Management of the Injured Tendon: Difficulties in Diagnosis and Treatment. A Systematic Review

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A Systematic Review

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Abstract

Background: Tendon injury is a painful and often debilitating affliction, which commonly presents to the sports medicine professional. Researchers have often struggled to determine the most appropriate way to manage this condition. Despite the plethora of literature on management strategies, there appears to be little stemming from sound scientific evidence. *Objective*: The aim of this is to identify studies that demonstrate a greater understanding of the pathophysiology of tendon injury and evaluate the most effective management strategies for this difficult condition. *Methods*: A systematic review of the literature was conducted. *Results*: The current review found support for the early use of corticosteroid injections, despite long term detrimental effects. The review also demonstrated exercise therapy designed to stretch and strengthen will be more effective in the long term. *Conclusion*: Individuals with tendinopathy should perform a regular strengthening and flexibility regime as early as possible. Patients with pain limiting daily activities may benefit from corticosteroids injections, to allow them to perform activities with reduced pain.

Keywords: Tendon pain, tendinopathy, eccentric exercise, corticosteroid injections, rehabilitation.

Background

Tendon injuries have for many years provided a challenging situation for the sports medicine profession; many conflictions exist regarding the exact nature and pathology to codify this complex injury (Sharma and Maffulli 2008). Tendon injury has either

been classified as acute or chronic, with acute injuries typically involving a sudden rupture, laceration or crush type injury (Curwin 2007). Chronic injuries tend to stem from repetition and overuse, it is this type of injury that has often been difficult to diagnose and manage (Curwin 2007). Research has suggested that chronic tendon injury may account for almost 50-60% of overuse injuries presenting to the sports injury clinic (Selvanetti et al 1997 and Kaux et al 2011), with 30% of all running injuries, thought to be linked to tendon pathology (Sharma and Maffulli 2005). It is an alarming consequence, that despite the high incidence, there appears to be a distinct lack of clarity into the most effective management of the injured patient (Sharma and Maffulli 2008).

The terminology used within the literature is often contradictory, with many researchers still referring to chronic tendon injuries as tendinitis, suggesting that the tendon is inflamed (Andres and Murrell 2008). It has been debated for years that the injured tendon has in fact very little if any inflammatory cells present, therefore the name tendinosis has been thought to be more appropriate (Abate et al 2009 and Rees et al 2009). Tendinosis is described as a degeneration of the collagen within the tendon (Sharma and Maffulli 2005). Much of the latest tendon research has argued that despite the plethora of literature on the topic, the exact etiology and pathology of tendon injuries is unknown. Researchers have suggested that without a histological examination the term tendinopathy would be a more effective classification for this complex injury (Abate et al 2009).

Macroscopically the normal healthy tendon is brilliant white with a fibroelastic texture. A network of parallel collagen fibers embedded within an extracellular matrix, with 90-95% of this matrix is composed of tenoblasts and tenocytes, while the remaining 5-10% consists of chondrocytes (Lin et al 2004 and Sharma and Maffulli 2005). The complex nature of the tendon structure allows it to withstand large forces, which are transmitted between muscle and bone to allow a complex series of movement (Killian et al 2012). Within the tendon a hierarchical structure exists, consisting at the smallest level tropocollagen, fibrils, fibers (primary bundles), fascicles (secondary bundles), tertiary bundles and the tendon itself (Lin et al 2004 and Sharma and Maffulli 2005). Tendons have been found to possess a low metabolic rate, making them more efficient at withstanding load and maintaining tension over an

extended period (Sharma and Maffulli 2005). Nevertheless, despite this tensile strength, overuse and degeneration can occur (Rompe et al 2009). Subsequently when injury does occur, the low metabolic rate of tendons can impose a detrimental impact on healing (Sharma and Maffulli 2005).

Rompe et al (2009) described tendinopathy as "A failed healing response, with haphazard proliferation of tenocytes, some evidence of degeneration in tendon cells, disruption of collagen fibers, and subsequent increase in non collagenous matrix" (p. 463). While this is a good description of the pathology of tendinopathy, there appears to be little in the way of scientific evidence to aid in understanding of the exact pathophysiology of the injured tendon (Alfredson et al 2007). Often when individuals experience tendon pain, they may have been experiencing degenerative changes for a number of weeks or even months prior to the symptoms arising (Abate et al 2009). A number of researchers have identified a phenomenon that describe this, "the iceberg theory" which was originally developed by Fredberg and colleagues (2008) which indicates that the degenerative changes may be happening below the surface and generally pain is commonly experienced at a later stage causing disruption to daily activities, which has been likened to the tip of the iceberg.

The most effective way to manage the injured tendon has sparked much debate within the research. Without a clear understanding of the exact pathophysiology it is understandable why there are no clear management strategies available (Abate et al 2009, Rees et al 2009 and Andres and Murrell 2008). Despite the lack of quality scientific evidence, there appears to be a number of methods proposed, with interventions including eccentric exercise (Allison and Purdam 2009 and Rompe et al 2009), Corticosteroid injections (Newcomer et al 2001 and Peerbooms et al 2010), orthotics (Donoghue et al 2008), and a combination of therapies (Kongsgaard et al 2009).

In this review, a systematic literature search on this specific topic is presented. The aim of this is to identify studies, which will develop a greater understanding of the pathophysiology of tendon injury and evaluate the most effective management strategies for this difficult condition.

Methodology

The following outlines the criteria for considering studies for this review.

Studies

The current review will be limited to Randomized Controlled Studies (RCTs). RCTs have been defined as studies where researchers allocate eligible participants to treatment and control groups on a random basis (Clarke and Oxman 2000).

Participants

This review will include studies containing males and females aged 18-60 with a clinical diagnosis of chronic tendinopathy/tendinosis and tendinitis. To be included in this review participants should have chronic tendon pain, which limits participation in daily and/or sporting activities. Pain in all major tendons will be included (i.e. Achilles, rotator cuff, peroneal, patellar and wrist flexors and extensors). Participants suffering from acute pain subsequently from a tendon rupture will be excluded from this review.

Interventions

Studies evaluating the various treatment strategies for the effective management of chronic tendon injury will be included, interventions including eccentric strength training, Shock Wave therapy, Corticosteroid injections, electrotherapy and other exercise prescription will be considered. All lengths of intervention periods will also be included. Surgical intervention of any kind will be excluded from this review.

Outcome Measures

Outcomes including clinical physiological testing (i.e. % strength increases) and patient self-reporting (e.g. pain reduction and functional improvements measured via interviews/questionnaires) will be included in the review.

Search Methods used to identify studies

Electronic Search

RCTs, meta-analysis and systematic reviews, will be identified by searching the following electronic databases. The studies will be limited to publications from the last 12 years.

- The Cochrane Central Register of Controlled Trials (CENTRAL) 2000-present
- PubMed 2000-present
- Scopus 2000-present

Other Resources

In addition to the electronic search a manual search of the reference lists of the selected studies will be conducted along with a manual search of the British Journal of Sports Medicine, American Journal of Sports Medicine and the Journal of Athletic Therapy from 2000-present.

Data Collection and Extraction

Titles and abstracts of each of the identified studies were screened for inclusion and subsequently the full text was located for further analysis. Irrelevant publications were discarded at this point. The retrieved publications were reviewed further to ensure they conformed to the studies inclusion criteria.

For each of the identified studies the following information was extracted from the study: Study, sample size/group allocation, design, Tendon Injured, procedure, intervention, outcome, and main findings.

Results

A review of the literature revealed 23,699 papers, and once limits were applied 8 papers were included for review. Figure 1 demonstrates the exclusion process for paper selection. A number of papers have been published with the aim of determining

the most effective way to manage the injured tendon, with particular focus on Achilles tendinopathy (Van der Plas et al 2012, Gardin et al 2010 and Rompe et al 2009) and lateral epicondylitis (Smidt et al 2002, Peerbooms et al 2010 and Bisset et al 2006). The most popular intervention strategies within the literature are Alfredson's heel drop eccentric exercise (Van der Plas et al 2012), Corticosteroid Injections (Newcomer et al 2001), Traditional rehabilitation (Smidt et al 2002), Shock wave therapy (Rompe et al 2009) and a combination of therapies (Kongsgaard et al 2009). Table 1 includes an overview of the studies included within the review.

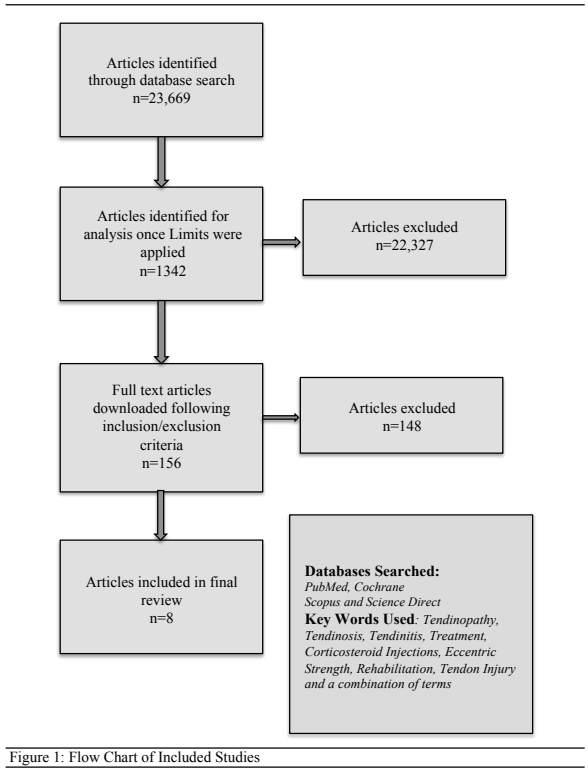

Figure 1: Flow Chart of Included Studies

Eccentric Strength Training

In 1998 Alfredson and colleagues first developed the heel drop exercise program for rehabilitation of achilles tendinopathy, which consists of 180 repetitions per day for 12 weeks. Despite the lack of scientific support for this method of rehabilitation researchers continue to adopt this protocol within their methodology (de Vos et al 2007 and Rompe et al 2009). The volume and intensity, which this protocol is performed, often raises concerns as to what clinical benefit this would pose to the patient. Researchers frequently request that participants perform exercises through pain and discomfort (Rompe et al 2009, Norregaard et al 2007 and Kongsgaard et al

2009), which if an individual has a particularly high pain threshold, would this have a detrimental impact upon the individual? One important issue coming from the current research is the lack of long-term follow-up studies (Van der Plas et al 2012).

Study/Year	Sample Size	Design	Tendon	Procedure	Intervention	Main Findings
Bisset, Beller, Jull, Brooks, Darnell, Vicenzino (2006)	198 Participants aged 18-65 with a clinical diagnosis of tennis elbow (3 Groups: Physiotherapy, Cortisone or wait and see)	RCT	Lateral elbow	Pre and post measures of global improvement, pain free grip force and the assessors rating of severity.	8 sessions of either physiotherapy (8 sessions over 6-wks for 30mins consisting of elbow manipulations and therapeutic exercise. Patients were also given home exercises and taught self manipulations), corticosteroid injections (A local injection of 1ml of 1% lidocane with 10mg triaminolone acetonide in 1ml to painful elbow, Instructed to return to normal activity) or wait and see (reassurance and modification of aggravating activity was given)	Overall 78% of the Injection group indicated success at the 6.wk follow up. 65% of the physiotherapy group indicated success and only 27% of the wait and see group had successful outcomes. At 52 weeks however the injection group were significantly worse than the other 2 groups. the physiotherapy group were significantly better than the wait and see group at the 6.wk follow up, however no differences were found at 52 weeks. the study found short term benefits for the use of physiotherapy and local injections, however in the long term the injections were significantly inferior to the other 2 groups.
Newcomer, Laskowski, Idank, McLean and Egan (2001)	39 participants aged 18-65 with lateral elbow pain (researchers from the study made the diagnosis) (2 groups: rehabilitation with sham injections and rehabilitation with a corticosteroid injection)	RCT	Lateral Elbow	Baseline, 4.wks, 6.wks, 8.wks and 6.mths measures of functional pain questionnaire, VAS, painless grip strength on affected side and maximal grip strength bilaterally	participants were either put into sham injection (Injected with a 5ml of 0.25% Bupivacaine hydrochloride) and the experimental group (Injected with 5ml of a 4:1 solution of 0.25% bipivacaine hydrochloride and Betamethasone (6mg/ml)). Both groups performed daily stretching (wrist flexor and extensors 2xdaily 3 reps of 30secs before and after band exercises) and strengthening exercises (wrist flexor and extensor band strength exercises 2xdaily 3 sets of 10 reps) for 8 weeks. participants also performed 7mins of ice massage 3xdaily. *Strength exercises started 1 week post injections.	The study found no significant differences between the groups other than the experimental group had a significant reduction in pain from the 8 week to 6 month. Due to there being no other significant differences the authors put this finding down to an error. The study found no benefit to the addition of cortisone injections in the treatment of lateral epicondilitis and therefore would not recommend this as a method of treatment. Participants did experience improvements in outcomes following the rehabilitation program.

Table 1: Study details meeting inclusion criteria.

Many researchers have published papers on the effectiveness of the eccentric training protocol, however a distinct lack of high quality papers exist, two RCTs were identified which examined the effectiveness of eccentric exercise on tendinopathy (Norregaard et al 2007 and Rompe et al 2009). Both trials look at the efficacy of eccentric exercise on achilles tendinopathy in 113 participants. All subjects had a clinical diagnosis of achilles tendinopathy prior to commencement of the study, with both studies utilizing the Alfredson heel drop protocol (Alfredson et al 1998). The Norregaard et al (2007) trial compared eccentric exercise with traditional stretching exercises, while the Rompe et al (2009) trial compared it to low energy shock wave treatment (SWT). In the Rompe et al (2009) study, both groups performed the eccentric protocol, whereas the Norregaard et al (2007) paper only one group

performed eccentric training. Rompe and colleagues followed up 16 weeks after the initial intervention, whereas Norregaard had a longer term follow up of a year.

Study/Year	Sample Size	Design	Tendon	Procedure	Intervention	Main Findings
Peerbooms, Sluimer, Bruijn and Gosens (2010)	100 participants with clinically diagnosed lateral epicondylitis. (2 groups: PRP (n=49) (mean age 46.9) and corticosteroid injection(n=51) (mean age 47.3))	RCT	Lateral Elbow	Baseline, 4.8, 12, 26 and 52 weeks post injection measures of VAS and DASH function scale.	Participants were either put into the PRP group (Injected with 27ml of their own blood from the non symptomatic arm with 3ml of sodium nitrate) and the Corticosteroid group (Kenacort 40mg/ml triamcinolon acetonide) Both were combined with bupivacaine hydrochloride 0.5% with epinephrine) Both were injected directly to the area of maximum tenderness and the surrounding tendons. Participants were then instructed to rest for the next 24hrs before commencing 2 weeks of daily stretches followed by 2 weeks of eccentric strengthening exercises. Participants were then allowed to return to their normal sporting activity.	The study found the cortisone group to be better initially only to decline from around 12 weeks, whereas the PRP group had gradual improvements throughout the entire study. The cortisone group were almost back to the pre VAS and DASH function intervention scores. the study concluded that cortisone injections may be a beneficial option in the short term, the PRP injections yielded the best long term outcome.
Smidt, Vanderwindt, Assendelft, Deville, Bos and Bouter (2002)	183 Participants with clinically diagnosed lateral epicondylitis. (3 groups: wait and see (n=59) (age 42-54), Corticosteroid (n=60) (age 41-54) and physiotherapy (n=64) (age 41-52)	RCT	Lateral Elbow	Baseline, 3, 6, 12, 26 and 52 weeks follow up, Primary measures (Main complaint, Day pain, Inconvenience, Severity of elbow complaints, Elbow disability and pain free grip strength) and Secondary Outcome Measures (Maximum grip strength, Pressure pain threshold and patient satisfaction).	Participants were either put into the wait and see group (Participants visited the GP once during the 6 week intervention where they were directed to management strategies to modify aggravating activities. Prescription of paracetamol and NSAIDs were given as necessary, individuals were indicated to await spontaneous improvement. the Corticosteroid group (A local injection of 1ml triamcinoloneaceonide (10mg/ml) and 1ml of lidocane 1%) Patients were injected into tender spots and instructed to avoid pain provoking activities, during the 6 weeks 3 injections 3 injections were required). The physiotherapy group: 9 sessions with a physiotherapist involving pulsed ultrasound, deep friction massage and an exercise program (Progressive, slow and repetitive wrist and forearm stretching, muscle conditioning and occupational exercises) for 6 weeks which intensified in 4 steps.	Overall 92% of the injection group indicated success with 47% in the physiotherapy group and 32% in the wait and see indicating success at the 6.wk follow up. At 52 weeks however the injection group dropped to a 69% success rate, while the physiotherapy group rose to 91% as did the wait and see group who indicated a 83% success rate. the authors found that corticosteroid injections may be beneficial in the short time, however the application of physiotherapy may be more successful in the long term.
Tonks, Pai and Murali (2006)	48 patients with a clinical diagnosis of lateral epicodylitis (4 groups: Observation (n=12) (M age 43.4), Physiotherapy along (n=12) (M age 43.8), Injection alone (n-12) (M age 48.2) and Physiotherapy and injection group (n=12) (M age 41.9))	RCT	Lateral Elbow	Baseline and 7 weeks follow up. Primary outcome measure: PFGS, and Secondary Outcome Measures: Extensor weight strength, pain score of the PRFEQ, the function score of the PRFEQ, the total score from the PRFEQ and any complications of treatments.	Participants were either put into the observation group (where participants received no treatment); Injection therapy only (Single injection of 10mg triamcinolone acetonide and of 2% lignocaine hydrochoride); physiotherapy only group (progressive, slow, repetitive wrist and forearm stretching and muscle strengthening, which was intensified in 4 stages) and finally combination of injection and physiotherapy exercises (as before).	The study found significant improvements in all outcomes in the injection only group, no significant improvements were found within the physiotherapy and the combined physiotherapy and injection groups at the 7.wk follow up.

Table 1: Continued

Study/Year	Sample Size	Design	Tendon	Procedure	Intervention	Main Findings
Norregaard, Larsen, Bieler and Langberg (2007)	45 patients with a clinical diagnosis of achilies tendinopathy. (2 groups: Eccentric group (M age 41) and Stretching group (M age 43))	RCT	Achilies Tendon	Baseline, 3, 6, 9, 12 weeks and 1 year follow up. Outcomes: Manual assessed tenderness, ultrasonography, KOOS questionnaire and Patient global assessment	Participants were either put into the Eccentric Exercise where they performed the heel drop (one round with knee straight and one with it bent) exercises (2-3 sets of 15 repetitions twice daily. Or the stretching group where they performed gastrocnemius and soleus stretches (5 repetitions of 30sec holds.	significant improvements were found within the groups with respect to the KOOS questionnaire, no differences were found however, between the 2 exercise groups at any of the follow ups. Tenderness and the ultrasonography slightly improved after 12.wks, however improvements were significant at the 1 year follow up on all outcomes, with no differences found between exercise groups.
Kongsgaard, Kovanen, Aagaard, Doessing, Hansen, Laursen, Kaldau, Kjaer and Magnusson (2009)	52 recreational male athletes (age 18-50) with a clinical diagnosis of patellar tendinopathy. (3 groups: Cortisone injections (n=12) (M age 34.3), Eccentric decline squat training (n=12) (M age 31.3) and Heavly slow resistance training (n=13) (M age 31.7)	RCT	Patellar Tendon	Baseline, 12 weeks and 6 months follow up. Outcome measures of VISA-p, VAS, treatment satisfaction, tendon swelling, tendon vascularisation, tendon mechanical properties, and collagen cross link properties.	Participants were either put into one of three groups, group 1: Cortisone injections (ultrasounded guided injections of 1ml of 40mg/ml methlprednisolon in 0.5ml lidocain (1%)) into the painful aspect of the patellar tendon. Group 2: Eccentric decline squat training twice daily 3 sets of 15 slow repetitions of unilateral squats on a decline board for 12 weeks. and group 3: Heavy slow resistance training 3 times weekly, three bilateral exercises (squat, leg press and hack squat) 4 sets of between 15repetiton max in week 1 to 6 repetiton max in week 12.	The study found positive short term benefits for all treatment modalities in all outcomes. After the 6month follow up, the ECC and HSR group maintained their improvements, while the CORT group declined significantly. It was also found that the HSR group had reductions in tissue abnormalities and positive changes in the ECM.
Rompe, Furia and Maffulli (2009)	68 patients with a clinical diagnosis of achilies tendinopathy (2 groups: Eccentric group (n=34) (M age 46.2) and Eccentric with shock wave therapy group (n=34) (M age 53.1)	RCT	Achillies Tendon	Baseline, 6 and 16 weeks follow up. Outcomes: VISA-A score, patients general assessment and Pain assessment	Participants were put into one of 2 groups, group 1 consisted of 12 weeks of eccentric heel drop exercises with knee straight and bent, exercises were to be completed twice daily, every day for the 7 weeks performing 3 sets of 15 repetitions of each exercise, participants were instructed to continue through mild to moderate pain. weight could be added when the exercises became easy. after 6 weeks participants were able to return to their previous sports/recreational activity. in group 2 in addition to the eccentric protocol followed by group 1, shock wave therapy was added after 4 weeks, 3 sessions were given at weekly intervals, the session involved 2000 pulses applied at a pressure of 3 bar.	This study found improvements in all outcomes at the 4 month follow up in both groups. The combined eccentric loading and SWT were significantly different than the eccentric exercise alone. The combination of repetitive low energy shock wave treatment had an 82% success rate.

Key: PRP:Platelet Rich Plasma; RCT: Randomised Controlled Trial; VAS: Visual Analogue Scale; NSAID: Non steroidal anti Inflammatories; M: Mean; VISA: Functional Outcome Measure; ECC: Eccentric Strength Group; HSR: Heavy Slow Resistance Training; CORT: Cortisone Injection Group; ECM: Extracellular Matrix; SWT: Shock Wave Therapy; DASH: Disabilities of the Arm, Shoulder and Hand; PRFEQ: The Patient Related Forearm Evaluation Questionnaire; PFGS: Pain Free Grip Strength; KOOS: Knee Injury and Osteoarthritis Outcome Score.

Table 1: Continued

The study by Rompe et al (2009) looked at the effectiveness of eccentric strength training (ECC) compared to the same eccentric protocol combined with shock wave therapy (ECC/SWT) on patients with midportion achilles tendinopathy. The study found that the implementation of a 12 week eccentric exercise protocol had a positive effect on the main outcomes VISA-A (ECC (PRE: 50.6 and 4 Month: 73.0 90% CI 28-100) ECC/SWT (PRE: 50.2 and 4 Month: 86.5, 90% CI 34-100)); Patient general assessment (ECC (PRE: 5.2 and 4 Month: 2.9, 90% CI 1-8) ECC/SWT (PRE: 4.7 and 4 Month: 2.1, 90% CI 1-6)) and finally pain levels (ECC (PRE: 7.0 and 4 Month: 3.9, 90% CI 0-8) ECC/SWT (PRE: 6.8 and 4 Month: 2.4, 90% CI 0-8)). Significant differences were found between groups, the study found that group 2 had significantly

better results at the 4 month follow up on all 3 outcomes (VISA-A (73 vs. 86.5, 90% CI -22.5-5.5, p=.0016); patient general assessment (2.9 vs. 2.1, 90% CI 0.08-1.5, p=.035) and pain (3.9 vs. 2.4, 90% CI 0.5-2.5, p=.0045)).

The Rompe et al (2009) study provides support for the implementation of shock wave therapy alongside eccentric exercise training on patients with achilles tendinopathy, however many limitations exist, including the lack of a control group. Without a control who either performed no exercise and received the SWT or no intervention at all, it is difficult to determine whether the results were due to the adopted protocol or by chance. The above study also looked only at the achilles tendon, which commonly features in much of the eccentric exercise literature. Adoption of the above protocol on alternative tendons may alter the outcome.

Another earlier RCT examining the effects of eccentric exercise on the healing tendon is that of Norregaard et al (2007), which observed the effects of eccentric strength training (ECC) compared to traditional flexibility exercises (FE) on patients with achilles tendinopathy. The study found significant improvements in both groups with regard to overall symptoms in ECC (weeks 6 $p<0.05$; and weeks 9, 12 and the 1 year follow up $p<0.01$) and FE (weeks 3, 6 and 9 $p<0.01$ and week 12 $p<0.05$) only the ECC group had retained significant improvements at the 1-year follow up. With regard to pain significant improvements were found in ECC (weeks 6 and 9 $p<0.05$ and at the 1-year follow up $p<0.01$) and FE (weeks 6, 12 and 1 year follow up $p<0.05$); Joint Stiffness only the ECC group demonstrated a significant improvement in week 9 ($p<0.05$) and with quality of life, saw the FE group gain significant improvements at weeks 6 and at the 1 year follow up ($p<0.05$). With respect to overall symptoms and pain improvements were found in both treatment groups, no significant differences were found between them. The study found that the implementation of either a traditional stretching or eccentric training program would have positive effects on the injured patient. Previous authors utilizing the eccentric protocol have advocated that patients exercise through pain (Alfredson 2003), However the above study did not encourage this, which may explain the similar findings between groups. As with the Rompe study Norregaard and colleagues failed to include a control group, which could affect the application of results to the larger population.

While the Rompe et al (2009) and Norregaard et al (2007) studies provide positive results, the lack of quality RCT studies is alarming, small sample sizes, poor control group allocation. Additionally there appears to be a lack of long-term follow-up studies. While Norregaard et al (2009) did conduct a follow up, participant retention was an issue with only 15 out of the original cohort of 45 were available. Future high quality research is required to strengthen the current body of literature.

Corticosteroid Injections

The use of corticosteroid injections for the treatment of tendinopathy has caused much controversy for many years (Nichols 2005), with much of the research supporting its early use, in the treatment of pain reduction. However the majority of literature has found the long term effects of cortisone injections to be detrimental to the individual (Bisset et al 2006 and Peerbooms et al 2010). Despite this conflicting argument the use of this modality is still widely used in the treatment of tendinopathies (Coombes et al 2010). 6 Randomized Controlled Trials (RCT) were identified which examined the effectiveness of corticosteroid injections on tendinopathy (Kongsgaard et al 2009, Bisset et al 2006, Smidt et al 2002, Tonks et al 2006, Newcomer et al 2001 and Peerbooms et al 2010). 5 of the 6 RCTs are examining the efficacy of corticosteroids on lateral epicondylitis in 570 participants (Bisset et al 2006, Smidt et al 2002, Tonks et al 2006, Newcomer et al 2001 and Peerbooms et al 2010). All subjects had a clinical diagnosis of lateral epicondylitis prior to commencement of the study. Newcomer et al (2001), Tonks et al (2006) and Peerbooms et al (2010) evaluated the effect of 1 injection throughout the trial, while the remaining performed as many as 3 (performed as required by the participant). 3 out of the 5 RCTs compared corticosteroid injections with exercise (mobilization and exercise (Bisset et al 2006) and strength and flexibility training (Smidt et al 2002 and Tonks et al 2006)). The remaining 2 studies compared cortisone to other injections (Placebo (Newcomer et al 2001) and Platelet-rich plasma (Peerbooms et al 2010)). When compared to various outcomes, positive results were demonstrated for the early use of corticosteroid injections in 4 out of the 5 trials, only the Newcomer et al (2001) study didn't support this outcome. 3 out of the 4 papers who compared injections to exercise included a control group (no intervention), and only the Tonks et al (2006) included an injection combined with physiotherapy group.

Bisset et al (2006), Smidt et al (2002) and Tonks et al (2006) evaluate the effectiveness of corticosteroid injections compared to an exercise intervention (eccentric strength and flexibility exercises) and a wait and see (no intervention) protocol. 431 participants with lateral epicondylitis performed interventions over 6 weeks with long term (52 weeks) follow up being completed in the Smidt et al (2002) and Bisset et al (2006) studies. In all 3 studies injections were given at the beginning of the intervention and with exception of the Tonks et al (2006) (one group performed exercise alongside injections) the remaining groups performed an exercise protocol for 6 weeks. The Smidt et al (2002) and Bisset et al (2006) trials compared cortisone injections with traditional physiotherapy exercise (Strength and flexibility) and a wait and see (No intervention). Both studies demonstrated an improvement at 6 weeks in the injection groups, however at the remaining follow ups (12, 26 and 52 weeks) a significant decline in function and increase in pain scores were noted. With regard to the exercise groups, in both studies the physiotherapy group was inferior to the injection groups, at the beginning of the study. However, long-term follow up demonstrated a steady improvement in pain and function levels following exercise.

Another study by Tonks et al (2007) also compared injections to physiotherapy and a wait and see, however they also added a combined physiotherapy and injection group. The study found that at the 7 week follow up the injection alone group had significant improvements in the outcomes pain free grip strength (PRE: 14.75 vs. 7 Weeks: 17.62, 95% CI 0.15-12.33), Pain (PRE: 5.0 vs. 7 Weeks: 2.12, 95% CI 1.59-4.25) and function (PRE: 5.0 vs. 7 Weeks: 1.58, 95% CI 1.25-4.05) no significant improvements were found in the physiotherapy group or the interaction between the injections and physiotherapy. The above study is in agreement with the Smidt et al (2002) and Bisset et al (2006) studies that also found corticosteroid injections beneficial in the first 6 weeks. However without a longer term follow up it is difficult to determine whether the course would follow a similar pattern.

Newcomer et al (2001) and Peerbooms et al (2010) compared the effects of corticosteroid injections with either sham injections or platelet-rich plasma injections respectively. Both studies included 2 groups with sham acting as control in the Newcomer study and PRP in the Peerbooms trial. Alongside the injections both trials included strength and flexibility exercises alongside their injection protocols. In the

Newcomer et al (2001) study significant improvements were noted in outcomes of function, pain and grip strength in both groups. In the Peerbooms et al (2010) study the corticosteroid group improved in weeks 4 and 8 from baseline (VAS: 65.8-42.9 and DASH: 131.2-84.7) from week 12 to 52 the corticosteroid group declined (VAS: 44.2-50.1 and DASH: 92.2-108.4). In contrast the PRP group had steady improvements throughout the length of the study, baseline to 52 (VAS: 70.1-25.3 and DASH: 161.3-54.7). The Newcomer study is the only paper included in this review which disputes the early benefits of corticosteroid use, due to no significance being found when comparing to sham injections, the Peerbooms study however is in agreement with the remaining papers. Although they identified statistically significant support for the early and long-term use of PRP, despite it being a relatively new and expensive procedure. While both the Newcomer and Peerbooms studies evaluate various injection types, it is important to note that the researchers included an exercise protocol, Bisset et al (2006), Smidt et al (2002) and Tonks et al (2006) have demonstrated the long term benefits of exercise on the healing tendon. Consequently this may have had an impact on the results.

Only one of the 6 RCTs evaluated the effectiveness of corticosteroid injections on patellar tendinopathy in 39 patients (Kongsgaard et al 2009). The study compared injections (2 injections) with ECC and heavy slow resistance training (HSR). The study found the corticosteroid group improved from baseline to week 12 (VAS: 58-18 and VISA-p: 64-82) whereas the group had deteriorated at the half-year follow up (VAS: 82-64 and VISA-p: 18-31), the ECC group had improvements from baseline to half-year follow-up (VAS: 59-22 and VISA-p: 53-76) as did the HSR group (VAS: 61-13 and VISA-p: 56-86) the results of the HSR were significantly ($p<0.05$) different at the half-year follow-up.

Despite the controversy, which surrounds the application of corticosteroid injections (Coombes et al 2010), the technique is still widely used. Support for the early use of cortisone was demonstrated in 5 out of the 6 studies, where improvements were noted in the first 6 weeks. All but one of the 6 studies performed follow ups of between 6-months to 1 year. Long-term use of cortisone injections was not supported within this review; all studies, with the exception of Tonks et al (2006) demonstrated declines in function and increases in pain at follow up. Further research is required with stricter

protocols in not only the injections given, but also the exercise protocols. Larger sample groups with more control groups are necessary. The recent Peerbooms study demonstrated some positive outcomes when implementing PRP into tendinopathy management; further examination of this is warranted to further examine the effects of PRP on the healing tendon. Another important point is the focus of research on the upper limb, with 5 of the 6 trials included looking at the lateral elbow.

Discussion

Management of the injured tendon has caused significant debate within the literature, with researchers often disagreeing on the most appropriate terminology and pathophysiology to use (Sharma and Maffulli 2005). Tendon injury often referred to as tendinitis, paratendinitis, tendinosis and tendinopathy can lead to confusion as to the exact pathology and therefore the correct treatment strategy to adopt (Abate et al 2009 and Woodley et al 2007). The current review identified many studies, which evaluated treatment strategies for the injured tendon. Issues existed however when the studies methodologies were examined, it was clear that there was a distinct lack of high quality scientific papers. The results of the current study found the most common methods utilized to manage the injured tendon were eccentric muscle strengthening (Van der Plas et al 2012) and the application of corticosteroid injections (Coombes et al 2010). Despite the conflicting evidence regarding the usage and more importantly the outcomes of both strategies, the treatments are still widely used (Allison and Purdam 2009, Newcomer et al 2001 and Rompe et al 2009). The most common sites for tendinopathy are the knee, ankle and shoulder and elbow (Brukner and Khan 2012). The current review found that in upper limb tendinopathies cortisone injections are most commonly used (Smidt et al 2002, Peerbooms et al 2010 and Bisset et al 2006) and for lower limb, the treatment of choice was eccentric muscle strengthening (Van der Plas 2012, Gardin et al 2010 and Rompe et al 2009).

In eccentric muscle strengthening, Alfredson's protocol is most commonly adopted, with 180 repetitions per day, it has often been described as a controversial procedure. Encouraging patients to complete exercises through pain is not often a method commonly adopted in clinical practice (Rompe et al 2009). Despite this the results of the current review found support for the implementation of eccentric exercise.

However, the lack of quality scientific studies available for review is a concern. Eccentric muscle strengthening has been thought to countervail the poor healing, with the promotion of collagen cross linkage formation, which will promote remodeling (Woodley et al 2007). The studies reviewed looked at eccentric exercise, alongside and compared to other therapies; SWT (Rompe et al 2009) and stretch training (Norregaard et al 2007), both studies found improvements in all interventions, however the Rompe et al (2009) study had significantly better results with the combined SWT and eccentric group. In the Norregaard et al (2007) study No differences were found within the stretching and eccentric groups. Addition of a control group and larger samples may have demonstrated different more significant findings. The length of rehabilitation in eccentric muscle strengthening is typically 12 weeks, where exercises are performed every day. According to the American College of Sports Medicine (ACSM) traditional strength-training protocols require the participant to have at least 24 hours recovery from an exercise session (ACSM Position Stand 2009), this may explain the varying results from studies and the distinct lack of RCTs.

A systematic review by Woodley et al (2007) evaluated the effectiveness of eccentric exercise in chronic tendinopathy. In agreement with the current review they found poor levels of evidence for eccentric exercise and tendinopathy, they found limited support for pain reduction and improvement in function. The study also found predominance in lower limb research, which concurs with the present study. While the present review found improvements in pain and function levels, the limited data presented should alert the reader to proceed with caution when applying results to a client group. The current review found support for eccentric exercise over long term, with poor improvements early on, which subsequently improved as the intervention progressed. One issue that the review indicated was the lack of long-term follow-up, would the effects of eccentric muscle strengthening still be apparent after follow up? A recent study by Van der Plas et al (2012) conducted a 5-year follow up study of the effectiveness of Alfredson's heel-drop exercise program on Achilles tendinopathy. The study found lasting improvements in pain and function at follow up, however complete resolution of symptoms was not found, another limitation of the study found that individuals were not restricted to receiving other therapies, therefore the improvements may not have come from the eccentric exercise alone.

Corticosteroid injections as a treatment for tendinopathy has been around for many years, with the main aim to reduce pain, so that the painful movements are less restricted, assisting in strengthening the area (Smidt et al 2002). The majority of research supports the use of cortisone injections in the early stages of tendinopathy; in agreement with the current study it was found that long-term use of cortisone even after one application had a deteriorating effect on pain levels and function (Peerbooms et al 2010, Smidt et al 2002 and Bisset et al 2006). Only the Newcomer et al (2001) study found no benefit to applying cortisone to the injured tendon. The current review found that early cortisone combined with a strengthening and stretching program had the best long-term effects for the patient. Supporting the theory that cortisone may reduce the pain to allow the patient to perform previously restricted activities (Bisset et al 2010).

The majority of published research on the use of cortisone appears to be on the upper limb, with a particular focus on the lateral elbow (Bisset et al 2006, Newcomer et al 2001 and Peerbooms et al 2010). The reason for the bias towards upper limb is, however unknown. The current review only identified one study that applied injections to the patellar tendon (Kongsgaard et al 2009). Further high quality research is required, which examines the effect of cortisone injections on lower limb tendons. The use of various protocols within studies could explain the poor outcomes, there appears to be a lack of clear procedure into the prescription of injections, with some studies using single injections (Newcomer et al 2001, Tonks et al 2006 and Peerbooms et al 2010) and others using multiples of up to 3 (Kongsgaard et al 2009, Bisset et al 2006 and Smidt et al 2002), in addition there are a number of studies including an exercise protocol alongside the cortisone, with few including control groups. Clearer methodologies are required to strengthen the current body of research.

A recent review published by Coombes et al (2010) into the effect and safety of corticosteroid injections in the management of tendinopathy, is in agreement with the current review Coombes and colleagues found support for the early use of cortisone with a deterioration in pain and function levels indicated during follow ups from as little as 12 weeks. It has often been postulated that application of cortisone injections can cause deterioration within the tendon, which may subsequently lead to rupture

(Coombes et al 2010), neither the current review or the review conducted by Coombes et al (2010) found any support for this, this however should be reviewed with caution as without histopathological examination this theory cannot be discounted (Sharma and Maffulli 2005).

Conclusion

Without a clear histopathological diagnosis it is difficult for the therapist to determine the correct course of treatment for tendinopathy, current research suggests that a combination of therapies may be most effective in the management of this difficult condition. Despite the conflicting evidence, there is an overwhelming support for the early use of corticosteroid injections in the early stages of tendinopathy, with combination of exercise therapy aimed to stretch and strengthen the healing tendon. Eccentric strength training, which aims to re-start the healing process of the injured tendon by repairing the collagen cross-links, has also had conflicting results. Application of the reviewed protocols to upper limb in eccentric exercise and lower limb in cortisone studies is required.

The results of the current study support the early use of cortisone to reduce pain and aid in the commencement of an exercise protocol; a flexibility and strengthening program should commence as soon as possible. This recommendation however required further research and therefore should be reviewed with caution.

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