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