# Therapeutic ultrasound applications

Ultrasound is the name given to sound waves that operate at very high frequencies that operate above the human threshold of hearing. The word Ultrasound has a Latin origin. Ultra meaning on "the far side of" so the word ultrasound simply means on the far side of the frequencies of sound waves. The human hearing range typically is between 20 - 20KHz with frequencies of higher being defined as ultrasound.

The origins of therapeutic ultrasound have, as is most common in the initial period of discovery of many technological advancements, a Military origin.

During the 2nd world War many submarines navigated around the waters using ultrasound waves and they found that the emission of these waves many fish were dying. After some initial confusion they found that this was because the ultrasound waves were heating the fish and subsequently killing them. This inevitably opened the door for the use of ultrasound and their effects on humans.

## Ultrasound application

Ultrasound has many useful applications. Within the medical framework ultrasound can be used for both Medical Imaging and Therapeutic treatment.

### Medical imaging

In the use of ultrasound for medical imaging the ultrasound waves are directed into living tissue by a probe using contacts that connect directly with the skin. To increase conductivity, a medium, such as a gel, is used which helps the passing of waves by increasing surface contact area and reducing any loss due to friction. The waves then penetrate the tissue and once they encounter any boundaries such as organs, tissues and bones of different density the waves are reflected back and detected by the probe. The machine then determines by the time taken for the waves to be reflected back to it the details of the tissue the waves have been able to penetrate and thus creates an image that can be viewed on a screen.

### Medical therapy

Aside from medical imaging ultrasound can also be used for medical therapy. The frequency commonly used operates at the frequencies between 0.7 to 3.3 Mhz. Because of the penetrating depth of ultrasound waves into living tissue is around 2-5 cm this makes it suitable for gaining access to tissues located beneath the skin surface and without the trauma of surgery to gain direct access to the tissue. The tissues that best absorb the ultrasound waves include tendinous connective tissue and ligaments of the muscles. Fascias around organs as well as the organs itself also have a good absorption. The great advantage of using ultrasound for medical benefits, apart from the reducing the need for invasive surgery is due to its heating and non heating affects on tissue properties. As the ultrasound waves are absorbed, the cells of the tissue vibrate and form tiny bubbles. This action energizes the membranes of cells which encourage cell repair. The gentle agitation softens any hard necrotic scar tissue and as the healing process advances the reduction in swelling and increased blood flow to the area greatly reduces pain in the directed area. This ultimately rapidly reduces recovery time making ultrasound a useful and non invasive method for therapeutical treatment.

## Application examples

### Lithotripsy

Hard calcified stones commonly found in places such as the kidney and gall bladder can become to large to pass the body by the circulatory excretory system. By Applying ultrasound waves in high energy pulses the hard stones can be broken into much smaller pieces that can easily by removed by the body.

### Phacoemulsification

This is the use of Ultrasound in modern cataract removal in the eye. After gaining access to the lens of the eye through the cornea of the eye an ultrasonic emitter instrument known as a Phaco probe is used. The probe has a specialised needle, commonly made of steel or titanium and the tip of this needle of the probe vibrates at ultrasonic frequency resulting in the destruction of the cataract via emulsification. As the cataract becomes broken down a suction pump is applied removing the cataract particles.

### Assisting in targeted drug delivery

The ultrasound waves, focused onto a specific area and delivered in intermittent pulses results in the extracellular matrix of cells to expand and contract rapidly. The agitation of the cell allows for greater permeability to pharmaceutical agents. By delivering in pulses the cells are prevented form absorbing too much energy and preventing necrosis. The same principle can also be applied to creating more populated laboratory cultures of microorganisms by increasing uptake of nutrients allowing for better microbiological analysis.

### Removal of cancerous tumours

In a process called MRIFUS which stands for Magnetic resonance imaging focused ultrasound surgery. Using MRI cancerous tumours can be located and the ultrasound beam focused to destroy the afflicted tissue.

### Treatment of varicose veins

During Endovenous laser treatment - where an optical fibre utilizing IR light is guided to the affected vein under the direction of ultrasound. The IR light once applied which causes the vessel to contract and then slowly removed resulting in a less dilated vessel.

### Destruction of harmful bacteria

In combination with antibiotics ultrasound can destroy bacteria due to their effects on bacterial cells walls from prolonged exposure. This method is becoming more important with the emergence of antibiotic resistant drugs.

### Blood clotting and its removal

One of the most recent areas of research has been not just in the removing of blood clots but in their actual formation from ultrasound pulses delivered at high frequency. The benefits of this are when massive internal haemorrhaging is taking place and blood loss needs to be stemmed quickly and effectively and thus reducing the need for rapid surgical intervention.

### Encouraging bone growth and remodelling by stimulation of osteoprogenitor cells

### Dental treatment

Ultrasound frequencies have proved to be particularly effective at removing plaque build up around the gum line.

## Controversy

As promising as therapeutic ultrasound is it is not without its critics. in a 2001 paper published in the Journal of American physical therapy by Valma Robertson and Kerry Baker, a review of the effectiveness of the use of ultrasound for musculo skeletal injuries was carried out. A total of 35 studies were citied which analysed the comparison between ultrasound therapy and a placebo for a range of disorders. The authors concluded that although for afflictions such as carpal tunnel syndrome and inflamed tendinitis of the shoulder there was no evidence that ultrasound provided for better healing than a placebo. It was also noted that a wide range of doses of ultrasound were used and no explanation given as to why it was unsuccessful despite the theoretical basis suggesting success.

## Links

### Related articles

### External links

### Bibliography

Robertson, V. Baker, K - A Review of Therapeutic Ultrasound: Effectiveness Studies, Journal of the American Physical Therapy Association - http://ptjournal.apta.org/content/81/7/1339.short Therapeutic Ultrasound in Physical Therapy - http://automailer.com/tws/ultrasound.html Halliday,D. Resnick,R. et al... Fundamentals of Physics,7th ED 2004, John Wiley and Sons Ultrasound Medline Plus- http://www.nlm.nih.gov/medlineplus/ency/article/003336.htm Ultrasound (sonography)- http://www.radiologyinfo.org/en/info.cfm?pg=genus Ultrasound therapy- http://www.mayoclinic.com/health/ultrasound/MY00308