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NEW TREATMENT MODALITIES IN
SOFT TISSUE INJURIES

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MODERN TRENDS IN MEDICINE

NOVEL TREATMENT MODALITIES FOR SOFT TISSUE INJURIES IN SPORT

Martin P. Schwellnus

MBBCh, MSc (Med), MD, FACSM, FFIMS

PROFESSOR OF SPORTS AND EXERCISE MEDICINE

UCT/MRC RESEARCH UNIT FOR EXERCISE SCIENCE AND SPORTS MEDICINE

Department of Human Biology

Faculty of Health Sciences

University of Cape Town

Sports Science Institute of South Africa

Boundary Road

Newlands

Cape Town 7700

South Africa

Email: martin.schwellnus@uct.ac.za

CONTACT DETAILS:

Tel: +27 21 650 4561

Fax: +27 21 686 7530

BRIEF BIOGRAPHY

Prof. Schwellnus is a sports physician, and co-ordinator of the Masters-degree program for the training of sports physicians at the University of Cape Town. He also is a partner in a sports and exercise medicine practice, is a member of the IOC Medical Commission, and is Vice-President of the International Federation of Sports Medicine (FIMS). He serves on the editorial board of the British Journal of Sports Medicine and has published extensively in the field of Clinical Sports and Exercise Medicine.

INTRODUCTION

Musculoskeletal injuries form a large proportion of the injuries reported in rugby players¹⁻⁶. It is also well established that the most common region to be injured in rugby union is the lower limb (in particular the knee, thigh and ankle)⁶. Furthermore, it is well documented that ligament (knee and ankle) sprain injuries and ruptures as well as muscle (hamstring, calf, quadriceps and groin) strain injuries and ruptures are the most common types of injuries sustained in rugby players⁶. These injuries are collectively known as “soft tissue” injuries and are therefore the most common injuries in rugby players.

Once a rugby player has sustained one of these “soft tissue” injuries, it is very important to ensure that this injury is correctly managed. The first step in the management of a soft tissue injury in a rugby player is to establish an accurate diagnosis of the injury. This requires a comprehensive clinical assessment by a sports physician and includes taking a detailed medical history and performing a systematic physical examination of the injured area and the surrounding anatomical structures. Special investigations may have to be performed to confirm the exact nature and severity of the soft tissue injury. Investigations that are used for this purpose include diagnostic Ultrasound (US), Magnetic Resonance Imaging (MRI) scanning or Computerised Tomography (CT) scanning. Once the diagnosis is confirmed, the second step is to start with the correct initial (first-aid) treatment. The initial treatment for soft tissue injuries will be discussed in a specific section in the BokSmart content. The main aim of subsequent treatment (after first-aid treatment) is to facilitate the healing process of the injured tissue so that the rugby player can return to full play as soon as possible without a risk of re-injury.

In the past two decades, there has been increasing interest in treatment modalities that could potentially increase the rate and quality of healing of soft tissue injuries in sport^{7,8}. This is still a very active area of medical research today. This review article will focus on some of the novel treatment modalities in the treatment of soft tissue injuries in sport. Specific novel treatment modalities that will be reviewed include the following: Hyperbaric oxygen therapy, Therapeutic ultrasound, the use of biological products in the form of Growth factors, and finally the use of Extracorporeal Shock Wave Therapy (ECSWT). The scientific evidence (using an evidence-based approach) for the use of each of these modalities will be reviewed. Clinical guidelines of administration and special considerations of each of these treatment modalities will be briefly discussed. Practical examples of their possible use in soft tissue injuries in rugby players will be provided.

TERMINOLOGY AND DEFINITIONS

For the purposes of this review paper the following terminology and definitions are particularly important. Hyperbaric oxygen therapy (HBOT): Hyperbaric oxygen therapy can be defined as treatment in a hyperbaric chamber (where the pressure is greater than 1 atmosphere absolute) while the patients inhale 100% oxygen during the session⁹⁻¹¹.

Therapeutic ultrasound (TUS): Therapeutic ultrasound can be defined as the application of ultrasound wave energy to treat medical conditions (including injured soft tissues) utilising the known biological effects of ultrasound on cells and tissues¹²

Growth factors comprise a number of proteins that are stored and secreted by cells in the body and can stimulate or retard the growth (including the healing) of tissue⁸.

Extracorporeal Shock Wave Therapy (ECSWT) can be defined as the external application of shock waves in the treatment of medical conditions¹³.

A REVIEW OF NOVEL TREATMENT MODALITIES IN SOFT TISSUE INJURIES IN SPORT

HYPERBARIC OXYGEN THERAPY (HBOT)

INTRODUCTION

Hyperbaric oxygen therapy (HBOT) is a therapeutic procedure where patients are treated in a hyperbaric chamber in which they are subjected to pressures greater than ambient barometric pressure at sea level while inspiring 100% oxygen¹⁰. HBOT has been well studied and is a recognised treatment modality for specific medical conditions that are encountered in diving medicine and general medicine¹⁰. It is used in the treatment of medical conditions such as decompression sickness, air embolism, carbon monoxide poisoning, crush injuries, burns, traumatic ischaemia, necrotising soft tissue wound infections, osteomyelitis, radiation tissue damage, compromised skin grafts, and cases of extreme blood loss¹⁰. Over the past two decades, there has been an increasing interest in the possible application of HBOT in 1) the management of sports injuries^{9;14} and 2) in the recovery following strenuous exercise^{11;14}. In the following section the possible mechanism/s and the evidence for HBOT in sports injuries, specifically soft tissue injuries, will be briefly reviewed.

PHYSIOLOGY AND POTENTIAL MECHANISMS FOR INCREASING HEALING OF SOFT TISSUES

It is well established that acute soft tissue injuries are associated with oedema, decreased blood flow (ischaemia) following the disruption of blood vessels, and eventual cell death. The increased swelling and the reduced blood flow decrease the amount of oxygen that is available for healing tissue. Therefore, the rationale for using HBOT in treatment of acute soft tissue injuries is to reduce swelling, and to increase oxygen delivery to healing tissue¹⁰. The proposed mechanisms by which HBOT may increase healing in acute soft tissue injuries include the following: reducing tissue oxygen deprivation (hypoxia), reducing inflammation, promoting vasoconstriction (to decrease further blood loss), controlling swelling, improving white cell (neutrophil) function, promoting the formation of healing tissue (collagen synthesis), and promoting new blood vessel formation¹¹. In open wounds, where there is a higher risk of infection, HBOT may also reduce the risk of bacterial infection from organisms that require oxygen (aerobic organisms)¹¹.

SCIENTIFIC EVIDENCE THAT HBOT IMPROVES SOFT TISSUE HEALING

The scientific evidence for the use of HBOT in soft tissue injuries has been reviewed^{9-11;14-17}. A number of studies have been conducted using

- 1) animal models of soft tissue injury (ligament transaction, muscle contusion),
- 2) recovery from delayed onset muscle soreness and
- 3) recovery from acute soft tissue injuries in humans (muscle strain injuries, ligament sprains).

The main findings of these studies can be summarised as follows:

- There is evidence from some animal studies that HBOT improves ligament healing (earlier return to normal stiffness and increased ligament strength) following a surgically transected medial collateral ligament¹⁰
- There is evidence from some animal studies that HBOT also improves muscle healing - improved functional and morphological recovery after 7 days following an experimentally induced muscle stretch injury¹⁸, increased muscle force production 25 days after chemically induced muscle injury in rats¹⁹, and transient enhancement of muscle contractility following an experimentally induced muscle injury in rats²⁰
- HBOT is more likely to improve soft tissue injury healing in areas where there is reduced blood flow (such as the muscle-tendon junction and in ligaments)¹⁷
- There is inconclusive evidence (from a meta-analysis of published data) that HBOT improves recovery in humans with delayed onset muscle soreness (DOMS)¹¹
- The strongest scientific evidence for the use of any treatment modality in clinical practice is based on results from randomised clinical trials (RCT's). However, there are very few RCT's that support the use of HBOT in the treatment of soft tissue injuries in humans¹⁴
- Therefore, based on the available evidence, the routine use of HBOT for soft tissue injuries is not recommended and requires further research.^{9;14}

POTENTIAL NEGATIVE SIDE EFFECTS AND OTHER BARRIERS TO THE USE OF HBOT IN SOFT TISSUE HEALING

There are potential negative side effects from HBOT¹⁴. The most important of these is oxygen toxicity. This refers to tissue damage that can result from increased production of oxygen free radicals as a consequence of sustained high concentrations of oxygen in the tissue¹⁴. Other barriers to the use of HBOT are the high cost of the treatment, safety control during treatment in a hyperbaric chamber¹⁴, and relative low availability of specialised facilities and expertise (hyperbaric chambers).

CURRENT CLINICAL GUIDELINES FOR HBOT IN THE TREATMENT OF SOFT TISSUE INJURIES IN SPORT

At present the routine clinical use of HBOT for soft tissue injuries in sport is not recommended. Further research is required to document the efficacy of treatment in human subjects¹. Furthermore, currently the high cost and general lack of facilities and trained staff will limit the general availability of this novel treatment modality.

THERAPEUTIC ULTRASOUND (TUS)

INTRODUCTION

The use of ultrasound as therapy in medicine (therapeutic ultrasound - TUS) has a long history of use (over 6 decades). Currently TUS is used widely in several clinical settings for the treatment of medical conditions such as cancer and thrombolysis (breaking down blood clots) as well as facilitating transdermal (through the skin) drug delivery¹². In the context of sports injuries, TUS is used widely by physiotherapists in the treatment of bone²¹ and particularly soft tissue injuries^{12;22}. The principle of TUS is based on the fact that ultrasound waves are 1) reflected off tissues that differ in their density, and 2) that absorption of the ultrasound (US) wave energy is highest in tissues that contain a larger concentration of protein (tendon, cartilage, and bone)²². TUS is delivered through the skin using a coupling medium (a layer of a jelly-like substance between the skin and the ultrasound probe) to ensure that ultrasound waves are conducted to the skin and deeper tissues²² where they will be absorbed or reflected.

The application of US to tissues can vary in the “dosage” depending on the power (energy delivery in Watts), power density (energy delivery in Watts/cm²), frequency (MHz), duty cycle (continuous or pulsed application), duration and number of applications²². The main therapeutic effects of US are 1) in the ability to heat tissues (that absorb the energy) – known as the thermal effects of TUS, and 2) the micro-thermal effects (acoustic streaming and cavitation – these were previously referred to as the non-thermal effects)²². There is some evidence that these effects may facilitate the healing of soft tissue injuries. The physiology as well as potential mechanisms for TUS in soft tissue injuries will now be briefly discussed.

PHYSIOLOGY AND POTENTIAL MECHANISMS FOR INCREASING HEALING OF SOFT TISSUES

The indications and use of TUS in soft tissue injuries will vary according to the stage of the soft tissue injury and healing process. The potential mechanisms for the use of TUS in the various stages of healing of soft tissue injuries have recently been reviewed^{12;22} and can be summarised as follows:

- TUS is contra-indicated immediately following injury when there is still active bleeding²²
- During the inflammatory phase, cryotherapy (ice application) and other modalities, rather than heating tissue using TUS is indicated²²
- However, in the inflammatory phase of healing, TUS has been shown to facilitate the degranulation of mast cells, which releases inflammatory mediators^{12;22} (the inflammatory process is important to initiate the healing of tissue following injury)
- In the proliferation stage of tissue healing (repair phase), TUS may be particularly useful. It has been shown that TUS stimulates (through cellular up-regulation) the activity of the healing cells (fibroblasts, endothelial cells, myofibroblasts)^{12;22}
- In the remodelling phase of healing, TUS has been shown to increase tissue strength and improve scar tissue mobility.²²

SCIENTIFIC EVIDENCE THAT TUS IMPROVES SOFT TISSUE HEALING

The scientific evidence that TUS improves soft tissue healing is based on 1) a number of studies (mainly animal studies) where the possible biological mechanisms for TUS on tissue healing have been investigated, and 2) a limited number of randomised clinical trials in human soft tissue injuries. A detailed discussion of the effects of TUS on tissue biology during the stages of soft tissue healing is beyond the scope of this section and these effects have been extensively reviewed^{12;22;23}. A summary of the evidence that TUS has beneficial effects at various stages of the biology of soft tissue injury healing through its thermal and micro-thermal (non-thermal) effects is summarised in Table 1.

Table 1: Scientific evidence that Therapeutic ultrasound (TUS) affects the biology of healing of soft tissue injuries through thermal and micro-thermal (non-thermal) mechanisms ^{12;22}

MECHANISM	STAGE OF INJURY/ HEALING	BENEFICIAL EFFECT OF TUS
Thermal effects	Inflammatory phase	
	Proliferative (repair) phase	Relief of pain and muscle spasm Increase blood flow to the injured area
	Remodelling phase	Increases the extensibility/flexibility of collagen-rich scar tissue
Micro-thermal effects	Inflammatory phase	Alters diffusion rates and membrane permeability Can activate immune cells to migrate to the injured site Can accelerate the inflammatory phase
		Proliferative (repair) phase
	Remodelling phase	Alter collagen fibre orientation

As previously mentioned, the strongest scientific evidence for the use of any treatment modality in clinical practice is based on results from randomised clinical trials (RCT's). In this regard, there is a distinct lack of RCT's that confirm the beneficial effects of TUS in the healing of musculoskeletal injuries in general, and more specifically, soft tissue injuries^{21;24-26}. In one published review from 2001²⁵, only 10 RCT's could be identified where the effects of TUS on musculoskeletal injuries were investigated in well conducted RCT's. In that review, only two clinical trials showed that TUS had any beneficial effects compared with placebo (in calcific tendinopathy of the shoulder, and the carpal tunnel syndrome). It was concluded at that time that there is little evidence that TUS is more effective than placebo in the treatment of patients with either pain in a wide range of musculoskeletal injuries or for promoting soft tissue healing²⁵.

Following that review, a current literature search (using suitable key words) revealed no published clinical trials (between 2002 and 2010) where TUS was used in the treatment of soft tissue injuries in humans. The only studies that were published in this period were studies in which TUS was used in the treatment of experimentally induced muscle²⁷⁻²⁹ and ligament³⁰ injuries in animals. The results of these studies are also not conclusive, with TUS showing potential benefits in reducing oxidative injury following muscle injury in some studies^{27;29}, stimulation of the inflammatory process following an experimentally induced ligament injury in animals³⁰, but no benefit in improving regeneration of muscle following injury in another study²⁸.

In conclusion, there is some scientific evidence, from experiments in animal studies, to suggest that TUS has a variety of biological effects that may positively influence soft tissue healing following injury at various stages (Table 1). However, there is a lack of scientific data from clinical trials in human subjects with soft tissue injuries to confirm that these biological effects translate to improved healing and earlier return to sport. Therefore, more clinical research studies are needed before stronger recommendations on the use of TUS in the treatment of soft tissue injuries in sport can be made.

POTENTIAL NEGATIVE SIDE EFFECTS AND OTHER CONSIDERATIONS IN THE USE OF TUS TO PROMOTE SOFT TISSUE HEALING

There is a substantial body of literature to determine the safety of ultrasound on biological tissues, mainly derived from research on the use of ultrasound as a diagnostic tool. The history of this research, including the studies related to the safety of US, has been reviewed³¹. Furthermore, TUS has been, and still is used extensively by physiotherapists³² without any major reported adverse effects^{12;22}. The special considerations in the use of TUS have also recently been reviewed²² and these include machine calibration, reducing the risk of infection during application of the ultrasound unit, and issues related to the use of the correct "dose" of TUS.

As previously mentioned, the application and biological effects of TUS can vary according to the “dosage” that is used. This has been identified as a possible concern, as there is little consensus on the correct “dosage” of TUS in the treatment of injuries²². However, it appears that particularly the power density (Watts/cm²), duty cycle (continuous treatment is when the TUS delivered with no pulses) and total treatment time are the critical elements in determining the dosage of TUS²². There is also some evidence that pulsed mode US may be more effective than continuous treatment²². Finally, the intervals of treatment sessions have also not been studied well. Most clinical benefits have been shown with regular and more frequent intervals of treatment, rather than infrequent (every 2-4 weeks) treatment intervals²².

CURRENT CLINICAL GUIDELINES FOR TUS IN THE TREATMENT OF SOFT TISSUE INJURIES IN SPORT

There are no well established or clear clinical guidelines on the use of TUS in soft tissue injuries in sport. However, there is evidence that TUS has potential positive biological effects in soft tissue healing and there is also a large body of experiential evidence by physiotherapists that TUS is a therapeutic modality that can be successfully used in the treatment of soft tissue injuries in sport^{12;22}. Furthermore, TUS is generally safe and has no documented adverse effects in soft tissue healing. Therefore, it can be recommended that TUS can be considered as adjunct therapy, mainly in the repair and remodelling phases of healing, following soft tissue injuries. Further clinical research in this area is strongly recommended.

GROWTH FACTORS

INTRODUCTION

In recent years there has been increasing interest in the use of biological products that could potentially improve healing of injured tissues, including soft tissues^{8;33-36}. More specifically, there has been an increased interest in using growth factors that are produced in the body to assist with tissue healing³⁷. There is a particularly high concentration of growth factors in the platelets, and currently, platelet-rich plasma (PRP) is the most commonly used biological product. PRP is one example of an autologous biological product that has been utilised and studied since the 1980's as a possible treatment modality in soft tissue injuries³⁴.

PHYSIOLOGY AND POTENTIAL MECHANISMS THAT PRP INCREASES HEALING OF SOFT TISSUES

Platelets contain a number of proteins and cytokines (in the α -granules), and other bioactive factors (in dense granules) that can initiate and regulate basic aspects of wound healing^{33-35;38}. By concentrating platelets from normal platelet concentrations in blood (150 000 - 350 000/ μ L) to 1 000 000/ μ L, growth factor concentrations in platelet rich plasma can be increased 3-5 times^{33-35;38}. There are a number of cytokines in PRP, including the following: transforming growth factor- β (TGF- β), platelet-derived

growth factor (PDGF), insulin-like growth factor (IGF-I, IGF-II), fibroblast growth factor (FGF), epidermal growth factor, vascular endothelial growth factor (VEGF) and endothelial growth factor^{33-35;38}. Other bioactive factors in the dense granules of platelets include serotonin, histamine, dopamine, calcium, and adenosine – these bioactive factors also affect biologic aspects of healing^{33;34;38}.

SCIENTIFIC EVIDENCE THAT PRP IMPROVES SOFT TISSUE HEALING

The use of PRP in the treatment of soft tissue injuries in sport has, in recent years, received increasing interest. As a result, there have been a number of scientific studies that have been reported where PRP has been used to treat soft tissue injuries in sport. These studies have been case series, non-randomised clinical trials, randomised clinical trials and evidence-based reviews. Furthermore, studies have been conducted in a variety of upper and lower limb soft tissue injuries. The existing evidence for PRP in the treatment of soft tissue injuries in sport is summarised in Table 2. Also included in this Table is a recommendation on the use of PRP in each injury and this is based on an analysis of the existing evidence from these studies.

Table 2: Scientific evidence (according to different types of studies) for the use of Platelet-Rich-Plasma in the treatment of upper and lower limb soft tissue injuries

UPPER LIMB INJURIES						
INJURY	CASES/ CASE SERIES	NON- RANDOMISED TRIAL	RANDOMISED CONTROLLED CLINICAL TRIAL	REVIEW / META- ANALYSIS	COMMENTS	RECOMMENDATION
Lateral epicondylopathy (elbow)	39	40		41	<ul style="list-style-type: none"> 79% improvement following autologous blood injection 93% patients receiving PRP improved at follow-up, small control group⁴⁰ Pilot level evidence⁴¹ 	Possible use (weak evidence)
Intra-operative rotator cuff repair	42				<ul style="list-style-type: none"> Reduced pain an improved function 	Possible use (weak evidence)

LOWER LIMB INJURIES						
INJURY	CASES/ CASE SERIES	NON- RANDOMISED TRIAL	RANDOMISED CONTROLLED CLINICAL TRIAL	REVIEW / META- ANALYSIS	COMMENTS	RECOMMENDATION
Plantar fasciitis / heel pain	43				<ul style="list-style-type: none"> Effective in resolution of symptoms (small case series) 	Possible use (weak evidence)
Mid-portion Achilles tendinopathy	34				<ul style="list-style-type: none"> Reports of positive results³⁴ 	Possible use (no evidence)
Achilles tendon tear		44			<ul style="list-style-type: none"> Improved ROM and early return to activity⁴⁴ 	Possible use (weak evidence)
Patellar tendinopathy (jumper's knee)	33	45			<ul style="list-style-type: none"> Animal studies review³³ Improvement in patients with PRP injections at 6 month follow-up⁴⁵ 	Possible use (weak evidence)
Intra-operative ACL recon	33				<ul style="list-style-type: none"> Review of animal studies³³ 	Possible use (weak evidence)
Acute ankle ligament sprains	33				<ul style="list-style-type: none"> Unpublished results, shortened return to play 	Possible use (weak evidence)
Acute muscle strains	46				<ul style="list-style-type: none"> Animal studies review⁴⁶ Unpublished results of 22 acute muscle injuries in elite athletes, shortened return to play⁴⁶ 	Possible use (weak evidence)

ACL: anterior cruciate ligament

PREPARATION OF PLATELET-RICH-PLASMA (PRP) FROM A BLOOD SAMPLE

PRP can be prepared using anti-coagulated (not clotted) blood that is drawn from an injured player. It is necessary to use blood that is not clotted, because the platelets become part of the clot in clotted blood. The following steps are therefore used to prepare PRP from blood that is drawn from the injured player:

- An anti-clotting agent (anticoagulant) is drawn into a syringe.
- The syringe with the anticoagulant agent is then used and a sample of blood is drawn from the injured player.
- The blood sample is then concentrated by spinning the sample in a centrifuge (once or twice). This separates the red blood cells and white cells from the platelets and plasma.
- The platelet-rich plasma (PRP), which is a specific layer of the sample that has been spun down, is then extracted. A commercially available double-syringe technique is available for this.
- The platelets which are now concentrated in the PRP sample, are “activated” so that they release the growth factors that are stored inside the cells. Platelets can be activated by clotting (clotting leads to release of growth factors from the α -granules – a process known as degranulation).

A number of other methods have also been used to activate platelets and include the following: 1) adding bovine thrombin, 2) adding calcium chloride to initiate the formation of autogenous thrombin from prothrombin, or 3) using type I collagen with PRP to create a collagen –PRP gel), 4) relying on in vivo (in the tissue) tendon collagen (at the site of injection) to induce clotting.^{34;38}

The PRP sample, with activated platelets that have released their growth factors, is then ready for injection into the area where the growth factors are needed to assist the healing of the soft tissue injury.

POTENTIAL NEGATIVE SIDE EFFECTS AND OTHER CONSIDERATIONS IN THE USE OF PRP TO PROMOTE SOFT TISSUE HEALING

There are some contra-indications to the use of PRP in human subjects. These contra-indications include the following³⁸:

- tumour or metastatic disease (cancer that has spread)
- an active infection
- a reduced platelet count
- pregnancy and breastfeeding.

Other special precautions and considerations that must be taken into account are as follows: the dosages of PRP are not yet well-established, the timing of administration is not yet well-established, the use of PRP may enhance mesenchymal stem cell migration and proliferation (theoretical possibility of cancer) or limit the differentiation of cells, preparation techniques are not yet standardised (which means that

concentrations and ratios of growth factors in preparations can vary from patient to patient)⁴⁷.

Furthermore, there are potential side effects when PRP is administered. These side effects include the following^{35;38}: discomfort during injection, acute swelling and pain may develop up to 48 hours after injection, with the use of bovine thrombin coagulopathies (clotting disorders) may develop, and the long-term side effects are not known.

Finally, for athletes that participate where doping considerations are important, the following has to be considered. In the latest WADA 2010 prohibited list of substances it is stated that Insulin-like Growth Factor-1 (IGF-1), Mechano Growth Factors (MGFs), Platelet-Derived Growth Factor (PDGF), Fibroblast Growth Factors (FGFs), Vascular-Endothelial Growth Factor (VEGF) and Hepatocyte Growth Factor (HGF) as well as any other growth factor affecting muscle, tendon or ligament protein synthesis/degradation, vascularisation, energy utilisation, regenerative capacity or fibre type switching are prohibited substances in sport. Platelet-derived preparations (e.g. Platelet Rich Plasma, "blood spinning") administered by intramuscular injection is prohibited but other routes of administration require a declaration of Use in accordance with the International Standard for Therapeutic Use Exemptions.

CURRENT CLINICAL GUIDELINES FOR THE USE OF PRP IN THE TREATMENT OF SOFT TISSUE INJURIES IN SPORT

The clinical efficacy of PRP has not yet been fully established in high-quality clinical trials⁴⁷. Furthermore, the exact timing of administration to assist the injury healing process has not been well determined. Therefore, more research is needed before PRP can be recommended for general use in the treatment of soft tissue injuries in sport. Currently, the guidelines for administration are a dose of 2-3 ml that is injected into the area of injury under diagnostic ultrasound guidance. There is some evidence that 1-3 weekly injections should be given. The practical guidelines for injection are as follows:

- The injured area must be clearly identified at clinical examination and soft tissue diagnostic ultrasound (recommended)
- Ultrasound guided injections are recommended
- The use of local anaesthetics is controversial (local anaesthetics can alter the pH and therefore potentially have negative effect on efficacy)
- The needle size must be at least an 18 gauge needle
- The PRP must be administered over a wide area (multi-planar administration)
- The player must be observed for at least 15-20 min after injection
- Pain killers (analgesia) must be provided for 24-48 hours after the injection and no non-steroidal anti-inflammatory drugs (NSAID's) must be given for about 2 weeks after PRP treatment.

EXTRACORPOREAL SHOCK WAVE THERAPY (ECSWT)

INTRODUCTION

The use of shock wave treatment in medicine dates back to about 20 years ago when this form of treatment was first used to disintegrate kidney stones¹³. These shock waves are generated outside the body using a shock wave generator¹³. Currently there are three different types of shock wave generators that are used: electrohydraulic, electromagnetic and piezoelectric¹³. As the shock wave passes through the tissues, both a direct pressure effect and an indirect shock wave effect can affect tissue biology¹³. The main physiological effects and the potential mechanisms for ECSWT will be briefly discussed.

PHYSIOLOGY AND POTENTIAL MECHANISMS FOR INCREASING HEALING OF SOFT TISSUES

The precise biological effects of shock wave therapy on tissue is not fully understood¹³. However, in recent years it has been established that ECSWT can affect the healing process in a number of different ways. These include the following:

- ECSWT decreases the expression of inflammatory cytokines (IL6) and MMP's (1 and 13) in cultured human diseased tenocytes⁴⁸
- ECSWT stimulates metabolism in tendinous structures (animal study) and this can accelerate healing process in injured tendons⁴⁹
- ECSWT increases neovascularization (new blood vessel formation) in tendons (animal study).⁵⁰

SCIENTIFIC EVIDENCE THAT EXTRACORPOREAL SHOCK WAVE THERAPY (ECSWT) IMPROVES SOFT TISSUE HEALING

Over the past 2 decades, there have been many studies published on the indications and possible therapeutic use of ECSWT in the treatment of soft tissue injuries in sport. The quality of scientific evidence for the use of ECSWT in sports-related injuries varies from cases/case series (weak evidence), to meta-analysis of randomised clinical trials (very good evidence). The existing evidence for the use of ECSWT in the treatment of soft tissue injuries of the upper and lower limbs is summarised in Table 3. Furthermore, recommendations for the use of ECSWT in the treatment of each of these injuries are indicated and are based on an analysis of the existing evidence.

Table 3: Scientific evidence (according to different types of studies) for the use of ECSWT in the treatment of upper and lower limb soft tissue injuries

UPPER LIMB INJURIES						
INJURY	CASES/ CASE SERIES	NON- RANDOMISED TRIAL	RANDOMISED CONTROLLED CLINICAL TRIAL	REVIEW / META- ANALYSIS	COMMENT	RECOMMENDATION
Chronic calcific tendinopathy (shoulder)	51	52	53-60		<ul style="list-style-type: none"> Effective compared with placebo⁵³ Improved pain and function^{51,54,60} Improved symptoms, not affect calcific deposits⁵⁵ Effective in reducing pain^{52,56-58} More effective than transcutaneous nerve stimulation (TENS)⁵⁹ 	Use (moderate evidence)
Lateral epicondylopathy (elbow)			61	62;63	<ul style="list-style-type: none"> Little benefit of ECSWT⁶¹ Little or no benefit^{62,63} 	Not use (good evidence)
Rotator cuff tendinopathy			64		<ul style="list-style-type: none"> No benefit over placebo⁶⁴ 	Not use (weak evidence)

LOWER LIMB INJURIES						
INJURY	CASES/ CASE SERIES	NON- RANDOMISED TRIAL	RANDOMISED CONTROLLED CLINICAL TRIAL	REVIEW / META- ANALYSIS	COMMENT	RECOMMENDATION
Chronic plantar fasciitis / heel pain	65		66-70	71	<ul style="list-style-type: none"> Improved pain, function and quality of life (QOL)⁶⁶ Higher energy density more effective⁶⁷ Effective in reducing pain⁶⁸ Improved pain and function⁶⁹ 71% good or excellent results⁶⁵ Effective (if applied with no prior local anaesthesia)⁷⁰ Effective treatment, small number of quality trials⁷¹ 	Use (good evidence)
Chronic mid-portion Achilles tendinopathy		72	73		<ul style="list-style-type: none"> Effective treatment⁷² Effective treatment when combined with eccentric training⁷³ 	Possible use (moderate evidence)
Chronic insertional Achilles tendinopathy		74	75		<ul style="list-style-type: none"> Effective treatment^{74,75} 	Possible use (moderate evidence)
Medial tibial stress syndrome		76			<ul style="list-style-type: none"> Effective treatment⁷⁶ 	Possible use (weak evidence)
Patellar tendinopathy (jumper's knee)	77	78			<ul style="list-style-type: none"> Satisfactory treatment⁷⁷ Similar outcome to surgery⁷⁸ 	Possible use (weak evidence)
Greater trochanteric pain syndrome		79;80			<ul style="list-style-type: none"> Effective treatment⁷⁹ Effective treatment, better than corticosteroid injection⁸⁰ 	Possible use (weak evidence)
Myositis ossificans	81				<ul style="list-style-type: none"> Some favourable result⁸¹ 	Possible use (weak evidence)

POTENTIAL NEGATIVE SIDE EFFECTS AND OTHER CONSIDERATIONS IN THE USE OF ECSWT TO PROMOTE SOFT TISSUE HEALING

There are a few contra-indications and special precautions to consider in the use of ECSWT. The contra-indications for the use of ECSWT are as follows:

- thrombosis (blood clot)
- disorders of blood clotting (e.g. haemophilia)
- concomitant use of medication that may affect clotting
- the presence of acute inflammation in the treatment area
- the presence of tumours in the treatment area
- gas filled tissue in the treatment area (e.g. lung tissue)
- major blood vessels and nerves in the treatment area
- pregnancy.

The most common side effect is mild pain and discomfort during a treatment session. Other side-effects that may occur during or after a treatment session include skin irritation, petechiae, haematoma and swelling.

CURRENT CLINICAL GUIDELINES FOR EXTRACORPOREAL SHOCK WAVE THERAPY (ECSWT) IN THE TREATMENT OF SOFT TISSUE INJURIES IN SPORT

The scientific evidence, as summarised in Table 3, indicate that there is good evidence that ECSWT can be used to promote soft tissue healing in rugby players with chronic plantar fascial pain and in calcific shoulder tendinopathy. In addition, there are a number of other soft tissue injuries where results of preliminary studies show there is a potential use of ECSWT in soft tissue injuries (Table 3). These injuries include tendinopathies (Achilles tendon, patellar tendon), greater trochanteric pain syndrome, medial tibial stress syndrome and myositis ossificans. However, more clinical trials are required before ECSWT can be recommended as standard treatment for these injuries.

The dose of ECSWT treatment varies for different injuries and anatomical areas but the following are general guidelines for the dose of ECSWT during a treatment session:

- Operating pressure: 1.5 – 2.8 bar
- Operating frequency: 10 - 15 Hz
- Number of impulses per treatment session: 500 (small area) to 3000 (larger area)
- In most injuries, the recommended number of treatment sessions is 3-5 with sessions scheduled a week apart.

SUMMARY

In summary, soft tissue injuries are very common in sport and particularly in rugby. Players with soft tissue injury require a recovery time during which tissue undergoes healing. The biology of tissue healing can potentially be affected by many factors and recently, there is a growing interest in therapeutic modalities that may positively affect this healing process ⁷. In this review, the potential mechanisms, scientific evidence and clinical application of four treatment modalities for soft tissue injuries were reviewed. It is clear that there are some modalities that show promising results, and may well become standard forms of treatment. However, further basic science and clinical research is required to determine the precise role of these modalities in the healing of soft tissue injuries in rugby players.

PRACTICAL APPLICATION: AN EXAMPLE OF A NOVEL TREATMENT MODALITY IN A RUGBY PLAYER

CASE STUDY: EXTRACORPOREAL SHOCK WAVE THERAPY (ECSWT)

A rugby player presents with gradual onset heel pain during and after playing (matches and training). There is no history of an acute injury. The pain is particularly severe early in the morning and subsides after walking for about 20 minutes. However, during rugby practice, and particularly after practices or matches the pain returns.

Clinical examination of the lower limbs shown no significant alignment abnormality, but there is evidence of a collapsed medial longitudinal arch of the foot (flat foot). There is tenderness over the medial (inner) heel area, which is aggravated when stretching the plantar fascia. An X Ray of the foot shows no bony heel spur, but there is evidence of some calcification at the origin of the plantar fascia which is confirmed on soft tissue diagnostic ultrasound. Evidence of a plantar nerve entrapment is excluded.

A final diagnosis of a plantar fascial injury with calcification is made.

In addition to custom-made inserts, the player is advised that Extracorporeal Shock Wave Therapy (ECSWT) may be of benefit in the treatment of this condition with really strong evidence that it is successful. Absolute and relative contra-indications to ECSWT are excluded and the player is then treated weekly, over 5 weeks, using the following ECSWT protocol.

	Week 1	Week 2	Week 3	Week 4	Week 5
Pressure (bar)	1.5	2.0	2.0	2.2	2.5
Number of treatment cycles	2000	2000	2500	2500	3000
Frequency (Hz)	13	13	13	13	13

The player is advised to continue with conditioning but to refrain from weight-bearing sports in the first 3 weeks to allow healing to commence. This period is also utilised to familiarise the player with the new inserts. At each visit, the early morning pain and stiffness is recorded. Once early morning pain has diminished, gradual return to weight bearing activities (including rugby) is commenced under the supervision of a biokineticist.

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