Low-intensity Pulsed Ultrasound

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***Abstract*- Low-intensity pulsed ultrasound (LIPUS) is the method of using short bursts of ultrasound, targeted on specific areas of the body such as bone fractures and the roots of teeth. LIPUS has shown to accelerate bone fracture healing, tooth growth and regrowth, and mandibular correction.**

I Introduction

Low-intensity pulsed ultrasound or LIPUS is a method of treating small areas with pulsing, usually 20 minute continuous applications of ultrasound. Ultrasound has been found to help in the repair of small fractures on bones, mainly those in the upper and lower appendages, carpal and tarsal regions and mandibular region. LIPUS is being considered to be used in the dentistry and orthodontics as a method to repair root damage and regrow the bond between roots and sockets [1]. The technology is available but is also still under research. Trials conducted to repair bone fractures have shown strong and promising results [2].

II Methods

In the majority of LIPUS applications the device, as shown in the model, uses a 1.5 MHz frequency that pulses with a width of 200 μs, repeating for twenty minute long sessions, once a day. The modern device can take the form of a small handheld device or a small machine. Most have a cord attached to a head that emits the ultrasound. When treating bone fractures, the device is applied directly to the fracture and turned on. The presence of ultrasound induces micromechanical stress which stimulates cellular responses of osteoblasts and chondrocytes and increases blood flow to the area [2]. The cellular and molecular responses and increased blood flow increase the activity of the fracture site and help accelerate repair [3][4].
An example of the device is shown below [5].

III Results

In a trials conducted from 1994 and 2004 on the effects of LIPUS in accordance to bone fracture healing, researchers found that the direct applications of the ultrasound accelerated the process of fracture healing in studies related to tibial and radial fractures. The results for other treatment trials were statistically inconclusive. The tibial and radial fracture trials grouped patients into two sets, one with LIPUS and the other with a placebo. The results of the radial fracture trials showed that the mean recovery time for the LIPUS versus the placebo group differed greatly, with the LIPUS group recovering in a mean of 61 days while the placebo recovered in a mean time of 98 days [3]. The trial conducted to test tibial fractures showed a mean time of 114 days with LIPUS and a time of 182 days with the placebo. The results of these show promise in the technology and shows how the tech may be limited to certain regions of the body, The image show below shows a collection of multiple trials showing the effects of LIPUS [3].

Trial	Radiographic definition of fracture healing*	Mean days to fracture healing or fraction of patients healed (no. of weeks)		Statistical significance (*P* value)
		LIPUS	Placebo	
Malleolar	Callus formation	14/15	12/15	No
Handolin *et al.*, 2005[34]		12th postop. week)	(12th postop. week)	
Handolin *et al.*, 2005[40]	Callus formation	8/10	9/11	No
		(12th postop. week)	(12th postop. week)	
Radial Kristiansen *et al.*, 1997[75]	Bridging of 4 cortices	61 ± 3 days	98 ± 5 days	Yes $P < 0.0001$
Tibial Heckman *et al.*, 1994[41]	Bridging of 4 cortices Bridging of 3 of 4 cortices	114 ± 7.5 days	182 ± 15.8 days	Yes $P = 0.0002$
Leung *et al.*, 2005[42]	Bridging 3 of 4 cortices	11.5 ± 3.0 weeks	20 ± 4.4 weeks	Yes $P < 0.05$
Emami *et al.*, 1999[37]	"Signs of healing like cortical thickening"	155 ± 22 days	129 ± 12 days	No
Rue *et al.*, 2004[43]		56.2 ± 19.6 days	55.8 ± 15.5 days	No

*Although individual trials may have reported other criteria for fracture healing, signs of radiographic healing were of interest for the current review.

IV Discussion

The LIPUS allows for an alternative to the standard method of bone fracture treatment. Some companies have begun development of 3D printed custom casts that are rigid yet minimally structured to allow for comfort of the user. These casts can utilize the LIPUS to aid in the recovery of the patient, yet these systems are expensive and require a external component when using the ultrasound [3]. Most devices that are given to patients using LIPUS must administer the ultrasound themselves at home which can result in errors such as missed application days, inaccurate application and damage to the device. Many companies have created versions that are handheld and easy to use. There is a lot of work to be done in this field, and future studies must try and find a larger group of patients to work with.

[1] Wikipedia: Low-intensity pulsed ultrasound <https://en.wikipedia.org/wiki/lowintensity_pulsed_ultrasound
[2] Emanuel Braga Rego, Takashi Takata, Kazuo Tanne, Eiji Tanaka, current status of low intensity pulsed ultrasound for dental purposes, 2012, 220-225, TODENTK-6-220, DOI:10.2174/1874210601206010220.
[3] Mundi R, Petis S, Kaloty R, Shetty V, Bhandari M. Low-intensity pulsed ultrasound: Fracture healing. *Indian Journal of Orthopaedics*. 2009;43(2):132-140. doi:10.4103/0019-5413.50847.
[4]Wikipedia: Chondrocyte <https://en.wikipedia.org/wiki/Chondrocyte>
[5] Image Inlet: LIPUS device <http://www.biottech.com/images/melmak2.png>