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Electro Physical Agents and Tissue Repair : Can we really make a difference?

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INTRODUCTION

Much as Electro Physical Agents (EPA's) have been a component of physiotherapy practice since the early days of the profession (the first edition of Clayton's *Electrotherapy and Actinotherapy* was published in the UK in 1948 and an interesting historical review can be found in Kahn 1994), the modalities, the rationale for their use and their delivery methods have changed considerably since the early days, and continue to do so. The most popular modalities used in current practice are in many respects quite dissimilar to those of 60 or more years ago though of course they are based on the same physical principles. Even in the last 10 years there has been a noticeable change in emphasis and delivery methods. The change in terminology away from the term 'Electrotherapy' to the broader, and more accurate Electro Physical Agents (EPA's) is not just a trend, but reflects a reality that the range and scope of interventions employed that extend way beyond 'medical electricity'. Ultrasound, shockwave, and body vibration for example are accurately included under the EPA banner, but clearly are not types of electrotherapy in the strict definition of the term.

Modern practice needs to be evidence based in order to retain its currency and justify its inclusion in clinical practice. It is sometimes said by 'critics' of EPA's that there is a 'lack of evidence' to support their use. There is in fact a wealth of published evidence, and possibly it is more an issue of awareness of this evidence rather than the evidence not actually being there. There certainly appears to be an evidence-practice mismatch - those modalities which are most widely employed do not necessarily match those with the strongest evidence - and vice versa (Watson, 2014). Some of the research can appear daunting and a substantial proportion is not published in the therapy journals per se, which can make access more problematic, but the evidence is there. Searching for and evaluating the evidence is an integral part of an individual's evidence based practice, and reviews can support the busy clinician by providing a concise summary of the evidence pertaining to a particular field or therapy area.

When EPA's are used in line with the evidence, they can be phenomenally effective. Used unwisely or inappropriately, they will either do no good at all or possibly make matters worse. This is not a principle that is only applicable to EPA's. Drug therapy used inappropriately would not be expected to be effective – neither would manual therapy, exercise therapy, acupuncture or any other

intervention when used at the wrong time or for the wrong reason or at the wrong 'dose' : hence the application of EPA's is no different to any other intervention. In the physical therapy domain, the EPA's are sometimes perceived as being 'different' in that (a) a machine is employed as part of the delivery system and (b) the practitioner must make an overt decision with regards dosage. Dosage decisions are in fact an everyday component of all therapies, but perhaps it is less obvious when determining the number of exercises that are needed to achieve a particular strengthening effect, or how long a static stretch needs to be held in order to achieve an increased range of motion?

The skill of the practitioner using EPA's is to make the appropriate clinical decision as to which modality to employ and when, and at what dose, using the best available evidence (Watson, 2010).

This brief review does not follow a 'cookbook' approach – and quite deliberately so. One of the commonly levelled criticisms of the evidence based practice philosophy is that treatment packages and care plans' become generic, but even on a limited consideration, this view can be rapidly dismissed (e.g. Olive and Solomonides 2009). A universal or generic treatment plan for every patient with whiplash, OA knee or a median nerve lesion can be completed. These 'plans' or 'care pathways' are unlikely to actually match the demands and needs of any one (individual) patient – and thus, without flexibility and modification, they tend to fail. The point about genuinely evidence based practice is that it enables the best evidence to be considered relative to a specific patient. There will be commonality between the presentation of any three patients with say OA knee, but there will be differences too – and it is the differences in presentation and context that make one treatment package more effective than another, and additionally, differentiates the more skilled from the less skilled practitioner.

The aim of this brief overview, following the philosophy outlined above is to consider WHICH of the EPA's have an EVIDENCED ROLE in the management of tissue damage and tissue repair, outlining their strengths and areas for optimal use. It does not, and makes no attempt to, provide a 'recipe' for the use of ultrasound for a grade 2 tear of the medial collateral ligament of the knee, nor a prescription for the use of shockwave as a treatment option for chronic Achilles tendinopathy. This information is available from multiple sources, including my own web pages (free and open access at www.electrotherapy.org). The overall aim of this brief paper is to consider WHETHER EPA's can have a POSITIVE EFFECT ON TISSUE REPAIR, and if so, which MODALITIES are most strongly supported by the evidence, and in which CLINICAL CIRCUMSTANCES are they most usefully employed.

TISSUE REPAIR – KEY ISSUES

The general model of tissue repair currently employed is not radically different from those presented 15 or 20 years ago. The understanding of the complexity of the repair process has moved on phenomenally in that time, and the number of papers published annually which inform our knowledge in this field has increased exponentially. More is now known about the complexity of the messenger systems which control the repair sequence, and about the interactions, interdependency and co-dependence of the various elements – together with a deeper appreciation of both what is 'normal' and how normality can drift (or be pushed or dragged) into abnormality, resulting in

delayed healing, stalled repair and adverse clinical outcome. A commonly employed general repair model is shown in Figure 1 and discussed in numerous publications including Watson (2006).

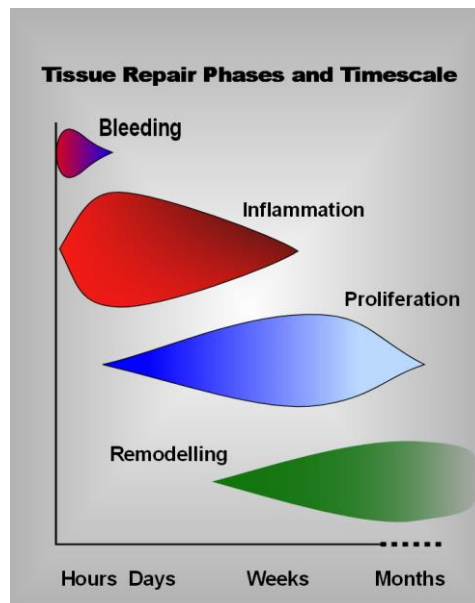


Figure 1 : General model of the tissue repair sequence

The essential division of the repair process into key, overlapping and interlinked phases (inflammation, proliferation and repair being those classically listed) is the commonly adopted approach, though it is important to state that this division into discrete phases is a matter of convenience rather than a reflection of reality - in the real world, all phases are fully integrated, and from the body's perspective, it is more like one continuous process (Figure 2) than a series of identifiable events.

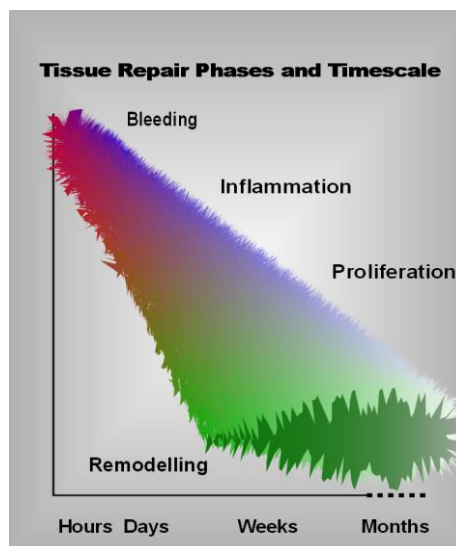


Figure 2 : Realistic 'integrated' tissue repair sequence without discrete phases

Within each of these key phases, a deliberately and carefully controlled series of events take place which culminate in a tissue which is repaired and has both structural and functional capacity which is

as close as possible to the 'original' tissue. Until stem cell research and development reaches everyday musculoskeletal therapy, we will not be 'replacing' the damaged tissue with 'new' ligament, or tendon. Most tissues are 'repaired' rather than 'replaced' or 'replicated'. The repair is essentially made from scar tissue – which is the best that the body can come up with. The quality and behaviour of this scar tissue can be overtly influenced by the environment in which the repair takes place, the behaviour of the surrounding tissue (i.e. things that the patient does to them self) and is "influence-able" by therapy intervention – including exercise, manual therapy and EPA's.

There is no evidenced argument that 'changing' the process of repair is an appropriate nor sensible option. The process of repair is well organised, comprehensive, and overall, a very effective sequence. In the therapy environment, we tend to see a disproportionate number of patients in whom the process has 'gone wrong' one way or another – skewing our perception of how effective the process actually is. The primary, logical and evidenced role of therapy is to support, facilitate, stimulate or enable (whichever term is preferred) the process – rather than trying to change it per se. The **inflammatory** events are essential to a successful repair – managing them is sensible (and evidenced), turning them off is not. **Proliferation**, during which the essential scar tissue is laid down is critical and again, therapy can positively influence these events, encouraging their progression into the final stage of **Remodelling**, during which the 'basic' or 'generic' repair scar tissue is refined, making it, so far as possible, capable of replicating the functional capacity of the tissue that is being repaired.

Our current understanding of the essential nature of chemical messenger systems as the drivers of the repair sequence means that it is now possible to identify HOW therapy influences the repair sequence. Therapeutic interventions (including manual, exercise and EPA based therapies) are capable of influencing the chemistry of repair, thereby exerting their influence (reviewed by Wang and Li (2010)). It is not argued here that therapy ONLY works through a biochemical pathway, but that there is a growing body of evidence to support the argument that this is ONE of the mechanisms of effect. For example, the capacity of low intensity pulsed ultrasound (LIPUS) to positively influence fracture repair is essentially one of a chemical pathway – the mechanical energy stimulates the expression of mediators, and it is this enhanced expression that results in a stimulating effect on the bony repair (Padilla et al (2014)). This does not change how the modalities are actually employed in practice, but does affect our understanding of the mechanism / how the effect(s) are achieved.

There is an additional 'strand' to this concept. Endogenous bioelectric activity – electrical activity which is internal to the body – as opposed to exogenous – electrical energy provided from a source outside the body (i.e. electrotherapy) – is understood to also have an influence on repair. Chemical changes alone do not explain all elements of the process of repair nor the total influence of therapy. The internal electrics of the body have a positive and supporting influence (Watson, 2008). Therapy can influence these events (positively) and thereby provide an additional pathway through which intervention makes a difference to tissue repair.

Microcurrent based therapies specifically target these pathways (Poltawski and Watson, 2009) – employing very small (by definition, less than a thousandth of an Amp) currents as a means to promote and support the small internal currents which are an essential element of a 'normal' repair sequence. We now appreciate that exercise and manual therapy also exert influences on these

endogenous currents, providing a potential mechanism by which different therapies can have a common target and a mutual mechanism of action. It is not suggested that manual therapy nor exercise therapy ONLY exerts a therapeutic influence by means of endogenous bioelectrics, but that this is a COMPONENT of their mode of action.

EPA's exert gross physiological, biochemical, bioelectric and neural mechanisms through which repair is enhanced (Watson, 2011). In this regard, their effects are not 'exclusive' and their use alongside manual and exercise therapy will, in almost all circumstances, provide an optimal environment in which the damaged tissue can progress through the essential sequence, resulting in an optimal outcome – a quality repair with maximal functional capacity – something that would be a reasonable aim (or intent) from any therapy treatment package. Selecting the optimal modality to achieve this result is a key element of the clinical decision making process, just as it is essential to identify the 'optimal manual therapy' and 'optimal exercise' programme to achieve the same end. There are times when EPA use is not indicated – just as there are times when manual therapy is not required, nor acupuncture nor stretching etc. This does not negate the value of EPA use in therapy – it just means that they are not essential in all circumstances – NO one therapy is essential in all circumstances. Knowing when they have an evidenced role to play and when best left to one side is key to therapy success.

ELECTRO PHYSICAL AGENTS THAT CAN INFLUENCE REPAIR

There are a wide range of EPA's - a selection of which are incorporated into Figure 3. This is not claimed to be a complete list of all modalities available - it is a representation of the range, and attempts to categorise them under three broad headings.

Electrical Stimulation Agents / Modalities	Thermal Agents / Modalities	Non Thermal Agents / Modalities
Transcutaneous Electrical Nerve Stimulation (TENS)	Infra Red Irradiation (IRR)	[Pulsed] Ultrasound
Interferential Therapy (IFT)	Shortwave Diathermy (SWD)	Low Intensity Pulsed Ultrasound (LIPUS)
Neuromuscular Electrical Stimulation (NMES)	Microwave Diathermy (MWD)	[Pulsed] Shortwave Therapy (PSWT)
Functional Electrical Stimulation (FES)	Other RF Therapies	[Pulsed] Laser Therapy (LLLT / LILT)
Faradic Stimulation	Hydrocollator Packs	[Pulsed] Microwave Therapy
Iontophoresis	Wax Therapy	Low Intensity RF Applications
High Voltage Pulsed Galvanic Stimulation (HVPGS)	Balneotherapy (inc spa/whirlpool)	Pulsed Electromagnetic Fields (PEMF's)
Low Intensity Direct Current (LIDC) and Pulsed LIDC	Fluidotherapy	Microcurrent Therapies
Twin Peak Monophasic Stimulation	Therapeutic Ultrasound	MAGNETIC THERAPIES
Diadynamic Therapy	Laser Therapy	Pulsed Magnetic Therapy
H Wave Therapy ; Action Potential System (APS)		Static Magnetic Therapy

Russian Stimulation : Medium Frequency Stimulation	Cryotherapy / Cold Therapy / Ice / Immersion Therapy	Microcurrent Therapy (MCT)
Rebox Therapy; Scenar Therapy, NRN (InterX) based therapy		(Radial) Shockwave Therapy
Microcurrent Therapy (MCT)		

Figure 3 : Listing of the more commonly encountered EPA's under Electric, Thermal and Non-Thermal groups

Without attempting to run through all modalities (not possible with this length of article), the group which are most able to directly influence tissue repair are those in the non-thermal group. Of these, the most commonly employed in current practice would be ultrasound, laser and pulsed shortwave. There is no doubt from the evidence base that LIPUS (an ultrasound variant), other radiofrequency applications (i.e. at frequencies other than shortwave), various magnetic field based interventions and microcurrent therapy are all capable of having a positive influence on repair. Whether they are currently used in therapy practice does not negate the fact that there is evidence to support their employment in practice (the evidence-practice mismatch).

Whilst **ULTRASOUND**, **LASER** and **PULSED SHORTWAVE** therapies all have a stimulatory effect on the repair sequence, the existing evidence would suggest that they are effective by stimulating the normality of the repair sequence - not by changing it. Whilst the energy delivered with a clinical ultrasound unit is technically very different from the radio energy, their effect on the inflammatory, proliferative and remodelling stages is remarkably similar. The primary difference between these interventions is WHERE that effect is achieved rather than a difference is WHAT the effect is (Watson 2006b).

ULTRASOUND energy is preferentially absorbed in tissue of high protein content, and collagen being the most prolific structural protein means that tissues such as **LIGAMENT : TENDON : JOINT CAPSULE : FASCIA AND SCAR TISSUE** will be high on the list. This is central to the clinical decision making argument. In order to have an effect on the tissues, energy needs to be absorbed. The tissues which preferentially absorb energy XxX will be those in which the strongest response is seen. Other tissues will of course respond - but to a lesser extent (reviewed in Watson 2008b; 2014b)

LASER energy, delivered to the tissues at appropriate levels (dose) will be primarily absorbed in the superficial tissues, especially those with strong vascularity - such as **SKIN, MUSCLE, TENDON SHEATH, JOINT SYNOVIUM**. It is effective at stimulating repair in these tissues, and it is not great surprise therefore that its use in open wounds is strongly supported, as is its effect in inflammatory presentations in synovial joints and lesions in musculoskeletal tissue - so long as they are sufficiently superficial for the delivered light energy to achieve sufficient penetration (probably 15mm or so maximum). Laser can, and is commonly employed in the treatment of a wide range of clinical presentations, but it is at it's most efficacious when directed at the tissues which absorb light energy at the wavelengths employed (e.g. Alves et al (2014); Newman and Horman (2014)).

PULSED SHORTWAVE also facilitates repair and recovery from injury. The energy delivered, at 27.12MHz radio frequency will be preferentially absorbed in the tissues of low impedance and high

ionic content. These are essentially the 'wet' tissues - **MUSCLE NERVE, BURSAE** and areas where **OEDEMA, EFFUSION OR HAEMATOMA** are present (Al Mandeel and Watson, 2008)

The common three modalities therefore are evidenced as being effective at stimulating repair in the tissues which absorb the energy being delivered. The choice between these modalities, based on the best available evidence therefore pertains primarily to the nature of the target tissue over and above any other clinical decision. If a patient presents with a ligamentous lesion, whether in the hand, the knee, the ankle or the acromio-clavicular joint, Ultrasound is more likely to be effective than any of the other options based on the nature of the target tissue. If the patient presents with a joint effusion or soft tissue swelling around an injured structure, pulsed shortwave is more likely to achieve maximal benefit.

Once the particular 'modality' of maximal potential benefit has been identified, the selection of the most strongly evidenced 'dose' is essential, but is certainly beyond the remit of this brief overview. If both the optimal modality and the optimal dose are employed, the EPA's can have a highly significant effect on the repair sequence. If the optimal modality is delivered at a sub-optimal dose, it would be illogical to expect maximal effect. Worse still, if a sub-optimal modality delivered at a sub-optimal dose is employed, there should be no surprise when no significant effect at all is the result. Clinical decision making with the EPA's focuses around this core concept (Watson, 2010).

The final section of this review will briefly consider modalities with 'tissue repair capabilities' - based on the evidence, but which might be less familiar to therapists.

LOW INTENSITY PULSED ULTRASOUND (LIPUS)

A relatively recent development in the use of ultrasound involves the application of the same modality, but at considerably lower power as a means to explicitly influence bone repair - so called low intensity pulsed ultrasound (or LIPUS). This is an evidenced intervention, being effective in the management of fresh fractures, stress fractures, delayed and non-unions.

Ultrasound has long been considered to be contraindicated near fracture sites as at higher doses, it can be a painful intervention (which makes it a useful technique to 'find' stress fractures). At very low dose however, it has been shown to have a positive effect on the rate of fracture healing - sufficient evidence in fact for NICE to support its use (NICE 2010; 2013).

The applied dose (1.5MHz; 0.03W cm⁻²; pulsed 20% at 1000Hz; 20 minutes; daily) is not possible to achieve with current clinical machines, even when turned down as low as possible - the power is some 3 x lower than most machines deliver on their lowest setting. Currently, specialised machines need to be employed, most commonly on a loan/rental, home use basis.

Research is currently underway which is considering the use of LIPUS across a range of other musculoskeletal presentations, but its use for bone repair is already established.

The modality and the evidence are summarised at the www.electrotherapy.org web pages, and the mechanisms by which the effects are achieved are reviewed in Padilla et al (2014) and a useful clinical review can be found in Bashardoust et al (2012), Griffin et al (2008) and Watanabe et al (2010) in addition to the NICE guidelines and review (NICE 2010 and 2013).

SHOCKWAVE

Shockwave based therapies, as the name would suggest, are not subtle, but are evidenced as being effective, most strongly in the treatment of chronic tendinopathies. Whilst there is an increasing range of clinical presentations for which this treatment is being investigated (including but not limited to slow and delayed fracture, open wounds, chronic muscular and ligamentous lesions), it is in the field of chronic tendinopathy where the existing evidence is most compelling.

There are multiple methods to deliver this energy, but in therapy, the RADIAL shockwave applications predominate. These are non-destructive in nature, but serve to stimulate a stalled or slowed tissue repair sequence, though, as the evidence would indicate, a strong pro-inflammatory stimulus.

The treatment is most effective when combined with a complementary tendinopathy management programme, including eccentric loading. There is a summary of the current evidence at www.electrotherapy.org and reviews in the literature include Romeo et al (2014) and Speed (2014).

MICROCURRENT THERAPY

Microcurrent based therapy is almost the antagonist to shockwave - in that it is a very low powered and truly subtle approach to the facilitation of tissue repair. It involves the delivery of a particularly small (magnitude) electric current - by definition, less than 1mA. This will be sub sensory in nature, and its mechanism of action, unlike other forms of electrical stimulation, is not to stimulate action potentials in peripheral nerves, but instead to support the endogenous currents which are endemic to tissue repair in the musculoskeletal environment.

This therapy has a long and established use in bone injury and the management of open wounds where it has been employed (with a variety of different names) for decades. More recently, its use in soft tissue and other musculoskeletal presentations has been researched, with a growing body of supportive evidence.

It appears to be at its most effective when employed for long treatment times (hours rather than minutes) and due to its sub-sensory nature, small battery powered treatment units and ease of application, home based treatment, potentially on an 'overnight' basis is gaining ground.

The evidence of its clinical efficacy and scope was reviewed in Poltawski and Watson (2009) and again a review of the evidence and mechanism of action is provided at the electrotherapy.org website.

SUMMARY AND CONCLUSION

This is a topic area that would easily fill an entire book, and therefore this paper provides a very limited review of the current position of EPA's as a means to positively influence tissue repair and healing.

The process of tissue repair, in both normal and disturbed modes, is considerably better understood with the emergence of research evidence. The capacity of therapeutic intervention(s) to influence

these processes is not in doubt. The electro physical agents (EPA's) are ONE of the methods by which tissue healing can be affected.

The evidence supports the use of various EPA's as a component of a treatment and management package. The evidence does not suggest that the EPA's are 'better' than other forms of intervention - but their integration or amalgamation into a comprehensive treatment programme will make a difference to the outcome.

It is important that the most appropriate (evidenced) modality is employed in each clinical circumstance. It is also important that the 'dose' (machine parameters) are carefully selected in order to achieve optimum effect. Used in such a fashion, the EPA's have evidenced support. Used unwisely, inappropriately or indeed, incorrectly, they provide no useful effect whatsoever, but exactly the same would rightly be said if manual therapy or exercise therapy were used in the same way.

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