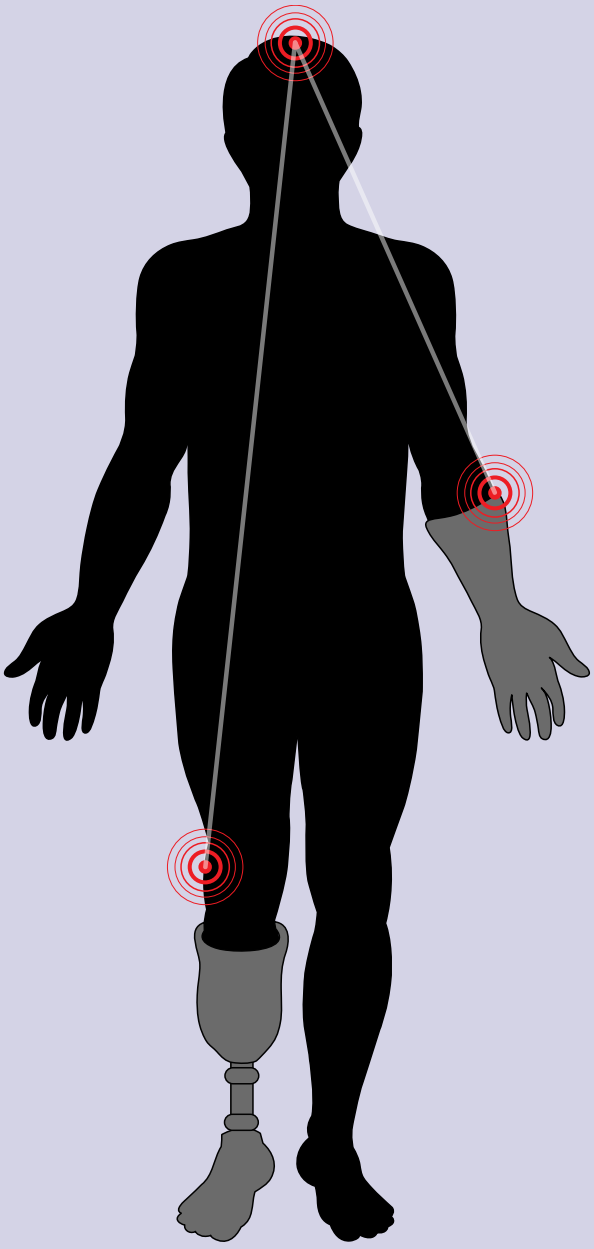
The War Amps

Pain and Phantom Limbs



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Please direct all correspondence to:

The War Amps

Tel.: 1 877 622-2472
Fax: 1 855 860-5595

info@waramps.ca
waramps.ca

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Phantom Limb Pain – Why Do Amputees Experience It?

Phantom limb pain has been around as long as there have been amputees. Even though the pain is generated from the brain, it is not "all in your mind"– it is very real indeed! Phantom limb pain is as real as if you were to hit your finger with a hammer.

What Research Has Been Done to Explain What Phantom Limb Pain Is and How It Is Caused?

Much research has been done on how pain may be generated in a limb that is no longer there. Pain "memories" and pain "gate" theories are among the possible explanations you will read about in this booklet.

Pain would not be experienced at all if the brain did not interpret signals coming in from various parts of the body via the spinal column. Pain is the body's safety mechanism to minimize further injury to the body. How can a pain message be sent from a body part that no longer exists? Current theories indicate an overall "body mapping" exists in the brain – even when a piece of the body no longer exists, the "body map" in the brain remains intact.

What Treatments Are Available?

Information on the current methods of pain treatment and the theories behind them are also included in this booklet. Simple treatments may work for you, such as heat or cold and warm or cool baths. It is important to keep in mind that just because a particular treatment works for one amputee does not mean it will necessarily work for another. Therefore, it is recommended you try a number of different strategies to find what works for you. You may also want to consult with your doctor or chronic pain specialists about your phantom limb pain, especially if it is severe and frequent.

The War Amps has compiled the material contained in this booklet from a number of sources to help you understand and deal with this phenomenon that has been misunderstood and often disregarded by others.

Phantom Limb Pain – An Overview

Phantom limb pain is experienced when the brain sends pain signals to limbs that are not there. The pain can differ in type and range in intensity. For example, a mild form might be experienced as a sharp, intermittent stabbing pain that causes the limb to jerk in reaction. An example of a more severe type is the feeling that the missing limb is being crushed. The pain often diminishes in frequency and intensity with time. For a small number of amputees, however, phantom limb pain can become chronic and debilitating due to the frequency and severity of the pain.

Phantom sensation is the conscious sensation that the amputated limb is still there. These sensations, typically experienced as a mild tingling, usually decrease with time.

This section of *Pain and Phantom Limbs* covers remedies tried by amputees that have provided some benefit in decreasing phantom limb pain. While reading, it is important to keep in mind that just because a remedy works for one amputee does not mean that same remedy will necessarily work for another.

The techniques for alleviating phantom limb pain covered herein have been gathered from many sources. Some are purely anecdotal. Our aim is only to provide information on some of the techniques available. You should discuss your pain management plan with your doctor or clinic team.

The War Amps accepts no liability for the interpretation and subsequent use of information found in this article.

Techniques for Dealing With Phantom Limb Pain (in Alphabetical Order)

Acupressure

Acupressure is a healing art that has been practised in China for thousands of years to treat a variety of ailments, including chronic pain. It is based on the concept that energy travels through the body along pathways called meridians and that blocks in this energy flow can lead to discomfort or even disease. Energy flow is promoted by pressing the appropriate "acupoints" on the body.

Acupuncture

Based on the same principles as acupressure, acupuncture involves the insertion of tiny needles into the skin at specific sites. Each needle is twirled for a few minutes or a low electrical current is applied. It is not fully understood how acupuncture works – the Chinese healing art stresses the energy flow of ch'i (or life force), while western medicine suggests it stimulates the production of endorphins, the body's natural painkillers.

Anesthetics

Pre-Operative: Epidural Blockade

When amputation surgery is performed, whether caused by trauma or disease, the amputee is often in pain before the surgery starts. It is theorized that this pain imprints on the brain and creates a "pain path," which then causes phantom limb pain after the limb is removed. By using an epidural – an injection of anesthetic to the spine (usually for a period of 72 hours prior to the surgery) – the pain message is blocked from reaching the brain and creating a "pain path."

It has been reported that people who have an epidural blockade prior to surgery experience less pain during the post-operative period, as well as a reduction in the frequency and severity of phantom limb pain. It is also thought that the epidural reduces pain by cutting off the pain messages associated with the surgery, which still register in the brain even though the patient is unconscious.

Post-Operative: Local Anesthetic

E.g., Lidocaine, Marcaine, Novocaine, Pontocaine, Xylocaine

Local anesthetics act on nerve cells by making them incapable of transmitting pain messages for a short period of time. Local anesthetics may be given as spinal (a small needle into the spinal column, in the lower back), epidural (a small needle and catheter into the spinal column, in the lower or mid-back), by local injection or a wide variety of nerve blocks. These may be used to relieve trigger points and reduce pain in the residual limb.

Biofeedback

Advocates of biofeedback believe phantom pain may occur due to anxiety, which can increase muscle tension and contribute to the pain cycle. Biofeedback is based on the premise that hyperactive muscles cause irritation in the cut ends of the nerves in the residual limb. In biofeedback, electrodes attached to the residual limb detect when the muscle is tensed and trigger a flashing light or buzzer to provide feedback. Once the amputee has become aware of the muscle tension, they learn to relax the muscle. When an appropriate decrease in muscle tension is reached, the feedback stops. The focus of this treatment is to teach the amputee how to relax the muscle(s), thereby relieving the pain.

Chiropractic

Some amputees may find relief through chiropractic, which means "treatment by hand." Chiropractic does not involve drugs or surgery, but instead concentrates on the spine in relation to the total body. Doctors of chiropractic, or chiropractors, specialize in the understanding and treatment of the different parts of the spine: bone (vertebrae), muscles and nerves. When a vertebral joint is not working properly, it can create an imbalance that disturbs the nervous system. This can lead to excess strain being placed on other joints, resulting in some form of pain. Through manual adjustment, or manipulation of the spine, chiropractics work to correct misalignments to alleviate pain.

Cold

Applying cold to the residual limb may help alleviate some of the discomfort associated with phantom limb pain or muscle spasms. Refreshing coolness can be administered through cold compresses, ice packs or cool baths. Amputees may also wish to try a cooling cream or gel. One such product is Biofreeze, an analgesic cryotherapy gel made from the extract of a South American holly shrub. Biofreeze creates a cooling sensation within the skin that can last for several hours. Another gel, Glenalgesic Blue, which contains menthol, alcohol and camphor, is a topical pain fighter for the prompt and temporary relief of muscular aches and pains.

[See also Heat.]

Cranial Sacral Therapy

This type of therapy, involving the study of bone and joint misalignment related to the head, has been practised by many different cultures for thousands of years. Therapeutic touch is applied to the head, and meditation and visualization techniques may also be used in conjunction with cranial sacral therapy. A therapist treating phantom pain may "massage" the missing limb, as well as encourage visualization of the lost limb in an effort to help amputees release any sense of grief, loss or anger toward the missing limb(s).

Desensitization

The nerves in the residual limb can be very sensitive, especially directly following the amputation. Not only does desensitization reduce nerve sensitivity, it can also reduce pain and discomfort overall. Rubbing the residual limb with a piece of terry cloth, gently manipulating it manually, tapping it or using a vibrating device can all help desensitize the nerves, alleviating sensation and pain.

[See also Massage.]

Dietary and Herbal Supplements

Some amputees have found certain dietary supplements or homeopathic food products help reduce phantom limb pain. Examples of dietary supplements amputees have tried include potassium, calcium, magnesium and injections of vitamin B-12. Certain herbal products have also been found useful by some amputees, including juniper berries.

Antioxidants such as Pycnogenol (a pine bark extract sold in Canada as a food product) and grape seed extract are extremely concentrated bioflavonoids, which, until 1936, were known as vitamin P. Antioxidants attack free radicals, which are unstable atoms inside our bodies that attack all body tissues, degrade collagen and reprogram DNA. Free radicals are believed to be the underlying cause in many diseases. Antioxidants are found in high concentrations in grape seeds and pine bark, and in lesser amounts in grape skins, cranberries, lemon tree bark and hazelnut tree leaves. Antioxidants are available in liquid and pill form.

**Amputees should always consult their doctor before taking any supplements or herbs, as they are not harmless and can have powerful side effects. They may also interfere or conflict with other medications being taken at the same time.*

Electrical Stimulation

Another theory behind phantom limb pain suggests it occurs because the nerves in the residual limb lack the stimulus once provided by the missing limb. Transcutaneous electrical nerve stimulation (TENS) and microcurrent electrical therapy (MET) with the product Alpha-Stim 100 are two examples of electrical treatment using low current at a low-frequency oscillation to stimulate the nerves and provide pain relief. Depending on the severity of pain, the battery-operated devices can be used for 10 to 20 minutes or more (recommended times and demonstration of how to use one of these devices may be provided by a medical professional). As TENS can cause arrhythmia, it should not be used by people with heart disease and neither TENS nor MET should be used by individuals with pacemakers.

Exercise

Exercise increases circulation and stimulates the production of endorphins (chemicals naturally produced in the brain that kill pain). Many amputees find that moderate and frequent exercise can help reduce phantom pain. Flexing and relaxing the muscles on the residual limb also helps some amputees.

Farabloc

Farabloc is a fabric that contains extremely thin steel threads but looks and feels like linen. The makers state that Farabloc has a shielding effect from ions and magnetic influences, which protects damaged nerve endings. It stimulates blood circulation and produces a pleasant feeling of warmth. It can be cut, sewn, washed and ironed like any other fabric and is available in blanket forms of various sizes. People may have socks, sheaths or custom residual limb covers made from Farabloc, or the material may be incorporated directly into a prosthetic socket.

Heat

Applying soothing warmth has been reported to help deal with occasional bouts of phantom limb pain. Warm baths, a heating pack or wrapping the residual limb in warm, soft fabric to increase circulation are all examples of how heat can be used. There are also rubs and gels that generate heat, such as Rub A535 or Tiger Balm. More advanced forms of heat therapy can be used under the guidance of a trained professional. Some amputees alternate between applying heat and cold.

[See also Cold.]

Keeping a Journal

Some amputees write down dates and times as well as other factors that may be present when they experience phantom limb pain, such as stress. A record kept over time may indicate factors that influence or trigger the occurrence, frequency or severity of an attack of phantom limb pain in the same way migraine sufferers have found that certain foods trigger their migraines.

LaKOTA

LaKOTA is an herbal line of products available over-the-counter. It is a natural analgesic developed for arthritis and other muscle and joint pains. Some

amputees advise it can also offer relief from phantom limb pain. LaKOTA is available in topical and oral forms.

Magnetic Therapy

Magnets are used to treat many conditions, including phantom limb pain. Magnetic therapy involves applying a magnetic field to the body to relieve pain and speed up the healing process. The application of electromagnetic fields has been shown to affect cell permeability and improve oxygen delivery to the cells, which can lead to better absorption of nutrients, improved circulation and clearance of waste products. Magnets may also reduce inflammation and pain and promote healing.

The magnets are usually incorporated into bracelets, belts or fabric straps and are available in differing strengths and sizes. Such products are available from several companies, such as Nikken and Bioflow.

**Consult your doctor before trying magnetic therapy to ensure it is a good choice for you.*

Massage

Massaging the limb is a good way to increase blood flow and circulation, which may help alleviate discomfort. Massage may also help reduce swelling and loosen stiff muscles, which can provide some relief from pain.

Medications

Medications are useful in the treatment of pain (especially chronic pain). However, many amputees prefer to try other avenues of relief first. It is important for the amputee to understand all the possible side effects of over-the-counter and prescription medications, including the implications of long-term use.

Anti-Inflammatory Drugs

E.g., acetaminophen (Tylenol), acetylsalicylic acid, ibuprofen (Advil, Motrin)

Anti-inflammatory drugs can reduce mild swelling or soreness and are useful for mild to moderate pain. They are non-addictive and may be effective for occasional bouts of phantom pain. One amputee reported using Tylenol Arthritis Pain for relief from his phantom limb pain.

Antidepressants

E.g., Effexor, Elavil, Pamelor, Paxil, Prozac, Zoloft

Although developed to treat depression, many antidepressants have been found useful in the treatment of many chronic pain conditions, including phantom limb pain. These drugs work centrally on the brain to either block or increase certain chemicals that help regulate normal brain function.

Anticonvulsants or Anti-Seizure Medications

E.g., Lyrica, Tegratol, Neurontin

Anticonvulsants have also been found useful in the treatment of phantom limb pain. They act directly on the nerves both in the residual limb and in the brain to alter neurotransmission, thus calming nerves in the residual limb that may have become over-active following amputation. These drugs are prescribed in small doses and are gradually increased to a level that promotes relief. It is also very important to decrease the dose gradually before ceasing to take the medication.

Narcotics

E.g., codeine, Demerol, morphine, Percodan, Percocet

Narcotics mimic the chemicals released by the brain in response to pain. Amputees who have only an occasional severe attack of phantom pain may benefit from a limited course of this type of drug.

**Narcotic prescription drugs are not suitable for all cases of phantom pain, so it is important to speak with your doctor.*

Meditation

Both physical and mental tension can make pain worse. Meditation may help reduce phantom limb pain by relaxing tense muscles and lowering anxiety levels. The aim of meditation is to produce a state of relaxed but alert awareness; this is sometimes combined with visualization exercises that encourage people to think of pain as something remote and separate from them.

Mirror Therapy

Viewing the reflected image of an intact limb in a mirror can fool the brain into thinking the amputated limb still exists. This technique has been proven to dramatically relieve phantom limb pain. By placing a mirror lengthwise facing the remaining limb, the reflection creates the illusion of two limbs moving together. This tricks the brain into seeing the amputated limb, overriding mismatched nerve signals.

Psychotherapy

Some amputees may find individual or group therapy beneficial. Some have even tried hypnosis. Trained professionals can help amputees learn coping skills and provide psychological and emotional support for dealing with pain.

Shrinker Socks

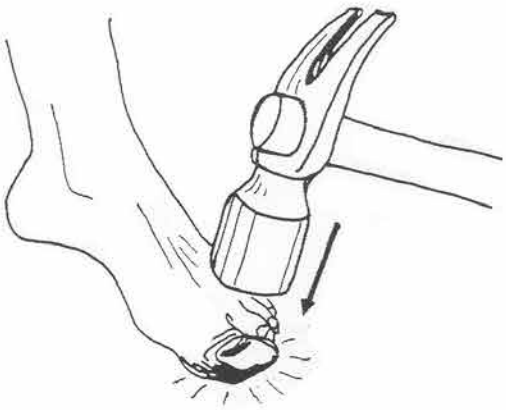
Bandaging and shrinker socks apply even pressure to the residual limb, which may help reduce or alleviate phantom limb pain.

Wearing Your Artificial Limb

As well as improving circulation, putting on your artificial limb and moving around may also help alleviate phantom limb pain.

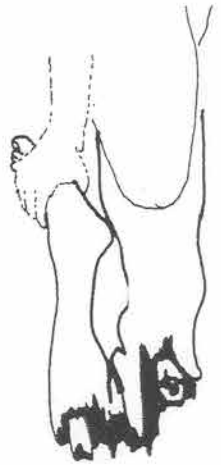
Common Types of Phantom Limb Pain

A rope-burn sensation between the big and second toe

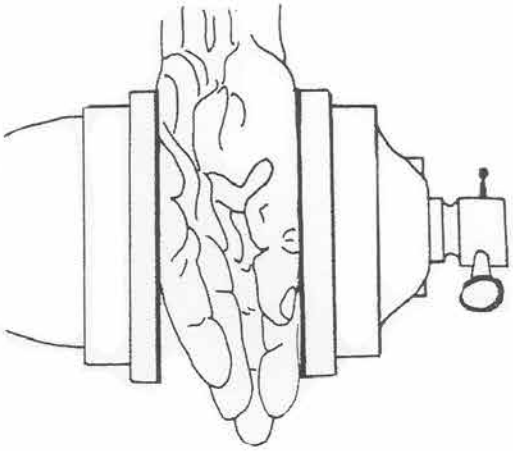


A hammer is smashing the big toe

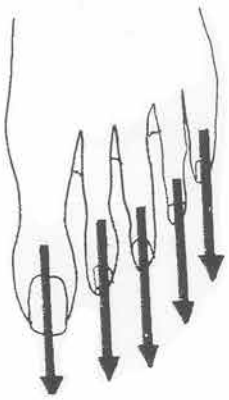
The fist is so tightly clenched that the finger nails are digging into the flesh in the palm of the non-existent hand



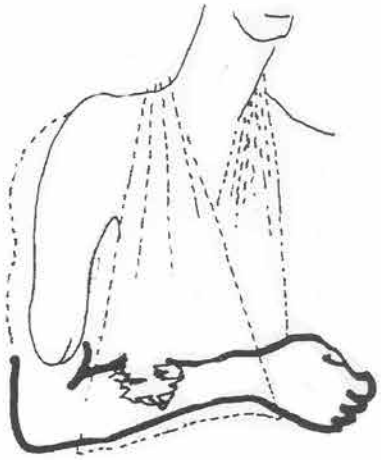
A feeling, for an above knee amputee, that the fibula and tibia are being broken in half



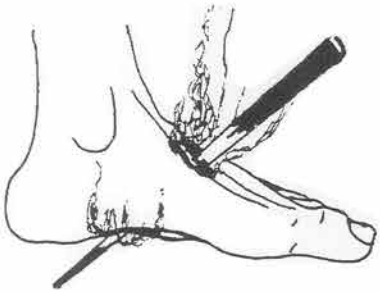
The hand is being crushed in a press



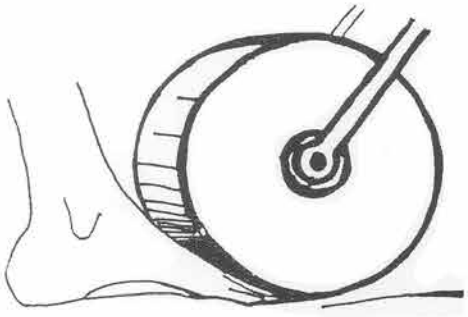
Five toes are being stretched



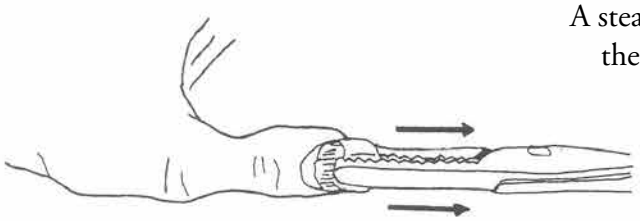
The bones of the non-existent arm are being shattered



A red-hot poker is being thrust through the foot



A steam roller is running over the front part of the foot



Pain and the Amputee

The following is an adaptation of an article written by the late Cliff Chadderton and published in The Fragment*, which was the Association's publication for War Amps members. The information contained in the original article was compiled following a series of visits to prosthetic centres and using responses to questionnaires completed by war amputees.*

Phantom limb pain is one among a number of possible sources of pain for amputees. This article covers phantom limb pain and other sources of pain related to amputation.

While reading this article, keep in mind the following three important facts about pain:

- Pain is subjective; what the amputee feels is difficult to describe to other people.
- People have different pain thresholds; what is unbearable pain without painkillers for one person may require no painkillers for another.
- Long-term discomfort is really pain in a disguised form; it indicates an underlying problem.

Phantom Limb Pain

A professional attempting to treat phantom limb pain must understand the theory of pain, which involves talk of peripheral-nervous receptors, myelinated fibres, stimuli and so on. For the amputee, it is sufficient to understand that there are two kinds of pain: pain in the residual limb and phantom limb pain. Residual limb pain can be located at a precise point (e.g., where there is a bony prominence), whereas phantom limb pain exists in a limb the amputee no longer has.

Prevalence and Treatment

Phantom limb pain is described as shooting, burning, cramping or crushing. The pain can be triggered by seemingly innocuous things such as cold, heat or coughing.

For amputees who suffer from phantom limb pain, emotional disturbances such as anxiety, depression and sleeplessness can bring on attacks. In other words, the psychological status of the amputee can have a significant impact on the course of the painful phantom limb phenomena.

The treatment of an amputee experiencing phantom limb pain must be approached on an individual basis. Simple treatment measures that can provide partial relief include manipulation of the residual limb, wrapping of the residual limb, baths, application of heat with hot packs, ultrasound and, in some instances, the putting on of the prosthesis and using it vigorously.

Medical reports indicate no single drug is proven effective in the long-term control of phantom limb pain. According to the surveys collected by The War Amps, war amputees are well aware that the use of anything except a mild analgesic can lead to serious drug addiction, so they take care to avoid the use of such medications.

Injection at the "trigger points" with a local anesthetic combined with steroid preparations sometimes works. The blocking of the "pain paths" is considered to be an unpredictable treatment, but could be tried under the supervision of a physician.

Transcutaneous nerve stimulation has been reported as successful. If an amputee is interested, he or she could discuss this with a physician. Hypnosis has been tried for phantom limb pain; again, this is something to be discussed with a physician.

Phantom Limb Pain and Age

Phantom limb pain can become more of a problem with age. This may be because as an amputee gets older, he or she will undergo changes that weaken his or her physique, which would in turn diminish tolerance to withstand pain.

Another factor is that, by the time the amputee reaches 60, if he or she has been an amputee for a long time, he or she will have taken many analgesics to control pain. The result is that the painkillers can be less

effective. There are also the related effects of long-term medication use – things such as gastric-upset, loss of sleep, etc. Surveys collected by The War Amps indicate that codeine – and possibly other painkillers – causes constipation, which puts the amputee into a vicious circle. The amputee is in pain, takes codeine and becomes constipated. This makes the amputee feel lousy, which makes the pain worse, and sometimes phantom pain develops.

There are other conditions secondary to the loss of a limb, such as weight-bearing, loss of muscle power, etc., that can aggravate the condition. The pain would be bad enough in itself, but if it is a leg amputee putting all of his or her weight on the remaining leg, for example, the pain can be exacerbated.

Phantom Sensation

The term "phantom sensation" usually refers to the awareness of the missing portion of a limb, typically experienced as a mild tingling sensation. It is rarely unpleasant; it is essentially just the fact that the amputee can still feel the presence of a limb that is no longer there, described in terms of numbness, pressure, temperature or mild pins and needles.

Anecdotal evidence suggests that, for some amputees, not feeling the phantom sensation of a missing limb can cause considerable difficulty. A leg amputee, for instance, might lose balance and stumble.

Neuromas

A neuroma is a small enlargement at the end of a nerve that can occur when a peripheral nerve is severed during amputation. Such nerves sometimes turn back in on themselves and combine with the fibrous nerve tissue, forming a neuroma.

Surgical treatment varies. Some doctors use gentle traction on the nerve followed by a resection or cutting of it with a sharp scalpel. Other surgeons will sometimes add a single ligature (a stitch) during surgery in an effort to prevent a neuroma.

If a neuroma is located well above the end of the residual limb and buried in adequate soft tissue, it usually would not cause any problems. A large neuroma situated at the end of the residual limb where pressure from the socket causes problems, however, will likely require intervention. A prosthetist can sometimes ease out the socket. If this is not successful and the pain worsens, the amputee may require further surgery.

As the amputee grows older, there appears to be a trend toward more pain from neuromas, possibly with surgical treatment being required. Injection with local analgesic steroids may alleviate the pain, but surveys and reports indicate this would only be temporary at best.

Medical reports indicate surgical excision is the treatment of choice; this has failed to yield uniform results, so the amputee should not be led to expect a cure necessarily. One medical report describes encasing the nerve stump in a "micro-porous filer sheet occluded by a silastic rod." The report indicates this technique has been effective and has also in some cases decreased phantom limb pain.

Bursitis and Tendonitis

Bursitis and tendonitis are often an aggravating or consequential source of pain secondary to amputation. Other conditions often experienced by amputees are tennis elbow, rotator cuff syndrome, carpal tunnel syndrome and arthritis.

Exercise (particularly muscle stretching) can be a source of relief; a physiotherapist can usually be of help in this regard. If the muscles in the remaining limb where the connecting joints are properly looked after and the ligaments, muscles and tendons are toned up with exercise, the pain will likely be less.

The amputee will also want to look at the possibility of interim methods of relieving this kind of associated pain, such as steroid injection, phenylbutazone tablets, etc. Painkillers are an option, but only do so in consultation with a physician and be vigilant for signs of addiction and other penalties of overuse.

Amputees who wish to remain active in sports such as golf, curling and sailing must recognize that such activities will cause additional strain on the remaining limbs. Accordingly, preconditioning exercise is a must. Discuss with your physician or physiotherapist ways of dealing with pain brought on by participating in these activities.

Referred Pain

Referred pain is pain that feels as if it is originating from one place but actually originates from another.

One article on referred pain gives an example: "Referred pain from the neck may masquerade as limb pain. This may be due to cervico-disc disease or osteoarthritis. Similarly, the lumbar-disc disease may produce referred pain to an amputated lower limb." In other words, an amputee may feel pain in his or her residual limb, but it may be coming from somewhere else. Discuss the possibility of referred pain with your doctor.

Discomfort

Discomfort can manifest as a persistent, gnawing, low-category type of pain. While you may be able to live with discomfort, it is important not to ignore it. It can wear you down over weeks, months or years, and tends to get worse. Because the onset is gradual, you may not pay mind to the discomfort until it shifts into significant pain. As such, be sure to discuss any discomfort with your physician.

Below Knee Amputations

The common causes of prosthetic pain for below knee amputees can be classified as:

- Excessive end bearing
- Uneven skin pressure
- Friction
- Loss of total contact
- Hammocking phenomena and inlet impingement

Excessive End Bearing

A callous can develop over the end of the residual limb – usually because it descends too deeply into the socket. For temporary relief, put on extra stump socks.

One amputee reported that he was unable to convince his doctor or prosthetist that his residual limb was sinking too far into the socket. He took a piece of clay, pressed it into the end of the socket, put on his prosthesis and tried to walk. He was then able to convince his doctor that he was experiencing excessive end bearing. More sophisticated methods include X-ray of the residual limb through the socket, with or without the use of dye, as well as the use of a polycarbonate (clear) check-socket.

Uneven Skin Pressure

If the amputee has an ill-fitting socket and there is uneven distribution of skin pressure, pain is sure to develop. Causes include swelling due to weight gain and excessive use of fluids, as well as a socket that is too tight. Eventually, uneven skin pressure can cause the skin to break down. For longtime amputees, this can be a serious problem.

The use of soft sockets, such as the Michigan Gel System, can alleviate problems caused by uneven skin pressure.

Friction

Friction can be a source of discomfort, if not outright pain. Improper fitting can be the cause, as well as contracture of the skin. The situation can worsen if an ulcer develops.

It is noted in surveys and reports collected by The War Amps Service Bureau that quite often the amputee will notice the skin is starting to look "bad" but will take no action because there is no pain. Because the situation can worsen if left untreated, it is advised that you see a doctor, prosthetist or physiotherapist at the first sign of a problem. For instance, a blister or ulcer should signal to immediately discontinue using your prosthesis and seek help.

Loss of Contact

Even though the residual limb is protected by stump socks and soft sockets, there must be contact. Without contact, there is no control of the prosthesis. The remedy is to do something about the ill-fitting socket. Loss of contact problems can be serious in cases where there is a vascular problem, diabetes, etc.

Hammocking

Hammocking is a frustrating problem brought on by the use of a stump sock. Hammocking occurs when a stump sock is suspended because of a snug fit and the residual limb is not allowed to interface properly with the inside of the socket. The combined effect increases compression and can quickly produce an ulcer.

Above Knee Amputations

Some of the problems for the above knee amputee include:

- Excessive pressure on the ischial tuberosity
- Adductor roll
- Choking
- Misalignment
- Excessive end bearing

Excessive Pressure on the Ischial Tuberosity

The ischial tuberosity is the seat of the socket. It is critical that the socket fits the amputee properly at this site. If it does not, it can cause the skin to breakdown. A temporary solution is the addition of more stump socks, or, if a suction socket is worn, the prosthetist may add a liner pad. If these measures fail, a new socket is necessary.

Adductor Roll

The adductor roll is a horizontal bulge of soft tissue on the residual limb that can affect above knee amputees. Some amputees do not mind this, but it can eventually prevent the proper wearing of a prosthesis.

The onset of pain brought on by an adductor roll may be over a long period of time, but can cause serious problems. The bulge of tissue can cause an improper fit of the prosthetic socket, which can go on to produce a variety of gait deviations. These gait deviations can cause further problems, including spinal pain, pain in the other leg, etc. Most above knee amputees know the symptoms of "vaulting" on the opposite limb to clear the foot during the swing phase. This may not be harmful immediately, but over a period of time, pain and discomfort are likely to develop.

Choking

Choking in terms of amputation refers to the constriction of the residual limb. Choking impedes the flow of blood to the distal (end) of the stump, which can cause problems (such as ulcers) if severe.

Misalignment

This typically affects above knee amputees with short residual limbs. The amputee will invariably complain of progressive pain and soreness. Correction can be achieved by demanding better alignment between the components that make up the prosthesis.

Excessive End Bearing

As with a below knee amputee, an above knee amputee's residual limb may descend deeper into the socket. Excessive end bearing can cause issues including bursitis, callous formation and ulcers.

Wrist Disarticulation

Many amputees with wrist disarticulation report irritation of the soft tissue over the ulna and radial areas. At best, the complaint is of tenderness or discomfort. At worst, skin ulcerations can develop.

Orthopedic surgeons and physiatrists report that this is a difficult problem to detect. As such, it is especially important that, if you are experiencing a problem, you see a physician as soon as possible. Certainly do not put up with a tight socket or a loose socket; both can cause chronic skin problems for this type of amputation.

Below Elbow Amputations

There are three common causes of pain in below elbow amputees:

- Pressure over the anterodistal end of the stump
- Choking
- Inlet impingement

Pressure Over the Anterodistal End of the Stump

Amputees with short residual limbs are vulnerable to high compression and sheer forces when lifting with the elbow in a flexed position. The conditions are made worse by poor total socket contact or inadequate tissue coverage. The first indications of a problem would be skin ulcerations and swelling. As always, it is important to see a physician at the first sign of trouble.

Choking

Often the amputee will increase the number of stump socks as a temporary measure; this leads to elevation of the distal portion of the stump and obstructs blood flow.

Inlet Impingement

Most below elbow amputees report that active flexing of the elbow causes them to feel pressure, which is not bad unless the pressure becomes pain. This so-called "elbow impingement" is a condition that calls for socket adjustment or the fabrication of a new socket.

Above Elbow Amputations

In above elbow amputees, there is a magnitude of forces working against the residual limb if a prosthesis is worn. In a short residual limb, total contact is usually poor. The amputee must remember that he is lifting a lot of weight with a very short residual limb – often skin-irritated and often with boney prominences. Some pain can be expected, but if it gets worse, greater problems will result.

Many above elbow amputees (including shoulder disarticulation) prefer not to wear a prosthesis due to discomfort or pain. Also, if the amputation occurred many years ago, the amount of function that could be obtained from a prosthesis for above elbow or shoulder disarticulation would be minimal. There are some above elbow amputees, however, who choose to wear a prosthesis for cosmetic effect. These prostheses are usually very light and would not, under normal circumstances, cause a great deal of pain or discomfort.

Pain – Current Theories and Treatments Related to Phantom Limb Pain

By Robert S. Feldman for Prosthetics and Orthotics

Since the great French military surgeon Ambroise Paré first described what was to become known as phantom limb sensation in 1554, the presence of phantom limbs has been reported almost universally. Phantom limb sensation may be defined as the conscious feeling that a limb is still present after amputation. It was discovered that non-painful phantom sensations were described as the normal feeling of a healthy limb in 22 percent of the cases, 18 percent felt a mild pins and needles or prickly feeling, and the remaining 60 percent described sensations from a mild constant electrical current to tickling. Since these patients were in no distress, and it is well known that most phantom sensations decrease in time, no treatment was necessary. However, included in this group of 73 patients were a number of amputees who experienced phantom limb *pain*.

Phantom limb pain may be defined as the conscious feeling that a very painful limb is still present even after amputation. Some 50 percent of those patients complaining of pain described it as constant knife jabs or a strong electrical current, 12 percent felt as though the limb was on fire, and others described sensations such as crushing and bad cramps. Since these patients are usually in extreme distress (some have been known to commit suicide), it is of paramount importance that its mechanism of control be understood and an effective cure discovered.

As previously stated, the presence of phantom limb sensation can be traced as far back as 1554 in the notes of Ambroise Paré. However, credit for the term "phantom limb" goes to the nineteenth century author S. Weir Mitchell. In an article written for the Atlantic Monthly in 1866, Mitchell wrote about George Dedlow, a fictitious quadrilateral amputee who took part in a spiritual séance in Stump Hospital, Philadelphia. The story states that a Sister Euphemia, acting as the medium, received a message from the spirit world which she tapped out on the table; the taps spelled out "United States Army Medical Museum, Nos. 3486, 3487" which happened to be the numbers given to Dedlow's legs. After this occurrence, Dedlow began to feel "re-individualized" and to the amazement of everyone present, arose and staggered across the room on limbs invisible. Many people who read this story apparently thought it was a true account and sent donations to Stump Hospital on behalf of the fictional George Dedlow. This response prompted Mitchell to write another magazine article titled "Phantom Limbs" to set the record straight.

Theoretical Case of Phantom Limb

Today, there are three main theories which attempt to describe the mechanism behind S. Weir Mitchell's phantom limbs. They are the central or gate theory, the peripheral theory and the psychological theory.

Gate Theory

The gate theory of pain has received much attention. This theory proposed that the dorsal horns in the spinal cord act much like a gate, being capable of modifying somatosensory input before perception and response occur. The altering of input by this neural mechanism is determined by the activity of A-beta, A-delta and C fibres (motor neurons), the whole being under the control of descending impulses from the brain, which act to inhibit the neural mechanism. The loss of sensory input after amputation would decrease the inhibition from the brain and therefore

increase the self-sustaining neural activity of the gate, thereby causing pain. The actual location of the neural mechanism is a rather large controversy among neurosurgeons today. It is from this theory that treatments such as electrical stimulation, dorsal column stimulation and various drug treatments have originated.

Peripheral Theory

The peripheral theory of phantom limb pain is much less developed and therefore much less accepted when compared to the gate theory. Stated simply, the peripheral theory proposes that persisting sensations from the nerve endings in the stump are assigned to those parts originally innervated by the severed nerves. This is also called referred or projected pain. Projected pain results from the fact that a stimulus applied to a peripheral nerve anywhere along its axon, causes impulses that are indistinguishable from those that originate at the receptors formed by fibres of that nerve. Unfortunately, complete analgesia of the peripheral nerve, or even posterior rhizotomies, in patients with phantom pain have not given satisfactory results in curing the pain, which if the peripheral theory were true, one would not expect to happen.

Another version of the peripheral theory credits phantom pain to possible changes in the central nervous system resulting from peripheral nerve injury. This faction theorizes that the phantom may result from the partial deafferentation and disordered reinnervation of spinal cord cells. As this concept contradicts wallerian degeneration, more research in this area is needed.

Psychological Theory

Psychological theories all tend to relate phantom sensation to "wish fulfillment" which results from the denial of the loss of a part, and phantom pain is described as resulting from denial of affect associated with the loss. Lawrence C. Kolb, a psychiatrist, has done much work with amputees suffering from phantom pain. He states, "The chronic painful phantom limb represents an emotional response to the loss of an important body part that is significant in the patient's relationship with others. Hostile feelings, with resulting guilt, develop toward those with whom the patient identifies as mutilating or mutilated and also toward those on whom he is dependent and whose rejection he fears. Pain may result from punishment for such hostile and guilty emotions."

A psychiatrist who has worked with amputees complaining of pain, Kolb views the phantom limb as part of a mourning syndrome – "Just as the widow finds it hard to believe that her husband is dead and often has a strong sense of his presence, so the amputee has difficulty in accepting the loss of his limb and he continues to feel it is present."

Part of the mourning syndrome is fantasy. Amputation arouses fantasies of personal mutilation (of the removed limbs) that are overcome by repression. An example of how repressed fantasies can cause phantom limb pain is illustrated by the case of a 14 year old boy who suffered severe phantom pain following amputation of a lower extremity due to osteogenic sarcoma. During an interview with a psychiatrist it was learned that the boy heard, from one of his school teachers, a story of a man in whom stinging pain had developed in a phantom limb. The man was informed that his amputated leg was being devoured and stung by ants. The pain stopped when the ants were removed. When asked what the boy thought had happened to his leg, he stated he thought it had been burned up. After being assured otherwise, his complaints of pain subsided.

Because attempts at neurosurgical treatment ultimately fail, the solution to the problem of phantom limb pain lies with the psychiatrists and psychologists. This rather narrow-minded statement is followed with a quote from Ronald Katz, an anesthesiologist, who has also devoted most of his life to the study of pain, "Each physician finds what he is trained to find, and the psychiatrist will find psychological problems in all patients. Whether or not such findings help in the treatment of the patient is another matter."

Methods of Treatment

Neurosurgery

Since pain is associated with one or more aspects of the nervous system, surgeons for many years have been destroying different parts of the nervous system from peripheral nerve to cerebral hemisphere in an attempt to decrease phantom pain. Destruction of the nervous system has two major setbacks as a form

of pain treatment; first, it provides only temporary relief of pain as it always returns; and second, this type of surgery carries the inherent risk of permanent neurological incapacity. Due to these shortcomings and to the relatively new theories on phantom pain, treatments have been developed which are less invasive and at least as effective as surgical procedures.

Electrical Stimulation

The gate theory has lead to the development of several treatments. Electrical stimulation is one such procedure which is designed to stimulate peripheral nerves lacking sensory stimuli due to the amputation. According to the gate theory this increase in stimuli should increase the inhibitory effects of the brain thus decreasing the hyperactive neural mechanism causing pain. In the past, electrical stimulation has shown only marginal results with most researchers achieving approximately a 50 percent success rate.

In 1977, John Miles and Sampson Lipton decided that patient selection for this form of treatment by diagnosis alone provided too unreliable a guide. They therefore devised a battery of tests which are given to each subject to determine the patient's suitability for electrical stimulation treatment. The test includes: (1) pharmacological assessments to withdraw addictive drugs and determine the patients existing analgesic regime; (2) psychiatric assessment in order to determine if any psychoneurotic disturbance existed; and (3) physiological tests to determine the integrity of the sensory system.

After assessing 20 patients, 12 were determined suitable for stimulator implant into the peripheral nerve. Results show seven obtained excellent relief of pain such that they no longer require analgesics, three patients obtained partial relief of pain. The authors go on to explain that at a later time the two failures were discovered to be unsuitable after all, and should not have passed the physiological tests.

Dorsal Column Stimulation

Dorsal column stimulation is another treatment developed since the publication of the gate theory. It is similar to electrical stimulation except rather than stimulating the peripheral nerve; the dorsal columns of the spinal cord are stimulated.

These results have been successful for up to two years of follow-up, thus permitting "cautious optimism" for this form of treatment. It is obvious that not much more can be said for dorsal column stimulation until the full results are available.

Pharmacological Treatment

Some doctors have been treating their patients with the drug Lysergic Acid Diethylamide (LSD-25). They base their treatment on the belief that some amputees may benefit from an increase in the neurotransmitter serotonin. Serotonin is thought to be one of the most important neurotransmitters in central modulation of pain, and there is evidence that deficient serotonin increases sensitivity to painful stimuli. LSD-25 is known to elevate levels of serotonin, therefore, when administered to individuals deficient in serotonin and experiencing phantom limb pain, the pain should cease.

Seven subjects were given low doses of LSD-25 every day for eight weeks; results were based on the observation of the daily use of analgesics. Results show that in five patients, LSD-25 produced improvement in pain and reduction in use of analgesics. Two of these five patients no longer require their pain medications. In the other two patients, LSD was ineffective and analgesic use remained unchanged.

Unfortunately, LSD-25, even in non-hallucinogenic doses, has side effects which include psychic reactions and perceptive distortion. It is also believed to be addictive in nature.

Biofeedback Treatment

The use of biofeedback in the treatment of phantom pain is based partly on the peripheral theory and partly on the psychological theory. Advocates feel that phantom limb pain may be the result of the anxiety – muscle tension – pain cycle. They base their treatment on the idea that amputees suffering phantom pain may have spontaneous muscular hyperactivity in their residual limbs (as a result of high anxiety levels) which are irritating the cut ends of the peripheral nerves. Biofeedback is a system by which these muscle contractions are made audible to the patient via electrodes. This feedback signal stops when an appropriate decrease in muscle tension is reached; thus the patient learns to relax his musculature and relieve pressure on the peripheral nerves.

Results of studies on the effectiveness of biofeedback in decreasing phantom limb pain are very similar to the results shown for all previously described treatments. Advocates state the reason for their small failure rate is the fact that some patients cannot learn to relax, and have strong psychological needs for their pain.

Psychological Management

A three-phased strategy in the psychological management of the amputee has been proposed. Phase one is prevention. In this phase an attempt is made to address the healthy coping mechanisms in each patient. This includes thorough discussions with a psychiatrist on the fears each patient (and the patient's family) may have. Phase two is crisis intervention. Here they consider the development of pain in the postoperative period and emotional crisis. Rapid intervention is therefore required in the form of psychiatric assessments of personal strengths and assets with the goals of alleviating anxiety, gaining reassurance and restoring coping mechanisms.

The final phase includes psychotherapy and behavioural therapy. It is their belief that many chronic pain patients use pain for secondary gain in terms of medication, disability payments, or in other ways in their family or marital relationships. These pain personalities pose extremely difficult treatment problems and therefore require behavioural therapy or psychotherapy.

Conclusion

Electrical and dorsal column stimulation, drug treatment, biofeedback and psychological care are the major non-surgical forms of treatment for phantom limb pain. Because the mechanism of phantom pain is still unknown, a definitive treatment that cures all patients is not yet available. It is possible that there exist several different mechanisms, some involving the nervous system, others involving psychological problems and perhaps some involving both. This would explain why each treatment described totally cures some patients and yet has no effect on others. Miles and Lipton (electrical stimulation treatment) are perhaps moving toward this concept since they run each patient through a battery of pharmacological, psychological and physiological tests to determine suitability for their form of treatment. It is the opinion of many medical authorities that when considering treatments for patients with phantom limb pain, each case should be thoroughly examined, neurologically and psychologically, in order to determine the best course of action.

Prostheses, Pain and Sequelae of Amputation, As Seen by the Amputee

The following is a revised version of a paper prepared by the late Cliff Chadderton for presentation at the 1977 Congress of the International Society for Prosthetics and Orthotics.

Methodology

With the co-operation of the World Veterans Federation, we requested information from 19 veteran organizations in 14 countries. We received replies from all. The enquiries were based on a questionnaire, the basic elements of which were:

Legs

- Weight of the prosthesis
- SACH feet versus articulated feet
- Wearing of rubber-soled shoes
- Cosmetic appearance
- Soft socket versus hard socket (for below knee amputees)
- Plug socket versus quadrilateral socket (for above knee amputees)
- Swing phase control units (for above knee amputees)
- Modular versus standard limb

Arms

- Munster fitting versus harness
- Myoelectric hands
- Cosmesis – hands
- Wearing of prosthesis (for above elbow amputees)

Adjustment

- Do you see yourself in your dreams as an amputee?
- Psychological effect of dismemberment
- Sequelae (medical) of amputations
- Recreational limbs

Fitting

One could draw a startling conclusion from the replies concerning comfort. It seems many amputees are prepared to accept an uncomfortable fit as "part of the game." A significant number of amputees suggested X-ray and film techniques should be used, as well as biomechanical devices to measure the accuracy of a prosthetic fit.

Information of New Prostheses

The amputees seem to be overwhelmingly of the opinion that there is a lack of information on the part of medical doctors in this area. It is also evident that, with certain exceptions, the amputees themselves are poorly informed on new prostheses.

Input at the Research Level

The responders stated they were unaware of any concerted effort to obtain opinions from amputees concerning the types of research that should be done to improve prostheses. To be fair, some replies indicated that "amputee input" may be going on but they did not know about it. Significantly, however, they felt that there should be more liaisons at the user level.

Pain

Universally, phantom limb pain appears to be a significant problem and the amputee feels very little is being done to develop remedial measures. A review of the replies indicates the usual advice is to take aspirin and a hot drink; clearly this has not been effective and the amputee is looking for something more effective.

Many amputees also complained of residual limb pain, as separate from phantom limb pain, stating that massage, heat treatments and sometimes surgery had been successful in alleviating this pain.

Weight of Prostheses

There are two distinct camps in the replies: some 62 per cent wanted lighter prostheses, but 12 per cent stated some weight was essential and felt good hardware should be used despite additional weight.

Feet

No trend was evident on the question concerning SACH versus articulated feet. There is, however, a small but dedicated group of amputees who sincerely believe that an articulated foot is far superior. This group described the SACH foot as "too springy" or "unstable."

Rubber-Soled Shoes

By far the majority of leg amps prefer rubber-soled shoes for stability and heel strike.

Cosmetic Appearance

Cosmetic appearance does not seem to be a factor. However, those who responded are all war amputees whose average age would be around 60, which could be a significant factor.

Sockets

By far the majority of below knee amputees prefer a soft socket (for comfort reasons). The question on the plug versus quadrilateral socket for above knee amputees elicited the information that, for the most part, the quad users are well aware of the advantages, stating them as being "better circulation," "more comfort," "easier standing," "taking the weight on the ischium," etc. Tragically, perhaps, many plug sockets users were unaware of the difference between the two types.

Controls

The question concerning swing phase controls elicited a very high response, indicating that a large proportion of the amputees are not familiar with the device. (We did not ask for information on stance phase controls as we were reasonably certain that the concept is not known to the majority of amputees.) It would seem from the replies that many more amputees would be prepared to try these devices if they knew of their existence!

Modular Versus Exo-Skeletal

Here again the majority of the amputees who replied (about 60 per cent) did not know the difference. There were, however, a dedicated group of modular users who recognized the advantages of alignment, light weight and cosmesis who were sold on modulars. A conclusion can be drawn regarding the necessity for dissemination of more information.

Munster Versus Harness Fitting

The below elbow amputee is very partial to a light fitting for a passive hand. Alternatively, hooks and a harness appear preferable when doing heavy work or engaging in recreation.

Myoelectric Hands

There was a distinct feeling among Second World War veterans that they had been passed over by the myoelectric stage. Many had apparently been told that they were too old to adjust to myoelectric fittings. The majority of the replies stated "yes" to the question of whether they would like an opportunity to be fitted with a myoelectric hand.

Cosmesis

The replies on cosmesis for hands contained some startling words such as "disgusting" and "lack of sensitivity." Surprisingly, many hand amputees appeared to have no knowledge of the cosmetic skins and stated they were wearing either brown or black leather gloves over their passive hands.

Wearing of Prosthesis (Above Elbow Amputees)

The rejection rate was predictably high. Some farsighted individuals (amputated on one side only) suggested they should get used to wearing a prosthesis in the event they develop medical difficulties in their other arm, arising from strokes, arthritis, etc. The

second part of this question indicated there is little knowledge of lighter prosthesis now available through the use of modular designs.

Dreams

The question on dreams was thrown in only for general interest. Those who responded seem to divide 50-50 as to whether they visualize themselves as amputees in their dreams.

Psychological Effect

Surprisingly, a large number of war amputees describe their feelings about the loss of their limb in terms of being "grief stricken," "lost my best friend," "embarrassed," etc. It should be remembered that this survey asked for truthful answers. The Adolph Meyer school of psychiatric thought may be of interest on this subject; that is, depression can follow from a physical disorder such as amputation.

Sequelae

Most of the replies indicated consequential disabilities. For leg amputees, it is a bad back and arthritis in the remaining leg and foot. For arm amputees, it is cervical pain and headaches. For both, gastro-intestinal problems were believed to result from ingestion of drugs, as well as "inner tension" associated with the continuing discomfort of amputation. Those who responded felt more study should be done upon the medical after effects and side effects of amputation.

Recreational Limbs

This question resulted in possibly the most significant response. There were requests for special legs for swimming, golfing, skiing, tennis, rowing and motorsports. Arm amputees requested the development of special prostheses for fishing, playing baseball, cricket, golf, tennis and rowing.

Pain "Killers" Seek Solutions

By Trish Crawford, February 1999, for the Toronto Star

Pain entered Lisa Bean's life eight years ago and only recently has started to retreat. Living in a remote Manitoba community and pregnant with her third son, Bean soldiered on through the pain in her hip and leg that began in her fifth month. She had to. Her husband was away seven months of the year flying helicopters and there were two toddlers at home to take care of, both still in diapers.

By the time she gave birth to a whopping 10-pounder in a delivery that fractured her tail bone, Bean was in full-fledged, all-out pain: Pain so bad she couldn't sit down; couldn't push the boys on a swing; pain so bad she was clinically depressed for two years.

"Something that should have been so ordinary, having a baby, became a nightmare," says the 41-year-old nurse of her long search for the proper treatments that have recently given her some pain relief and the chance to live a normal life.

"Chronic pain – pain that won't go away and reduces the quality of life of an individual – is not well understood by the medical profession," says Dr. Allan Gordon, director of the Wasser Pain Management Centre at Mount Sinai Hospital. The neurologist says this is because traditional pain relief methods don't work; the sources of the pain are difficult to find and, in some cases, defy logic, as in phantom limb pain.

Among the astonishing discoveries about chronic pain (pain that persists for six months or more) is that you don't need a body part to feel pain, you don't need to be conscious to experience a painful incident and sometimes drugs prescribed for entirely other uses can be effective. Although Gordon has had a lifetime interest in helping people with chronic face and head pain, about five years ago a network of 20 pain experts from a wide variety of fields began to jointly treat a broader spectrum of pain patients at Mount Sinai.

Lisa Bean is one of those patients. Chronic back pain had greatly changed her life by the time she reached treatment two years ago. She moved her family from Manitoba to Ontario to be closer to expert help.

The nurse had given up on the idea of working a regular hospital shift and instead, she took training in foot care in order to work in a community setting with less stressful hours. "Pain has a domino effect on every part of your life," says Bean, who now lives in Peterborough. Although not pain-free, the occasional use of a back support, new time-released medications and regular medical supervision means she can now live, work and play with some degree of physical comfort.

Mount Sinai's pain centre, named for Toronto philanthropists Larry and Mario Wasser, is a regional resource taking patients referred by perplexed physicians from across Ontario. Many of the experts are also professors at the University of Toronto and are part of the university's pain program. They are training the next generation of doctors, nurses and dentists to be more aware of and sympathetic to an unseen ailment that can destroy well-being, family and jobs.

The team is also conducting research, publishing papers and working on establishing new standards and procedures in the field.

For instance, Dr. Jacqueline Gardner-Nix, a family physician with extensive experience in palliative care, has recently worked on new national guidelines for doctors on the administration of narcotic drugs, such as morphine. It takes monster amounts of these high-powered drugs to make a dint on chronic pain, explains Gardner-Nix, because the narcotic receptors of the patients have become dulled. However, since these drugs are potentially addictive and standard amounts usually given are quite low, many doctors fear the professional scrutiny or bad side effects upping the amounts might produce, she says. Other pain centre team members include:

- Psychologist Lucia Gagliese, who has been running support groups for chronic pain patients to help them find techniques to help them relax, conquer and cope with pain.
- Dr. David Mock, dentist-in-chief at Mount Sinai, who has been collaborating with Gordon

for more than 20 years as they sought to help people with cranio-facial pain.
- Dr. Howard Tenenbaum, a periodontist who specializes in cranio-facial pain.
- Dr. Susan Haley, deputy chief of anaesthesia at Mount Sinai, who supports using additional anaesthetics to prevent chronic pain.
- Dr. Joel Katz, a psychologist who had done extensive research on phantom limb pain, which is severe in about 10 percent of amputations. His studies demonstrated patients' pain memories.
- Psychiatrist Peter Moran, who had discovered some patients experience chronic pain on the site of an assault or as the result of traumatic event.
- Pain nurse Marilyn Galonski who acts as central reference point for patients as they receive treatment from a variety of professionals.

For instance, Galonski will check for patients if a change in symptoms requires them to return to the clinic, keep track of their experiences with medications and answer questions that crop up in day-to-day living. Gardner-Nix is perplexed that tools are available to alleviate the pain and suffering of the dying, but society lets the living suffer with no relief. "We have respect for the dying but there is an apparent lack of respect for the agony of pain patients. Their families are in chaos as the result of a disastrous accident. We seem so worried about turning people into addicts that we won't help them." Research on addictive drugs shows that only one in five people faces the risk of becoming physically dependent, she says and doctors are given guidelines and questionnaires to pin-point those at risk.

"I feel I'm on a mission to change people's thinking (about drug treatments). Because of my wide experience in the cancer area, I feel we can build on that … and handle much larger doses while treating patients with respect, sympathy and compassion."

Another drug issue emerging is the effect anti-convulsants and anti-depressants have on conquering the most resistant chronic pain, she says, adding she is always searching for a way to help the more than 180 chronic pain patients on her roster.

Jim, a 32-year-old student who suffered severe whiplash a decade ago when he was struck from behind on his motorcycle, had visited many doctors and tried many pain-killing medications without success. He missed months of school when he found it impossible to sleep because of the pain in his back.

Surprisingly, it was an anti-convulsant prescribed by Gardner-Nix that finally brought him some relief about 18 months ago, says Jim. Because it's not clear why anti-convulsants work on chronic pain, Jim decided he probably had finally recovered and stopped taking his medicine. "I was in excruciating pain all over again," he says.

A recent group interview with the pain management team highlighted the following issues and mysteries about chronic pain:

- **The Gate Theory:** When you hit your finger with a hammer, pain travels along the nerves of the hand and arm into the spinal cord through a "gate," then up into the brain where it is registered. In this way, pain really is in your mind. In chronic pain patients, this gate stays open giving a constant pathway for the pain. Conversely, some people seem to be able to close this gate – such as legendary Maple Leaf Hockey player Bobby Baun – who continued to play a game with a broken leg.
- **Pain prevails:** Even when people undergo a general anaesthetic, it appears sometimes they will later feel the painful effects of the operations of procedures that were done on them. This is most severe in people experiencing the breaking or sawing of bones in invasive chest surgery. Doctors are experimenting with using an epidural – an anaesthetic put directly into the spine as is often done during childbirth – as well as the general.
- **Pain has memory:** This trait of pain (also called plasticity) means that a terrible pain from injury, surgery or illness leaves an indelible but changing "imprint." Patients who have an arm or leg amputated, for instance, can continue to feel excruciating pain from the lesions, tumours or injuries on a body part no longer there. Extensive documentation of phantom limb pain has finally convinced many medical practitioners it was real, says Katz, "even though they wondered how someone could feel pain in the absence of the body part." This leads to the

surprising conclusion "you don't need a body part to feel pain," he says.

Katz says chronic pain challenges many past assumptions and beliefs about pain. For instance, it has always been assumed patients under general anaesthetic felt nothing. However, pain in patients, who prior to surgery had no pain, lead researchers to plan for ways to "block the noxious impact at the time of surgery."

Since pain is "registered" in the brain in order to be felt, doctors opted to administer another anaesthetic in the back which prevented any pain messages from travelling up the spinal cord to the brain. Studies show that sedated patients given an epidural at the beginning of their surgery experience less pain afterward, says Katz, adding that some surgeries, such as opening the chest wall, appear to result in more pain later than other types.

Some medical teams have been quicker to look at this technique than others. Katz points out dental surgeons have frequently used freezing as well as general anaesthetics for their operations. Says Haley, an anaesthesiologist: "Bodies are experiencing pain, whether the person is aware or not."

Pain control is not a large enough part of most medical school training, although dentistry is one specialty where it is stressed, says Tenenbaum, a periodontist. Because of this, few dentists will let a patient experiencing pain leave their office without trying to do something for them, he says, sometimes causing even more problems for the patient. However, the watchwords have to be diagnose, then treat" says Tenenbaum, because pain in the jaw can come from joints, nerves or other sources than teeth. Take Johan Aitken's case for example. Aitken, 65, began to experience piercing toothache in mid-December while hosting a dinner party. After taking a painkiller, she spent a restless night before arriving on her dentist's doorstep the next morning. He quickly sent her to a specialist who immediately sent her to the Mount Sinai experts. The pain wasn't a toothache but a tic douloureux, a type of facial neuralgia or nerve pain. The U of T professor quickly got relief with the proper medicine and had a holiday in New Zealand before returning to work. She says she was concerned she might be treated like a complaining old lady but was delighted to see how seriously her complaint was taken and how quickly she was treated by Tenenbaum. And she was pleased with the follow-up care.

Unfortunately, many people have suffered a long time before being referred to the clinic, says Mock, Mount Sinai's dentist-in-chief. "Many patients have been in pain a long time; from car accidents, assaults, even just having a tooth out." Mock points out that the clinic's goal is pain management, not pain cure, because sometimes the most a doctor can do is help a person live as normal a life as possible. "We want to lessen their pain and be able to say, 'Go on with your life.'"

Patient Guide to Chronic Pain

This guide was written by Dr. Alan L. Russell, of Bramalea, Ontario, who ran a small pain clinic. Although Russell prepared this text as a guide primarily for his chronic pain patients, amputees may also find this information helpful.

In running a small pain clinic over the years, I have found that purely verbal communication with patients often fails to answer their anxieties and queries. I would estimate that only 20% or 25% of the remarks made at the first consultation are remembered or understood. This guide is based on asking 50 patients what they wanted to know about chronic pain, and then returning the rough drafts to the same patients and asking for their comments. In this way, I feel we have a two-way attack on the problems of communication. One of the reasons many chronic pain patients are turning again to lay therapists is that the latter seem to be able to put the problem in simple, layman's terms. Understanding chronic pain is about 25% of the battle.

What is Chronic Pain?

Chronic pain is defined as pain persisting for more than six months from its onset. The question of what is actually pain is very difficult to define and, although many academic definitions exist, the only person who can understand or can describe a particular patient's pain is the person who has that pain. One of the best definitions of pain is: bodily or mental discomfort or suffering, affecting the quality of life. Pain is always real to the patient, whatever the cause.

Lack of Interest

Chronic pain is the commonest cause of continuous suffering and disability in North America and results in the loss of tens of billions of dollars every year. However, for some unexplained reason, pain research and treatment seems to be the Cinderella of medicine. In this lack of public support for the subject of chronic pain lies a hidden truth: there is something wrong with the concept of chronic pain. Does chronic pain exist? Are the people who have it merely weak or malingerers? One of the latest strides in pain management has been the acceptance by many medical doctors that chronic pain should be treated as a disease entity.

Chronic Pain Syndrome

In the last few years, it has become recognized that the patient with chronic pain is also suffering from a whole range of symptoms which have been described as the Chronic Pain Syndrome. These include frustration, depression, sleep disturbance, martial and financial problems, destruction of self-image, antagonism to society and the medical profession and – most important of all – the feeling that no one cares or can help. The ramifications of the Chronic Pain Syndrome extend to drug dependence and addiction and the problems related to drug side effects. It is not unusual to find patients under the care of a number of doctors and on numerous medications, some of which are antagonistic to each other.

Frustration of Doctors

When working in a chronic pain clinic, one is faced with a situation where the "success rate" is very low, perhaps as little as 20% to 25%. Here, in dealing with cases where one cannot produce rapid results, one has to use skills now mostly lost to the medical profession. Chronic pain does not mean that a continuing destructive process is occurring and the pain is a warning that should be accepted as such and acted upon. That is the main difference between acute and chronic pain – the former is a useful warning sign, whereas the latter is destructive and serves no useful purpose.

Development of Chronic Pain

In some cases, damage due to either injury or infection has caused a disruption of the normal body function, which has not completely returned to normal, thus

causing chronic pain. Usually, however, the actual damage has healed but the pain seems to continue beyond its useful purpose. (Understanding this is important, as understanding the problem is halfway to solving it.) This can be looked upon as a situation where the original pain has produced a pathway to the central nervous system, which for some reason does not close off. Although pain signals stop coming from the periphery (site of original injury), a circle or circuit develops along this pathway which maintains the chronic pain. It is believed that the longer the pain continues, the more fixed this self-generating pain cycle becomes.

Why Me?

In many cases of chronic pain, the original injury occurs due to no fault of the sufferer. There is a strong sense of frustration: Why has this happened to me? What have I done to deserve this? This is compounded by the slowness of legal compensation and settlement of any work-related claims. The problems involving legal and compensation systems taken together with the financial loss (often never fully recovered) tend to produce feelings of depression and frustration. And these feelings themselves lower the body's ability to withstand the shock of pain.

The whole cycle is magnified many times with the development of chronic pain. Even when a fair degree of recovery has occurred after a long period of pain suffering, there is always a feeling of deep apprehension that the pain will return.

Living with the Pain Patient

One reason for the difficulty in defining pain, especially chronic pain, lies in the fact that this is a very personal suffering. It is now recognized that pain lasting more than six months goes on to develop the Chronic Pain Syndrome with its attendant personality changes, depression, loss of self-esteem and other changes. All these problems affect not only the pain patient but also relations with spouse and children. These effects on the family are mirrored and reflected back on the pain patient, further aggravating this ongoing situation and weakening the strength to fight it. It is well documented that, as a result, marriages become strained, divorces occur and problems managing children at home and in school are common. These peripheral or spin-off effects of the original injury can never be fully compensated. Even after physical and financial recovery, a deep scar exists in the family unit.

The Future

For years, one of the commonest problems that doctors encountered was the relief of pain. However, doctors in the Western world have now started to think about making the body heal itself of pain. In a book called *The Puzzle of Pain*, Ronald Melzack describes his work on the Gate Theory of Pain. It is an interesting and informative book. Melzack's ideas have stimulated a great deal of modern pain research. It is now accepted that the human body has a pain-controlling mechanism. Not only does skin heal after being cut, but the human body has a built-in mechanism that will turn pain off. Examples of this mechanism have been observed for many years: severe pain totally obliterated in the heat of battle or a game. There are many known cases of soldiers with bullet wounds continuing to fight, unaware of any pain.

The big question is why this mechanism does not function to attack the development of chronic pain; we still do not appear to have the answer to this problem. However, a number of techniques are being developed that activate the body's own pain-fighting mechanism or block the pain cycle locally.

Pain Control

New techniques, being developed at a very rapid rate, can be divided into two major categories.

First, there are those techniques involving surgical or other major physical invasions of the body. Included in these are section of the nerves carrying the pain; section of the part of the spinal cord severing the pain-carrying tracts; and implantation of electrical nerve-blocking units in close proximity to the spinal cord. These techniques may be available at the large pain clinics most often associated with universities and are really a last resort with a poor track record.

The second category involves techniques designed to strengthen the body's own pain-fighting mechanism and block pain without being destructive. Included in the category are non-addictive drugs which act locally at the pain site, conventional physiotherapy and hypnosis.

It is important to stress that very rarely will a treatment or technique produce a miraculous result. While most doctors in the field of chronic pain have geared themselves for the long struggle involved in management, it is still disheartening that many people still seem to be impatient and become disillusioned and further depressed upon failure of one or more techniques. In some cases, however, time should be given by both parties involved in the treatment plan… there is no quick miracle or fix for chronic pain.

Patient – Doctor Dialogue

When dealing with chronic pain, dialogue between patient and doctor is of vital importance. As each case is unique in itself and in its management, every patient and doctor will have something special to add to this dialogue.

Support Group

With the evolution of better pain management, it is hoped that chronic pain societies – along the lines of Alcoholics Anonymous – might develop an association with clinics. Recovering patients would provide support to those less fortunate, whether this support be advice or help with legal or compensation fights.

Phantom Limb Sensations and Phantom Limb Pain in Child and Adolescent Amputees

Research conducted by a fellow amputee

The phantom…

In the late nineteenth century
on the east U.S. coast,
a neurologist studied
the lost limb ghost.

He said: Phantoms occur
in some amputees,
most commonly in those
who lost a limb after surgery.

Some phantoms are painful;
some are pain free,
they're a natural part
of being an amputee.

Despite the considerable amount of research on phantom limb sensations (feeling that missing limb exists) and phantom limb pain (pain in the missing limb) in adult amputees, there is little information with respect to child and adolescent amputees. For my research project, 60 child and adolescent amputees, ages 8-18 years, completed a questionnaire and participated in a phone interview. The questionnaire was aimed at determining the number of amputees who have phantom limb sensations and/or phantom limb pain, what they feel like, how long they last, how strong they are, and what factors may trigger them.

And the Survey Said…

- Less than half of the amputees had phantom sensations and/or phantom pain.
- The loss of a limb due to an accident, cancer or medical problem increased the chance of an amputee having phantom sensations and/or phantom pain.
- A small percentage of amputees born missing a limb reported having phantom sensations and/or phantom pain.
- Phantom sensations occur more frequently than phantom pain.
- Phantom sensations are as strong as phantom pain (both rated a strength of 5 on a scale from 0-10; 0 being no sensation/pain and 10 being strongest imaginable sensation/pain).
- Both phantom sensations and phantom pain last for only a short time, usually a few seconds.
- Phantom sensations were most commonly described as "tingling," "numb," and "itchy."
- Phantom pain was most commonly described as "tingling," "uncomfortable," and "knife jabs."
- Touching the stump, not wearing a prosthesis, and cold weather are the most common triggers of phantom sensations and phantom pain.

What Do These Results Mean to You?

Child and adolescent amputees have phantom sensations and phantom pain. The phantom sensations and phantom pain are real and not a sign that an amputee is "going crazy." Through research, science has moved closer to understanding how phantom sensations and phantom pain work and finding ways to prevent, manage and treat them.

A warm thank you is extended to the staff of the CHAMP Program and the amputees for participating in my study. Survey conducted by Champ Krista, B.Sc. (Hons).

The Phantoms! Phantom Limb Pain and Sensations

By Lynette Duncan, September 1998, for Issue 13 of the
Chedoke Amputee Peer Support Newsletter

Description

Phantom limb pain is a phenomenon experienced by 50% to 80% of the amputee population. It is described as any feeling intense enough to be called painful, emitting from the amputated portion of the limb. These feelings are individual and varied. Some phantom limb pains have been described by patients as itching, mild warmth, burning, and squeezing.[1] The pain can be infrequent, experienced less than two weeks out of the year, or it can be chronic and debilitating. A constant uncontrollable itch on the bottom of a phantom foot left an amputee suicidal.

Along the same lines of phantom limb pain is phantom sensation. Phantom sensation is the feeling that the amputated limb is still intact. One patient could still feel his amputated hand clutch a cup of coffee; another, a double arm amputee, could still feel his arms swing when he walked. There is reported a right-armed amputee who learned to play tennis with his left arm, but still had trouble serving when his phantom arm insisted on holding the racquet.[2]

Sometimes the phantom sensation can telescope to reach objects or be located in an odd position. One amputee felt his phantom arm extend from his shoulder at a right angle. He would always walk through a doorway sideways to avoid hitting his phantom arm. A phantom foot has been felt dangling beneath the residual limb and not physically connected to the body, but still unquestionably belonging to the patient.[3]

Phantom experiences are not limited only to amputees. Spinal cord injury patients also experience phantoms.

Phantom limb pain and sensation should not be confused with stump pain. Stump pain is the feeling of pain such as burning, throbbing, or shooting occurring in the residual limb.

Phantom limb pain and sensation has been addressed for close to 500 years, but the name "phantom" wasn't coined until 1866, when S. Weir Mitchell, an American neurologist, developed the name. Until quite recently, it was considered a "psychological" phenomenon.

Former and Current Hypotheses on the Causes

A recent survey of 2,700 amputee veterans showed that 69% had been told or their physician implied that the phantom was all in their heads. As late as the 1970's, most literature stated that phantom sensations were created from a psychiatric disturbance due to the loss. However, many studies have since shown that persons with phantom pain are no more or less likely to suffer

1 Phantom Limbs, Ronald Melzack, Scientific American Vol. 266, No. 4, page 120

2 James Shreeve, Touching the Phantom, Discover, June 1993, Vol. 14, No. (not listed)

3 Roger W. Davis, M.D., Phantom Pain and Stump Pain, American Congress of Rehabilitation Medicine and the American Academy of Physical Medicine and Rehabilitation, Vol. 74, January 1993

from psychological abnormalities than the population at large. Many amputees have been sent to psychiatrists for physiological conditions.[4]

One of the oldest and more common beliefs involved the cut nerve endings in the stump. The cut nerve ends grow nodules which are known as neuromas. The neuromas continue to generate impulses. The impulses flow through the spinal cord into parts of the brain. These brain areas include the thalamus (a central way station of the brain); then onto the somatosensory areas of the cortex, the presumed centres for sensation. This is the classical concept of the brain, where neurons fire and transmit signals from the nerve endings through the spinal column to the brain and back as sensations.

Based on this assumption, medical treatments to relieve pain have included cutting the nerves just above the neuroma at the roots. Pathways in the spinal cord have also been cut and areas of the thalamus and cortex that receive this sensory information have been removed. Although traditionally this has brought temporary relief to some patients, the pain usually returns. It should also be noted that this procedure never eliminated the phantom sensation, only the pain.

Recent discoveries have clearly directed the path of phantom pain and sensations to the brain; however, the exact cause and cure are still being researched and investigated. In this paper, I will explain what we know, what we think we know, and the research behind the hypotheses. It should be noted, however, that this research is still in its infancy. We do not know for sure exactly what causes phantoms. We can only hypothesize at this time.

Melzack's Hypothesis

One of the foremost hypotheses comes from Ronald Melzack, Ph.D., a professor of Psychology at McGill University and Research Director for the Pain Clinic at Montreal General Hospital.

He, of course, agrees that phantoms lie in the brain, but not just in the somatosensory system. He believes far more of the cerebrum is involved.[5]

His theory draws into account that an explanation must be made for the variety of sensations a person feels, and to the extent of reality the patient feels of the phantoms – even the free-floating phantoms belong to the self.

Melzack postulates that a network of neurons creates a neuromatrix. Not only does the brain respond to stimuli, but it continuously generates a pattern of impulses indicating the body is one's own and is intact. He refers to this neuromatrix pattern as a neurosignature. He feels that if the brain operated in this way, signals would emit, creating a sensation of having a limb when the limb no longer existed.

For this hypothesis to work, Melzack believes the neurosignature to be quite extensive and to include at least three major neural circuits. The first is, of course, the classic sensory pathway to the somatosensory cortex via the thalamus as has been previously discussed.

A second system consists of the pathways leading through the reticular formation of the brain stem to the limbic system. This is the system responsible for emotion and motivation. He includes this system because paraplegics who suffer complete severing of the spinal column high in the upper body still report experiencing themselves in their old bodies and describe feeling much like they did before their injury, with these feelings including exhaustion, pain, and pleasure.

The third and final system stems from the cortical regions of the brain. These regions are responsible for the recognition of self and the evaluation of sensory signals. The parietal lobe is a main player in this region. Studies have shown that patients who have suffered lesions of the parietal lobe in one hemisphere have disowned parts of their bodies. One patient pushed one of his own legs out of the hospital bed, insisting that the leg did not belong to him.

The theory involves a combination of sensory information passing through all three systems working in parallel. The information is shared between the

4 Lt. Col. Richard A. Sherman, Ph.D., and John G. Arena, Ph.D., Phantom Limb Pain: Mechanisms, Incidence, and Treatment, Critical Reviews in Physical and Rehabilitation Medicine 4 (1,2): 1-26 (1992)

5 Melzack

systems, with the information converted to an integrated output which is then sent throughout the brain. This information is then processed in the matrix, which recognized the neurosignature and the output contains the assurance that the sensation is occurring in one's own body.

The matrix of the brain, Melzack postulates, is largely pre-wired, dependent more on genes than on experiences. This is due to the number of patients born without limbs who still experience the phantom. This goes against a commonly held belief that those losing limbs before the age of six do not experience phantoms.

An explanation is given for the fading of phantom limb pain and sensation that sometimes occurs over time. It seems that the cerebral neurons that once responded to the amputated limbs develop increasingly strong connections with the remaining intact body parts and eventually begin to serve those areas.

Ramachandran's View

Another researcher in the field of phantoms is neuroscientist Dr. Vilayanur Ramachandran of Scripps Institute in La Jolla, California. His hypothesis revolves around his research on nerve impulse. These nerve impulses or synapses travel through the brain stem signalling other synapses, thus sending the information through the thalamus and up to the somatosensory cortex. He then describes this portion of the brain as being "laid out as a French garden." He notes that nerve impulses beginning in the thumb stimulate an area of the cortex that only serves the thumb. It is located next to an area that serves only the index finger. This "garden" continues digit by digit. The arm lies next to the shoulder, then the trunk. Except for a few unusual pairings (i.e., the toes are laid out next to the genitalia), the body is laid out on the brain in an orderly fashion, with the areas with the most number of nerve endings, for instance, the hands, receiving the most area of cortex space. Ramachandran describes it as "if there exists a tiny, orderly, though distorted version of one's self – a homunculus-outlined on the pleated surface of the brain."[6]

Since the early 1960's, it was a long-held belief that the adult brain was "hardwired" and could not change after a critical growth period in infancy. This belief was centered on a Nobel Prize-winning study by David Hubel and Torsten Wiesel. This study demonstrated that a newborn kitten whose eye was patched during a critical period of neural growth would experience permanent blindness. It showed that during this period the functional eye encroached over the patched eye's allotment of cortex. The patched eye was never able to recover.

Because of the Hubel and Wiesel study, it was long believed that once the brain was "hardwired," it would be unable to change.

Does the Cortex Remap?

Ramachandran's theory suggests that when a limb is missing, the cortex remaps itself. To really explain this theory, I must first explain the two studies, both involving monkeys, from which this theory began.

The first experiment occurred at the University of California at San Francisco in the 1980's with research involving a monkey whose finger was amputated. Researchers Michael Merzenich and Jon Kass of Vanderbilt University discovered that when the fingers on either side of the amputated digit were stimulated, nerve impulses from the neighbouring sections appeared to have been remapped into the vacated cortex. At that time it was noted that the distance the nerve impulse traveled across the vacated region of the cortex was the distance of an axon. When two fingers were amputated, the impulse travelled, but the distance wasn't as great. The 1980's monkey research opened a new door in this field. With this study, they began to believe a brain could adapt, but the hardwiring had to remain in place.

Pons' Study

In 1991, a new study from Timothy Pons of the National Institute of Mental Health gave new evidence that began to change what neuroscientists believe as to the way in which a brain could change, grow, and evolve. Pons' study used the twelve "Silver Spring" macaque monkeys. These monkeys had their sensory nerves from one arm cut where it entered the spinal cord.

6 Shreeve

Animal activists sued, and due to a court order, the research was put on hold while the animal rights trial was tied up in the courts. Twelve years later, it was decided that four of the monkeys had deteriorated to the point where it was in their best interest to be euthanized. Prior to their demise, Pons was allowed to plant electrodes in their cortexes in hope of seeing where 12 years of dormancy would lead. Due to the results of Merzenich's prior experiment, he expected to find a couple of millimetres of encroachment – no more than the length an average nerve axon could reach.

"We were astounded," said Pons. "Instead of a little bit of trespassing from both sides, we discovered that the face region had completely invaded the neighbouring cortex. In each of the four animals, the entire hand and arm zone responded when we stimulated the face."[7]

With no stimulation or nerve input coming in from the arms for 12 years, nearly a half inch of cortex (a third of the touch map) changed its alliance to the face.

How this happened is still a mystery. Pons acknowledged, "We don't have the mechanism yet to explain it." Possible explanations suggest that new connections grew between neurons, creating links across the empty area. This was highly speculative because until this time it was believed that adult brains could not grow any new neurological connections; they were only capable of losing them. Yet there have been even more recent studies on monkeys showing that new axons can sprout from already existing cells in the spinal cord. Pons has hypothesized that the changes in the monkey may be a consequence of relatively modest growth occurring in more constricted places farther down the touch pathway, before they even reach the cortex. He speculates that one point could be the thalamus (the gatekeeper). Nerve impulse travelling from the face must pass through the thalamus at the same time that it is receiving information from the hands and arms. Usually they just interchange without making connections. Without input from the hand and arm, over time even a little sprouting of axons near the facial nerves passing through the limb's portion can create new synapses.

7 Touching the Phantom, James Shreeve, Discover, June 1993, Vol. 14, No. 6, page 35

When the Pons study was announced in 1991, Ramachandran was inspired by the brain's ability to change. For years he had been working on the mystery of blind areas in eye retinas. He was puzzled by how everyone has a blind area about 15 degrees off centre, yet we don't walk around with blind spots. He had suspected that this occurred due to the remapping or filling in of synapses delivered to adjacent parts of the visual cortex.

Phantom Limb Results

When Ramachandran read Pons' paper, it occurred to him that possible remapping or filling in is what happens to phantom limb sufferers. So in 1993, he began recruiting upper limb amputees for experiments to test his theory. He began with a teenager who had lost an arm in an auto accident only four weeks prior. Ramachandran began his test by brushing a Q-tip along the volunteer's blindfolded face.

"Where do you feel that?" he asked.

"You are touching my face," said the teenager, "but I also feel my left thumb tingling."

"And here?" asked Ramachandran, stroking the skin above his upper lip.

"You are touching my index finger."

"Now," he said, as he moved the Q-tip to his upper lip.

"My pinkie."

Ramachandran continued running the Q-tip along the subject's trunk, intact arm, etc., without any response. But when he touched the Q-tip to an area just above his stump, he received the response, "There, my thumb tingled again…now my index finger…the ball of my thumb…"

With this study, Ramachandran was able to neurologically locate his missing limb by touching the areas that border the cortex regions.

One was on his face, the other on his shoulder; just exactly as Pons discovered with the monkeys. This suggested that much of the same cortex encroachment that occurred with the monkeys occurs in phantom limb patients also.

This experiment was performed on six other patients.

All of them experienced remapping to some degree. One patient had lost both his arm and shoulder. Ramachandran was able to trace his entire missing forequarter across his face. The shoulder was located in the jaw joint and the elbow across the elbow-like bend of his lower jaw. The hand and fingers were found on his chin.

Another patient, who was not an amputee, but one of the rare individuals who experience phantoms when his nerves were yanked from his spinal cord in an automobile accident, had water dribbled on his face. The patient claims it felt as if water was literally being poured on his arm.

Theories Disagree

One of the most remarkable observations was the short amount of time it took for this remapping to occur. The first volunteer had only lost his arm four weeks prior. Because of this, Ramachandran disagrees with Pons' neuron-sprouting theory, because there just isn't enough time for sprouting to occur. Ramachandran believes that hidden circuits already exist and, as long as normal stronger inputs occur, the hidden circuits remain dormant. When input stops, the hidden circuits allow for the expansion of one cortical area into another one.

Pons has openly disagreed with Ramachandran's theory, saying that there is no evidence of latent circuits waiting to be unmasked. As I mentioned earlier, there is no known cause as yet for phantoms. There is only speculation and theory. We do know that phantoms are physiological, not psychological. There is mystery waiting at the cortex. More studies need to be performed before relief can be found for many phantom sufferers.

In the meantime, here are some suggestions for alleviating phantom pain.

Phantom Pain Relief

As stated, at this time there is no cure; surgical cutting of the nodules brings only temporary relief. A recent survey suggests that less than 1% of the respondents found permanent relief from a number of different treatments attempted.[8]

The LEAPS organization adds that some persons who have not found help though home remedies have found help through self-hypnosis, biofeedback, and chiropractic.

As you can tell by these suggestions, none are based on the latest facts stemming from the neurological basis for phantom sensations. Many are based on the theory that phantom pain is caused by circulation constriction.

Many studies on blood flow and temperature during phantom pain sensation and stump pain relative to the intact limb have been performed over the years. It has been reported that many times during stump and phantom pain there is a remarkable difference in the blood flow and temperature stemming from the stump and that of the intact limb.

These studies have also shown a relationship between the rate of change and the intensity of the pain.

The researchers insist that this does not mean that the rate of blood flow (circulation) causes phantom and stump pain. It could be that the pain subsequently causes the change in blood flow and temperature.[9]

These studies have also led to temperature biofeedback. The patients learn to tell when their blood flow changes; thus they attempt to increase blood flow in the stump by attempting to relax, thus dilating the peripheral blood vessels. This increases blood flow to the cool area, thus decreasing the pain's intensity. Researchers state that although this helps some people, circulation is not the cause. If it were, all phantom pains would be stopped, not just some.

Other methods of pain relief include stimulation of the stump with electric currents, acupuncture, and hypnosis. Some patients have found relief from medication that is used to counteract epilepsy.

Another interesting method of pain control that has helped some patients was developed by Dr. Ramachandran, who was mentioned earlier. He developed a mirror box. When an amputee places his remaining limb in the box, the mirrors trick the mind into seeing the missing limb. This has allowed patients to feel like they are actually moving their missing limb. Patients whose pain is such that they feel their fingers clenching into their palms are now able to place their

8 Sherman and Arena

9 Roger W. Davis, M.D

intact arm into the box and let it manipulate their phantom arm, thus moving their phantom fingers away from their palm. This box has actually helped some people.[10]

Due to the cortex research discussed in this paper, we know that the above suggestions are not the cure, although many people have been helped by them. Until a cure is found, anything is worth trying.

Research is continuing and leading us deep into the brain. The research in just the last few years has demonstrated the plasticity of the brain. Not only is this good for phantom limb sufferers, but also for those who suffer from any ailment involving the brain. We are getting closer; but as yet, the exact cause and cure remain a mystery.

10 Shannon Brownlee, Karen Mitchell, US News and World Report, October 2, 1995, page 78

Treating Phantom Pain: Challenging and Ongoing

By Lauren Green, July 2002, for O&P Business News

Phantom pain is an especially challenging form of chronic pain because it does not respond consistently to any one type of treatment.

Chronic pain is the focus of study for many medical researchers. Phantom pain is an especially challenging form of chronic pain because it does not respond consistently to any one type of treatment. The study of phantom sensation and phantom pain is an ongoing process, and progress is slow.

"Phantom limb pain is the norm. More than 80 percent of amputees experience a clinically significant amount of phantom pain at some point during their lives," said Dr. Richard Sherman, a physiologist and psychologist who has spent the last 30 years working with amputees. "It used to be thought that one half of one percent of amputees to five percent of amputees had phantom limb pain. The reason is that the amputees were afraid to admit they had pain in the part that was missing, because they thought the doctor would think they were crazy."

Referred Pain

The reason the residual limb can cause pain in the phantom limb is because of a phenomenon called referred pain, Sherman said.

"If you bang your elbow on a door, your elbow hurts, but you feel pain and tingling in your forearm and your hand," he said. "You didn't hurt your forearm or hand, but you feel the pain there because you started the signals at the nerve in your elbow that normally collects information from your forearm and hand. Similarly, someone with back pain may feel tingling in their leg, but there's nothing wrong with the leg. If you cut off the leg and there is something wrong with your back, you are still going to feel the tingling in your leg."

Referred pain occurs when the brain becomes confused as to the source of the pain. The brain does not know the specific locations in which signals are collected, and if something goes wrong with the nerve on its pathway to the brain, the body feels pain where the nerve is supposed to collect the information.

The Problem of Treatment

The biggest problem with treating phantom pain is the fact that different people respond differently to various treatments. Everything from over-the-counter non-steroidal anti-inflammatory drugs (NSAIDs) to nerve blocks to morphine has been attempted, with varying degrees of success. Not surprisingly, with the number of different responses to treatments, a number of widely different treatments have been developed in the ongoing battle to reduce or eliminate phantom pain.

One nonintrusive product available for pain sufferers is based on the theory that outside electromagnetic stimulation can adversely influence phantom limb pain. Farabloc is based on the same principal as the Faraday Cage, a conducting cage used to protect electronic equipment by blocking electromagnetic waves. The product is cloth woven with invisible steel fibers small enough to allow the cloth to be cut or sewn like any other fabric. The makers of this fabric claim that it relieves intermittent phantom pain when applied to the residual limb at the onset of the pain.

A study published in the *Canadian Journal of Rehabilitation* and posted on the Farabloc Web site indicates that the fabric does, in fact, offer some relief to certain people. According to the study, most of the participants reported their greatest pain relief while using the fabric. On the other hand, only a few reported complete or near complete pain relief, and one subject even reported greater pain with the fabric.

In another study published in the *British Columbia Medical Journal*, Farabloc was similarly found to reduce pain in patients suffering from either phantom pain or delayed onset muscle soreness. Measured pain relief in both studies averaged at about 3 points on the visual analog scale.

According to the manufacturer, Farabloc stimulates circulation and aids muscle relaxation. The company does not suggest that constant pain sufferers use Farabloc. While the studies indicate that Farabloc is a promising noninvasive and nonchemical treatment for phantom pain, they also make clear that, as with all other treatments, many people will respond differently. The researchers in both studies suggest that further investigation into the effects of Farabloc is necessary.

The Underlying Problem

Some studies have suggested that the circumstances surrounding the amputation, in particular the pain the amputee feels, may have an effect on the phantom pain felt after the operation. Dr. Lowell Reynolds, the medical director at the Center for Pain Management in Loma Linda, Calif., believes that severe pain before amputation, such as a violent traumatic amputation, may put a patient at higher risk of developing phantom pain acutely, but he is cautious in this belief.

"The literature is somewhat mixed in chronic phantom limb pain," he said. "It appears, for instance that central blockades may reduce acute phantom limb pain postoperatively. It may not, however, alter the incidence of phantom limb pain long-term."

Sherman echoes Reynolds' caution with this theory.

"Our data do not support that," he said. "It's still quite controversial. It may be true, but there are studies that do not support it."

Sherman said that a survey of 10,000 American veteran amputees showed that almost none of the standard treatments for phantom pain, such as medication and surgeries on the spine and residual limb, work.

"The treatments amputees receive are usually random," he said. "They're not based on the patient's problem, so it's random whether or not you get a treatment that will fit the underlying problem."

The underlying problem can be one of several things. Sherman's research shows that different descriptions of pain have different underlying physiological causes. Burning or tingling phantom pain is caused by too little blood flow in the residual limb. Cramping and twisting descriptions are caused by muscle spasms in the residual limb. While it hasn't yet been scientifically proven, Sherman believes that shocking and shooting pain is caused by nerve problems in the residual limb.

Tailor-Made Treatment

Each cause of phantom pain has a specific treatment, said Sherman, and patients can be taught to control their pain themselves.

"If somebody reports cramping or twisting phantom pain, since we know that's due to muscle tension problems, we can use techniques such as biofeedback. We can show people the spasms on a computer monitor and teach them to stop the spasms on their own."

The same treatment can be done for patients with burning phantom pain by teaching them to control their circulation.

"When you have an amputation, your circulation gets all messed up. Then, as you age, your peripheral circulation gets worse and worse. What we are doing is showing them how much blood flow is in the residual limb and how to increase it. There is a voluntary connection between your mind and how much blood is flowing in your limb, and you can control that."

Brain Plasticity and Pain

According to the commonly accepted theory, neurons in the brain that once represented the missing limb are driven by the stimulation of other body parts, generally those closest to the site of amputation. The theory of cortical remapping suggests that when a limb is amputated, the section of the cortex that belonged to the missing body part essentially is reorganized to receive input from other parts of the body. The degree of reorganization is thought to relate to the amount of phantom pain felt by the patient.

Training an amputee to determine the location and frequency of stimuli may go a long way towards helping reduce phantom pain through cortical remapping, according to a study performed by the

University of Heidelberg's Central Institute of Mental Health in Mannheim, Germany. Dr. Herta Flor, the chair of the department of cognitive and behavioral neuroscience, created a sensory discrimination training program in which electrodes were attached to the residual limb of five arm amputees. All of the amputees had been suffering from phantom pain for at least two years and most of them for more than 10 years.

While similar to the biofeedback techniques used by Sherman, the purpose of the training was not to control blood flow or muscle spasms, but to increase awareness of stimuli on the residual limb. During a two-week period, patients learned to discriminate the frequency and location of random, non-painful electrical stimuli applied to eight locations on the residual limb. Clinicians noted a significant change in the trained patients, while the control group showed no significant change.

"The patients made significant progress in their discrimination ability. They had a mean reduction of phantom limb pain of about 60 percent, and a mean change in brain reorganization of 1.5 centimeters," Flor told *O&P Business News*. "We believe that the discrimination training provided behaviorally relevant input to the brain and 'tricked' the brain into a mode as if input were again coming from the missing limb."

The study was a one-time experimental study and was not designed as true training for the amputees. According to Flor, however, the patients still had significantly reduced pain for three months following the two weeks of training.

"There is so far no effective treatment for phantom limb pain," she said. "The effects of this brief experimental intervention were substantial. Therefore, we believe that this intervention might be used clinically."

Flor and several researchers from the University of Tuebingen performed a study that examined the cortical remapping in amputees who used myoelectric prostheses and those who did not. The research confirmed with functional magnetic resonance imaging that phantom pain occurs less in amputees who regularly use myoelectric prostheses, and that the pain decreases over time. Together, these studies make a strong case that the brain can be tricked into behaving as if the missing limb were present, thereby reducing phantom pain and sensation.

Neurostimulation: A Last Resort?

Tricking the brain is one option in the battle against phantom pain, but for amputees whose chronic pain will not respond to any readily available treatments, neurostimulation may provide relief. A neurostimulator sends electrical impulses into the body to block pain, and for chronic pain sufferers, it can be a step towards living more normally.

There are two types of neurostimulators available. The spinal cord neurostimulator is more common and is planted under the skin near the spinal cord, similar to an epidural. The neurostimulator sends electrical impulses through a special medical wire called a lead, which blocks the pain signals being sent from the affected area.

The deep brain neurostimulator operates on the same principle, but the electrical impulses stimulate specific structures in the brain rather than the spinal cord. Deep brain stimulation is still experimental for phantom pain patients, although it has proved effective in treating patients with Parkinson's disease or similar motor dysfunctions.

Medication Management

In his everyday practice, Reynolds treats chronic, acute and cancer pain in all age groups using a variety of treatments such as medication management, injectable therapies, implantable therapies, acupuncture, electrical stimulation, and physical therapy. Reynolds has used spinal cord neurostimulators in patients with chronic and unresponsive forms of phantom pain. While electrical stimulation has had its detractors, Reynolds said he has had success with the treatment.

"Spinal cord stimulation and deep brain stimulation can be successful in the treatment of phantom limb pain if the patients are properly selected and screened," he said. "With stimulation, the patients tend to feel the vibrating or pulsating sensation instead of their underlying pain sensation."

Reynolds recommends spinal cord stimulation for those patients who have unsuccessfully tried more conservative therapy. After a successful stimulator trial of three to seven days and a psychological screening evaluation, the patient may proceed with the permanent implantation.

"While this may not be considered a treatment of last resort, we do recommend that patients try treatments that are more conservative first," he explained. "We feel this is prudent for cost containment purposes as well as from a risk benefit standpoint. In those patients that have been properly selected and screened, however, spinal cord stimulation can provide significant cost savings to both patients and third party payers. This modality can significantly reduce medication intake, and in so doing, can reduce potential medication side effects."

As for the long-term effectiveness of the treatment, Reynolds is optimistic. "Our short-term success has been excellent, and the long-term follow-up, which continues, has been encouraging," he said.

Looking for Answers

Although the causes of phantom pain are becoming better understood and the treatments more effective, much work needs to be done to eliminate this problem in amputees. One recent discovery by researchers at the Hebrew University of Jerusalem may push phantom pain research to the next level. The study examined 23 strains of mice for pain levels following nerve injury. The different strains of mice showed varying degrees of susceptibility to acute and chronic pain, and researchers are now trying to find the gene that causes the varied pain responses. It is hoped that the identification of the gene may lead to a similar discovery in humans, thereby enabling direct targeting of the gene with drug treatment.

Sherman suggests that any new research into the problem of phantom pain be observed with guarded optimism.

"If you look at the literature, there would be all kinds of excitement about a technique and then it just died out, mainly because the researchers didn't do follow-ups," he said. "They'll follow up for two or three months, but the placebo effect for pain lasts six months. You have to follow up your patients for at least six months to know if you are having any effect at all."

Ultimately, the majority of researchers will agree that more research and study is needed if the problem of phantom pain is to be fully understood and effectively treated.

Phantom Pain: Unlocking a Mystery

By Miki Fairley, May 2004, for the O&P EDGE

An accomplished amateur athlete named John had lost his left arm just below the elbow. "When I play tennis, my phantom will do what it's supposed to do," John said. "It'll want to throw the ball up when I serve or it will give me balance in a hard shot. It's always trying to grab the phone. It even waves for the check in restaurants," he laughed.

This experience is from Public Broadcasting Service (PBS) online and is a case from "Ramachandran's Notebook" (www.pbs.org).

Vilayanur Ramachandran, director of the Center for Brain and Cognition at the University of California-San Diego and adjunct professor of biology at the Salk Institute for Biological Studies, San Diego, has been called a Sherlock Holmes of neuroscience. Among his many noted accomplishments in the realm of neuroscience are the strides he has made toward understanding phantom limb pain and sensation. More about his ground-breaking work will be discussed later in this article.

Pain and Sensation

A Philadelphia, Pennsylvania, physician coined the phrase "phantom limb" shortly after the Civil War, when thousands of soldiers underwent limb amputations, with phantom pain and sensations arising. In one study of over 7,000 military amputees, over 80 percent reported phantom pain. The type of pain can vary; for instance, being felt as burning, stinging, cramping, shooting, and twisting.

"Phantom sensation" is a feeling that the missing limb is still present. "Just after the amputation, the phantom usually feels as though it is the same size and shape as the amputated portion of the limb," says LTC Richard A. Sherman, PhD, chief of the Surgical Research Service, Madigan Army Medical Center, Tacoma, Washington, in his book, *Pain after Amputation–a Lifelong Problem?* "Most people feel that they can move and control it as well as they could control the limb itself," he adds. "The sensations are so real and normal that many young, traumatic lower-limb amputees frequently try to get up and walk away a day or so after their amputations."

"Phantom sensations normally include all the sensations you would feel in an attached limb, including a sense of position, temperature, itching, and very occasionally, a ring or other item worn for many years," he continues. "The phantom frequently rests in the last position the limb was in before it was amputated."

'Telescoping' Limb

Sherman then discusses "telescoping," noting that as time passes, the limb's shape becomes less vivid. For example, a below-knee amputee can at first feel the calf, ankle, and foot. Gradually the foot "telescopes" into the end of the residual limb so that eventually the calf and ankle seem to have disappeared. However, telescoping doesn't happen if phantom pain is present, and if phantom pain occurs even years after the amputation, the phantom "grows" to its original shape and vividness, Sherman says.

John, mentioned in "Ramachandran's Notebook," had a telescoped phantom hand, feeling as though it were attached directly to the residual limb with no arm in between. "However, if an object such as a teacup were placed a foot or two away from the stump, he could try to reach for it," says Ramachandran. "When he did this, his phantom no longer remained attached to his stump, but felt as if it were zooming out to grab the cup."

"On a whim, I started thinking, What if I ask John to reach out and grab this cup, but pull it away from him before he "touches" it with his phantom? Will the phantom stretch out, like a cartoon character's rubbery arm, or will it stop at a natural arm's length? How far

can I move the cup away before John will say he can't reach it?…Or will the physical limitations that apply to a real arm also apply to the phantom?"

So Ramachandran placed a cup in front of John and asked him to grab it. Just as John reached for the cup, Ramachandran yanked it away. What happened?

"Ow!" John yelled. "Don't do that!…I had just got my fingers around the cup handle when you pulled it. That really hurts!"

In the notebook, Ramachandran ponders, "Hold on a minute. I wrench a real cup from phantom fingers and the person yells, "Ouch!" The fingers were illusory, of course, but the pain was real–indeed, so intense that I dared not repeat the experiment."

Brain 'Remapping'

These startling experiences illustrate the depth of the mystery of mind and body regarding phantom pain and sensation–a mystery that is beginning to be somewhat revealed.

According to the National Institute of Neurological Disorders and Stroke (NINDS) of the National Institutes of Health (NIH), "Scientists believe that following amputation, nerve cells rewire themselves and continue to receive messages, resulting in a remapping of the brain's circuitry. The brain's ability to restructure itself, to change and adapt following injury, is called plasticity."

Understanding of phantom pain has improved tremendously in recent years, NINDS notes, explaining that investigators previously believed that brain cells affected by amputation simply died off. They attributed pain at the amputation site to irritation of nerves located near the residual limb.

"Now, using imaging techniques such as positron emission tomography (PET) and magnetic resonance imaging (MRI), scientists can actually visualize increased activity in the brain's cortex when an individual feels phantom pain," the NINDS website (www.ninds.nih.gov) explains. "When study participants move the stump of an amputated limb, neurons in the brain remain dynamic and excitable. Surprising, the brain's cells can be stimulated by other body parts, often those located closest to the missing limb."

In the mid-20th century, Canadian neurosurgeon Wilder Penfield, MD, discovered that the entire surface of a person's body is mapped on the surface of the brain, according to "Ramachandran's Notebook." When a certain body part, such as a foot, is touched, neurons in the part of the brain mapped for the foot respond.

Tim Pons, PhD, of the NIH, and his colleagues found that, while working with monkeys, sensory information coming from a body part, such as the face, could invade cells for the part of the brain mapped for a dysfunctional body part, such as a paralyzed arm. The brain thus began to modify Penfield's map when part of it was no longer receiving impulses.

Neurons in the brains of adult monkeys grow and make new connections in somatosensory areas when they are massively deprived of sensory input, according to a paper in the April 25, 2000, issue of PNAS, the *Proceedings of the National Academy of Sciences* (www.pnas.org). This strongly suggests that neuronal growth underlies the brain's reorganization following such injuries, according to the writers: Neeraj Jain and Sherre L. Florence, psychology professors at Vanderbilt University, Nashville, Tennessee; Hui-Xin Qi, research associate; and Jon H. Kass, psychology professor, also of Vanderbilt.

"We have suspected for some time that this is the case," says Jain. "But, until recently, the prevailing view has been that this kind of regenerative growth is unlikely to occur in adult brains. Hopefully, this new insight will suggest ways to stop or reverse phantom limb sensations…"

Ramachandran also wondered about the "mapping."

By blindfolding Tom, an upper-limb amputee, so he couldn't see where he was being touched, Ramachandran took a Q-tip and starting stroking various parts of his body surface and asked Tom where he felt the sensations. For instance, he moved the Q-tip to Tom's upper lip. To Tom, it felt that Ramachandran was not only touching his lip, but also his missing index finger.

"I soon found a complete map of Tom's phantom hand–on his face!" reports Ramachandran. "I realized that what I was seeing was perhaps a direct perceptual correlate of the remapping that Tim Pons had seen in his monkeys. For there is no other way of explaining

why touching an area so far from the stump–namely the face–should generate sensations in the phantom hand; the secret lies in the peculiar mapping of body parts in the brain, with the face lying right beside the hand."

Ramachandran encountered another amazing phenomenon: "I also found a second, beautifully laid out map of his missing hand–tucked into his left upper arm a few inches above the line of amputation. Stroking the skin surface on this second map also evoked precisely localized sensations on the individual fingers."

Virtual and Augmented Reality Technology

More research has continued, with the goal of stopping phantom pain and sensations. One promising avenue uses "virtual reality" (VR) and "augmented reality" (AR) technology. What is the difference? According to Jim Vallino, Department of Software Engineering, Rochester Institute of Technology, Rochester, New York, "virtual reality" has been defined as "a computer-generated, interactive, three-dimensional environment in which a person is immersed."

"Augmented reality" is an area of virtual reality in which a composite view is generated for the user, Vallino notes on the Rochester Institute website (www.se.rit.edu). "It is a combination of the real scene viewed by the user and a virtual scene generated by the computer that augments the scene with additional information," he explains.

Thranhardt Lecture

VR and AR research relative to phantom limb pain was a subject of one of the Thranhardt lectures during the 2004 Annual Meeting and Scientific Symposium of the American Academy of Orthotists & Prosthetists (AAOP) in New Orleans, Louisiana. Presented by Malcolm MacLachlan, PhD, of the Trinity Psychoprosthetics Group, Trinity College, University of Dublin, Ireland, the study also involved researchers from the Cappagh National Orthopaedic Hospital, Dublin; IDS Ltd., Dublin; the Department of Electronic & Electrical Engineering, University College, Dublin; MIT Media Lab Europe, Dublin; and the Department of Psychology, Cardiff University, Wales.

The discussion noted that previous research on referred phantom sensation from body parts represented on adjoining regions of the somatosensory cortex to the phantom limb "has been interpreted as a dramatic indication of rapid cortical remapping post-amputation." Of particular interest has been evidence that greater neural plasticity is associated with more severe phantom limb pain, MacLachlan noted in a proceedings paper for the lecture.

The lecture mentioned experimentally induced phantom experiences, such as the "Mirror Box Illusion" used by Ramachandran and colleagues. People with upper-limb amputations were asked to place their intact arm into a box, with a mirror down the mid-line, so that when viewed from slightly off-center, the reflection of their arm gave the impression of having two intact arms.

However, a regular mirror reflects the image of the intact limb, while the way the phantom is perceived and experienced may differ greatly from both the original limb before amputation and from the remaining intact limb.

For instance, for some persons, the phantom limb may be shorter, longer, continuous, or have "gaps" in it, in comparison to the original limb. This may explain why the "Mirror Box" technique was therapeutically positive for some people, but for others had only moderate effectiveness or none at all.

"We have developed VR technology to produce authentic phantom limbs by giving preeminence to people's descriptions of their own phantom experiences and encoding these into the parameters used to generate the virtual phantom image," MacLachlan said.

Potential Technology Applications

VR technology has the potential to reduce or remove phantom limb pain, according to MacLachlan. Also for elective amputations, preoperative use of AR technology "offers a unique opportunity to enhance patients' preparation for post-amputation changes in their physical appearance, and thus potentially reduce post-operative shock and trauma."

A prosthesis may be invested with a person's emotional response to their limb loss: it may come to embody ability or disability, MacLachlan said. "We believe that there is great potential for virtual and augmented reality to allow people to further customize their prosthetic limbs, through trying on a broad range of designs prior to fitting, in order that prosthesis users can contribute more fully to their personalized development."

He added, "Perhaps the greatest challenge to our increasingly sophisticated technology is to consider not just the biotechnological ramifications for body function, but also the psychosocial implications for body image and overall wellbeing."

Ouch! Those Phantom Pains Really Do Hurt – Brain Link Mapped to Missing Limbs

By Joseph Hall, January 1998, for the Toronto Star

The phantom pains suffered by many people with amputated limbs are no hallucinatory ghosts, according to a new University of Toronto study.

Often thought to be figments of an amputee's imagination, sensations that seem to spring from missing body parts are actually rooted in the brain's main sensory sorting centre, says the study, published in this week's edition of the journal *Nature*. The study shows a direct physiological basis for the pain "which patients have tended not to report or to ignore," says U of T physiologist Jonathan Dostrovsky, a study author. "They've felt they might be considered to be having illusions."

Information from the study was obtained during brain operations on six amputation patients who were suffering chronic and severe phantom pain or pain from the adjacent stump region. The U of T and Toronto Hospital team found the fault lies in the thalamus region of the brain. This is the major command centre for sensations, not only touch, but hearing and vision, said Dostrovsky. The sensations portion of the thalamus is itself divided into segments specifically responsible for individual body parts, he added.

"There is a very clear mapping of the body so you can find regions that respond to touch in the fingertips and the lips and the toes and so on," he says. But should one of these body parts go missing, Dostrovsky says, the corresponding thalamus segment continues to function regardless. That orphaned segment can often be stimulated by the stump region next to the amputated part, he says. "And although the brain cells in the area now respond to stump input, the messages they're sending are still interpreted by the brain, by our conscious awareness, as coming from the phantom (missing limb)."

During the brain operations, surgeons mapped the touch sensory areas of each patient's thalamus to find a home for experimental electronic stimulators they hoped would interrupt the discomfort. Using electronic impulses to do the mapping, surgeons found that stimulating the regions corresponding to the missing body parts, the patients, who were awake, could feel their amputated segments.

The work may well lead to new methods for dealing with phantom pain and for new understanding about the ways our brains adapt to traumatic changes, researchers say.

Phantom Limb Sensations

Dr. Jonathon Dostrovsky, a physiologist, and Dr. Karen Davis, a neurophysiologist, both at the University of Toronto, were interviewed on Quirks and Quarks. *The following is an excerpt.*

Interviewer: Dr. Davis, if this sensation is real, what's actually going on?

Dr. Davis: That's something we're trying to understand. Obviously the limb is not there anymore, but what we're finding is the representation of that limb in the brain is still there, in some of these cases. And so somehow that representation triggers theses sensations from something that no longer exists.

Interviewer: Now what do you mean by representation?

Dr. Davis: What we mean is that there's a so-called body map of all the surface of your body in the parts of the brain, in one particular area, the sensory thalamus, an area we were looking at. And every part of the body has a map in that part of the brain.

Interviewer: So how does that relate to what's going on in the limb?

Dr. Davis: Basically, if you remove that part of the body, that doesn't necessarily mean that that part of the brain that represents that part of the body is gone. The input to that brain part is missing, but the brain cells are still there. And they can still be programmed to trigger sensations from the missing body part – the map can still be there.

Interviewer: So how do these brain cells get stimulated if, say, the hand is gone and that hand map in the brain is still there?

Dr. Dostrovsky: First of all, it's possible, quite conceivable, that you don't need stimulation or input and can still have a sensation from the part of the map. Because when we go into the brain with our micro electrodes and record these signals that these nerve cells are sending on to the cortex, we find that in many cases the cells are spontaneously active. In other words, they're firing and sending messages even when there's no sensory stimulus occurring at the skin. Normally, presumably these inputs or these messages are being ignored, but it's possible that following amputation, these messages can become more important and sustain the sensation or the phantom. Another phenomenon that we've discovered is that many of these cells that we believe used to represent the now-missing limb, are being activated by intact parts of the skin in adjacent regions, in many cases the stump…And what is new and novel about our findings is that when we stimulate these regions electrically, artificially, the sensations that we induce are now…are still referred back to the original part of the body, and not the new part of the body which has taken over the cell's responses. So there's a mismatch.

Interviewer: So in other words, the nerves that would normally have come from, say, the fingers, travelling up the arm to this map in the brain, would be still in the stump of what's left of the arm. And when you stimulate that, then that still goes to that map, saying fingers, even though the fingers aren't there. Is that the idea?

Dr. Dostrovsky: That's correct, but in addition, nerves that never used to go to those cells and that originated from adjacent parts may also activate those cells. These are new connections occurring in the brain.

Interviewer: How did you figure this out?

Dr. Davis: Dr. Dostrovsky and I and a team of researchers have been involved in this sort of mapping procedure for a number of years. It's a common procedure that we're involved in with any patient that's having neurosurgery.

Dr. Dostrovsky: We have a very fine-tipped electrode, there's a fine wire that we insert in to this map, and we can record the messages that the cells around the tip of the electrode are sending on to the cortex. And we can also stimulate from the electrode tip.

Interviewer: So by using your electrode in the patient's brain you can figure out what signals these nerve cells in the brain's map of the body are getting, and you can also create artificial signals? Can you give me an example of that?

Dr. Dostrovsky: If we take a patient and we find, for example, a region where the cells respond to touching the fingertip, now if we stimulate from the electrode at that same site, the patient will feel a tingling sensation on the same site, on the fingertip. The patient won't feel it as occurring in the brain, where we're stimulating, but will feel it as coming from the fingertip. Now in these amputation patients, we see a different picture. We might find cells that are responding to the stump. We touch the stump and they respond. But now when we stimulate, they have a sensation on say, the fingertip in this case rather than the stump.

Interviewer: Even though the fingertip isn't there.

Dr. Dostrovsky: That's right. And also this is quite abnormal. Normally in a patient with a normal map, if the cells respond to the stump and are stimulated there, they'd feel a sensation on the stump.

Interviewer: Well, what does this tell you about how the brain perceives sensation?

Dr. Davis: I think one of the hypotheses that we're looking at is that what difference we can find in these patients that have amputations that have ongoing phantom sensations and those that don't have phantom sensations. And the question is, why in some patients does the brain remap itself in such a way that does not lead to pain or phantom sensations, and in other patients you have quite a different finding. So what predisposes someone to take one route or another is something that we have to look at more carefully.

The Haunting Agony of Phantom Limb Pain

Excerpts from an article by Colin Muncie, March 1995, for the Medical Post

George Mills trained pilots and planned to see action in the Pacific during WWII. After miraculously escaping unscathed from a crash landing he suffered a motorcycle accident paralysing his left arm. Over the next few years, doctors exhausted their limited medical options to alleviate George's phantom limb pain. His paralysed arm was amputated above the elbow. He suffered serious phantom limb pain immediately in his missing left hand. "It felt like the cuticle of each nail was burning fiercely. My thumb felt as if it was dislocated at its base and it felt like a nail was being driven into the palm of my hand.

He describes three levels of pain: 1) "A constant, nagging pain in one or more places in my missing hand. It was there all the time when I tried to relax." 2) "A growing, swelling pain that usually began at night. It would build up to a peak, then subside to a constant pain. There was nothing I could do about it except grit my teeth and sweat it out." 3) "The worst of all – a sudden, driving pain in the hand that came without warning. It would make me jump, gasp and grit my teeth until it eased up."

He searched out experts and tried everything available to deal with it: nerve blocks, spinal stimulation by electrodes, drugs, acupuncture, hypnosis, biofeedback and even transcendental medication. Nothing made any difference.

Later he read about a surgical procedure called dorsal root entry zone (DREZ) introduced to North America from France by Dr. Blaine Nashold, professor of neurosurgery at Duke University Medical Center, North Carolina, who had helped phantom limb pain sufferers.

Dr. Finnie (George's family physician) heard about it at the same time – they tracked down one of the few doctors in Canada using the DREZ technique successfully to treat phantom limb patients.
Dr. Vanderlinden commented "I didn't know whether you could relieve pain that had been present for going on 50 years. I though there may have been changes in nerve cells in the brain itself. In all cases of chronic pain, there is an association with some emotional overlay to this pain, and that is the suffering. Also, there is anxiety, a form of fear, and anger is usually present as well. The closer we are to the more physical type of pain with the minimal amount of emotional overlay, the better our results are with surgical treatment." In addition to the phantom limb pain George suffered, he also felt as if his missing limb was still at a 90° angle to his shoulder.

Dr. Vanderlinden went right back to George's original history "it was obvious he had suffered brachial plexus injury. Since DREZ was the choice for brachial plexus, it was certainly worth trying on George."

During the operation, George's spinal cord was exposed from about the third cervical segment to the first thoracic segment, revealing that the original diagnosis of brachial plexus avulsion was correct, says Dr. Vanderlinden. "You couldn't see any of the dorsal or posterior nerve roots in the involved (left) side, but they were all present on the other side. We could see nerve roots down below and above, but in between there weren't any, so this gave us a good guide where to make our lesions. We made a series of lesions (46), using a fine-tip, hand-held electrode, until we saw the surface of the cord beginning to char. What we were trying to do was destroy the nerve cells in the spinal cord that had generated uncontrolled electrical activity for almost 50 years. That was the source of George's pain. When George awoke about 7:30 p.m. from anaesthesia, Dr. Vanderlinden was at the foot of his bed. "Oh my God, doctor," he said "there is no pain!" (And the pain stayed away.)

Master of Its Own Deception: How the Brain Sees Limbs That Were Never There

By Amanda Onion, February 1998, for Fox News

Karen Valley sometimes feels an itch on her left arm, but there's little she can do about it. Since birth, she's had no arm there to scratch.

Phantom limbs are nothing new in the world of science. People often report feeling a tingling or even pain in limbs that have long been amputated. Neurologists have attributed this phenomenon to a neural map developed in the brain when the limb was in place. After the limb is taken away, the imprint of the hand or leg or arm remains and fools the brain into sensing its presence.

But that doesn't explain why people like Valley, who are born without a limb, still feel what was never there in the first place.

Psychologist Ronald Melzack of McGill University agrees with the notion that the brain responds to a neural map of the normal body image. His latest study, however, takes that theory one controversial step further and argues that the brain's neural map of the body is something we are born with – not something that is solely learned.

"Our perception of our body is not a passive process that merely reflects inputs from the body, "Melzack writes in his report published in the science journal *Brain*, "but is continuously generated by a distributed neural network in the brain."

That may be why Valley often leaves cupboard doors open after trying to shut them with her phantom left hand or drops objects she has reached out to catch, only to realize her brain was confused again. Melzack would argue Valley's brain is responding to an old, genetic blueprint – made up of neural networks – that still shows it can count on all her extremities to carry out a task.

Melzack's study, conducted over a period of several years, surveyed a group of 125 mostly adolescent people who were either born without a limb or who lost one before the age of 6. Of those born without a limb, 20 percent told researchers they felt the distinct presence of a phantom limb. Among those who underwent amputations before the age of 6, 50 percent experienced the same sensation.

Not only does Melzack's work dispute earlier beliefs that phantom limbs only occur in people who undergo amputation after infancy and therefore carry a prolonged memory of their lost limbs, his claims also draw him into the volatile debate of nature versus nurture.

Until recent years, the brain was commonly regarded as a blank slate that is built upon by learning. One of the earliest challengers of that notion was Noam Chomsky, a renowned linguist who argued in 1959 that children's ability to learn language so quickly must be explained by the presence of a "language organ" existing in the brain at birth.

Likewise, by demonstrating that people born without limbs are still able to sense them, Melzack argues that the brain begins life equipped with a ready-made map of the body.

"It seems to run against a lot of the recent thrust in neuroscience which says that it's all plastic, it's all learned," said Steven Pinker, a psychology professor at MIT and author of the book *How the Brain Works*.

Vilayanur Ramachandran, a psychologist at the University of California at San Diego and established guru of the phantom limb phenomenon, is now doing work to demonstrate the complex interaction between the brain and its environment. He suggests that the brain is guided both by inherent information and by learning.

"People go away from Melzack's study thinking, 'Oh my God there's a fixed body image,'" he said. "What I'm saying is that your body image is fixed, but also tremendously malleable."

Ramachandran points to his study of leprosy patients in India to be published this year in *Brain*. Leprosy is a disease in which bacteria infect nerve cells in the limbs of the victim, who then loses feeling in the extremities. Eventually, fingers, hands, arms, and legs are eaten away by infection. Leprosy victims, Ramachandran found, do not experience phantom limbs.

"So what happened to your genetic phantom?" he asks. "The guy doesn't have a phantom because the brain is slowly adjusting itself, reshaping its body image because the arm is being knocked off bit by bit."

During the slow process of impairment that occurs during leprosy, he explains, the brain sends signals to the limbs and eventually learns they are no longer functioning.

This differs from cases in which people born without limbs are unable to reshape their body image, Ramachandran explains, because the brain requires the initial presence of an arm or leg and its gradual deterioration to learn that the body shape is changing. With no information coming from the missing extremity, the brain's original map of the body image remains undisturbed.

But something curious happens when the stump of a leprosy patient is amputated. Rather than further reshaping the body image to accommodate the lost stump, the phantom limb – complete with fingers or toes – returns.

This occurs because there are two representations of the body image: the old representation and the revised one. Amputation of the stump disturbs the new image, causing the brain to revert to the original one with the full phantom limb.

Melzack's and Ramachandran's work implies the human brain includes a set of tools for specific learning which can adjust, albeit gradually, to an external change in the body. "This addresses an absolutely classic problem in neurobiology," said Ron McCay, a neurologist at the National Institute of Health. "It asks what people are like when they are born and how much they are capable of learning."

But for Valley, the latest findings carry more personal implications, as scientists offer her more concrete explanations for a sensation that she had earlier chalked up to her own imagination.

"I always thought I was a fruit because the cases you hear about are the ones who have lost limbs in accidents or in surgery," she said. "It's always just been an issue for amputees."

To prove the brain's wiring is not fixed, Dr. Ramachandran surveyed people shortly after they underwent amputation to learn how quickly the brain adjusts to a lost limb.

Among those who had lost a hand, he found a common, bizarre phenomenon: When he touched their faces, they felt his fingers on their phantom hands. When they drew their mouths into smiles, they sensed their phantom hands moving. The reason? Crossed wires.

"The face area and the hand area in the brain are right next to each other," he said. "So when you remove the hand, the nerves going from the face to the face area now invade the territory the hand has vacated and take over."

Their findings seem to counter Dr. Melzack's claim that the brain is guided by a genetic blueprint. Within 24 hours after amputation, Dr. Ramachandran's subjects were already experiencing a change in their brains' reception.

But Ramachandran argues the amputees' experiences do not suggest that the brain abandons its genetic blueprint. The original layout of neurons in the brain remains in place; some receptors simply begin registering signals from other parts of the body.

Geoffrey Shultz, a research fellow who worked on the McGill study with Melzack, points out that his team never doubted the network of neurons in the brain were not susceptible to change.

"Adaptation occurs, but there still seems to be some kind of built-in, underlying framework in the brain on which we experience our body," he said. "There may be some adaptation, but the blueprint is always there."

In the case of the hand amputees, it appears the brain is still following its genetic map of the body – it's just taking a few wrong turns.

The Influence of Phantom Limbs

Excerpts from Chapter 4 of Human Limbs and Their Substitutes *by Paul E. Klopsteg, PhD, and Philip D. Wilson, MD, et al., published 1954*

Chapter by Bertram Feinstein, James C. Luce and John N.K. Langton

Various painful conditions frequently develop among persons who have suffered loss of limb. They may arise indirectly from amputation, as, for example, chronic low back pain in the lower-limb amputee who is forced to assume a radically modified and unnatural gait in order to control his prosthesis. Or, in spite of the most careful surgical techniques, structural deformity resulting from healing processes can produce severe discomfort and pain. Finally, inherent in the amputated state itself is the problem of phantom sensation and phantom pain – formidable in its devastating effect on the sufferer and in the obscurity of its origins. Pain arising from any of these sources is often severe enough to impede seriously or even to defeat completely the efforts of the amputee to make the adjustments required of him.

The amputee is deprived of a portion of his normal self. Loss of somatic components crates a deep-seated disturbance in his functional patterns, and it would therefore be unreasonable to expect immediate and uncomplicated adjustment. Our problem is to analyze the factors which inhibit adjustments, factors which may arise from the persistence of previous functional patterns or from the recent structural alterations. There are, of course, the more tangible factors of such "organic" disturbances as changes in peripheral nerves, vascular and neurovascular abnormalities, and traumatic or inflammatory alterations of other stump tissues. Because of their evident nature, such conditions have provided an easy point of attack which, unfortunately, seems to have discouraged study of the less obvious underlying deviations from normal function. A careful study of amputees, however, demonstrates the importance also of considering dysfunction central as well as peripheral. Treatment directed toward an evident lesion occasionally permits the amputee to wear a prosthetic device with slight discomfort, but the phantom, painless or painful, still remains. A high incidence of morbidity exists among amputees as a result of pain problems. Adequate therapy depends upon an understanding of the basic mechanism involved.

The Phantom Sensation

The phenomenon of the phantom limb was first recorded, as far as is known, in 1551 by Ambroise Paré (33), whose comment, in Elizabethan translation, ran as follows:

A most clear and manifest argument of this false and deceitful sense appears after the amputation of the member; a long while after they will complain of the part which is cut away. Verily it is a thing wondrous strange and prodigious, and which will scarce be credited, unless by such as have seen with their eyes, and heard with their ears the Patients who have many months after the cutting away of the Leg, grievously complained that they yet felt exceeding great pain of that leg so cut off.

Three centuries later, after the American Civil War, Silas Weir Mitchell (32) said in Lippincott's Magazine of Popular Literature and Science:

The feelings and delusions entertained by men who have lost members have often been the subjects of casual notice in surgical treatises, from Ambroise Paré's time to our own, but even in the best books there is yet no clear and detailed statement as to this subject, which for interest alike popular and scientific is hardly to be surpassed, even in this time of scientific sensationalism.

He has supplied the classic description in vividly appropriate language:

A person in this condition is haunted, as it were, by a constant or inconstant fractional phantom of so much of himself as has been lopped away – an unseen ghost of the lost part, and sometimes a presence made sorely inconvenient by the fact that while but faintly felt at times, it is at others acutely called to his attention by the pains or irritations which it appears to suffer from a blow on the stump or a change in the weather.

Weir Mitchell lacked no material for observation among the estimated 15,000 amputees of the Civil War. At that time the phantom member was still surrounded with folklore, such as the necessity for careful burial of amputated limbs in order to prevent phantom pain. He pointed out that phantom sensation, or consciousness of the lost member is almost universally a sequel of major amputation and that its subjective pattern is remarkably constant. The chapter on phantom limbs in Mitchell's classical work (31) on nerve injuries was the first study of considerable scope in this country. A systematic description of the phenomenon by Guéniot (9) appeared in France 11 years earlier.

Consciousness of the missing member may or may not be described as unpleasant, but it is often subject to intermittent unpleasant sensations, such as itching, tingling, and pain. These sensations may be aroused in the phantom member by a variety of changes within the amputee's body or environment. Thus changes of weather are reputed to cause sensory phenomena in stump and phantom to the extent that the amputee may become a local weather prophet. Pain entering the phantom syndrome may assume clinical importance. If it is excruciating and persists for long periods, it may take a heavy toll of mental and physical well-being.

Instances of a phantom following the loss of nose, breast, or penis have been known, as well as the phantoms commonly following the complete or partial loss of a limb. Phantoms also occur in conditions other than amputation, such as hemiplegia and brachial plexus lesions. The patient thus may have, in addition to his real limb, a phantom limb (10, 26, 27, 30, 41).

Types of Phantom Sensation

Among writers on this subject there is a tendency to distinguish between phantom sensations which are painful and those which are not. The painless from has been called variously the "natural phantom," "phantom sensation," and "phantom-limb impression." It is most often described as a tingling which is not unpleasant and is frequently even pleasant. It has been likened to an exaggeration of tingling in a normal part. Herein such a phantom is referred to as a "painless phantom." A phantom with any of the numerous sensations ranging from unpleasantness to pain is referred to as a "painful phantom."

Henderson and Smyth (14) distinguished three kinds of phantom sensations:

(a) mild tingling, which forms the basic part of the phantom in nearly every case and probably arises in the cerebral cortex;

(b) stronger pins and needles induced momentarily by touching a neuroma in the stump;

(c) occasionally, superadded sensations which may be disagreeable and painful and probably have psychogenic basis.

In our own investigations, we have been unable to differentiate as sharply between various types of phantom sensation. We have found that the same individual may experience several different types of phantom sensation, either simultaneously or on different occasions. Experimental procedures have produced changes in sensation which warrant the assignment of no particular type of phantom sensation to a specific etiological factor or functional level of the central nervous system.

Incidence of Phantom Sensation

Awareness of phantom after amputation is the rule. When its presence is denied, repression or distortion of the fact may be suspected. Frequently the patient's attitude is guarded; he tends to ignore his phantom sensations and is reluctant to admit them lest his sanity be questioned. Even so, the incidence of phantom sensation is high – 145 in our series of 150 cases, an incidence similar to that obtained by others who report 85 to 98 percent

Pattern of the Painless Phantom

In the usual phantom, only the distal portions of the missing member are felt. An amputated lower limb is most likely to be represented by a phantom foot; an amputated upper limb, by a phantom hand. When the

phantom hand or foot is incomplete, the thumb and index finger in the "hand," and the big toe, instep and heel in the "foot" tend to be present. As a rule, digits in the phantom are felt with unequal intensity. Joints may be felt more strongly than areas distal to them, for example the elbow joint more than the forearm. Fairly frequently the phantom is shorter than the corresponding normal limb.

The patterning of the painless phantom bears no resemblance to the areas of distribution of the major peripheral nerves (28). Thus the partial nature of the phantom cannot be ascribed to the involvement of certain nerves in the stump. The pattern of the phantom consists rather of those parts which are most mobile and endowed with the highest degree of sensory function. This is borne out by an early observation by Mitchell (31) that amputation of an upper limb is more apt to be followed by a phantom than amputation of a lower limb, although the validity of this observation is questionable in view of the high incidence of phantom sensation generally (about 95 percent). The distribution of the phantom pattern, however, does strongly suggest a Gnostic gradient of the limb – a concept which is useful for understanding the origin and nature of the phantom phenomenon.

Onset and Duration of the Painless Phantom

Following amputation, most patients are aware of the phantom immediately. Frequently it is so vivid that they find it difficult to realize that the amputation has actually been performed. In only a few instances is the onset of the phantom delayed. Of our series of 145 cases, in 124 (85.5 percent) onset of phantom sensation was immediate, in 11 (7.6 percent) after less than 1 month, and in 10 (6.9 percent) from 1 month to 1 year after amputation. The major factor in this delay was the depression of consciousness due either to injuries or to drugs. Since a large proportion of our patients were war casualties who had received multiple injuries or who were kept under sedatives for purposes of transport, some time might have elapsed before they were able to analyze their sensations. Frequently this original phantom sensation continues, unmodified in shape and composition, for many years despite subsequent surgical procedures. Very rarely have we observed a process of gradual shortening leading to complete disappearance of the phantom image – a process assumed by some investigators (14) to represent the natural history of the phantom.

Voluntary and Involuntary Movements of the Phantom

In relatively few cases, amputees report the sensation of voluntary movement of the phantom part. These movements are fairly gross and consist of flexion and extension of the hand or foot. The fine and accurate movements are apparently never experienced. In one mid-thigh amputee, the foot was the only part of the leg retained as a phantom, and this was located on the posterior and distal aspect of the stump. The patient experienced some voluntary plantar flexion of his "toes." If he persisted in this manoeuvre, there arose in the phantom foot a cramp-like sensation which, with further persistence, became quite painful. This proprioceptive type of painful sensation leads to an intense desire to relax the phantom. Unfortunately, in most instances this is impossible and may account for the frequent comment, "If I could only open my hand, the pain would go."

The sensation of spontaneous involuntary movement in the phantom is rarely reported. On the other hand, spontaneous involuntary movement of the stump is not infrequent and, in our experience, is usually associated with bouts of severe phantom pain. A young woman had her right arm amputated at the level of the upper third of the humerus. Following amputation, she suffered severe, cramp-like pain in a clenched phantom fist as if the "fingers" were forcing the "thumb" into the palm of her "hand." The intensity of this sensation built up gradually until sharp, stabbing pains were felt in the phantom thumb and then began shooting upward toward the stump. The stump actually jerked, apparently in time with each stab of pain.

The phantom limb may change its position in response to an external stimulus, as noted by some amputees when they begin wearing an artificial limb. Not infrequently a shortened phantom may, on the application of the prosthesis, lengthen and actually become identified with the artificial limb. One young man with an amputation above the knee felt a sensation as if the shortened "foot" were appended to

the stump. While wearing his prosthesis, however, he was aware of the phantom foot coincident in position with the artificial foot.

Phantom Pain

Mastery of the limitations imposed on normal living by his physical handicap is a real challenge to the amputee. Achievement in this respect gives a deep sense of satisfaction. The pain of a phantom, however, may be an even greater obstacle to overcome. Those afflicted by phantom pain are confronted with a very real but completely intangible problem which cannot be solved by any exertion of "will power." Frustrated attempts at adjustment may eventually undermine morale.

This point is well illustrated by the case of a young marine wounded in the left arm during the Okinawa campaign. Battle conditions rendered even first-aid treatment impossible for 3 days. Amputation was necessary because of ensuing infection. The patient was kept under heavy sedation for approximately a month while being transported to a base hospital in the United States. As he became more aware of his condition, he began to suffer from a severely painful phantom hand. The pain was continuous, sharp, and stabbing, as though the base of his "middle finger" were "being jabbed with an ice pick." Superimposed on this focal pain was a general sensation of intense cramping as though the "fingers" of the "hand" were in acute flexion.

In the next 4 years many surgical and psychotherapeutic procedures failed to alleviate his pain, and with each new failure he redoubled his own efforts to meet his problems. He undertook a most complicated and vigorous course of callisthenics that absorbed his entire attention and led to remarkable proficiency in the use of his prosthesis. It was almost as though the overcoming of physical limitations might somehow obviate the mental state which arose from the pain. But this state of affairs continued until he developed psychotic symptoms which manifested themselves in unpredictable outbursts of hostility against his friends and in a complete inability to cope with the course of studies he had undertaken simply as another obstacle to be overcome.

In this, as in almost all instances of phantom pain, a transformation of the usual pain experience into something the sufferer regards as purely a mental abnormality seems to have taken place, the "reality" of somatic reference being lost. Once such a state of mind has become established, the individual is dominated by what he feels to be a figment of his imagination. Thus obsessed, he gives up all reasonable efforts to deal with his "real" problems.

This is not the description of an isolated case, for such a sequence is not uncommon. Reports on the incidence of phantom pain range from one to 50 percent. In our original series, 35 percent of the subjects had a painful phantom at one time or another. In many instances the pain continued over a period of years. As in the case of a sixty-nine year old dentist who's left lower limb had been amputated above the knee at the age of nine. His pain following amputation was immediate and continuous and has, if anything, become worse during recent years.

We began our investigations with an unselected group of amputees; but in the latter part of the study, because of the interest aroused, a disproportionate number of amputees with painful phantoms were referred. We feel that these factors are discernible in other series reported in the literature. Evaluation of the pain is beset with difficulties, for not only is it different in different patients but also in the individual patient at various times.

In the majority of our cases, initial attack was immediate. Only in a few instances did the onset of pain occur some years following amputation. A veteran of the First World War, who lost his left lower limb above the knee in 1921 as a result of injuries sustained in 1918, had a painless sensation of a phantom foot immediately following amputation. The "foot" was felt in the normal position with no awareness of an intervening "leg." About 10 years later, while sitting quietly playing cards, he experienced a sudden, excruciatingly painful shock in the phantom foot. There were no obvious precipitating factors, such as trauma or emotional upset. He has had, since that time, similar attacks two or three times a week, as well as a continuous "crushing" sensation in the "heel."

The onset of phantom pain immediately following amputation might well be associated with the mechanism of the phantom phenomenon per se, but the delayed onset of pain is even more puzzling.

Why should a phantom limb become painful some years after amputation? And why this apparent lack of exciting or precipitating factors?

Phantom pain, once established, characteristically persists in the majority of cases. We have observed that, of those amputee who have suffered moderate or severe phantom pain, the condition has been transitory in only 35 percent. It should be pointed out again that these figures represent cases investigated at one particular point; and therefore, of course, no accounting can be made for what may occur at a later date. One of the most baffling problems, and one which tends to negate statistical analysis, is the occurrence of unpredictable and encouraging remissions which may leave the individual free of pain for many months. No constancy in the course, frequency, duration, or severity of attacks is apparent in the individual case. One of our patients had a history of phantom pain of 14 years duration. During this time he was able to mask completely his painless phantom by concentrating on other matters. Attacks of pain in the phantom, however, experienced at irregular intervals, days to months apart, occurred precipitously and with prostrating severity regardless of mental preoccupation. On the other hand, cases of constant, severe phantom pain have been observed over a period of 3 years without remission.

Treacherous as verbal descriptions of pain may be, one finds again and again that the amputee's descriptions of his phantom pain tend to fall into certain categories. Three broad types stand out: a "postural" type of cramping, squeezing character; a burning pain; and pain of a sharp, shooting, or lancinating character. The same subject may complain of a mixed type of pain, but analysis of the component sensations usually places them in these basic categories.

The cramping type of pain is usually associated with a strong spatial impression of the phantom member, the patient being able to describe in great detail the painfully contorted posture that the phantom seems to have assumed. These individuals may say that their pain would be relieved if only voluntary movement of the phantom member were possible, or they may liken the pain to severe and persistent external pressure. The proprioceptive content seems to be paramount.

The second, burning type of pain is less common than the first but is apt to be more severe and unremitting. It is not described so graphically as the postural type but may be more irritating and serious. Fluctuations in intensity are common in this type of pain, but generally its prognosis in the absence of active therapy is bad in that it tends to become progressively more intense and the patient seems less able to make a tolerable adjustment to its existence.

The sharp, lancinating type of pain is not uncommonly superimposed upon one or other of the foregoing types – as a severe, often unpredictable, but usually transient or intermittent phenomenon. Not infrequently the amputee states that his phantom is ordinarily painless, although at intervals he will be overwhelmed by an episode of sharp, shooting pain. Often he states that the pain seems to have its origin in the stump and to shoot distally through the phantom. Occasionally pain of this type develops a cyclical nature, tending to recur at rather regular intervals, the attacks being days, weeks, or even months apart; and it is often accompanied by violent, clonic, muscular contractions of the stump.

Some observers believe that a particular quality of pain points to a particular etiological mechanism underlying it. For instance, the burning type has been thought to have a "vascular" and therefore a sympathetic basis; the "postural" type has been predicated upon the fact that amputation affects pathways reaching the posterior columns; the sharp, lancinating type has been assumed to arise from neuromas of the stump. Such hypotheses of etiology, so attractive in their simplicity, have prompted many therapeutic procedures. Sympathetic blocks and sympathectomise have been used in cases of burning pain; rhizotomies and sectioning of the posterior columns have been tried specifically for the "postural" or pressure type of pain. Unfortunately, such procedures have not been reliable in relieving painful phantoms, nor have they provided incontrovertible data on the specific etiological factors.

Although the majority of amputees describe their phantoms as painless, awareness of the phenomenon is usually described in terms of numbness, pins and needles, temperature, position, and pressure. These sensations seem to vary in intensity in the individual case, and certainly they will vary in different subjects. And the variations in degree of discomfort strongly suggest that the painful state may well be an accentuation or exaggeration of the types of sensation

ordinarily experienced in the painless phantom. Thus, tingling or pins and needles may become a lancinating type of pain; temperature variations, a burning pain; postural or positional abnormalities, a cramping pain. That this hypothesis is correct is strongly suggested by the observations of many amputees who state that, while they do not ordinarily experience what they consider a painful phantom, they are afflicted by severe, exceedingly annoying paresthesiae. These manifestations often are more difficult to tolerate than an actual "ache" which they would feel justified in classifying as "pain."

Attempts have been made to relate the presence of phantom pain to the position of the phantom, to pre-amputation position and pain, to withdrawal reflexes, and so forth. We do not see the rationale behind such reasoning. We have not found that pain in the phantom bears any relationship to preoperative posture or pain, nor does the presence of pain cause any characteristic postural representation of the phantom.

Methods of Investigation

Throughout the literature, and in our own observations, one point stands out: painful or otherwise, phantom phenomena have not yet been explained satisfactorily in terms upon which adequate therapy may be based. As has been so often observed in clinical medicine, multiple concepts of etiology and therapy are tantamount to admission of lack of reliable understanding. In the treatment of phantom pain, certain methods of therapy have proved of some, if limited, value and have thereby gathered a group of exponents. We do not mean to deprecate or to minimize the value of these efforts, for in few patients in any measure of relief more appreciated than in those who suffer phantom pain. Scores of papers have appeared since the days of Ambroise Paré, amassing great numbers of diverse observations, almost all of the same order, never reaching a point of vantage from which the whole problem might properly be surveyed.

One is led unavoidably to the conclusion that this observational method alone is no longer productive. Various therapeutic measures provide the injection of procaine. Injections of 2 to 10 cc. of 1 percent procaine solution were therefore made into the interspinous tissues of various segments. No effort was made to infiltrate a particularly large area, and no attempt was made to block major nerve trunks. All tissues outside the immediate area of injection retained their normal sensitivity.

In each instance where the dominant segment had been affected, phantom pain and paresthesiae decreased in intensity, and in some cases there was complete remission. Unlike the saline injection, however, injections of procaine never completely obliterated the phantom pattern. The characteristic response was a progressive numbness, and although certain minor portions of the phantom faded from awareness, the general pattern remained intact. Several subjects reported a definite change in "emphasis" of the phantom pattern which remained, apparently as a permanent state.

This effect, unlike the spectacular "filling-in" phenomenon noted with saline injections, occurred gradually, becoming noticeable hours later when the immediate effects of the injection had worn off. In one such case, the amputee reported that his pre-injection phantom consisted of the first three "toes," a narrow band along the plantar surface of the medial "arch," and the "heel." The "toes" were particularly prominent and painful. After procaine injection into the interspinous tissues between L4 and L5, the "heel" retained its prominence, and its representation was slightly increased to include the distal portion of the Achilles tendon. The "toes" and "instep" were barely noticeable. When the patient was last seen, this condition had persisted for two months, and all painful episodes then experienced seemed to arise only from the "heel."

Other effects in connection with procaine injections included a general feeling of relaxation in the phantom (particularly noticeable in those subjects who reported sensations of severe muscle spasm) and general warming of the phantom limb. Injections of procaine apparently alleviate the cold and cramp-like sensations reported by amputees suffering from phantom pain. Effects of the injections usually lasted 6 to 12 hours. In some cases, however, changes in the level of intensity and in the region of emphasis of phantom sensation seemed to continue indefinitely.

Our experiments indicate that, using solutions of saline and procaine, no simple and obvious relations exist between alteration of sensory input and alteration of phantom sensation. The balance of sensory inflow

in the amputee has already been grossly upset by loss of limb. Further alteration of sensory inflow produces in the pattern and intensity of the phantom bizarre changes usually outlasting the duration of the experimentally induced stimulation. Formulation of neurophysiological mechanisms to explain these effects awaits further experimentation.

Some Psychological Aspects of Pain

Unfortunately, a discussion of the psychology of pain is complicated by the difficulties which accompany an attempt to subject a perception to "objective" analysis. For the experience of pain is a perception in the psychological sense, that is, an awareness of a situation presented to the senses and having some degree of organization and meaning. It is, therefore, an inherently subjective experience, lying pretty well beyond the scope of objective, analytical techniques. Even under the most carefully controlled experimental conditions, the investigator finds that his data reflect the character of the "situation," or the mode of reaction or adjustment to this situation, but never the elusive perception itself which remains locked in the obscurity known as the "higher integrative functions" of the central nervous system.

Although pain, or at least overt discomfort and withdrawal from noxious stimuli, is a universal common denominator at all levels of animal life, animal experimentation has proved of little value in its study. Only in the human subject – possessing the unique quality of verbal analysis of perceptions, inadequate as this may be – has experimental work been rewarding. Even at this level, psychology has had to be largely the passive recipient of contributions from other fields which concern themselves with such situational factors as will excite both the perception and the reaction to the perception. Hence, in discussing the psychology of pain one finds himself classifying the pertinent observations from such diverse fields as physiology, neurology, clinical psychiatry, and even social anthropology.

The noxious situation which gives rise to pain perception may lie in the external environment, or it may arise within the *milieu intérieur*, for example, the pathological distension of a hollow viscus. In either case, the resulting perception is attendant upon the action of the afferent nervous system and is itself a phenomenon of the integrative functions of the highest levels of the nervous system. Various pain reflex actions, involving both autonomic and voluntary neuromuscular systems, reflect the coordinative actions of the nervous system at different levels. Hence the psychology of pain concerns itself with the receptors involved in the pain experience, the types of stimuli that are interpreted as painful, their threshold values, and the bodily responses occasioned. Such findings have been supplied largely by neurological and physiological techniques.

Effects of pain upon the organism, such as the disruption of normal function, the limitations imposed upon activity, and the psychic changes induced by the experience of pain, are all aspects of the psychology of pain which fall within the realm of clinical psychiatry. Beyond this, the various human reactions and adjustments to pain, and very likely even the pain perception itself, are strongly influenced and molded by social concepts and their pressure upon the individual. An interesting corollary: *In such anthropological studies of the social import of pain may be revealed the impetus for the comparative development in various cultures of the medical sciences themselves*.

Threshold and Pain Perception

A remarkable observation on the perception of pain is that, although there exist extreme variations in some instances in the threshold of painful stimuli necessary to excite the perception, the threshold for normal individuals within certain racial stocks is relatively constant (2). Deviations from normal thresholds seem to be connected with abnormal emotional affect[1]. An extreme example of high threshold is found in conditions of congenital insensitivity to pain (7, 20). In these cases all other sensory stimuli, particularly those of touch, pressure, and temperature, elicit normal reactions. Yet pricking of the skin or compression of the Achilles tendon causes no painful sensation, withdrawal reflexes, or autonomic reactions of any kind. There is no evidence of hysteria or of organic defect in the conduction mechanism; these subjects simply seem to disregard the "painful" situation.

1 "Affect," in its psychological usage here, refers to emotional tone influential in shaping perceptual and volitional activity.

Many well-known examples suggest the importance of cultural and emotional attitudes in the ability to disregard pain. The influence of the tribal ideal of austerity and stoicism is typified in the case of the legendary Spartan boys who held glowing coals under their arms. The influence of the religious guilt and atonement complex drove the Anchorites to their masochistic exploits of self-flagellation while Oriental mysticism, striving for an emotional detachment from physical and temporal experience, enables the Indian fakir to disregard self-inflicted pain and the coolie to endure discomfort and physical hardship.

Such examples of abnormally heightened pain thresholds are of interest in that they emphasize the importance of the emotional tone or affect which is a component of pain perception. By contrast, they also emphasize that, under experimental conditions, normal, healthy individuals of relatively homogeneous background have a rather narrow and constant range of threshold stimuli. A study of pain thresholds in a series of 150 individuals showed that all the subjects fell within ±5 percent of the mean threshold value (37). Mean thresholds, however, were shown by another study to differ markedly with age and racial stocks (2). Thresholds for individuals of Mediterranean and Negro ancestry were lower than those of subjects of Northern European descent.

The transient factors which may alter the individual's threshold to painful stimuli are of interest not only clinically but also because they affect our daily experience. Most remarkable, nervous strain and fatigue, the factors we are most apt to employ as excuses for "giving way" to unbecoming emotional conduct, raise the individual's threshold to painful stimuli. Attitude, suggestion and autosuggestion have all proved effective in varying degrees in raising pain thresholds (49).

A common form of suggestion or autosuggestion influencing the pain threshold is found in the unquestioning reliance on medication for relief of pain. The relief of pain resulting from what is believed an act of medication has been demonstrated by the administration of placebos. There may be an elevation of the pain threshold comparable to that obtained by the use of aspirin (49).

Hypnosis has been found approximately as effective as alcohol in elevating the threshold for pain perception. Both hypnosis and alcohol have been found by Wolff *et al.* (50) to be slightly more effective, if less practical, than aspirin. For comparison's sake it might be mentioned that Wolff *et al.* (51) found 0.015 gm of morphine sulphate twice as effective as aspirin under experimental conditions.

A discussion of psychological agents which alter the thresholds of pain perception must include the effect of pain itself. That continuous or chronic pain profoundly affects the pain thresholds has been commonly observed, but definite statements are lacking in view of the apparently insurmountable difficulties in subjecting this problem to objective evaluation. Clinical impressions and purely qualitative observations must provide the basis for discussion. We found that, with amputees suffering from chronic phantom or stump pain, even the simplest procedures, not affecting the pathological condition directly, often produced abnormal reactions to the painful stimuli. Even in persons who voluntarily sought help for the alleviation of pain, a comparatively slight stimulus, such as palpation or needle prick, produced grossly disproportionate pain. Curiously enough, some of these individuals exhibited a remarkable ability to bear pain, both that incidental to therapeutic measures and pain incurred in what they knew to be purely experimental procedures. While the perception of pain in these individuals seems generally to occur at a lowered threshold, reactions to pain vary widely from unashamed, explosive emotionalism to a high degree of stoicism.

Another example of chronic pain reducing the threshold of pain perception is the failure of milder analgesics, at first successfully employed, to relieve protracted pain. It is often noted that a moderate dosage of codeine must be gradually increased to control chronic or recurring pain and finally must be abandoned in favour of something stronger, such as morphine, in order to produce the same analgesic effect, even in cases where there has been no change in the underlying pathological condition. Whereas it is not possible in these cases to rule out the pharmacological problem of drug habituation and tolerance, even the most casual observation reveals the increasing irritability and alterations of response which constitute the gross psychological manifestation of the lower threshold. Continual lowering of the threshold of pain taxes and finally exceeds the ability of the

analgesic to elevate the threshold above the level at which pain would be felt. In cases of intractable pain, this vicious circle can perpetuate itself to a tragic end.

Mechanism in the Interpretation of Pain

To attempt an examination of the psychological mechanisms involved in this process is perhaps only to name them rather than to analyze them. Yet even this is of value in directing our thinking. The mechanism of "facilitation," that process of building up automatic behaviour patterns in response to a repeated stimulus, must play an important part in the process whereby previous pain experiences lower the threshold to subsequent painful stimuli. Lashley's experiments (23) would indicate that learned behaviour, based on visual perception and memory, is a function of cortical "patterns of excitation." Such patterns can be built up, or facilitated, to the point where they may, if the connecting pathways are intact, exist independently of "specific" association areas of the cortex. This work provides a neurophysiological concept for facilitation and learned behaviour which seems to consist in the cultivation of dominant or low-threshold association pathways for habitually recurring stimuli. Continual usage – facilitation – renders these now predestined pathways more easily accessible to stimuli of lower intensity and probably at the same time produces an increased associative correlation within the nervous system.

If such a mechanism of patterns of excitation can be conceived, another phenomenon, "augmentation," may enter the process whereby thresholds are lowered, apparently by the experience of pain itself. These patterns of excitation in cases of chronic pain may be operating continuously, so that subliminal stimuli provide sufficient impetus for continuing the activity of the patterns of excitation. The problem of conditioned stimuli further complicates the issue, from a clinical standpoint at least, in that the patient tends to associate any therapeutic procedure, or indeed any environmental factor of any sort, with his painful state. Such conditioned or "substituted" stimuli may set in motion the patterns of excitation directly or through the mediation of associated emotional effect. The sight of a nurse or physician, the sight of a hypodermic needle, or the patient's very presence in the treatment room is commonly observed to have startling effects in lowering pain thresholds. These effects, lightly ascribed to "apprehension," are more properly conditioned stimuli and are worthy of respect as ineluctable mechanisms which may retard or defeat the therapeutic effort that, inadvertently, gives rise to them.

Integration of Pain Perception – The Body Image

The integrative processes whereby sensory impulses precipitate the appreciation and localization of pain are at present best explained in psychological terms. Simple, point-to-point representation in the central nervous system is an unsatisfactory concept for the consideration of pain, at least of the pathological type, which is not, as we have seen, a simple, discrete sensory modality but a complex involving the total organism and overlaid with complex physiological and emotional reactions. The individual's habitual and less complicated contacts with his environment, either external or internal, are managed with the immediacy characteristic of subconscious integration.

The pattern into which sensory impressions are correlated within the realm of consciousness was first described by Head and Holmes (13), who referred to it as the "body schema" or the "plastic body image." This plastic image is built up throughout life as a spatial-sensory concept formulated by constant sensory inflow of every type, exteroceptive as well as interoceptive – postural changes, touch, pressure, pain, visual experience, and Gnostic sensations. Such an image is an ever-present concept resulting from the individual's aggregate sensory experience. It forms a "gridded background" against which it is possible to measure and interpret new sensory stimuli and to control reactions to them. The gymnast and exhibition diver utilize this concept extensively. The complicated series of postural adjustments, upon which depends the successful completion of their feats, can be not only controlled but predicted during the maneuvers by the feeling of "rightness" they experience when the inflow of postural sensation corresponds to the immediate requirement of the body image.

Riddoch (35) defines the concept of the body image by giving it a threefold origin: that component derived from postural sensation; that from cutaneous sensibility; and, least important, that contributed

by visual sensation. He emphasizes, however, that regardless of their diverse origins, the three components contribute to a single functional unit.

The discriminative process involved in localization of pain appears to vary markedly with the particular type of tissue in which the pain impulses have their origin. The pain arising from a pinprick or bee sting is instantly and accurately localized on the surface of the body; the pain arising from deeper structures, as from an inflamed appendix or broken bone, gives a generalized ache often only vaguely related to the site of the pathological condition. It has been suggested that, while not the only factor involved in referred pain the differences in the "density" of the body image play an important part in variations in pain localization. The superficial or cutaneous sensations play a constant and dominant part in our adjustments to the external environment, thus providing an overwhelming mass of material which is inculcated into the superficial portions of the body image. The deeper structures, on the other hand, are largely "silent" until some abnormal state suddenly disrupts the tranquility of the *milieu intérieur*. Refined sensory discrimination in such cases is not possible because the body image has only a hazy and amorphous character in its representation of regions which contribute only infrequent sensory experience to awareness.

An interesting and striking indication for the existence of the body image, aside from its normal functional aspects, is provided by the phantom-limb phenomenon. The body image is thought to persist as an intact perception, unmodified by the physical fact of amputation. Indeed, the loss of flesh-and-blood limb may be said to "unmask" this portion of the body image. The amputee, fully aware of his physical loss, is acutely conscious of the enduring perceptual existence of the lost member.

Conclusion

The facts that should be assimilated into an explanation of phantom limbs make up a large and heterogeneous accumulation. The problem has been examined on many different levels of description-biochemical, physiological, psychological, and psychiatric. In explaining phantom phenomena, there is ever-present danger of not realizing the potentially parallel or complementary nature of these facts which are derived from different studies. In causing phantom sensation, for example, a vascular insufficiency of the stump need not exclude an abnormal excitation at certain segmental levels of the spinal cord nor a faulty projection of sensation into the missing limb. Yet arguments are commonly heard supporting this or that factor as the cause of phantom sensation and of pain, to the exclusion of others.

Similarly, the history of investigation of phantom phenomena is marked by two rival camps: peripheral versus central. The emphasis today, we hope, is shifting to how peripheral and central factors interrelate and complement one another and away from whether or not one set is more "important" than the other. Demonstrable pathological conditions in the stump, in the conducting system between the stump and brain, in the brain, and in consciousness should be considered as different parts or aspects of one continuum.

The amputee, having lost a functional portion of his body, is subject to problems which arise from the abrupt change that he inevitably must make in his action and attitude patterns. Briefly, these attitude-action changes are largely amenable to conscious control and redirection as they pertain to his external relationships. He must reorganize his patterns of motor function in order to overcome gait difficulties or to develop dexterity in caring for his immediate needs. He must recognize early that an amputation is not a single, isolated event in his life but that it recurs again and again, many times a day, as it is brought into being anew with every minor frustration he must face. Possibly even his broader objectives must be recast; economic and occupational adjustments must be made at the expense of considerable time and difficult retraining. All these factors are ordinarily included under such terms as "overcoming a handicap," too often forgetting a second and more fundamental fact that the amputee has suffered profound "internal functional" changes as well.

The central nervous system is in a constant state of activity played upon continuously by afferent impulses which appear to maintain a normal state. Thus, when a large source of impulses is lost and remnants of neural connections are grossly disrupted, the status of the central activity must undergo a change. Furthermore, disruption of previously existing patterns of nervous functions seems to precipitate the emergence of new

patterns which reflect the character of the activity intrinsic to the remaining, anatomically intact portions of the nervous structure.

Perception of the phantom limb is a direct expression of such altered function. It is a projection of the body image, that aggregate of previous sensory experience which, with amputation, is "unmasked" for the first time as a special entity in that it now exists quite apart from any immediate sensory or functional (motor) activity. Prior to amputation, the integrity of the peripheral system makes interpretation and projection of stimuli conform to the patterns regarded as physical reality. Destruction of this system frees other levels of the nervous system to project the retained impression of aggregate sensory experience in accordance with patterns apparently based upon the relative frequency and functional importance of this body of experience.

Thus, the phantom image is "weighted" in favour of those portions which have been more dominant in supplying sensory experience. The fingers, for example, adept at exploring and sampling, contribute a far greater mass of sensory information than does the adjacent forearm. Likewise, the cutaneous nerves, subserving exteroceptive sensation, play a much greater part in sensory experience than do the nerves of the more sparsely innervated deeper structures. Knowledge of these innervation patterns, in terms of their differing types and densities in various tissues, when integrated with their functional roles provides a broader explanation for the peculiarities of the phantom representation.

A phantom image may be reported by the amputee to be either painless or painful. Our attempts to correlate pain with distance, superimposed "causes" have been of no significance, and we tend to regard phantom pain as an intense manifestation of the phantom phenomenon. The inherent nature of the painful phantom can be better appreciated when it is realized that every phantom limb, painless or painful, is described by the amputee in terms of paresthesiae. Such terms as "pins and needles," "tingling," "pressure," burning," and "numbness" are almost invariably used to fill in or give "substance" to the phantom when it is being described. It has been pointed out that descriptions of painful phantom states are similar to those of the non-painful ones, the basic difference being the individual's evaluation in terms of intensity.

We are faced with a difficult problem concerning the origin or etiology of these paresthesiae and dysesthesiae. It has been suggested that the "sensations" may arise from the altered, aberrant functioning of the mutilated peripheral portion of the nervous system. Inevitably, vascular changes occur in the stump, with consequent alterations in local pH and metabolite conditions. Another factor which may play a part in the peripheral mechanism of the phantom phenomenon is the possibility of artificial synapses at the cut ends of the peripheral nerves. More centrally, it may be that a state of abnormal excitation exists at the cord level of the nervous system, arising directly from alteration produced by the sensory loss at the periphery.

The segment, as we have defined it, is to be regarded as a "functional" entity. While based, of course, upon neuroanatomical organization, the term is applied to the functional interplay of nervous activity in structures immediately related, not spatially necessarily, by common centers of innervation. It has been demonstrated that the various tissues of the same segment affect one another through the medium of their nervous inter-connections. Such segments have been "blocked in" to a certain degree by observing the total effects of pain referral in series if intact individuals. In the amputee, the entire segment has not been wiped out. Yet the segmental interplay is disarranged by its now-altered interconnecting activity. Further, alterations artificially produced at the level of the segmental activity in the amputee may profoundly change his perception – to the point of modifying the phantom image and even abolishing it. Such effects are not uniform in all cases and may be produced by a variety of mechanical and chemical stimuli.

The internal functional changes that arise as a natural sequel to amputation are common to all amputees, although their overt importance may vary greatly among individuals. The other category of amputee problems, the modification in his action-attitude patterns, is subject to wide individual variation. Certain basic factors, such as the effects of emotion and attention on sensory perception, or more particularly pain perception, have been discussed. Details of the psychodynamics of invalidism and handicap have not been pursued here. These factors, while in many amputees possibly of primary importance from the therapeutic standpoint, are individual in their application. It is sufficient to say

that, while the phantom phenomenon appears to be, in itself, what is poorly described as an "organic" manifestation, psychotherapy may accomplish a great deal in handling the problems in the action-attitude sphere. Resolution of these difficulties may often have a marked effect upon the intrinsic problems of the painful phantom.

In the light of these observations, other therapeutic measures presently employed for the relief of a painful phantom are of interest. First is interruption of anatomical pathways leading to the perceptual levels, and second are attacks on the perception itself at psychic levels. In the first, the surgical approach, there is a great diversity in points of attack, all based on the same theory. Interruptions of sensory pathways range from stump revision and neurectomies at the periphery through rhizotomies, cordotomies, and tractotomies to cortical ablations and lobotomies. The autonomic system, too, has been the subject of surgical intervention in the form of sympathectomise. But the results, on the whole, have been unsatisfactory in our opinion, particularly in view of the severity of the procedures.

As for the second, while we have emphasized the psychiatric problems which may arise from amputation, it seems an almost insurmountable obstacle to deal, in this manner, with a condition arising from such obvious organic dysfunction on the basis of psychotherapy alone. Although carefully conceived training courses on use of the prosthesis, and help and counsel for the amputee in meeting his social and economic problems, are of great value, the fundamental dysfunction manifesting itself in the phantom phenomenon and pain syndrome remains.

The painful phantom is not a pathological entity which may be dealt with by a particular procedure. It is, rather, an alteration of over-all nervous function which must be modified if clinical improvement is to be obtained. No particular level of the nervous system is at fault. This, to look for a "simple cause," a "trigger area," or a "focus" to which may be attributed an excitatory role is as fruitless as to seek a panacea. The understanding of these phenomena and the concomitant advance in therapeutic procedures depend not so much upon acquiring additional clinical detail as upon a proper use of the great wealth of descriptive and experimental observations now available. Out of the evaluation, correlation, and integration of these facts should come comprehensive and workable hypotheses that may be tested and modified by further experimental work.

A Few Tips

Reprinted from the Times Colonist *"Good Health" column, a tip from a general practitioner, himself an amputee:*

About two years ago, an amputee patient complained of phantom limb pains. I found his potassium to be low, so I prescribed a supplement. His pain stopped in 48 hours.

A few months later, I had the same phantom pain. (I, too, am an amputee). I took a few doses of potassium, and my pain stopped. My potassium was normal, however. I have since prescribed this for patients with the problem and have had good results. I am in general practice; therefore this is a very limited trial, of course.

A tip from Patrick Watson, Chairman, Canadian Abilities Foundation, Toronto, Ontario (excerpts):

By accident (or intuition), the last time it hit (the phantom limb pain in the form of electric shock in my missing foot), I tried this: alternating hot and cold showers, as hot as I could stand for several seconds, then turning to as cold as the system had to offer, and back again, four or five cycles.

Success! What had looked like an all-day session of shocks just simply, quietly, immediately… stopped!

This has now worked twice in a row (my attacks come less than 10 times a year).

Tips from North Texas Amputee Support Group News*:*

- Wrap stump in warm, soft fabric, such as a towel. The warmth will sometimes increase circulation.
- Mentally exercise the phantom limb in the area that is painful.
- Mentally relax the phantom limb and your stump.
- Do some mild overall exercise to increase circulation.
- Exercise the stump.
- Tighten the muscles in the stump, and then release them slowly.
- Put an elastic bandage or shrinker sock on. If you have your prosthesis, put it on and take a short walk.
- If you have discomfort with the prosthesis, take it and the prosthetic sock off and put it on after a few minutes. Sometimes the stump is being pinched and changing the way it is on will relieve the pressure on the nerve.
- Change positions. If you are sitting, move around in your chair, or stand up to let the blood get down into the stump.
- Soak stump in a warm or hot bath, or use shower massage on stump.
- Keep a diary of when the pain is most severe.
- Wrap stump in a heating pad.

Excerpts from an article on neuromas from North Texas Amputee Support Group News*:*

In an informal presentation at the April meeting of the North Texas Amputee Support Group, Dr. Frank Gottschalk indicated that it was most important for amputees to learn to differentiate between phantom sensation, phantom pain, pain from neuromas and the "ordinary" pain from wearing a prosthesis. Separate and apart from phantom pain is pain caused by neuromas. A neuroma is a mass growing from a nerve, usually consisting of nerve fibres. When the nerve is cut during amputation, it attempts to regenerate, forming a neuroma. Everyone who has an amputation will have a neuroma, however neuromas can also result from nerve injury without amputation; often these traumatic neuromas are more difficult to treat than ones that occur in amputation.

The size of the neuroma is usually from ¼" to 2-3 inches, but the size doesn't seem to be critical in determining whether or not it will be painful. Pressure on the neuroma causes pain at the neuroma; it is not a sensation in the missing limb. It is experienced as pain only and does not occur as a sensation of heat, cold or other non-painful feelings. When an amputation is done, the surgeon will generally try to "bury" the severed end of the nerve as deeply as possible in soft tissue so that the resulting neuroma will be less

susceptible to pressure. Additionally, a number of techniques have been tried to prevent the neuroma from growing, including covering the severed nerve end with plastic, splicing two severed nerves together so there is no open end, splitting the nerve into two or more parts, or even crushing the end of the nerve; some surgeons will drill a small hole in the bone and tuck the nerve into the bone.

Other than isolating the neuroma from pressure, none of these techniques seem to make much difference in either the formation of neuromas or the pain experienced from them; in fact those techniques that cause additional trauma to the nerve actually make the problem worse. Treatment of pain from neuromas may involve injections of cortisone or injections to numb the neuroma. Sometimes a solution may be injected into the neuroma to kill the nerve tissue, but such a procedure can be tricky since they don't want to affect the surrounding tissue. In severe cases, the pain may be treated by cauterizing the nerve at the spring.

Generally, treatment requires surgery to find and bury the neuroma so that pressure on it will no longer cause pain. In severe cases of phantom pain or neuroma pain, the best results may be obtained through the comprehensive efforts of a pain management center. No matter what treatment is used, for that treatment to be properly chosen and effectively administered it is important that the amputee understand the nature of the pain and communicate that information clearly to his or her physician.

Pycnogenol

Pycnogenol is a concentrated complex of nutrients extracted from the maritime pine found only in southern France. It is composed of a combination of flavonoids that naturally occur in some fruits and vegetables. Pycnogenol acts as an antioxidant, attacking free radicals in the body. Oxidants can break down your tissues, causing health problems and accelerating the normal aging process. Antioxidants fight oxidants, and pycnogenol is considered by authorities to be many times more powerful than vitamins C and E.

Claims for this product include:

- Improves skin and respiratory problems.
- Helps inflammatory diseases like arthritis.
- Improves blood circulation and helps with heart and stroke disease.

We have heard from amputees who feel this product has helped ease their phantom limb sensation/pain.

**The Health Protection Branch of Health Canada has informed The War Amps that this product is being sold in Canada as a food product but cannot be sold making any "implicit or explicit therapeutic claims."*

Vitamin B-12 for Phantom Pain

The following is based on the personal account of a War Amps member who was experiencing phantom pain very regularly.

After having tried various pain killers to ease his phantom limb pain, it was suggested he try vitamin B-12 injections. He began taking 1000 cc of vitamin B-12 every two weeks. This was to be reduced once every three weeks at a later time. No vitamins were taken orally.

He was very pleased with the results. On occasion he noticed "the phantom pain starting up, but then it goes away."

At first he was taking a dose of 100 cc, but then jumped to 1000 cc, which seems much more effective. He stated that any of the vitamin not used by the body is expelled with no side effects.

Farabloc

Farabloc is a fabric that contains extremely thin steel threads but looks and feels like linen and can be cut, sewn, washed and ironed like any other fabric. The makers state: “Farabloc, through its shielding effect, protects damaged nerve endings. Farabloc stimulates blood circulation and produces a pleasant feeling of warmth.” This fabric is available in blanket forms of various sizes.

For more information, call 1 866 941-4711 or visit farabloc.com.

Umbrellan

Umbrellan is a unique, patented knitted fabric that combines maximum elasticity with an electromagnetic screen. Relieves or eliminates phantom pain, phantom sensations and idiopathic residual limb pain. Visit the medi website at mediusa.com for more information.

Phantom Limb Pain or Sensations: Patient Information

From NovaCare, 1997

Phantom limb or phantom sensation is the feeling that the amputated limb is still there. It is thought that phantom sensation results from the brain's memory of the "old" body image channelled through the nervous system pathways. People report that they are able to "feel" their toes wiggle or fingers tingle after the amputation. Very young children do not seem to experience phantom sensation to the extent that teens and adults do. Some phantom sensations are painful. Warmth, increased activity, and massage of the residual limb may be helpful in alleviating discomfort. While these sensations may concern you, they are normal and should eventually decrease.

Some people have found help through self-hypnosis, biofeedback and chiropractic. If you have not found relief through any of these home remedies and the pain is not able to be controlled through normal medication, a pain centre should be considered. A pain centre offers a variety of approaches of relieving phantom limb pain from TENS units to medication. Hopefully, the pain will lessen with time as nature takes its course.

Possible Relief From Phantom Limb Pain

Reprinted from the Northern Nevada Amputee Support Group Newsletter*, August 1991*

Henry Dewing is a man who has survived nine amputations due to a circulation disease. Beginning with his toes, he eventually lost both legs below the knee and several fingers. So when Henry tells us that something helps him, we consider him to be well qualified and worthy of attention.

Henry discovered that Juniper Berry helps control phantom pain. This common berry is a herb that has been used for a very long time. Phantom pain is not new.

Several of the amputees in the group have gotten relief by using Juniper Berry including a very recent above knee amputee and others. Juniper Berry is available at some health food stores.

Phantom Pain Management

From O&P Business News, *September 1998*

Amputee Chiropractor Develops Unique Treatment Methods

Joseph A. LaScala, Temperance, Michigan, a doctor of chiropractic and himself a double BK amputee, has found a successful way of alleviating the plague of phantom pain. He has developed techniques for treating the pain as well as aligning the spine and pelvis of amputees to better receive a prosthesis. To his knowledge, he is the only practitioner in the country and possibly the world who has developed these techniques; he is compiling his knowledge of phantom pain treatment into a book on the subject. He even uses his techniques to alleviate his own pain – by talking a colleague through the adjustments.

Spinal alignment is very important for amputees, LaScala explains, as quoted in an article in the Monroe [Michigan] Evening News, March 1, 1998. A misalignment can cause problems with the fit of a device: For instance, if the hips are misaligned, the leg can't be measured correctly. When the body naturally corrects the problem, the prosthesis will suddenly feel all wrong – and there's nothing worse than a prosthesis that doesn't fit right, says LaScala.

Joe LaScala was working for a railroad when an accident led to the amputation of both legs: He had suffered 38 broken bones in his feet. The accident left him near death, and he doesn't remember much about the following weeks. After a long and arduous recovery, the young husband and father had to face the question of how he was going to support his family. Since he could no longer work for the railroad or do construction work, he decided to go back to college. He began as a business major, according to the *Evening News* article, but his advisors, when they saw his science grades, steered him toward the health care field.

LaScala then met a doctor of chiropractic, who invited him to spend some time with him. "I liked what I saw," says LaScala. After his own experiences, treating patients without drugs also appealed to him, and he was impressed with the results of chiropractic. He now works at Advantage Chiropractic, P.C., in Temperance, Michigan, where he combines his own life experience and his profession to help other amputees. He also is treating some orthotic patients.

LaScala envisions a day when chiropractors will become members of hospital medical teams. "The chiropractic field is not as it used to be, where chiropractors are fighting medical doctors, and medical doctors are fighting chiropractors," he says in the article. "I want to work together as a team with the doctor." Although LaScala says chiropractic is not a cure-all, since for some phantom pain has psychological origins, he asks, "Why not try something simple and non-invasive first?"

His treatment techniques have been highly successful, LaScala told *O&P Business News*. "The results I get are great. The patients are responding to care, which benefits everyone. It makes the prosthetist's and medical doctor's jobs so much easier. But most of all, my patients are out of pain, and their prosthesis or orthosis fits much better."

Farabloc Relieves Pain, University Study Finds

Farabloc, a proprietary product manufactured by the Farabloc Development Corporation, Port Coquitlam, British Columbia, Canada, has shown positive results in alleviating phantom limb pain in a double-blind study conducted at the University of British Columbia from 1990-1992 under a contact funded by the British Columbia Ministry of Health.

What is Farabloc? Based on the same principle as the Faraday Cage to block external magnetic influences, Farabloc is made of a series of ultra-thin steel threads woven in a specific pattern into a linen fabric which can be sewn into a garment, such as a sleeve, glove, sock, vest, or even laminated into a prosthetic socket. The patented, non-prescription fabric may be applied repeatedly without losing its effect, can be machine

washed and dried, and can be cut, sewn, and ironed like any other fabric, says the manufacturer. If dissatisfied, the purchaser also can return the product within 30 days for a full refund.

Of the 52 amputees who met the criteria for the study, 34 completed it, according to an article in the *Canadian Journal of Rehabilitation*, Volume 6, No. 3, 1993. The subjects were consenting adults with upper or lower extremity amputations and healed residual limbs who were experiencing episodes of phantom limb pain, rather than constant pain. (The manufacturer does not recommend Farabloc for constant phantom limb pain.) They were referred to the study by their physicians, prosthetists, or rehabilitation therapists, and were not associated with the study authors as their patients. To qualify for the study, subjects had to be at least 19 years old, able to comprehend English, grant informed consent, understand the use of a Visual Analogue Scale (VAS) to report pain relief, and be able to keep a log for recording each pain episode, including date, time, duration of pain, time when garment was applied, and duration of wear. Subjects were excluded if they were experiencing skin irritations on the residual limb, undergoing new treatments, were involved in a compensation claim, had problems with their prosthesis, had changed their normal use of their prosthesis or obtained a new prosthesis, or had a diagnosis of neurological or psychological disorder.

Of the 34 sequentially randomized participants, 18 began the treatment with Farabloc and 16 with the placebo. The placebo fabric was identical to Farabloc in colour, thickness, and texture but without the wire mesh, which is invisible. The characteristics of the two groups were similar. None of the subjects was addicted to or used narcotics, antidepressants, anticonvulsants, neuropleptics or other prescription agents for pain relief. During the trial, none reported any allergic or other problems associated with the use of Farabloc. In all, 21 subjects reported their greatest pain relief during Farabloc intervention. However, only one subject in each group showed complete or near-complete pain relief with Farabloc. "The results were statistically significant ($p<.001$) in favour of the Farabloc period," said the study authors quoted in the article in the Canadian Journal of Rehabilitation. "Of the 34 subjects, 21 reported their greatest pain relief during Farabloc intervention. However, the clinical significance of the findings may be questioned since only two subjects reported complete or near complete pain relief with Farabloc, and the number of potential users is limited. Nevertheless, Farabloc is a relatively inexpensive alternative compared to other therapeutic measures currently available." Study authors were Tali A. Conine, DHSc, PT; Cecil Hershler, M.D., Ph.D., FRCP(C); Steacy A. Alexander, B.Sc., PT; and Robert Crisp. B.Sc., PT.

Just why and how Farabloc works is not fully understood. The manufacturer offers some working theories:

- Frieder Kempe originally postulated that Farabloc works by shielding nerve endings from the aggravating effect of external electrical and magnetic fields. Kempe developed the Farabloc concept in Germany in 1969 to help his father, a World War II amputee.
- Dr. Hershler, one of the Farabloc study authors, hypothesized that chronic pain is caused by alteration in the blood flow deep in the muscles. He believes that Farabloc increases circulation, thereby causing pain relief.
- A theory proposed by the company involves electrical currents from swollen, torn, or inflamed tissue that send "pain messages" to the brain. The firm's Web site notes, "Since the late 1700s, scientists have been aware that our bodies generate electricity. Today… a person's health can be evaluated by measuring various electrical waves," including through such tests as the EEG and EKG. With every move, the body radiates energy currents, the company says. "When you feel pain, it means the hurt area in your body is sending energy currents to your brain – currents that tell you to feel pain. The best way to stop pain in its tracks is to eliminate or reduce those energy currents, before they reach your brain."

Alternative Therapies Help, Say Hospitals

Alternative therapy modalities can often provide relief for chronic pain when more traditional methods fail, two hospitals have found. Such techniques include relaxation techniques, stress management, biofeedback, and other mind-body methods. "We've had the pain

management program for 15 years at Spaulding and have found that the mind-body approach is much more effective than mechanical range-of-motion and physical therapy techniques," says Rick Leskowitz, M.D., consulting psychiatrist to the pain management program at Spaulding Rehabilitation Hospital, Boston, Massachusetts, quoted in an article in Occupational Health Management via NewsEdge Corporation.

Spaulding's inpatient pain management program uses an interdisciplinary approach, with all patients evaluated and treated by physical therapy, occupational therapy, physical medicine, and psychological services. A program is then tailored to each patient based on an assessment and whether he/she is open to some of the alternative techniques. Along with biofeedback, stress management and other techniques, the program also uses energy-based therapies, such as therapeutic touch. These modalities help people dramatically shift their pain the article says, noting that an amputee had been successfully treated for phantom pain with therapeutic touch. Outcomes data show positive results from the program as a whole, but because it is an interdisciplinary approach, it is impossible to say what component was the most helpful, Leskowitz says.

The pain management center at Beth Israel Deaconess Medical Center, also in Boston, offers a ten-week outpatient clinic for persons who have had chronic pain for at least three months. "Our program is designed to give people active coping tools they can use themselves to help manage their symptoms," says Carolyn Guberman, Clinical Research Coordinator, quoted in the article. Patients learn to understand the pain process and their role in managing it. They learn how to examine factors that can affect pain, such as lifestyle, diet, and physical and emotional tension. Each group usually is composed of from 20-25 persons with a wide range of diagnoses but all with the common experience of chronic pain. The program is co-directed by Margaret Caudill, M.D., Ph.D., DABPM; and Carol Wells-Felderman, MS, M.Ed., RN, CS, both specialists in pain medicine. Caudill developed the program after studying 109 chronic pain patients who averaged 12 doctor visits a year. After the patients attended 10 behavioural medicine-based outpatient sessions, all visits to doctors dropped by 36%, the article noted.

*O&P Business News *publishes this information for the benefit of our readers; however, we do not promote or advocate any particular theory or treatment.*

Pain Management: Perioperative Pain

By G. Edward Jeffries, MD, FACS, July/August 1998, for inMotion

Dr. Jeffries discusses pain experienced around the time of an amputation

Introduction

While it is hoped that none of the people reading this article will ever experience an amputation in the future, the fact that many of you may be peer visitors for people about to undergo amputation makes it important to discuss pain around the time of an amputation.

The time when most people come in contact with the pain of amputation is the "perioperative" period. That is the period immediately preceding, during, and immediately following the amputation. It is becoming more and more apparent that the perioperative period is extremely important in the long-term pain picture. For that reason, we will discuss in some detail some of the important aspects of pain management during the perioperative period.

Preoperative pain

Unfortunately, some people experience significant pain in the preoperative period. This may be because of preoperative disease such as gangrene, ischemic vascular disease, tumor, infection, or trauma. These conditions can be highly painful right up to the moment when the person is anesthetized for the surgery. There are increasing suggestions in the medical literature that excellent pain relief (analgesia) for painful conditions in the preoperative period may result in a decreased incidence of ongoing postoperative pain.

This pain and anxiety relief may require the use of narcotic and non-narcotic pain medications, anti-anxiety medications, and other techniques that should be familiar to the physician, surgeon and anesthesiologist who are providing care. This is not a time to suffer in silence. The pain that is being experienced is using the chemicals produced by the brain to deal with pain and stress at a very rapid rate. If they remain depleted, they are not present in the postoperative period to assist with recovery. Going to the operating room for an amputation in a calm, relatively pain-free state is much more conducive to an easy recovery than going to the operating room after days or weeks of severe, unrelieved pain and/or anxiety. The person about to undergo amputation should ask for, and even demand if necessary, adequate relief of preoperative pain and anxiety.

Intraoperative pain

As anyone can readily imagine, an amputation is an incredibly painful surgical procedure. Every type of tissue in the limb is cut or severed in doing the amputation including skin, muscle, bone, tendon, nerve, and blood vessels. Every one of these tissues has abundant nerve endings and all can hurt during and after the insult of the amputation. Anesthesia prevents the person from actually experiencing the pain during surgery but may not prevent pain patterns from being formed in the brain. As was mentioned with preoperative pain, intraoperative pain seems to correlate well with long-term post-amputation pain. Decrease of the severity of intraoperative pain may lead to diminished levels of long-term post-amputation pain.

It is obvious to everyone that an amputation is and is expected to be a very painful event. Anesthesia has been used for amputations when it was available ever since it was invented over 100 years ago. Usually that anesthesia has been a type of general anesthetic that puts the person to sleep, making them totally unaware of the amputation and its painful nature. Recently it has been found in several studies that interrupting

the painful nerve impulses before they reach the brain may actually decrease the probability of long-term post-amputation pain.

It has been known for many years that the pain impulses could be prevented from reaching the brain by injecting in or around the nerves with chemicals known as local anesthetics. These include novocaine, cocaine, procaine, marcaine, lidocaine, and others. This could be done with either an injection into the nerve or nerve sheath itself, the spinal cord, or the area just outside the spinal cord, or a combination of these places.

When the anesthetic is injected into or near the nerve itself, this is referred to as a nerve block. These can be very useful when the nerve is easily located, such as in the finger and some other locations or during the actual amputation when it is seen. The anesthetic can last for several hours if a long acting anesthetic is used. This technique can be used for amputations anywhere and it is necessary to use direct nerve injections in the upper extremity where epidural anesthetics and analgesics are not feasible. This can be used either by itself or with a general anesthetic for the amputation. The anesthesia or analgesia can be prolonged by placing a small plastic tube into the area of the nerve sheaths and injecting it either continuously or repeatedly for several days post op.

When the anesthetic is injected just outside the spinal cord, but inside the spinal canal, it is referred to as an epidural block. These are very commonly used now for delivery of babies because they have few complications and can be prolonged for hours if needed. They are most often given by inserting a small flexible plastic tube through a needle into the epidural space. The needle is withdrawn and the small tube remains lying alongside the spinal cord. Anesthetic and analgesic medications can be injected through the tube to relieve pain or completely anesthetize the area served by the nerves in the area. This can be used by itself for amputations or in conjunction with a general anesthetic. Since the plastic tube can be left in place for several days, the pain relief can be prolonged for several days. It is necessary for an anesthesia doctor to carefully monitor the epidural to make it safe, but they are highly effective, during and after surgery for excellent, complete pain relief for many people undergoing amputation. There are two small series of patients treated in this manner that reported no significant phantom pain in up to one year of follow up after the amputation. This appears to be one of the most exciting developments in management of amputation pain. The author has used the intraoperative and postoperative epidural technique for amputations that he has performed for several years and can report similar results in virtually no significant phantom pain.

The other technique for use of local anesthetic is by injecting it into the spinal cord to mix with the spinal fluid. This is referred to as a "spinal" block. These also give profound anesthesia and pain relief and can last for many hours after the surgery if long-acting agents are used; however, they cannot be prolonged for days without reinjection. Since there is suggestion that the long-term anesthesia or analgesia may prevent long term pain, the only real advantage to the "spinal" block it that it is technically easier to do than an epidural or nerve block.

Along with the block techniques that have been mentioned, the use of a general anesthetic for sedation, amnesia, and general support is often used. A combination of techniques is often employed by the anesthesiologist. The patient about to undergo an amputation should always discuss the anesthetic plans with the anesthesiologist and surgeon and request information about the techniques mentioned in this article. Many highly qualified anesthesiologists may not be aware of the potential long-term benefits from intraoperative and postoperative epidural and nerve block techniques, even though they often utilize the epidural technique for delivering babies. Ask for them to discuss it in detail. If they have questions, they can call the ACA for copies of the recent articles upon which these suggestions are based. Each patient has the right to ask for the optimum anesthetic and analgesic management. This is the time when an informed consumer is his/her own best advocate.

Immediate Postoperative Pain

The first 72 hours following an amputation is considered the immediate postoperative period. During this time swelling occurs, tissues are stretched, severed nerves are not sending normal afferent impulses to the spinal cord, and many other new realities are being experienced. Tension, fear, anger, and denial may be producing a strong emotional "stew" for the new amputee to experience. For most new

amputees, this is physically the most difficult period with the most severe pain being experienced. There is clear evidence that adequate relief of pain and anxiety during this chaotic period is extremely important in determining long-term postoperative pain.

In addition to the previous discussion of epidural and nerve block techniques for pain relief, it is important to consider other types of pain relief in the postoperative period. These include narcotic and non-narcotic analgesic medications, anti-anxiety medications, anti-depressants, and others.

Narcotic pain medications such as morphine, Demerol, Fentanyl, and others have been used for many years for relief of severe pain. They can be injected intravenously, intramuscularly, epidurally, and subcutaneously as well as taken orally. The use of these strong pain medications has been the cornerstone of relieving pain following an amputation. There are some new medications available as well as a major new way of administering some of them that have made a significant impact on relief of pain. The new medications themselves won't be discussed since the new amputee cannot order his or her own medications; however, the new technique of administering them will be mentioned.

The new administration technique is referred to as Patient Controlled Analgesia (PCA). This means that the patient himself or herself actually controls the timing of the doses of pain medication. To do this, a small electric pump containing a syringe of pain medication is hooked to a switch. When the patient pushes a button, the pump gives a premeasured dose of the pain medicine. The doctor has determined how much medicine is safe to give and how often it can be given. The medicine is given through an intravenous tubing so that it enters the circulation immediately. A small amount can be given as often as every six to ten minutes. This has several benefits compared to the traditional injection in the muscle. It is much quicker to take effect. It does not have as much of a chance to over sedate the patient with a large dose of medicine. It does not require the nurse to come to the bedside each time pain medicine is needed. It usually actually takes less medicine to relieve pain in each 24-hour period.

In addition to narcotic pain medications, less potent non-narcotic analgesics include aspirin, acetaminophen, ibuprofen, and other non-steroidal anti-inflammatory drugs. These all have very useful roles when properly applied and should be used with guidance from the surgeon and anesthesiologist.

Other medications that can be helpful include tranquil-lizers such as Vistaril, anti-depressants such as Elavil, and anti-seizure medications such as Neruontin. A full discussion of these medications and their use is beyond the scope of this article since they are usually used more in the later postoperative period. They will be discussed in the next article in this series regarding post-amputation pain and its management.

First Six Weeks Post-Amputation

During the first six weeks following an amputation, many changes are occurring rapidly. Most of them are good changes with decrease of pain and swelling and increase of mobility and accommodation to the physical reality of amputation; however, there are many real problems in this period, physical as well as emotional.

There is typically decreasing need for pain medication but may be need for medicine to help with sleep or to deal with anxiety or depression. There is change in physical activity and the need to learn new methods of dealing with formerly routine tasks. Coming home from the hospital may be highly desired but also feared because it requires increased physical efforts and the emotional challenge of dealing with old relationships and demands despite a new physical reality.

Fears of dependency, inadequacy, and unacceptability may be the most important but unspoken part of the new amputee's thoughts. Questions about the ability to work or maintain physical independence may demand a share of the emotional resources being dedicated to achieving the ability to walk or to bathe independently.

While the physical pain may decrease dramatically, the emotional turmoil may spiral uncontrollably during the six or eight weeks after an amputation. This stress may significantly affect the amputee's ability and willingness to deal with the remaining physical pain. The chemicals in the brain that help deal with pain and stress may be used up by this time, making the amputee experience one of increased pain, anxiety, and stress.

The next article regarding post-amputation pain will discuss in detail the medical management of post-amputation pain during the months following an amputation.

Pain Management: A Discussion of the Various Techniques and Types of Drugs Currently Available for Pain Control With Medicines

By Christina Shoski, MD, September/October 1998, for inMotion

The purpose of this article is to inform you of the various techniques and types of drugs currently available for pain control with medicines. The author, editor and the ACA do not recommend any one specific drug or intervention. Our intention is to educate and to inform. By having an understanding of what is available and how and why specific drugs and treatments work, you will be better able to discuss your options with your health care professionals and make informed decisions. You'll be better able to take an active role in managing your own pain, and in choosing among the treatment options currently available for treating pain, before surgery, immediately after surgery, and for the long-term treatment of chronic post amputation pain, both stump and phantom pain.

Medicines are only one of many types of pain treatment. Many alternative therapies are available, such as biofeedback, self-hypnosis, relaxation, and use of electrical stimulation (TENS) units. These will be addressed in future articles. The causes of pre and post amputation pain are as varied and individual as the number of people reading this article. Although very common after amputation, not all people go on to develop long-term chronic phantom pain. It is a major problem at first, however, the natural course of pain is usually to decrease in both frequency and severity with time. The degree of pain also varies from person to person, and therefore, the treatments will be different. Not all medicines or other interventions will be applicable to all people. Treatment may include a single drug or more commonly, a combination of medications, therapies and procedures. Each person's pain should be addressed individually; therefore, we highly recommend that you consult with a qualified pain management professional who offers a comprehensive pain management program near you.

Avoidance of Pain

What to Do Before Surgery?

The advantages of early medical intervention in the treatment of pain cannot be overemphasized. The medical profession is just learning that the effects of chronic pain have long reaching importance. Besides the obvious advantage of greater comfort while you heal, early treatment of pain offers other important advantages. You may get well faster. New research has proven that chronic pain can cause changes in the body. "Stress hormones" released from injured tissue can effect breakdown of body tissue, increase metabolic rate, alter blood clotting, cause water retention, impair immune function, interfere with normal digestion and cause anxiety and depression. With less pain you can start your rehabilitation process sooner, become mobile faster, and get your strength back more quickly. You may leave the hospital sooner. Early mobility may also improve one's results, and avoid complications such as pneumonia or blood clots. Pain causes stress and emotional disturbances, and can interfere with sleep.

Chronic Post Amputation Pain

What Can Be Done for Phantom Pain?

THERE IS NO MAGIC PILL. At this point in time there is no one medicine that specifically treats and will cure phantom pain; however, we do know that phantom pain is a type of chronic neuropathic pain (pain caused by changes in the nervous system), and there are now many varied effective medicines available for this other than the old standard "pain pill." The degree of pain varies from person to person, as will the specific reasons for causing the pain. Amputees may suffer not only from phantom pain, but from a variety of conditions that will result in chronic pain problems, and can also aggravate phantom pain. Stump pain and neuromas may be caused by a number of reasons, and therefore, the treatments will be different. Abnormal and excessive stress and strain on remaining limbs, muscles and joints, may also be the source of pain. Vascular abnormalities and diabetes may further complicate the pain management problems; therefore, your treatment plan should be tailored to your specific needs and circumstances. This may include a single drug or combination of medicines. The following is a list of drugs commonly used for treating chronic post amputation pain.

Medicines Used for Chronic Pain

Non-Steroidal Anti-Inflammatory Drugs: NSAIDS

Examples: Acetaminophen (Tylenol), aspirin, ibuprofen (for example Motrin, Advil)

These drugs work by reducing swelling, inflammation and soreness, and relieve mild to moderate pain. Depending on your degree of pain, these may lessen or eliminate the need for stronger drugs. There is no risk of addiction, and they are the first drugs of choice to treat chronic pain. They may be very effective for stump pain, and local conditions such as skin irritation, swelling, joint problems, muscle aches in stump and remaining limbs, and may be all that's needed for mild phantom pain.

Antidepressants

Examples: Elavil, Pamelor, Paxil, Zoloft, Prozac

Originally used only to treat depression, it is now well established that antidepressants are very useful in the treatment of many chronic pain conditions, including phantom pain. These drugs work centrally, in the brain by either blocking or increasing certain neurotransmitters, those chemicals that help regulate normal brain function and increase pain threshold. Since they act directly in the brain you may require less other pain medication. People in chronic pain have good reason to become anxious and depressed, which only makes the pain feel worse. Sleep deprivation is common with any chronic pain condition, and some antidepressants are also beneficial in helping a person sleep at night. Usually low doses of antidepressants are initially prescribed and many people will report an improvement in their pain with use of these drugs.

Anti-Convulsants or Anti-Seizure Medicines

Examples: Tegratol, Neurontin

These types of drugs have been used successfully for post amputation pain, both stump and phantom pain, and are also effective in treatment of diabetic neuropathy. They work directly on the nerves both in the residual limb and in the brain, by altering neurotransmission. After amputation, the remaining severed nerves may become over-excited, which causes excessive or abnormal activity. This is similar to a seizure. These drugs act by calming down the nerves in the residual limb, and raising seizure threshold in the brain, like turning down the flame under a pot that is boiling over. It is usual to start with small doses, gradually increasing the dose to achieve pain relief and avoid side effects. As the phantoms become less frequent or severe with time, it is important to stop these drugs gradually. They should not be stopped abruptly.

Narcotics (Opiod Analgesics)

Examples: Morphine, Demerol, Codeine, Percodan, Percocet

Morphine is a naturally occurring substance obtained from the juice of the opium poppy. The other narcotics are chemical variations of the same natural

substance. They work centrally in the brain to decrease our ability to feel pain. These drugs remain the mainstay of pain management for post surgical pain, trauma, and cancer pain. They may be given by IM or IV, PCA, epidural catheter, orally, or transcutaneous patch. They are highly effective and should be used in these situations; however, they are addictive, and as healing occurs narcotics should gradually be tapered off and management of pain should be switched to nonaddictive pain killers.

Although very effective for treatment of short-term pain, they are not effective in the chronic management of phantom and stump pain. Usually a person becomes tolerant of the narcotic and requires more and more to get the same degree of relief. The person may become addicted and dependent, with poorer and poorer pain control and with increasing depression and disability. It is the rare amputee whose pain is eliminated by narcotics over a long period, and even fewer who can be maintained on a level dose without developing tolerance and addiction. The only notable exception is cancer pain.

There is a valid use for oral narcotics on a limited basis for treatment of phantom limb pain. This is for those amputees who have only an occasional flare-up of phantom pain, where short-term use, perhaps one or two pills will be all that's necessary to stop the attack. If the phantoms cannot be controlled sufficiently by a short-term course of oral narcotics, other medications or pain control methods should be used.

Sedatives and Hypnotics

Examples: Valium, Xanax, Haldol, Thorazine

It is generally agreed that these drugs have no role in the treatment of phantom pain because they are not only ineffective in relieving the phantoms, but also tend to be habit-forming. They may increase depression and in long-term use do nothing to improve sleep disturbances that may be due to chronic pain. The only exception to this would be the short-term use for severe, disabling anxiety, stress or psychosis, which may be a result of amputation in certain individuals.

Local Anesthetics

Examples: Novocaine, Pontocaine, Xylocaine, Marcaine

These drugs have long been used to produce local and regional anesthesia. They act by changing the chemistry of the nerves cells, and therefore, making them unable to function and transmit pain impulses. They may be given by spinal, epidural, local injection and a wide variety of nerve blocks. They are extremely useful, not only for anesthesia, but can decrease pain by placing dilute solutions through catheters placed in various locations throughout the body. Nerve blocks may be valuable as a diagnostic tool to identify people who may benefit from specific surgical procedures used to treat phantom pain, and may be helpful as therapy in certain specific cases. Local anesthetics may also be used to relieve trigger points, and may help to treat certain stump pain.

Miscellaneous Drugs

Many drugs have been used to try to treat or cure phantom pains. They work in a variety of ways to affect nerve conduction and chemistry. Overall, the results have been poor, only a few people have achieved success. Each of the following drugs has been very effective for only a small number of people: Propanolol, Mexilitine, Clonidine, Calcitonin, Clonazepam, and Ketamine.

All drugs have side effects, some are minor, and others may be more serious. All drugs may interact with other drugs you may be taking. The effect of mixing several drugs may be potentially very dangerous. In general, most drugs are broken down by the liver, and eliminated by the kidneys, and damage may be done to these organs in certain situations. People with preexisting liver or kidney disease should be very careful about taking only medicines prescribed by their doctors. Drugs may affect blood formation, clotting and may cause bleeding; therefore, certain blood tests may need to be done to make sure these organs are working correctly and to check blood counts and the effects of blood thinners on blood clotting. Be sure your doctor knows about your allergies, and any and all other medications you may taking. Before taking any drug it is imperative to ask the following

questions. What is it, how does it work? How should it be taken? What should I expect? What are the side effects? What tests may be necessary?

Conclusion

There are many methods to control pain. Medications are only one way. Although we don't have a drug that is specific and will cure phantom pain, treatments are available that have proven effective in the majority of people. Many times this may be a combination of drugs, or other pain control techniques. Seek professional help, and inform yourself.

Physical Therapy Management of Lower Extremity Amputations

Text from Chapter 2, Preoperative and Postoperative Care and the Responsibilities of the Physical Therapist, of Physical Therapy Management of Lower Extremity Amputations *by Gertrude Mensch and Patricia M. Ellis, published 1986*

Clinical Evaluation of Pain

Pain is a subjective experience that cannot be measured with accuracy (Jeans et al., 1979). It is also difficult to determine the precise nature of pain. However, the different kinds of pain encountered by amputees must be discussed since pain is a guide for treatment planning in clinical practice. It can affect the amputee's performance and influence treatment progression. Various pain experiences are often indicators of corresponding stump conditions. Pain in the remaining leg suggests how much walking the amputee is able to tolerate. The recognition of stump pain helps in determining whether or not an early postoperative cast removal is necessary.

For clinical use, the nature of the objective description of pain can be broadly classified into:

- pain of intrinsic origin
- pain caused by extrinsic factors
- phantom limb pain

Intrinsic pain, also referred to as internal pain, tissue pain, or physiological pain, is of an organic origin and is the result of an underlying pathology. It includes:

- bone pain
- vascular pain
- nerve pain
- wound pain

Bone Pain

This pain is recognized as a deep ache and is often compared with a severe toothache. Bone pain may be present if a long weight-bearing bone has been severed because the periosteum that surrounds the bone (except for the articular surfaces) and is pain-sensitive, is responding to bone trauma. However, when a weight-bearing bone remains intact (e.g., knee disarticulation) bone pain is rarely a problem.

If the bone end that has been severed is sensitive to early partial weight-bearing, cast removal prior to the scheduled length of time may not be indicated immediately because the sensitivity of the periosteum will ease in time. The painful sensation will gradually diminish as healing takes place. Weight bearing should be deferred in order to avoid further irritation. However, if the intensity of the bone pain in the early postoperative phase persists and is present during rest, stump examination is indicated.

As ambulation activities progress, bone end sensitivity is more likely to be experienced when soft tissue coverage is minimal. Soft tissue coverage (as in a transtibial stump with a long posterior flap) should provide a weight-bearing "cushion" distally, thus helping to protect the sensitive bone end.

Vascular Pain

Vascular pain may also be referred to as intermittent claudication or ischemic pain. It is described as a throbbing, pulsating, biting pain and is occasionally combined with a sensation of "icy" coldness. Amputees with a history of circulatory disease express a feeling of the limb being "caught in a vice." This pain results from muscle tissues being deprived of adequate blood to the remaining leg. It can also be present in the stump. If vascular pain occurs in the stump in amputees with advanced peripheral vascular disease,

the amputee may be restless and may change the position of the stump frequently. Ambulation activities must be monitored carefully, allowing ample rest periods during treatment sessions.

The presence of intermittent claudication is easily recognized by the onset of pain during ambulation and by an easing of the pain at rest. The intensity of pain will force the patient to rest. However, the symptoms will reduce or diminish with rest.

Cast removal in the early postoperative phase is not usually indicated because, if the cast is removed, swelling will occur and vascular pain will increase without cast support of the tissues. As an alternative to cast removal, isometric muscle contractions with adequate rest periods are advised. For example, one can start with five contractions followed by 30 sec of rest and increase the activities according to tolerance. Another factor to be considered is the resting position of the stump. This should not produce undue stretch stresses on the stump tissues. An uncomfortable, prolonged stretch (e.g., the hamstring muscles in a transtibial stump) will cause the amputee to tighten muscles in response to the stretch. This constant muscle tension can adversely affect stump vascularity and increase ischemic pain.

If muscle cramping is a postoperative problem, one can evaluate the amputee's tolerance for ambulation by practicing static muscle contractions. Treatment may then progress to active muscle work of the surrounding joints not inhibited by the cast (e.g., in a transtibial amputation the amputee exercises the major muscle groups of the hip). The amputee's ability to cope with this activity will indicate:

- the amount of activity the muscles will tolerate before requiring rest
- the amputee's readiness to progress to gain training and graduated weight bearing at this time

Nerve Pain

Nerve pain is described as a sharp, shooting, flashing pain. Patients very often compare it with an electric shock. It should not be confused with phantom pain. It may be experienced as a radiating type of pain or it may be localized. Neuralgic pain occurs as a response to mechanisms such as compression of sensory nerves. Cast removal is not indicated.

Radiating, neuralgic pain is sometimes followed by muscle cramping or tetany since this type of never pain causes the muscles to tense (Jean et al., 1979). In patients with peripheral vascular disease, this muscle tension produces cramping or titanic type of contraction, thus superimposing vascular pain on the already present neuralgic pain. Radiating nerve pain may also be more central in origin (e.g., sciatic nerve irritation owing to exacerbation of a preexisting back problem).

Localized nerve pain can be diagnosed by palpation. A small area of acute pain may be triggered by localized pressure if a neuroma is present in that area. A neuroma, which does not develop immediately postsurgically, is recognizable during the active rehabilitation phase. It is a sensory fibrous growth with sensory fibers that develops at the end of the transected nerve (Mital et al., 1971). If the neuroma is not deeply embedded in soft tissue, it can cause a considerable amount of pain on socket contact.

Wound Pain

Surgical wound pain may be perceived as superficial or deep in natures. Superficial pain is not a cause for much concern. However, deep pain must be investigated immediately.

Superficial

Superficial pain usually covers a localized area, and pain is experienced as a superficial skin burning or can be described as a skin friction or "soreness." Some amputees compare this discomfort with the feeling of "having hair pulled," others describe the sensation as skin "being pinched." Cast removal for this condition is not necessary.

Superficial wound pain may be aggravated when a fluid-soaked gauze-dressing adheres to the open area, which then dries and becomes "crusty." Each muscular contraction will then produce a slight pull on the dressing, thus increasing the sensation of superficial wound pain.

Deep (Infection)

Deep wound pain, resulting from a serious soft tissue infection, is a constant, excruciating, burning pain that may be accompanied by a foul odor. Wound infection, if untreated, can produce necrosis and generalized

toxicity (fever, disorientation). Pain in the stump can become so intense that cast removal is necessary to allow drainage of the wound, particularly if it is caused by local inflammatory edema pressing against the cast wall. The surgeon will decide on the subsequent treatment for infection control.

Pain of Extrinsic Origin

Extrinsically caused pain is produced by external influences such as pressure, heat, and leverage on the stump tissues. It is a pain resulting from an external mechanism.

Cast Pressure

Cast pressure, if localized, is usually caused by either a wrinkle or by plaster of Paris crumbs in the stump sock. This irritant causes local pressure and can be compared with walking with a stone in one's shoe. It is an annoying pain sensation that usually results in a number of gait deviations.

Inadequate Socket Fit

A socket that is too small or too tight produces stump choking and can lead to ischemic pain. A socket that is too large is malaligned either by slippage or by rotation, and causes incorrect pressures on the stump, because the position of the anatomical landmarks and the contours of the socket walls are misplaced.

Pressure areas are often visible on the skin when the case, or the training unit, is removed. The causes of pain that are extrinsic in origin are more readily observed and can be more easily treated than pain that is caused by an underlying pathology.

Clinical Comments

Postsurgically, when the stump is still protected by a nonremovable cast, a generalized continuous stump aching, if not diagnosed as ischemic pain, may indicate nonhealing or a breakdown of the suture line. (Delayed healing of the surgical site can occur if the amputation was performed at marginal level, and/or if basic postoperative care principles were not met, e.g., loss of cast suspension, early uncontrolled weight bearing.) If this pain persists, the cast should be removed and the suture line evaluated. Following stump inspection and subsequent treatment, a nonremovable cast may be reapplied to give the stump an undisturbed wound healing environment. Gait training will be delayed.

Pain can also cause a problem when the amputee attempts to diminish stump pain by assuming the position of most comfort, which, unfortunately, tends to be flexion. If the stump pain persists for a long period and the amputee submits to the more comfortable, flexed position, a contracture can and will develop.

Prolonged pain will decrease the amputee's ability to cope (Jeans et al., 1979). It will reduce the tolerance level emotionally, as well as physically. It can also disturb the amputee's sleep pattern. If this occurs, the amputee's motivation and endurance for the rehabilitation program will be reduced, thus lengthening the rehabilitation time.

Phantom Limb Pain

Phantom limb pain, affecting only some amputees, refers to pain in the part of the extremity that has been amputated and should not be confused with pain in the stump. Phantom limb pain can vary in nature and intensity. It is often described as a cramping or burning and is occasionally accompanied by the feeling or sensation that the amputated limb is in an awkward position (Melzack, 1971). Clinically, it has been observed that phantom pain does have a tendency to occur in patients who have experienced either prolonged or severe pain in their extremity prior to amputation surgery (Koerner, 1969; Melzack, 1971; Mital et al., 1971).

It should be stressed that phantom limb pain does not always occur, but, if it is present, it is usually experienced by the amputee immediately following amputation surgery. As a rule, phantom limb pain will subside and become more of a phantom limb sensation (Melzack, 1971; Mital et al., 1971). The transition from phantom pain to phantom sensation, which may take place during the first few weeks following surgery, is gradual. Amputees often continue to describe their phantom limb feeling a as pain when, in fact, it is no longer pain but a sensation that encourages an awareness of a complete body image. Phantom limb sensation or awareness is most useful in amputee gain training (Koerner, 1969) since it enhances proprioceptive feedback.

In extremely rare cases where severe phantom limb pain is permanently present, prosthetic rehabilitation is questionable since the phantom limb pain will be aggravated by muscular activity, forcing the amputee to avoid any attempt at gait training.

Summary

It must be understood that pain differentiation is seldom easy because the amputee's description of pain if often vague. Pain cannot be measured objectively. The pain threshold in individuals varies greatly, and emotional stresses can also affect the severity of existing pain.

The foregoing classification may be used as a guide in clinical evaluation of the various types of pain and will prove to be useful:

- in assessing the amputee's activity potential
- in judging if cast removal is indicated
- in determining the rate of treatment progression
- in reporting to physicians and to other amputation clinic team members

No attempt has been made here to provide the neurophysiological explanations of pain or an analysis of pain chemistry. However, diagnostic pain evaluation is clinically important since it will affect the treatment course that the physical therapist may take as a result of the amputee's pain.

It must be understood that since leg or stump pain are factors in amputation rehabilitation, then normal gait patterns cannot be achieved because the amputee will try to avoid or decrease the severity of the pain and will compensate by demonstrating postural gait deviations.

Phantom Limb Pain Management: A Drug-Free Solution

By Jean-Pierre Gibeault, P.Eng., President and CEO of OrtoPed

This is a review of the research, literature and testimonials on the alleviation of phantom limb pain by Farabloc, a fabric with electromagnetic shielding properties. This review looks to determine its efficacy when worn by amputees. Research comparing results from Farabloc use to results associated with placebo fabric are reviewed, as well as presentation of testimonials from amputees.

The first objective of this literature review is to bring forward the tangible and practical effects of a drug-free solution for phantom limb pain (PLP). The second is to provide prosthetists with information regarding the dispensing of this solution to their patients.

Phantom limb pain is a painful sensation perceived in the missing limb after amputation which affects the majority of amputees. PLP is distinct from stump pain, which is pain in the residual portion of the limb, and phantom limb sensation, which is any sensation (paresthesia, dysesthesia, hyperpathia) of the missing limb without pain. PLP is characterized by a cramping, stabbing or crushing sensation in the missing extremity, which may be of an episodic or continuous nature. Phantom limb pain can be very severe and disabling.

Statistically Speaking

A publications review leads us to believe that in the first year after amputation, 60 to 70 percent of amputees experience PLP. Research also shows that is does diminish with time. In a series of studies, 72 percent of amputees experienced PLP one week after amputation, 67 percent had pain six months later, and 60 percent continued to have pain at seven years. These studies addressed PLP and differentiated PLP from stump pain and phantom limb sensation.

A study conducted in the 1980s reported that of 2,694 amputees surveyed, 51 percent experienced PLP severe enough to hinder lifestyle at least six days per month. It was also reported that 27 percent of the amputees in the study experienced PLP for more than 15 hours per day, and a further 21 percent reported daily pain over a 10 to 14 hour period.

Treatment Options

A wide variety of treatments for this condition have been studied and researched including neurosurgical, pharmacological, physical, and psychological strategies. Going back to 1980, literature reviews have identified a large number of techniques for treating PLP, but concluded that few produced relief and that placebo responses were common.

Some treatment recommendations for PLP have suggested regimens in line with the management of neuropathic pain states, although trials of treatments for neuropathic pain rarely include patients with PLP and the pathophysiology of PLP remains poorly understood.

In independent research, and in its application with amputees over the years, the Farabloc solution has clearly demonstrated its positive effect on PLP.

Farabloc Spells Relief

Farabloc is a light and strong fabric consisting of a woven mesh of eight micron metal and polyamide threads. The fabric is physically similar to linen and is easily tailored and laundered in a washing machine. The fabric is incorporated in the production of limb covers, socks, gloves, jackets, blankets, wrapping bands and other custom-designed apparel for application

on painful parts of the body. Farabloc represents a drug-free pain relief system published as PubMed indexed to MEDLINE journals.

Reducing Painful Pathways

A number of studies have proposed that the alteration of the electromagnetic field (EMF) has an effect on biologic systems.

It is important to preserve the permeability of the membrane of a healthy cell. Research studies have demonstrated that cells exposed to the electromagnetic field spectrum will experience a variable change in cell membrane permeability and receptor proteins.

Research on Low Frequency (LF) EMF exposure to lymphocytes shows a reduction in cell membrane fluidity and an increase in superoxide dismutase. As the EMF frequency increases, there is an increase in the cell membrane permeability. Research shows that low energy LF EMF reduces permeability while high energy high frequency (HF) EMF increases permeability.

Protecting healthy cells from HF EMF is important because an increase in permeability of these cells will have negative effects.

Other authors have speculated that an alteration in EMF may have biological effects secondary to stabilization of the cell membrane including an enhancement of antioxidant properties. This could explain the reduced levels of anti-inflammatory markers in the delayed onset muscle soreness study.

Farabloc is a very effective electromagnetic shield for high and ultra-high frequency electromagnetic fields. EMF high frequencies in the range of 1 MHz (radio frequencies) and above are substantially blocked by a double layer of Farabloc. The shielding capacity of the fabric is limited at the lower frequencies and has been found to generally have a positive effect on biologic systems such as reduction of cell membrane permeability and bone healing.

Research Results

In a review by Halbert et al. published in Clinical Journal of Pain (2002) a reference is made to a study of 34 patients – 24 with amputation of the lower extremity and 10 with upper extremity amputation. All patients presented complaints of phantom limb pain. Patients with residual limb complications, compensation involvement, prosthetic fitting complications or neuropsychological problems were excluded.

The patients were divided into two groups in a randomized double-blind, cross-over design and treated with either Farabloc/placebo or placebo/Farabloc fabric fitted over the residual limb.

Pain was evaluated by the use of a visual analog scale (VAS). The zero point on a 10 cm line represented "no pain relief" and the other extreme, 12, represented "complete pain relief."

VAS was measured at the outset, the end of the first phase, after the crossover and washout period, and at the conclusion of the study. Repeated measures analysis of variance and Tukey's multiple pairwise comparison range test were used to analyze the results. Significance was set at $p<0.01$ and $p<0.05$ respectively.

The study reported that pain was significantly reduced in the Farabloc group compared to the placebo group as shown in ($p<.001$). The pretreatment, placebo, and Farabloc means demonstrated a significant effect on pain reduction by Farabloc ($p<.05$).

The greatest pain relief in the 34 subjects occurred during the period when double layers of Farabloc covered the residual limb of the amputated extremity.

Nine of the subjects reported pain relief of greater than five points on the VAS scale, while the average relief was measured at three points. One subject reported increased pain while using Farabloc. The nature of the study does not allow for any explanation of these positive results.

Customer Testimony

Larry Gardner of Vancouver, BC, became an amputee in 1974 as a result of a motorcycle injury. He started experiencing PLP two years after his amputation. "Phantom pain comes on strong with sharp, shooting pains originating in the bottom of my residual limb," he explains. "I experience the pain in my 'missing' shin, knee or foot area," he specifies. "The sensation for me is like an electric shock of pain or a sharp

stabbing feeling. The pain can come on fast or slow with a wide range of intensity. It may last a few hours or a few days or longer."

As with most amputees suffering from PLP, the throbbing pain had a serious effect on Gardner's life and lifestyle. "The pain, being unbearable at times, causes much discomfort in my life. It affects my sleep, my relationships, and my attendance at work."

Prior to discovering the Farabloc solution while researching PLP on the internet, he used Tegretol (carbamazepine, a nerve relaxer) and Tylenol with codeine, without satisfying results.

Gardner has been using Farabloc for 10 years and is satisfied with the drug-free result he experiences. "When I feel the pain coming on, I put the cover over my stump, and I feel the pain decrease almost immediately, accompanied by a warm feeling." Comparing his pain to his electric guitar amplifier turned up to nine or ten, he maintains that the Farabloc cloth turns it down to about a two or three! "Finally, actual pain relief without medication," enthuses Gardner. "I have relied on Farabloc's shielding properties for a decade now. For me, the important thing is simply to halt the pain, just like any pain sufferer wants. Farabloc works for me. Simple as that."

Universal Application

This light and strong fabric, similar to linen, is easily tailored to make a limb cover. This apparel can be custom-tailored or selected from a catalog of available shapes and sizes. The cover is washable in a home washing machine and has shown that it will last beyond its warranty period. The same fabric is also available to prosthetists for lamination in prosthetic sockets.

After Review: The Judgment

This electromagnetic shielding fabric, worn on the residual limb or laminated in a prosthetic socket, reduces phantom limb pain suffered by amputees when assessed in a placebo-controlled double-blind cross-over study. This is supported by a significant number of testimonials from amputees.

Mirror Therapy – Expanding Global Access to Phantom Pain Care

By Beth D. Darnall, PhD, November/December 2010, for inMotion

Phantom pain is often a chronic, debilitating condition that affects about 80 percent of people following limb loss. Of those who acquire phantom pain, as many as 85 percent report continued phantom pain 2 years after amputation, and for some people, phantom pain may last for decades. People who are bothered by phantom pain are more likely to report greater distress and depressive symptoms. Thus, phantom pain may have a major negative impact on quality of life. For these reasons, it is important to improve access to phantom pain care.

Mirror therapy was first described as a successful treatment for phantom pain by Dr. Vilayanur Ramachandran in the mid-1990s. Since then, several case reports have described similar success with the treatment. In 2007, results from a randomized controlled trial of mirror therapy were published in *The New England Journal of Medicine*. The findings from this study showed that mirror therapy was effective for reducing phantom pain after 4 weeks of regular practice. Mirror therapy was also shown to be superior to placebo and mental visualization comparison groups.

Mirror therapy works by essentially "tricking the brain" out of pain. Because pain signals are processed in the brain, we can change the brain "input" and get different "output" in terms of pain. When mirror therapy is practiced, the brain receives information that both limbs are intact and functional. It is now widely accepted that cortical restructuring occurs in the brain when this new information is received, and that the restructuring lessens or resolves the pain.

Historically, mirror therapy is described as being therapist-guided and it is often described as involving a specific set of exercises that must be followed. However, my research has shown that therapist guidance with mirror therapy is optional, and one need not follow a structured set of exercises to achieve good results. In other words, mirror therapy is quite simple, and it is something you can do yourself at home. All you need is a mirror and dedication to practice the treatment daily.

I first realized the simplicity of mirror therapy after treating a gentleman with phantom leg pain. With minimal instruction, he purchased a mirror and began doing mirror therapy for 20-25 minutes each day at home. He made sure to watch the mirror while performing gentle movements with his intact leg. He simply moved his intact leg any way he wished; he got creative to keep his interest up while doing the treatment. He reported enjoying the treatment because he found it relaxing and he started noticing pain reduction. Within several weeks his phantom pain had resolved completely and he was able to taper off all of his pain medication.

Based on the success of this case study, we recently conducted a pilot study with 40 people with phantom limb pain to further test the idea that mirror therapy can be self-delivered at home. Study participants were shown a brief demonstration of mirror therapy (either in person or via a DVD demonstration) and they were asked to practice the technique for 25 minutes daily. Participants self-treated at home with no therapist guidance (however, participants did have the ability to call me or the study coordinator with questions). Study findings showed that self-delivered mirror therapy is indeed effective for phantom pain. Almost half of the participants reported phantom pain reduction, with an average pain reduction of almost 40 percent. Ten participants reported phantom pain reduction greater than or equal to 40 percent. Two participants reported

100 percent phantom pain resolution. Like all medical treatments, not everyone in the study benefited from mirror therapy, but the study results suggest that many patients may effectively self-deliver mirror therapy at home with a simple mirror. Self-treatment with mirror therapy may reduce pain medication prescriptions and medical costs, thus reducing the cost burden of limb loss. Most importantly, successful self-treatment may reduce suffering and may improve quality of life.

While mirror therapy is simple and can be done at home, some people may benefit from added structure and guidance. Like any behavioural plan, mirror therapy only works if it is practiced daily, and many people may have trouble staying on track with a daily practice plan. In these cases, seek guidance from a local therapist.

Currently, global outreach efforts are underway to educate physicians and practitioner who treat amputees in developing countries about mirror therapy and its ease of use. The End the Pain Project is a non-profit organization that is providing mirror tool kits containing printed instructions for mirror therapy and non breakable mirrors – all free of charge to medical organizations and patients in Vietnam, Cambodia and Somalia. Due to the limited availability of medical resources in many regions of these countries, self-delivered mirror therapy may help people with phantom pain from limb loss of all etiologies (causes), including the large percentage of people in these countries who are survivors of landmines, military conflicts or other trauma.