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FASCIA CONGRESS: CLINICAL METHOD REVIEW

The effect of mechanical load on degenerated soft tissue

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Supraspinatus tendinosis

Summary
Objective: To present a form of therapeutic mechanical load, Graston Technique® (GT)—an instrument-assisted soft tissue mobilization method) in three case studies including supraspinatus tendinosis, Achilles tendinosis, and plantar fasciosis.
Method: In each case study, case history and functional testing confirmed the presence of a condition characterized by degenerated soft tissue. Each condition was treated according to the GT protocol. GT is a patented form of treatment using stainless steel instruments designed with a unique curvilinear treatment edge, contoured to fit various shapes of the body.
Results: The GT method of load deformation to soft tissue resulted in the elimination of pain and normalization of the positive functional tests that revealed the conditions of supraspinatus tendinosis, Achilles tendinosis, and plantar fasciosis.
Conclusion: This method of mechanical deformation load on soft tissue lesions is unique for its ability to both detect and treat areas of degenerated tissue. It deserves further consideration for basic research.

Introduction

Mechanical loading whether by injury, exercise, compression, stretching, friction massage, instrument-assisted soft tissue mobilization, or passive motion affects the extracellular matrix (ECM). The most important cell in the ECM is the fibroblast that when stimulated reproduces the ECM including collagen, elastin, cytokines, and growth factors. Standley (2007) stated that injury strains fibroblasts and fascia in negative ways and in contrast manual muscle treatment (MMT) strains fibroblasts/fascia in curative ways. Both injury and MMT increases the number of fibroblasts in fascia with injury creating pro-inflammatory mediators

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and MMT healing by increasing anti-inflammatory mediators. Recent studies have shown that eccentric exercise for chronically injured Achilles tendinosis resulted in healing due to an increase in type I collagen synthesis (Langberg et al., 2007; Fahlstrom et al., 2003). It appears that there is a direct relationship between collagen metabolism and recovery from injury in human tendons. 'Fibroblast proliferation and activation are key events in the healing process of connective tissue-based structures and are responsible for the gene expression and thereby production of cellular mediators of healing and synthesis of collagen' (Lundon, 2007). It appears plausible that anything that can significantly increase fibroblastic proliferation in the acute or chronic stage of injury may be associated with healing.

While Graston Technique® GT is used to mechanically mobilize scar tissue, increasing its pliability and loosening it from surrounding healthy tissue, it is hypothesized that for degenerated connective tissue GT re-initiates the inflammatory process by introducing a controlled amount of microtrauma to the affected area. A healing cascade is created by enhancing the proliferative invasion of blood, nutrients, and fibroblasts to the region resulting in collagen deposition and eventual maturation (Davidson et al., 1997; Gehlsen et al., 1999). Cyclic mechanical stretching of human tendon fibroblasts has shown to increase the production of prostaglandin E2 and cyclooxygenase expression (Wang et al., 2003). Yang et al. (2005) hypothesized that repetitive, small magnitude stretching was anti-inflammatory, whereas large-magnitude stretching is pro-inflammatory. Since Standley (2007) demonstrated that manual light myofascial treatment was anti-inflammatory an interesting study would be to compare GT from the standpoint of using light versus deep pressure and another study comparing instrument-assisted methods with myofascial release methods.

The term tendinopathy is used as a general term to represent either tendonitis or tendinosis since only biopsy of the tissue can truly differentiate between the two. Current literature describes tendonitis as 'rare' compared with tendinosis (Khan et al., 2000). Histopathologic examination of symptomatic Achilles, patellar, rotator cuff, and elbow tendons do not show inflammatory cells (Khan et al., 1999). In a report on 163 patients with chronic Achilles tendinopathy biopsy studies concluded that tendinosis appeared to be the major lesion in chronic Achilles tendinopathy while the paratenon was rarely involved. Nor does histological evidence support the evidence of inflammation in chronic plantar fascia problems (Wearing et al., 2006). Lemont et al. (2003) performed a histological study on 50 cases of heel spur surgery for chronic plantar fasciitis and concluded that 'plantar fasciitis' is a degenerative fasciosis without inflammation, not a fasciitis. The subject of tendinopathy is still controversial and in a recent review (Fredberg and Stengaard-Pedersen, 2007) concluded that an inflammatory process may be related to the development of tendinopathy and that inflammatory mediators play a role in chronic tendinopathy. In both Achilles and supraspinatus tendinosis, there is a significant decrease in total collagen content and altered collagen cross-linking resulting in an aberrant collagen network similar to fibrosis (De Mos et al., 2007). In chronic Achilles tendinopathy, some fibroblasts may acquire morphological and biochemical features of contractile cells and become Myofibroblasts (Ehrlich et al., 1994). Myofibroblasts create forces required for wound contraction and synthesize abundant amounts of collagen thereby becoming responsible for the formation of permanent scarring and the shrinkage of peritendinous tissue. This connective tissue buildup around the tendon is thought to cause increased intratendinous tension and pressure, resulting in increased friction between the tendon, paratenon, crural fascia, and the skin (Paavola et al., 2002). According to Kraushaar and Nirschl (1999), since tendons have an intrinsic capacity to heal, healing can occur if a fibroblast-driven process integrates old and new collagen in order to contribute to the final stability of the matrix. Khan et al. (2000) state that 'The focus of any conservative management program should be to encourage collagen synthesis, maturation, and strength.' They also state that the time for full recovery for an overuse tendinosis at initial presentation takes 3–4 months compared with an overuse tendinitis that takes several days to 2 weeks (if chronic, 4–6 weeks).

The use of small curved metal tools known as strigils were used on the human body in ancient Greek and Roman baths to scrape dirt and sweat from the body, Gua Sha is a healing technique that originated in Asia. According to Nielsen, Gua Sha website, 'It involves palpation and cutaneous stimulation where the skin is pressured, in strokes, by a round-edged instrument; that results in the appearance of small red petechiae called 'sha,' that will fade in 2–3 days.' Instruments such as soup spoons, coins, or slices of water buffalo horn have been used to remove blood stagnation considered pathogenic, promoting normal circulation and metabolic processes. Gua Sha lets blood from the tissue and is not let from the skin (Nielsen, 2002). Transverse friction massage clinically described by

Chamberlain (1982), Cyriax (1984) was based on the theory of creating a traumatic hyperemia and the prevention of adhesion formation. Recent information of the effect of mechanical load producing fibroblastic proliferation and the creation of new collagen. may be a critical reason for the effectiveness of both friction massage and GT. The use of GT represents a very fine extension of the hands, making them more sensitive in detection and treatment. While there are no studies to compare the sensitivity of the hands versus stainless steel the reverberating qualities of stainless steel become obvious when evaluated.

Instruments (Figure 2) like GT 1 can be used for broad areas and GT 3, GT 6 for localized areas. The instruments are able to distinguish distal fascial restrictions in the kinetic chain, allow patients to feel the restriction along with the practitioner, reduces the time of treatment (Cyriax originally recommended 15–20 min of friction massage) and reduces strain on the practitioner. A frequent complaint of manual therapists relates to repetitive motion injuries to their own bodies (Albert et al., 2007; Snodgrass et al., 2003). The highest report of pain and discomfort to 502 Canadian registered massage therapists occurred mostly in the wrist and thumb. While reports by clinicians using GT about relief of upper body stress is anecdotal an interesting study by Hayes et al. (2007) compared the use of Graston Technique instruments with the metal end of a reflex hammer. They concluded that the specially designed instruments GT were more effective in decreasing discomfort/fatigue. Originally, the GT instruments were modeled from wood and then aluminum, before settling on stainless steel.

TherapyCare Resources, Inc. of Indianapolis, IN, USA, wants prospective users to understand that expertise in GT is much more than the instruments. They offer a package including didactics along with the six instruments. Included are two 12 h modules of instruction. At present (Arnolt, 2008), there are more than 4500 clinicians using GT including more than 550 out-patient physical therapy clinics, chiropractic offices, and the medical staffs of more than 70 professional and amateur sports organizations. GT is currently in the curriculum of most chiropractic colleges and taught as an elective at the Department of Physical Therapy, Indiana University, Indianapolis, IN, USA.

Research

Unfortunately, this paper precludes the presentation of all the research available on instrument-assisted soft tissue mobilization. The interested reader should consult websites such as www.grastontechnique.com and the performance dynamics website for further outcome and case studies. The following are some important studies especially with respect to the effect of instrument-assisted mechanical load on fibroblast proliferation.

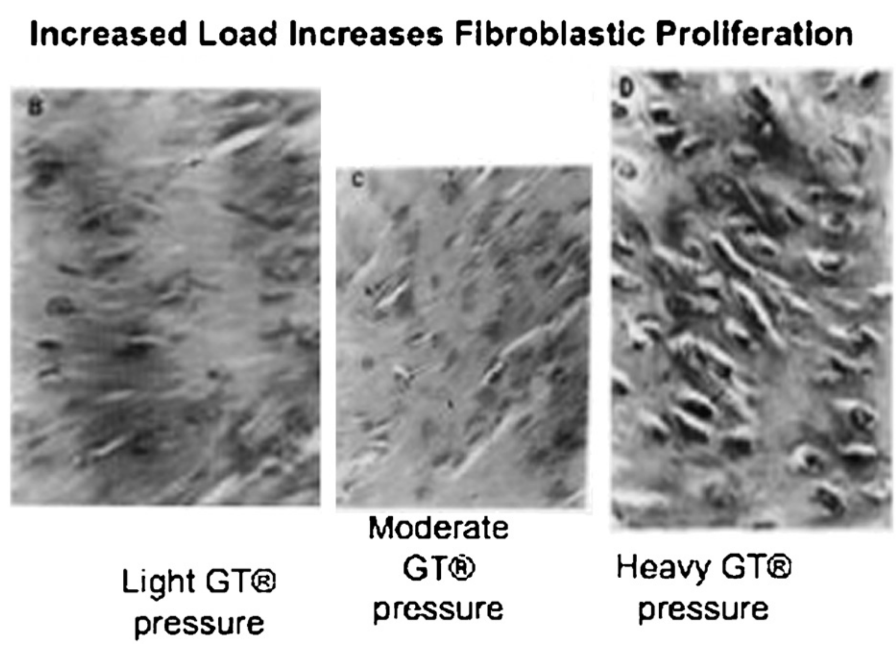

Figure 1 Heavy pressure promotes increased fibroblastic proliferation to a greater degree than light or moderate pressure. Published with permission from the American College of Sports Medicine.

Davidson et al. (1997) used an Augmented Soft Tissue Mobilization (ASTM) technique with metal instruments on the Achilles tendons of rats injected with collagenase into the tendons to create a chronic tendon inflammation. They divided the tendons into Group A: control, Group B: the tendinitis group, Group C: the use of ASTM on the tendinitis group and Group D: use of ASTM on normal tendons. The ASTM was used after allowing 3 weeks of healing, for 3 min every succeeding 4 days on Groups C and D. They hypothesized that ASTM would facilitate tendon healing by the recruitment and activation of fibroblasts. Light microscopy demonstrated that Group C showed the most significant increase of fibroblasts of all the groups. Group B with tendinits and no ASTM showed more fibroblasts than the control Group A and the normal Group D. There was no significant difference between Groups A and D although the Group D (normal tendons) manifested occasional areas with increased numbers of fibroblasts. When fibroblasts actively synthesize collagen, there is the presence of rough endoplasmic reticulum within the cytoplasm. Electron microscopy demonstrated most highly developed rough endoplasmic reticulum in the fibroblasts of Group C.

Gehlsen et al. (1999) also used an enzyme-induced injury with collagenase to create tendinitis and divided the injured rats into five groups: A: tendinitis, B: tendinitis plus light ASTM, C: tendinitis plus medium ASTM, D: tendinitis plus extreme ASTM, and E: control group with surgery only. The Achilles tendons of each group were harvested 1 week after the last ASTM treatment. Treatment consisted of 3 min every 4 days for a total of six treatment sessions. The ASTM massage was given distal to proximal and proximal to distal along the length of the tendon. Cocoa butter was used as a lubricant between the skin and the instruments. Figure 1 depicts fibroblast response related to variation in GT pressure. Heavy pressure promoted the healing process to a greater degree than light or moderate pressure.

Loghmani et al. (2006) investigated the use of instrument-assisted cross fiber massage using Graston Instruments on acute ligament healing. On 20 rats bilateral medial collateral ligaments were surgically transected. Seven days post-operatively GT was used for 1 min to the left MCL, 3 times/week for three weeks for a total of nine sessions. Medium pressure was used. The contralateral limb served as an internal control and was not treated. The ligaments treated with Graston Instrument-assisted cross fiber massage were found to be 31% stronger ($p<0.01$) and 34% stiffer ($p<0.001$) than the untreated ligaments. While ligament healing was accelerated the authors state that 'additional research on the effects of instrument-assisted cross-friction massage on other types of ligament injuries, long-term effects on ligament healing, comparison of treatment interventions and ligament injuries in human subjects is needed.' This study dealt with GT on an acute lesion. Cyriax recommended immediate cross-friction massage of an acute MCL sprain for 15–20 min to prevent the formation of adhesions (Cyriax and Cyriax, 1985).

A prospective multi-center case series of 1004 patients treated with GT for carpal tunnel syndrome, cervical pain, de Quervain's syndrome, epicondylitis, fibromyalgia, IT Band syndrome, joint sprain, lower back pain, muscle strain, painful scar, plantar fasciitis, post fracture pain, and tendinitis. A visual analog scale was used for ratings in four domains: function, pain, numbness, and achievement of treatment goals. For all conditions treated, there was a significant decrease in pain ($p<0.001$) and numbness ($p<0.002$), and increase in function ($p<0.001$). Most patients achieved a high percentage of their treatment goals (Perle et al., 2003).

Method/results

Figure 2 depicts the six patented stainless steel instruments that are designed to adapt to the various tissue/shapes/curves of the body. The benefits of using particular instruments for particular areas of the body plus the strokes used such as brushing, strumming, J-stroke, sweeping, framing, swivel, fanning, and scooping are taught in Module I. The protocol for GT is shown in Table 1. Stretching is important for fostering proper alignment of new connective tissue and helps to lengthen shortened muscle groups. Toyda et al. (1999), Buckley et al. (1988) demonstrated that cells align to the direction of the tensile load by reconstructing their cytoskeleton.

Bruising is not necessary for GT to be effective. It is hypothesized (Carey, 2006) that bruising may occur due to localized microtrauma and associated scar tissue breakdown. Scar tissue and adhesions are poorly vascularized and as it separates from healthy tissue the capillaries that have infiltrated the scar may rupture. The patient should be apprised of this possibility in advance of treatment. The bruise usually dissipates within 3 days which is a reason most GT treatments are given only 2 times per week in the same area. Bruising and the release of restrictions is often regarded as a positive sign towards healing so tissue remodeling and strengthening can occur without the constraint of the restriction. Anecdotally clinicians have found that post-bruising usually results in more rapid healing of the patient. Module I (initial 12 h) offered by TherapyCare Resources (Carey, 2006) includes a list of red and yellow flags regarding contraindications to use of GT (see Table 2).

This paper deals with some case studies emphasizing the functional testing of a lesioned area and treatment by GT. Case studies unfortunately beg for larger cohort studies and the time required for healing in each of the following case studies relates only to these specific cases. Outcome studies can be found at the websites listed above. Complete discussion of etiology, pathophysiology, and differential diagnosis of the following case histories is beyond the scope of this paper.

Figure 2 6 Graston Technique® instruments.

Case study: supraspinatus tendinosis

A 45-year-old female presented with anterior shoulder pain of 4 weeks duration. There was no past history of shoulder pain or trauma to the area. Patient exercises three times a week and recently increased weight lifting for the upper extremity. Examination revealed a stable shoulder including negative labral tests. There were no associated cervical spine findings referring to the shoulder area. Positive functional tests included pain and slight weakness on resisted abduction at 90° in the scapular plane with the thumb up (supraspinatus). The supraspinatus is first tested without scapular retraction (Hammer, 2007). If the muscle tests stronger with scapular retraction (Figure 3) then the scapular muscles are considered weak and a possible reason for a weak supraspinatus. An active and passive painful arc (pain between 60° and 130°

Table 1

GT® PROTOCOL

Procedure	Rationale
Tissue warm-up At least 3–5 min of either: Local tissue exercise Moist heat Ultrasound Or 10–15 min of cardiovascular	Increase blood flow and tissue heating
Use of GT: 2 treatments per week on same area. 30 s to 1 min for localized lesion 3–5 min for local region (i.e., shoulder) 8–10 min for treatment of all areas combined	Break up soft tissue restriction; create new extracellular matrix
Stretching: Immediately after GT 1–3 30 s stretches Mattes Active Isolated Stretching[a] (2 sets of 12)	Lengthen shortened structures; realign fibers
Strengthening: High-repetition, low-load one to two sets of 15; isotonic rubber tubing, eccentric contraction Cryotherapy (if necessary)	Strengthen weak or lengthened structures Minimize post-treatment inflammation, soreness, and bruising

[a] Mattes (2000).

Table 2

RED FLAGS: absolute contraindications
Open wound-unhealed suture site/sutures
Thrombophlebitis
Uncontrolled hypertension
Kidney dysfunction
Patient intolerance/non-compliance/ hypersensitivity
Hematoma
Osteomyelitis
Myositis ossificans
YELLOW FLAGS: relative contraindications
Anti-coagulant medications
Cancer
Varicose veins
Burn scars
Acute inflammatory conditions i.e., synovitis
Inflammatory condition secondary to infection
Acute rheumatoid arthritis

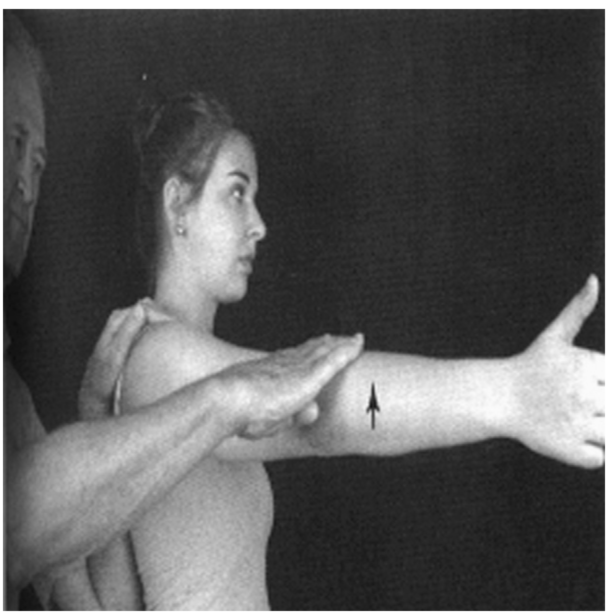

Figure 3 Testing of supraspinatus with scapular retraction.

abduction in the scapular plane) was present indicating involvement of the bursal side of the supraspinatus insertion. Pain (active or passive) at end-range abduction indicated possible involvement of the underside (articular side) of the supraspinatus (Hammer, 2007). There was significant tenderness at the musculotendinous portion. With regard to the use of GT, the patient is positioned and treated with their shoulder in extension and medial rotation to better expose the insertion area (Figure 4).

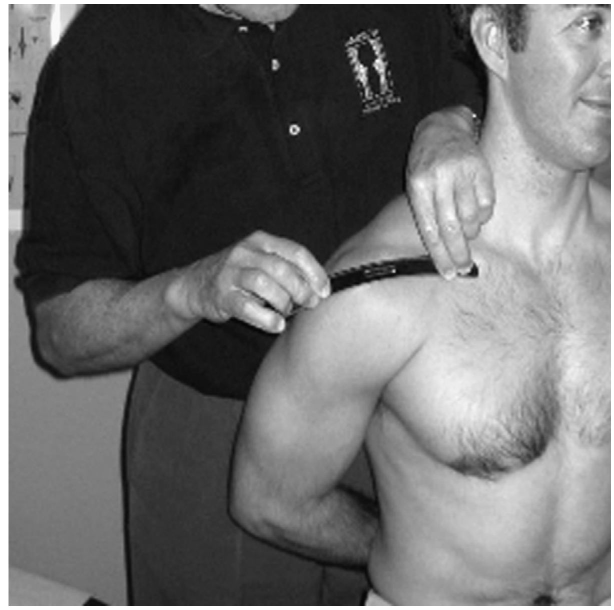

Figure 4 GT 5 for supraspinatus insertion.

Practitioners report that improved clinical results seem to occur when using GT with perturbation or motion (Figure 5) that is for example having patients use a theraband during treatment. The shoulder girdle may also be tested by the patient resisting anterior, posterior, inferior, and superior motion to help find additional associated painful fascial restriction areas. In this case, there was pectoral pain on resisted anterior motion of the shoulder (Figure 6). Additional areas of treatment included (Figure 7), the musculotendinous area; (Figure 8) the pectoral area; and (Figure 9), the dorsal axillary shoulder fascia. Patient was seen two visits per week for 5 weeks and discharged asymptomatic with normal functional testing of the positive tests. Originally, friction massage for the supraspinatus insertion was concentrated near the greater tuberosity tenoperiosteal area (Cyriax and Cyriax, 1985) but based on findings of additional supraspinatus insertion sites, it is important to use GT over a larger area. According to new anatomical findings by Clark (1992) the supraspinatus interdigitates with the infraspinatus laterally, has a slip that forms a roof over the biceps tendon and intermingles with fibers of the subscapularis tendon beneath the biceps tendon. All of these insertional areas must therefore be considered and treated.

GT protocols were followed. Internal and external shoulder stretches based on Mattes technique (Mattes, 2000) were performed immediately after GT and taught to the patient for home treatment. Painless isotonic rubber tubing exercises for the rotator cuff muscles were given within

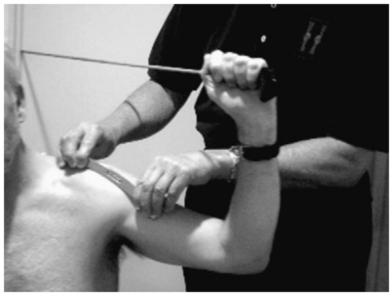

Figure 5 GT 5 of supraspinatus insertion area during external rotation with motion or perturbation.

Figure 6 Shoulder protraction revealed pain in pectoral area.

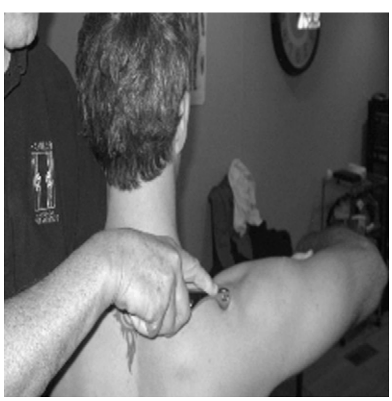

Figure 7 GT 2 for musculotendinous portion of supraspinatus. The shoulder must be elevated 90° to treat this area.

a week followed 2 weeks later by a series of cuff exercises (dumbbells maximum weight up to 5 pounds without pain) two sets of 15. Exercises for scapular stabilization were prescribed.

Case study: Achilles tendinosis

A 46-year-old athletic male (tennis, jogging) presented with a 4-month history of gradual increased

Figure 8 Treating the pectoral fascia with GT 4.

Figure 9 Treating the dorsal axillary shoulder fascia with GT 4.

Achilles pain and morning ankle stiffness. There is a good correlation between the severity of the disease and the degree of Achilles morning stiffness. Tendinopathy typically presents with pain 2–6 cm proximal to the tendon insertion after exercise. The patient noticed that there was increased pain at the beginning and end of a run, with a period of decreased pain in between. He felt that the painful right tendon appeared 'slightly thicker' than the non-painful side. A tender, nodular swelling was present in the middle third which is believed to signify tendinosis (Galloway et al., 1992). The central portion of the tendon is the least well perfused and the most vulnerable to ischemic insult (Galloway et al., 1992). Functional testing revealed decreased ankle dorsiflexion and shortening of the hamstrings and triceps surae on the right-hand side compared with the left. The chronic tendinosis must be differentiated from the acute phase where there is diffuse swelling and increased tenderness. It is important to note that there may be a combination of an acute section and chronic degeneration, occurring in two separate areas. The paratenon that surrounds the tendon is where the inflammation occurs and may occur along with degeneration of the body of the tendon, but the major degenerated lesion in chronic Achilles tendinopathy is located at the central tendon (Astrom and Rausing, 1995).

The Graston Technique® instruments are first used to scan for all areas of restricted fascia found on examination including the hamstrings, triceps surae and local areas of the ankle including the body of the Achilles tendon and paratenon. Increased thickness and palpatory tenderness is often found on the anterior border of the medial central portion of the tendon (Figure 10); posterior crural fascia (Figure 11). Figure 12 depicts testing for gastrocnemius shortening. Figure 13 demonstrates GT for the gastroc/soleus and related fascia. The hamstring areas must be investigated as part of the kinetic chain. GT treatment of the hamstrings can be done with active motion (Figure 14), and during contraction (Figure 15).

Figure 10 GT 6 on anterior medial portion of Achilles tendon.

Figure 11 GT 4 for posterior crural fascia.

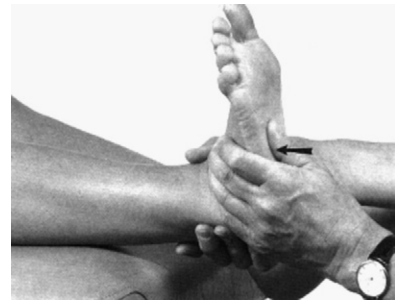

Figure 12 Testing gastrocnemius for shortness.

Figure 13 Treating gastroc/soleus using GT 5.

Figure 14 Treating hamstrings during active motion using GT 1.

Perturbation methods that increase pain are valuable in allowing the practitioner to find associated painful areas in the kinetic chain. For example, determining areas of pain while a patient stands on a stair and eccentrically stretches the area. All of these methods were used and followed by stretching in the office and with eccentric stretching at home. This patient was treated twice per week for 6 weeks and discharged asymptomatic. There was normal range of motion of foot dorsiflexion, the gastoc/soleus and decreased thickness of the central portion of the tendon.

Case study: plantar fasciosis

A 50-year-old female presented with the typical plantar symptoms of heel pain that extended distally to the arch of the foot. As in most cases,

Figure 15 Treating hamstrings during contraction with GT 4.

pain occurred during the first steps after rising in the morning. Pain had gradually increased over a 3-month period. In this case, pain increased during the day and decreased in the afternoon. Weight-bearing exercise aggravated the foot but at times the pain improved as the tissue warmed up. Palpation revealed focal tenderness at the medial calcaneal origin of the plantar fascia and medial arch. Examination revealed tightness of the triceps surae and Achilles tendon on the painful side resulting in decreased ankle dorsiflexion compared with the normal side. Examination found a pes planus foot type and lower-limb biomechanics creating a lowered medial longitudinal arch resulting in excessive tensile strain of the fascia. Degenerative changes that occur in the plantar fascia have also been linked to vascular and metabolic disturbances, the formation of free radicals, hyperthermia, and genetic factors (Wearing et al., 2006). The effect of GT on reducing pain by decreasing fibrosis might be based on the fact that the pain in the plantar fascia is related to the amount of fascial thickness. It was found by sonographic measurement that the plantar fascia of a symptomatic foot was thicker than the plantar fascia of the asymptomatic foot. In the symptomatic foot fascial thickness positively correlates with abnormal arch angle and peak regional loading of the midfoot (Wearing et al., 2007). GT assessment always includes assessing the related kinetic chain for shortness and fascial restrictions including the Achilles, triceps surae to the hamstrings and also the anterior and lateral thigh and leg musculofascial areas. The Achilles tendon is often restricted in dorsiflexion. It has been found that increased tension on the Achilles tendon relates to increased strain on the plantar fascia and

Figure 16 GT 3 treating calcaneal fascial origin.

stretching of tight Achilles tendon is a plausible mechanical factor for overstraining of the plantar fascia (Cheung et al., 2006). After palpating for areas of tenderness on the foot and surrounding kinetic areas the practitioner scans the lower limb and foot with one of the instruments to determine where major fascial restrictions are present. GT was directed at similar areas described for Achilles tendinosis. GT detected restrictions at the calcaneal fascial origin (Figure 16) and distal plantar fascia (Figure 17). Along with the use of GT, stabilization of mechanical factors such as taping and orthotics should be considered. This patient received 12 treatments over a 6-week period and was advised to obtain orthotics. Stretching of the posterior calf muscles and Achilles tendon were performed at home and in the office. In this case, the patient discontinued care due to an insurance problem but stated that she was 95% better. She no longer complained of morning pain but stated that every so often she was aware of slight discomfort. There was minimal to no tenderness over the medial calcaneal origin and arch. The instruments detected minimal fascial restriction compared to

Figure 17 GT 6 treating distal plantar fascia.

the initial visit. Equal range of dorsiflexion compared with the asymptomatic foot was present.

Conclusion

The failure of collagen remodeling in tendinosis is one of the main detriments to healing. Healing can occur if a fibroblast-driven process occurs that integrates old and new collagen (Kraushaar and Nirschl, 1999). It is well established in the literature that many types of mechanical loads reproduce the ECM by the production of fibroblasts. Some questions that must be answered is how does GT compare with other instrument-assisted methods, how does GT compare with other varieties of manual techniques. What is the effect of mechanical load on acute versus chronic injuries? Further studies could determine the amount of load necessary and how it might be related to the production of pro- or anti-inflammatory mediators. It is possible that the direction of the load might influence the chemistry (Standley, 2007). Studies that compare treatment of pre-biopsied degenerated areas with post-treatment are important. Graston Technique® is not meant to replace a clinician's hands but rather to complement them and to be combined with all other soft tissue techniques and methods of rehabilitation that have proven to be useful.

References

Albert, W.J., Currie-Jackson, Duncan, C.A., 2007. A survey of musculoskeletal injuries amongst Canadian massage therapists. Journal of Bodywork and Movement Therapy 12, 86–93.

Arnolt, M., 2008. President of Therapy Care Resources, Indianapolis, Ind. (personal communication).

Astrom, M., Rausing, A., 1995. Chronic Achilles tendinopathy. A survey of surgical and histopathologic findings. Clinical Orthopaedics Related and Research 316, 151–164.

Buckley, M.J., Banes, A.J., Levin, L.G., et al., 1988. Osteoblasts increase their rate of division and align in response to cyclic, mechanical tension in vitro. Bone and Mineral 4, 225–236.

Carey, M.T., 2006. Graston Technique® Training Manual, Therapycare Resources.

Chamberlain, G.J., 1982. Cyriax's friction massage: a review. Journal of Orthopaedic and Sports Physical Therapy 4 (1), 16–22.

Cheung, J.T., Zhang, M., An, K.N., 2006. Effect of Achilles tendon loading on plantar fascia tension in the standing foot. Clinical Biomechanics (Bristol, Avon) 21 (2), 194–203.

Clark, J., 1992. Tendons, ligaments, capsule of the rotator cuff. Journal of Bone and Joint Surgery 74 (A), 713–725.

Cyriax, J., 1984. Textbook of Orthopaedic Medicine. Bailliere-Tindall, London.

Cyriax, J., Cyriax, P., 1985. Illustrated Manual of Orthopaedic Medicine. Butterworths, London, pp. 87–110.

Davidson, C.J., Ganion, L.R., Gehlsen, G.M., et al., 1997. Rat tendon morphologic and functional changes resulting from soft tissue mobilization. Medicine Science and Sports and Exercise 29, 313–319.

De Mos, M., van El, B., DeGroot, J., et al., 2007. Achilles tendinosis: changes in biochemical composition and collagen turnover rate. American Journal of Sports and Medicine 35 (9), 1549–1556.

Ehrlich, H.P., Desmouliere, A., Diegelmann, R.F., Cohen, I.K., et al., 1994. Morphological and immunochemical differences between keloid and hypertrophic scar. American Journal of Pathology 145, 105–113.

Fredberg, U., Stengaard-Pedersen, K., 2007. Chronic tendinopathy tissue pathology, pain mechanisms, and etiology with a special focus on inflammation. Scandinavian Journal of Medicine Science Sports 18, 3–15.

Galloway, M.T., Jokl, P., Dayton, O.W., 1992. Achilles tendon overuse injuries. Clinics Sports Medicine 11, 771–782.

Gehlsen, G.M., Ganion, L.R., Helfst, R., 1999. Fibroblast response to variation in soft tissue mobilization pressure. Medicine and Science in Sports and Exercise 31 (4), 531–535.

Hammer, W. I., 2007. Functional Soft Tissue Examination and Treatment by Manual Methods, third ed. Jones & Bartlett, Sudbury, MA, pp. 33–161.

Hayes, D., Loghmani, M.T., Lubitz, R., Moore, E., 2007. A comparison of 2 instrument-assisted soft tissue mobilization techniques: effects on therapist discomfort/fatigue and treatment time. Journal of Orthopacdic and Sports Physical Therapy 37 (1) orthopaedic section abstracts: OPL19:A17.

Khan, K.M., Cook, J.L., Bonar, F., et al., 1999. Histopathology of common tendinopathies: update and implication for clinical management. Sports Medicine 27 (6), 393–408.

Khan, K.M., Cook, J.L., Taunton, J.E., et al., 2000. Overuse tendinosis, not tendonitis. Part 1: a new paradigm for a difficult clinical problem. Physics and Sportsmedicine 28, 38–48.

Kraushaar, B.S., Nirschl, R.P., 1999. Tendinosis of the elbow (tennis elbow). Journal of Bone and Joint Surgery 81-A (2), 259–276.

Langberg, H., Ellingsgaard, H., Madsen, T., et al., 2007. Eccentric rehabilitation exercise increases peritendinous type I collagen synthesis in humans with Achilles tendinosis. Scandinavian Journal of Medicine and Science in Sports 17, 61–66.

Lemont, H., Ammirati, K.M., Usen, N., 2003. Plantar fasciitis: a degenerative process (fasciosis) without inflammation. Journal of the American Podiatric Medical Association 93 (3), 234–237.

Loghmani, M.T., Avin, K., Burr, D., Warden, S., 2006. Instrument-assisted cross-fiber massage accelerates knee ligament healing. Orthopaedic Section Abstracts: Platform Presentations

#17. Journal of Orthopaedic and Sports Physical Therapy 36 (1), A7.
Lundon, K., 2007. The effect of mechanical load on soft connective tissues. In: Hammer, W.I. (Ed.), Functional Soft-tissue examination and Treatment by Manual Methods, third ed. Jones & Bartlett, Sudbury, MA, pp. 33–161.
Mattes, A.L., 2000. Active Isolated Stretching: The Mattes Method. Aaron L Mattes PO Box 17217, Sarasota, FL 34276-0217, USA.
Nielsen, A. Gua Sha website: 〈http://www.guasha.com/〉.
Nielsen, A., 2002. Gua Sha A Traditional Technique for Modern Practice. Churchill Livingstone, Edinburg.
Paavola, M., Kannus, P., Jarvinen, T., Khan, K., et al., 2002. Current concepts review: Achilles tendinopathy. Journal of Bone and Joint Surgery 84-A (11), 2062–2076.
Perle, S.M., Perry, D.G., Carey, M.T., 2003. Effects of Graston Technique on soft tissue conditions: a prospective case series. In: WFC's seventh Biennial Congress, Orlando, FL, World Federation of Chiropractic, pp. 344–345.
Snodgrass, S.J., Rivett, D.A., Chiarelli, P., Bates, A.M., et al., 2003. Factors related to thumb pain in physiotherapists. Australian Journal of Physiotherapy 49 (4), 243–250.
Standley, P., 2007. Biomechanical strain regulation of human fibroblast cytokine expression: an in vitro model for myofascial release? Presentation at Fascia Research Congress, Boston, DVD from 〈www.fasciaresearch.com〉.
Toyda, T., Saito, S., Inokuchi, S., Yabe, Y., 1999. The effects of tensile load on the metabolism of cultured chondrocytes. Clinical Orthopacdics and Related Research 359, 221–228.
Wang, J.H., Yang, J.F., Yang, S., et al., 2003. Cyclic mechanical stretching of human tendon fibroblasts increases the production of prostaglandin E2 and levels of cyclooxygenase expression: a nove in vitro model study. Connective Tissue Research 44 (3–4), 128–133.
Wearing, S.C., Smeathers, J.E., Urry, S.R., Hennig, E.M., Hills, A.P., 2006. The pathomechanics of plantar fasciitis. Sports Medicine 36 (7), 585–611.
Wearing, S.C., Smeathers, J.E., Sullivan, P.M., Yates, B., Urry, S.R., Dubois, P., 2007. Plantar fasciitis: are pain and fascial thickness associated with arch shape and loading? Physical Therapy 87 (8), 1002–1008.
Yang, G., Im, H.J., Wang, J.H., 2005. Repetitive mechanical stretching modulates IL-1beta induced COX-2, MMP-1 expression, and PGE2 production in human patellar tendon fibroblasts. Gene 363, 166–172.