USE OF THE GRASTON TECHNIQUE® IN CLINICAL PRACTICE BY CERTIFIED ATHLETIC TRAINERS

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

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ABSTRACT

The Graston Technique® is a common treatment that combines a warm-up, Instrument Assisted Soft Tissue Mobilization (IASTM), stretching, and strengthening protocols. The treatment is commonly chosen by clinicians to treat musculoskeletal injuries. The purpose of this study was to determine how the Graston Technique® is used in clinical practice by certified athletic trainers to compare to recommendations made by the Graston Technique®. Factors such as time, expense, lack of training in the Graston Technique®, availability of resources, and an overall lack of evidence-based recommendations may have influenced inconsistencies in clinical practice. Although the technique is not always performed according to recommendations, these findings suggest both clinicians and patients report objective and subjective improvements when treating musculoskeletal pathologies regardless of the techniques used.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF APPENDIX FIGURES

CHAPTER 1. INTRODUCTION

The Graston Technique® is a form of Instrument Assisted Soft Tissue Mobilization (IASTM) that combines soft tissue mobilization with stretching and strengthening protocols. The purpose of the Graston Technique® is to reduce adhesions and restrictions that result from musculoskeletal injury.[1] The Graston Technique® is indicated for pathologies such as epicondylitis, tendinopathies, sprains, strains, localized pain, or restricted range of motion.[1] Treating these dysfunctions may also reduce pain and increase range of motion which may improve comfort and functionality for patients.[1]

To begin the treatment, a warm-up is performed to prepare the tissues prior to using the Graston Technique® instruments. The warm-up also assures optimal nutrient and blood flow to the target tissues.[1] Next, a variety of stainless steel instruments are used with varying strokes and pressures to reach both deep and superficial structures.[1] Sweeping, fanning, brushing, strumming and the J-stroke encompass the strokes performed with the six Graston Technique® instruments. The Graston Technique® instruments were developed with the contours and joint shapes of the body in mind and fall into two categories: convex or concave.[1] The use of a convex surface on a concave body part allows for equal dispersal of pressure as the instrument glides over the area. The dispersal of pressure allows for greater patient comfort since the instrument is gliding over a larger treatment surface. In addition, a convex instrument allows for greater precision in the treatment area. When using a convex instrument over a convex body part, maximum pressure is localized in one area. Although this allows for greater precision, it is often less comfortable for the patient. A recommended Graston Technique® treatment time with the instruments is 8-10 minutes.[1] Stretching is used immediately following to enhance mobilization in the tissue. Then, establishing proper electrical signaling with strengthening exercises is attempted to trigger biological responses stimulating repair.[1] Strengthening is ideally performed with low load and high repetition exercises to the target tissue. This model reinforces the SAID principle and may help stimulate repair.[17] The Graston Technique® incorporates as much active treatment as possible to ensure the body positively adapts to the stresses and changes applied. It is recommended the Graston Technique® be performed with at least 72 hours between treatments.[1] Resolution of pathologies should take approximately eight treatments.[1]

Statement of the Problem

Although having many recommendations on the use of the instruments, strokes, and pressures, research on how the Graston Technique® is used clinically by medical professionals has not been studied. The Graston Technique® is meant to be taught the same way to all clinicians, but the methodology of previous research shows inconsistencies. Without studies on how the Graston Technique® is applied to clinical practice, it is difficult to ensure the treatment is performed according to recommendations.

Purpose of the Study

The purpose of this study was to determine how the Graston Technique® is used in clinical practice by certified athletic trainers to compare to recommendations made by the Graston Technique®.

Research Questions

1. What training do certified athletic trainers have in the Graston Technique®?
2. What pathologies do clinical ATs treat with the Graston Technique®?
3. What elements of the recommended Graston Technique® protocol do clinical ATs perform?

Definition of Terms

Anechoic: tissue that appears black on diagnostic ultrasound such as simple fluid or seroma.[2]

Anisotropy: an artifact that occurs when the transducer is not perpendicular to the tissues causing structures to appear more hypoechoic than normal.[2]

Brushing: a Graston Technique® stroke in which a local pressure is used to scan and desensitize small areas, as well as prepare the tissues for deeper treatment.[1]

Echogenicity: the ability of a tissue to reflect ultrasound waves based on density and water content of the tissue[2]

Fanning: a Graston Technique® stroke in which the contact points of the instrument are moving at different rates in an arched path.[1]

Hyperechoic: greater echogenicity resulting in the bright appearance of higher density tissues such as tendons, ligaments, and bone on diagnostic ultrasound.[2]

Hypoechoic: lesser echogenicity resulting in the dark appearance of low density tissues or tissues with higher water content, such as muscle, on diagnostic ultrasound.[2]

IASTM: Instrument Assisted Soft Tissue Mobilization is a type of soft tissue mobilization in which the clinician performing the technique uses tools or instruments to stimulate the healing process.[3]

Isoechoic: equal echogenicity within tissues on diagnostic ultrasound.[2]

J-stroke: a Graston Technique® stroke that is used to mobilize deep and superficial restrictions and is performed in a J-shaped pattern.[1]

Strumming: a Graston Technique® stroke in which deep, linear strokes of small amplitude are performed perpendicular to the tissues to mobilize specific restrictions in the tissues.[1]

Sweeping: a Graston Technique® stroke in which the contact points of the instrument are maintained at a constant rate moving in one direction in a linear or curvilinear path.[1]

Tendinitis: inflammation of a tendon.[4]

Tendinosis: degeneration of the tendon caused by untreated inflammation and repetitive stress.[4]

Assumptions

1. It was assumed that participants were clinical certified athletic trainers who were members of the National Athletic Trainers' Association.

Limitations

1. The amount of previous knowledge with the Graston Technique® may have impacted participant's perception of the survey.
2. A self-report survey was used which could lead to bias.
3. A pilot study was not performed prior to the current study.

Delimitations

1. Participants were recruited through the National Athletic Trainers' Association.

CHAPTER 2. REVIEW OF LITERATURE

The purpose of this study is to determine how the Graston Technique® is used in clinical practice by certified athletic trainers to compare to recommendations made by the Graston Technique®. The research questions that will guide the study are: 1) What training do certified athletic trainers have in the Graston Technique®? 2) What pathologies do clinical ATs treat with the Graston Technique®? 3) What elements of the recommended Graston Technique® protocol do clinical ATs perform? This review of literature is organized into several categories including: massage therapy, Instrument Assisted Soft Tissue Mobilization (IASTM), Graston Technique® and associated injuries, diagnostic ultrasound, and conclusions.

Massage Therapy

Massage therapy is one of the earliest treatments used for pain and dysfunction caused by musculoskeletal disorders.[5,6] The technique often incorporates soft tissue and joint manipulation performed by a clinician with their hands or a handheld device.[7] Different massage strokes are performed over the soft tissues of the body with varying pressures to rehabilitate physical function or to relieve pain.[8] Various massage styles exist, but the techniques often include effleurage, petrissage, friction, tapotement, and vibration.[5,7,8] Effleurage is a stroke that is performed using a gliding motion to prepare the tissue for deeper strokes. After effleurage, petrissage is used which includes lifting and squeezing the tissues to penetrate deeper tissues. Friction incorporates a penetrating pressure that is applied rapidly with the fingertips to break up adhesions in the tissue. To conclude the treatment, tapotement and vibration are often used and require striking and shaking the tissues at a rapid rate. Different stroke sequences are performed and customized to the need of the patient.[5] Massage therapy is a popular treatment option for resolving tissue dysfunction and pain caused by musculoskeletal disorders.

A type of massage known as deep transverse friction massage is applied to soft tissue structures to manage inflammation and pain. Deep transverse friction massage is applied only at the site of dysfunction with a depth of friction tolerable to the patient.[9] The strokes are performed transversely to the associated tissue unlike other styles that are applied longitudinally.[8] Although no significant evidence exists, deep transverse friction massage is often clinically indicated for breaking adhesions found in soft tissue.[9] The transverse strokes are proposed to mobilize the cross links between collagen fibers and aid in realignment and repair of the associated tissues.[9] Deep transverse friction massage is commonly used for the treatment of restrictive adhesions in soft tissues, but limited evidence exists to advise significant indication of the method.

Massage therapy, specifically deep transverse friction massage, is used for reducing damage and scarring caused by inflammation and may be indicated for treatment of lateral elbow tendinopathy.[9] Stratford et al[10] examined the effects of phonophoresis and deep transverse friction massage on the signs and symptoms associated with lateral elbow tendinitis. Participants reporting tenderness on palpation over the lateral aspect of the elbow and pain in the lateral elbow during wrist extension were included in the study. Forty participants with lateral elbow tendinitis diagnosed by the researchers were assigned to receive either deep transverse friction massage performed after therapeutic ultrasound with a placebo gel (n=11), therapeutic ultrasound and a placebo gel only (n=9), deep transverse friction massage performed after phonophoresis using 10% hydrocortisone (n=10), or phonophoresis with 10% hydrocortisone only (n=10). The participants received nine treatments over three weeks.

In the groups receiving deep transverse friction massage, a clinician provided massage transverse to the fiber direction of the extensor carpi radialis tendon with enough pressure to reach the tendon sufficiently for ten minutes.[10] This massage is used to remodel collagen and to soften adhesions in the tendon.[11] The treatment groups received phonophoresis or therapeutic ultrasound with a non-medicated gel which acted as a placebo phonophoresis treatment. These groups received the intervention for six minutes. Other parameters of the phonophoresis treatment were not specified.

To measure the efficacy of the treatment groups, a visual analog scale (VAS 0-100) was used, grip strength was measured in kilograms of force, a functional index was reported, and successes in performing a strengthening program were measured prior to the first treatment and two weeks following the last treatment. For the functional index, participants reported painful functions associated with elbow use. In addition, the participants were tested on their ability to complete a pain-free strengthening program two weeks after treatments. The results of this study were not significant in indicating deep transverse friction massage as a treatment for lateral elbow tendinitis. Participants in the groups receiving deep transverse friction massage reported only slight improvements in pain on the VAS (MD -6.60, 95% CI -28.60 to 15.40), grip strength (MD 0.10, 95% CI -0.16 to 0.36), functional index (MD 1.10, 95% CI -1.00 to 3.20) and functional status (RR 3.3, 95% CI 0.4 to 24.3).[10] Although a suggested method for reducing inflammation and associated symptoms of lateral elbow tendinitis, deep transverse friction massage was not shown to be statistically or clinically supported for its treatment in this study.

Deep transverse friction massage and its effects were further examined by Schwellnus et al[11] on athletes with iliotibial band friction syndrome. Seventeen participants reported chronic pain (greater than four weeks) over the iliotibial band causing restriction or prevention in running distance or speed were included. The participants were randomly assigned to one of two treatment groups during day 3 to 14 of the trial. All subjects in both groups were rested from day 0 to 14 and received daily stretching from a clinician and ice therapy two times per day. From days 3 to 14, all participants received ultrasound and stretching performed by a clinician. The ultrasound treatment was performed with parameters at 1 MHz, 0.5 W/cm^2 at a continuous rate for five to seven minutes. The treatment duration was increased throughout the study. For days 3 and 4, the treatment was performed for five minutes. On days 5 and 6, the ultrasound was performed for six minutes and on days 7 and 10, the treatment was performed for seven minutes. Deep transverse friction massage was added from days 3 to 14 in one treatment group. The massage was performed over the most tender area, as reported by the participant, at a constant pressure. Slight discomfort was noted, but the participants were to report if severe pain was experienced.

In addition to the treatments, participants performed a 30-minute functional treadmill running test on days 0, 3, 7, and 14. Participants reported pain on a VAS (0-10 mm) each minute and researchers used this information to calculate total pain and percentage of maximal pain during running. Furthermore, conventional pain scores on a VAS (0-10 mm) were recorded for treatments spanning the two-week period. Both groups experienced statistically significant decreases in pain over the treatment period ($P < 0.001$), but no significant differences existed between groups ($P = 0.25$).[11] The researchers concluded the use of deep transverse friction massage is not recommended for the management of iliotibial band friction syndrome.[11] Due to the addition of several treatments during the span of the trial, it is difficult to determine which interventions had an effect. Based on the limited research available on deep transverse friction massage, it is not shown to be effective in the management of iliotibial band friction syndrome. Although deep transverse friction massage does not have significant evidence in controlled research suggesting its use for chronic tendinous injuries, the method may act as a stepping stone for other methods that may be more successful.

Instrument Assisted Soft Tissue Mobilization

Instrument Assisted Soft Tissue Mobilization (IASTM) encompasses a broad range of tool assisted techniques to treat soft tissue deficiencies. Tools varying in material, shape, and size are used to aid in healing soft tissue injuries. Using tools as an aid during IASTM treatments produces microtrauma to soft tissue, promoting the body to heal and restore elasticity and function.[3] Instrument assisted soft tissue mobilization treatments stimulate inflammation in the body and may also be used to decrease pain involved with injury and the inflammation response.[12] When inflammation is prompted, fibroblasts and fibronectin are released, which aids in the synthesis and realignment of collagen.[13] Areas containing adhesions and scar tissue are often addressed during IASTM treatments to restore elasticity. Resolution of these areas may also provide an increase in range of motion (ROM).[14] Variations of IASTM techniques exist differing in names and types of tools used. The most common methods of IASTM are Gua Sha, Astym, and the Graston Technique®. The effects of varying types of IASTM may provide an ideal environment for musculoskeletal injury healing.

Gua Sha

Gua Sha is an Eastern Asian therapy technique that aims to guide blood and waste to the surface of the skin to promote healing.[14] The technique involves *gua* or scraping of the skin to produce petechiae and ecchymosis, also called *sha*. Gua Sha practitioners scrape the skin with hard objects containing smooth edges to remove impurities within deep tissue, so fresh blood may flood the area.[15] This technique is used for various illnesses and injuries including those of the respiratory, musculoskeletal, and digestive systems.[15] The goal of Gua Sha is to restore normal circulation so the body may function optimally.

Pain relief is often a common goal of therapies such as Gua Sha and chronic neck pain (CNP) and chronic low back pain (CLBP) are indications of the technique. Lauche et al[16] examined Gua Sha as an intervention for 39 participants (mean age 49.23 ± 10.96 years) reporting CNP (n=21) and CLBP (n=18). Participants were randomly assigned to either the treatment group or the control group. Participants in the treatment group received one Gua Sha treatment. All participants rated their pain using a VAS and pressure pain thresholds (PPT) at sites of maximal pain and adjacent pain were taken as baseline measurements. Pressure pain threshold is the minimum force applied to an area which induces pain. The measurements were taken at the site patients reported the most pain, as well as the surrounding area. Post-treatment measurements of VAS and PPT were taken from both groups directly following treatment and seven days after the baseline. Participants reporting CNP and CLBP showed a greater reduction in VAS ($P = 0.03$) and PPT ($P = 0.01$) scores after receiving the Gua Sha treatment when compared to the control group immediately after the intervention. Seven days after the treatment, VAS and PPT scores were still significant for patients with CNP ($P = 0.05$) and CLBP ($P = 0.03$) receiving Gua Sha. With further research, Gua Sha may provide an effective treatment for patients with CNP or CLBP.

Research on CNP has been advanced by Braun et al[17] using similar methods to show the effect of Gua Sha on pain reduction. Forty-eight participants (58.5 ± 8.0 years) were randomized into either the treatment group (n=24) or the control group (n=24). Participants qualified for the study if they reported restrictions of cervical spine mobility for at least three months. The treatment was delivered to the upper back and neck. A qualified Gua Sha therapist used a small lid with a rounded edge, along with skin lubricant, to apply the treatment to participants while they were in a seated position. The treatment was performed until sha was present or until the maximum amount of petechiae arose. This was indicated by palpating the skin allowing slowly fading blanching. The skin was pressed, and the treatment continued until no further sha had arisen; therefore, the treatment was personalized to the patient. Participants in the control group were treated with a heat pack containing dried ginger, a Chinese medicine ingredient. The heat pack was applied to the neck of the participant in a seated position for 15-20 minutes. The duration of the control treatment was decided based on the average duration of a Gua Sha treatment.

The VAS during motion and at rest, the neck disability index (NDI), and the Short-Form Health Survey (SF-36) were all used as treatment outcomes. The NDI distinguishes neck pain disability using questions answered on a Likert scale. Higher scores on the NDI indicate higher neck pain disability. Pain during motion and at rest, along with the NDI scores were collected before treatment, immediately following, and seven days following the treatment. The SF-36 reveals physical and mental quality-of-life. Higher scores on the SF-36 indicate a better quality of physical and mental health. Measurements of the SF-36 were only taken before and seven days following treatment.

After the post-treatment measurements were taken, neck pain severity reduced significantly in the group receiving Gua Sha. The VAS pain scores decreased from 61.3 ± 14.00 mm to 22.2 ± 22.3 mm in the treatment group. The VAS pain scores of the control group decreased from 58.3 ± 16.2 mm to 50.3 ± 23.4 mm. A statistically significant difference existed between groups of -29.9 mm on the VAS pain scale (95% CI: -43.3; -16.6; $P < 0.001$). Similarly, significant group differences occurred for the NDI ($P < 0.001$). Participants receiving Gua Sha improved from a mean score of 32.8 ± 11.5 to 21.8 ± 12.9. This led to a reduction in the NDI score by 8.5 (95% CI: -13.6; -3.5; minimally clinically importance difference = 3.5) revealing less disability due to neck pain. Like the other measures, the results of the SF-36 improved with the Gua Sha treatment. Participants in the treatment group reported significantly greater patient satisfaction (55.7 ± 33 mm vs. 26.0 ± 28.7 mm; *P* = 0.016; MCID = 4.9). Like Lauche et al,[16] Braun et al[17] reported statistically significant improvements in participants receiving Gua Sha for neck pain. Although positive results with a single Gua Sha treatment occurred, more research should be conducted examining the long-term effects of multiple treatments.

Astym

Like Gua Sha, Astym incorporates the use of tools to promote healing in soft tissue. The use of the handheld tools allows the clinician to identify dysfunctional tissue and apply appropriate treatment pressures and strokes to resolve deficiencies. Astym has been shown to increase fibroblast activation and number, as well as fibronectin production, which may improve collagen organization and normalize tissue function.[18] Application of an Astym treatment includes elements other than scraping of the tissue. The entire kinetic chain is assessed, and dysfunctional soft tissue is identified. Stretching and strengthening of the tissue is performed to load and align tissue. Detecting and reducing dysfunctional areas will reverse restrictions in movement and may reduce pain.[18] Astym, as an IASTM technique, stimulates natural body processes to promote soft tissue healing and reduce pain.

The use of a non-invasive treatment, such as Astym, on chronic tendinopathy may relieve symptoms and improve function. Sevier[18] examined the effects of Astym and eccentric exercise on chronic lateral elbow tendinopathy to determine the best method to improve the injury. The research examined pre-existing evidence on eccentric exercise as a treatment option for tendinopathy and explored other potential options. Participants (N=113) were either assigned to four weeks of Astym treatments (n=57) or four weeks of eccentric exercises (n=56). The

Disability of the Arm Shoulder and Hand Scale (DASH) was used to measure patient perception of disability caused by chronic lateral tendinopathy. The secondary outcome measures were a VAS for pain with activity and a VAS for function. In addition, maximum grip strength was used as an objective measure of disability. Primary and secondary outcomes were measured at baseline, 4 weeks, 8 weeks, 12 weeks, 6 months, and 12 months. All measurements indicated the degree to which chronic lateral elbow tendinopathy affected participants.

After completion of the study, participants in the Astym treatment group showed significant improvements in all measurements. The DASH scores and maximum grip strength scores improved more significantly than participants in the eccentric exercise group. A significantly greater decrease in DASH scores was found for the Astym treatment group (-13.3 vs. 7.8; $P = 0.047$) and grip strength increased more significantly in the treatment group (9.4 lbs vs -1.9 lbs; $P = 0.008$). The VAS for pain and function also improved in the Astym treatment group (-15 vs. -12; p = 0.55), but was not statistically significant. All improvements were throughout the 12-month span. Although the results of the Astym treatment group were not statistically significant for VAS pain and function, VAS scores improved by 3 in this study, indicating some clinical significance (MCID for 10 cm VAS = 1.37)[19]. At the conclusion of the study, participants did report less pain and increased function. Clinically, perceiving less pain and better function may have positive effects on performance of patients. Range of motion may be increased, pain levels may continue to decrease, and patients may be able to complete activity without reluctance. The results of this study support Astym as an effective treatment in resolving symptoms related to chronic lateral elbow tendinopathy, both immediately and months following treatments.

Likewise, Achilles tendinopathy is a common soft tissue ailment that may benefit from the use of Astym treatments. Insertional tendinopathy accounts for about 25% of all Achilles tendinopathy cases.[20] Pain, swelling, and decreased function where the tendon attaches to the posterior calcaneus exists in cases of insertional Achilles tendinopathy. Additionally, midportion Achilles tendinopathy is described as dysfunction 2-7 centimeters proximal to the insertion and accounts for more cases of tendinopathy. Typically, eccentric exercise is indicated to treat Achilles tendinopathy.[20]

To investigate another treatment method for Achilles tendinopathy, McCormack et al[20] studied 16 participants with insertional Achilles tendinopathy treated with Astym. The participants were assigned to either the treatment group or the control group. Eight participants were assigned to the treatment group and received an Astym treatment and completed eccentric exercises. The remaining eight participants were assigned to the control group and only completed the eccentric exercises. To establish baseline measures prior to testing, participants completed the Victorian Institute of Sport Assessment Achilles-Specific Questionnaire (VISA-A) and the numeric pain rating scale (NPRS). Participants completed the VISA-A, a self-report measure, to determine the severity of their Achilles tendinopathy. Higher scores on the VISA-A determine a less severe case. Additionally, the NPRS consisted of three self-reported values of participants' "worst" pain and "best" pain. These values were averaged, and the final number was collected. In addition to the baseline measurements, the VISA-A and NPRS were taken post-treatment at 4, 8, 12, 26, and 52 weeks. The follow-up of 26 and 52 weeks were considered long-term. Another self-report measure, the GROC questionnaire, was given to determine whether the treatment was successful over the given timeline. Participants with a score of +5 or higher were considered to have a successful experience. The GROC questionnaire was completed by the participants during the follow-up at week 12.

Participants showed significant improvements for both short-term ($P < 0.01$) and long-term measures ($P < 0.01$). Pain was similar between both groups; however, all other outcomes were improved greater in the group receiving the Astym treatment along with the eccentric exercise. The minimal clinically important difference (MCID) for the VISA-A is 12 points and scores of the Astym group improved from 36.6 (18.8-54.5) to 90.7 (79.2-102.1) over the 52 week experiment.[20] Scores for the NPRS improved from 4.6 (2.8-6.4) during the baseline measurement to 0.67 (-0.6-1.9) during the 52-week follow-up measurement (MCID 1 point).[20,21] McCormack et al[20] provided evidence for the efficacy of Astym for treatment of insertional Achilles tendinopathy in both the short-term and long-term.

While Astym was reported as beneficial to treat elbow and Achilles tendinopathies, Astym research is still limited in participant size and treatment varieties. Sevier[18] and McCormack et al[20] used subjective measures to determine the efficacy of the Astym treatments on lateral elbow tendinopathy and Achilles tendinopathy. In both studies, the Astym treatments resulted in improved patient outcomes. Although the available research is significant in providing some evidence for different types of tendinopathy and long-term efficacy, more research still needs to be performed at a greater scale on more tendinopathies and larger sample sizes.

Graston Technique®

The Graston Technique® is a form of IASTM that combines soft tissue mobilization with stretching and strengthening protocols.[1] To achieve the successful resolution of injury, the Graston Technique® allows the clinician, as well as the patient, to be included in the treatment and rehabilitation process. The clinician's role lies in performing specialized soft tissue mobilization along with guiding the patient in the completion of various stretches and strengthening exercises to complement the treatment. The Graston Technique® is completed using specialized stainless steel instruments to supplement the clinician's hands and to decrease energy expenditure by the clinician.[1] This IASTM technique builds upon other methods with the use of patient-involvement to provide a more encompassing treatment for soft tissue dysfunction.

Indications and Contraindications

Any condition resulting in restricted tissue and decreased function may benefit from the Graston Technique®. The Graston Technique® manual[1] suggests using the method on pathologies such as epicondylitis, tendinosis or tendinitis, sprains, strains, and localized pain or restricted range of motion.[1] Similarly, Gua Sha is often indicated for regional pain and for functional problems that cause impaired movement.[17] However, instrument assisted soft tissue mobilization treatments like Gua Sha and Astym are often used for painful musculoskeletal conditions.[17,18] Common conditions studied by IASTM researchers include tendinopathy and dysfunction in the structures of the neck.[17,18,20] Such pathologies create soft tissue restrictions that may benefit from not only IASTM, but from specialized stretches and strengthening protocols integrated into the Graston Technique®.

Although many indications for the use of the Graston Technique® exist, it is not suitable for a variety of musculoskeletal pathologies. Increased inflammation may not benefit all conditions, especially those that may be worsened by the microtrauma caused from the instruments. Examples of contraindicated conditions are uncontrolled hypertension, hematoma, myositis ossificans, hemophilia, and rheumatoid arthritis.[1] In these conditions, increased bleeding or inflammation may worsen the condition and cause detrimental effects.[1] The Graston

Technique® should not be used over unhealed or open wounds as this may worsen the wound or cause infection.[1] In addition, the excess pressure and movement applied during a treatment session is contraindicated for fracture sites as this may cause more instability in the bone.[1] Finally, a patient's intolerance to the treatment is also a contraindication of the treatment. The goal of the Graston Technique® is not only to resolve the patient's soft tissue dysfunction, but to ensure patient involvement and comfort throughout the process. Although the Graston Technique® may be beneficial for a variety of soft tissue dysfunctions, some conditions may be worsened with its use.

Warm-up

The Graston Technique® incorporates other aspects of treatment to enhance the efficacy of the IASTM performed.[1] Prior to performing IASTM and creating micro trauma to the tissue, a warm-up must be performed. It is ideal to have the patient perform an active warm-up that raises the core temperature, but a passive warm-up such as a moist heat pack may be used if the patient is unable to complete the active warm-up. Warming the tissues assures more pliable tissue along with greater micro capillary perfusion.[1] Preparing the tissues prior to using the Graston Technique® instruments assure optimal nutrient and blood flow to the target tissues.[1]

Instruments

Aside from the additions of stretching and strengthening to IASTM, the Graston Technique® is performed with unique instruments to provide a quality treatment for soft tissue dysfunction. The developers of the instruments believed a stainless steel makeup was most beneficial for the clinician and patient.[1] In contrast, when Gua sha was practiced in Chinese tradition, a worn-down coin or Chinese soup spoon was used to provide a sturdy object and smooth edges to rub the skin in a linear fashion.[15] While the Astym technique was developed with the use of plastic tools, the Graston Technique® instruments are made of stainless steel which allows the clinician to feel and identify inconsistencies as reverberation occurs over damaged tissue.[1,20,22] The instruments complement what the clinician is feeling with their own hands and allows for more precise identification of damaged or dysfunctional tissue. Since stainless steel is heavier than other materials, the weight of the Graston Technique® instruments allow for deeper penetration into the tissue while requiring less effort from the clinician. Use of the instruments allows the clinician to focus on the technique rather than providing deep pressure into the tissue.[3] Creators of the Graston Technique® instruments claim the use of stainless steel tools provide the opportunity for the clinician to identify irregularities in the tissue and provide the most accurate treatment possible with the least amount of effort.

The Graston Technique® instruments were developed with the contours and joint shapes of the body in mind[1] and fall into two categories: convex or concave. The use of a convex surface on a concave body part allows for equal dispersal of pressure as the instrument glides over the area. The dispersal of pressure allows for greater patient comfort since the instrument is gliding over a larger treatment surface. In addition, a convex instrument allows for greater precision in the treatment area. When using a convex instrument over a convex body part, maximum pressure is localized in one area. Although this allows for greater precision, it is often less comfortable for the patient.

Along with unique surfaces, the instruments also contain varying edges. The Graston Technique® instruments contain either single-beveled or double-beveled edges to further customize treatments to the contours of the soft tissue found in the body.[1] Instruments with single-beveled edges allow for isolated pressures. The single-beveled edge allows for deeper, more precise penetration into the soft tissue. However, a double-beveled edge on an instrument limits tissue penetration and increases patient comfort. Instruments with a double-beveled edge allow for comfortable passes over thin tissue or structures that lie superficial under the skin. The varying treatment surfaces of the Graston Technique® instruments reflect the unique contours of the body, allowing for customized treatments.[1]

Six instruments differing in weight and size to accommodate the complex contours on different surfaces of the body are available. The GT1 instrument is the largest of the instruments and is used for large muscle groups (trapezius, latissimus dorsi, paraspinals, quadriceps, hamstrings, gastrocnemius).[1] The innovative design of the GT1 instrument (Appendix A) differs from the instruments used in previous IASTM methods. The Graston Technique® is first in introducing an instrument that is sizable for the use on large muscle groups in contrast to the small handheld instruments developed for Gua Sha and Astym.[15,18,20] This long instrument contains concave and convex treatment edges and lever arms to allow the clinician to comfortably prepare the tissue for deep and localized treatment in a controlled matter.[1]

Alternatively, the GT2 instrument (Appendix A) is designed with concave treatment edges that accommodate convex landmarks of the body.[1] On one side, this instrument contains a double-beveled edge for patient comfort and can be compared to the smooth edges of the coins or soup spoons often used for Gua Sha.[15] On the other side of the GT2 instrument, a single-beveled edge along with knobs on the ends of the instrument, allow for deeper precision and localized treatments.[1] The GT2 instrument is effective for treating soft tissue around body landmarks such as the malleoli, patella, and humeral epicondyles.[1]

For increased penetration and localization, the GT3 instrument (Appendix A) is most commonly used.[1] The instrument has only one treatment surface containing a small, single-beveled edge. This treatment instrument is effective in treating small areas with finesse and precision because the size allows for one contact point on the tissue. In comparison, Astym utilizes tools with decreasing areas of surface contact to achieve a precision treatment.[20] Prior to beginning localized treatments, the GT4 instrument (Appendix A) is the most commonly used instrument as it is useful in scanning the tissue to recognize soft tissue restrictions due to the single-beveled edge and convex surface of the instrument.[1] The GT4 instrument is most useful on concave surfaces, but may also be used on a convex surface for preparatory localization before the use of other instruments.[1] To start more aggressive treatment strokes, the area must be prepared to desensitize the area and identify the restrictions using the GT4 instrument.

A more aggressive option for convex-shaped soft tissue includes the GT5 instrument (Appendix A).[1] This instrument contains a single-beveled concave edge and is useful in releasing restrictions close to bony prominences, like the ribs, but may be more uncomfortable for the patient.[1] Finally, small treatment areas; such as those on the hands, wrists, and feet; may be treated with the GT6 instrument (Appendix A). This instrument contains two concave edges. One edge is single-beveled and the other is double-beveled. A treatment tip and a hook lie on the ends of the instrument. The small surfaces allow treatment for the most precise and localized areas between metacarpals, metatarsals, and phalanges.[1] Instruments varying in size, edges, and purpose introduce an innovative treatment style not seen before in IASTM methods like Gua Sha and Astym.[15,18,20] The Graston Technique® instruments are designed to accommodate all soft tissue restrictions in all areas of the body.

Treatment Strokes

To further customize Graston Technique® treatments, different strokes and application techniques are performed. Sweeping of the tissue can be performed with any of the six instruments. The sweep stroke allows the clinician to scan for tissue dysfunctions and may aid in edema reduction.[1] While performing a sweep of the tissue, the contact points of the instrument are maintained at a constant rate moving in one direction in a linear or curvilinear path.[1] When the instrument contact points are moving at different rates in an arched path, the stroke is classified as a fan stroke.[1] Fanning serves to scan the tissue and can be performed with the GT1, GT2, GT4, or GT5 instrument.[1] When this stroke is performed, one end of the instrument is stabilized while the other end is moved across large areas of tissue with resistance.

In contrast, scanning and desensitization of small areas is accomplished with brush strokes.[1] Similar to the strokes performed in Gua Sha and Astym, a brush stroke should only be performed in one direction.[1,15,22] The GT3 instrument allows for small amplitude brush strokes for preparation of deeper treatment strokes.[1] To begin specific mobilization of restrictions, a strumming stroke is performed. Strumming consists of deep, linear stroking motions. The stroke should be performed perpendicular to the fiber direction and in small amplitude.[1] The angled portion of the GT1, GT3, and the centered contact point of the GT4 instruments are indicated for strumming.[1]

Deeper treatment strokes are performed in a linear fashion perpendicular to the tissue fiber direction in contrast to the strokes performed in Gua Sha and Astym that are performed parallel to the fiber direction.[1,15,22] Uniquely, the J-stroke, typically performed with the GT3 instrument, is used for mobilizing superficial and deep restrictions.[1] The J-stroke is performed by moving the instrument in a J-shaped pattern over the target tissue.[1] Lastly, framing is performed with the small treatment edges of the GT3 instrument or one of the knobs of the GT2 instrument. Framing is performed with a series of J-strokes and scooping maneuvers to release soft tissue tension in areas close to bony landmarks.[1] Along with introducing a diverse range of instruments, the Graston Technique® initiates the use of more specified strokes than the unidirectional strokes of Gua Sha and Astym.[1,15,22] The unique instrument design, along with varying treatment strokes, may allow for effective release of soft tissue restrictions with the Graston Technique®.

Stretching and Strengthening

Following the Graston Technique® soft tissue mobilization, stretching and strengthening exercises are performed to prepare the tissues to accept the changes made.[1] Stretching is used immediately following to enhance mobilization in the tissue. Establishing proper electrical signaling with strengthening exercises is attempted to trigger biological responses stimulating repair.[1] Strengthening is ideally performed with low load and high repetition exercises to the target tissue. This model reinforces the SAID principle and may help stimulate repair.[17] Applying appropriate tensile stress to the tissues following soft tissue mobilization and stretching will allow the tissues to adapt.[1] The Graston Technique® incorporates as much active treatment as possible to ensure the body positively adapts to the stresses and changes applied.

Hamstring Flexibility

Hamstring tightness and decreased knee extension are commonly reported in the active population and may benefit from the mobilization of soft tissue restrictions in the muscles and tendons of the posterior thigh. Nejo et al[23] examined the effects of the Graston Technique® applied to 45 healthy individuals with hamstring tightness. Participants were asked to avoid strengthening or stretching the hamstrings 72 hours prior to the treatment. Diagnostic ultrasound was first used to determine adipose thickness over the mid-hamstring. Passive range of motion (PROM) of the knee was measured with the participants in a supine position with their hip flexed 90°. Three measurements were taken with a goniometer and then averaged and recorded as the final measurement. Participants were randomly assigned to one of three treatment groups: the Sham Graston Technique® (Group 1), only Graston Technique® (Group 2), or Whole Graston

Technique® (Group 3).[23] The sham treatment was performed using a different edge of the Graston Technique® instruments with light strokes, while the only Graston Technique® group received a moist hot pack and the Graston Technique® strokes. This group received approximately 10 long strokes with the GT1 instrument, short strokes on smaller areas with the GT4 instrument, and one minute of short strokes on smaller areas with the GT3 instrument. This sequence was repeated until a ten-minute treatment was completed. Finally, the Whole Graston Technique® group received a moist hot pack, the Graston Technique® strokes, as well as passive stretching and strengthening exercises.

The participants in the Groups 1 and 2 had PROM measured again immediately following treatment. However, group 3 received passive hamstring stretching and completed hamstring curls before having their PROM re-measured. Nejo et al[19] reported significant increases in PROM in Group 2 ($P = 0.004$) and Group 3 ($P = 0.001$).[23] These results provide some evidence in using the Graston Technique® to improve range of motion, but more research is indicated to determine how the Graston Technique® may improve hamstring range of motion, as well as range of motion in other areas of the body.

Muscle Tear

Muscle injuries are more commonly being examined with musculoskeletal diagnostic ultrasound. This method allows for a quick diagnosis of damage in muscles that may be treated with the Graston Technique®.[24] Faltus et al[24] performed a case study on a 24-year-old male with a palpable defect in his anterior mid-thigh from a soccer-related injury. This individual had injured the area twelve months prior. The patient reported a “palpable indentation” in the anterior thigh but did not elect to seek formal treatment for the initial injury. When the re-injury occurred twelve months after the initial injury, the patient sought treatment at a sports medicine clinic.

The patient described a “pulling sensation” at this time and had a visible and palpable defect in the proximal anterior thigh.[24] Although the defect was palpable, the researchers examined the area with diagnostic ultrasound to confirm the damage. The imaging revealed fibrotic tissue within the musculature of the anterior thigh where the palpable defect was found.

Along with the findings from the imaging, the patient had latent trigger points in the lateral thigh.[24] In addition, the patient had a positive Ober’s test in the involved extremity; however, range of motion, prone knee flexion, and hamstring flexibility were equal in both legs. Although flexibility was equal bilaterally, the researchers reported a stiffer end-feel in the affected leg. The patient reported getting into knee flexion and terminal knee extension to be harder with the affected leg.[24] Using the patient’s past medical history and clinical presentation, the researchers considered multiple differential diagnoses and concluded the patient reinjured his rectus femoris muscle.[24]

To treat the injury, five sessions of the Graston Technique®, along with eccentric strengthening and stretching exercises, were administered over six weeks. The Graston Technique® was performed in accordance with the manual[1], but specific strokes were not detailed in the study.[1,24] As the patient’s tolerance increased, the Graston Technique® was applied to the quadriceps femoris muscles and tendons during active movements such as knee extension and lunges. The researchers did not follow a specific treatment timeline during the study; all treatments were tailored to how the patient felt during the session. Following all Graston Technique® treatments, an ice massage was applied over the injured area.

After completion of the treatment, the area was examined once again with diagnostic ultrasound. The size of the defect remained essentially unchanged (1.71 cm vs 1.63 cm); however, the hypoechoic zone was reduced, indicating decreased edema.[24] The patient reported improvements in function (Global Function Rating: 80% vs 90%), strength, and pain levels (7/10 vs 2/10 on a VAS scale 0-10 with activity) following the treatments. Although this study provided supporting evidence indicating the use of both diagnostic ultrasound and the Graston Technique® to identify and treat a muscle injury, higher levels of research should be performed to enhance the support for both modalities.

Tendinopathy

Conservative treatment of chronic Achilles tendinopathy including the Graston Technique® consists of case study research. Miners[12] incorporated active and passive tissue warm-up, the Graston Technique®, Active Release Therapy (ART), eccentric exercises, and cryotherapy treatments for a 40-year-old male with chronic bilateral Achilles tendinopathy. The patient received treatments twice per week for three weeks in addition to three other sessions designed to monitor progress.

Treatment sessions began with an active and passive warm-up. This warm-up included a five-minute heat pack application accompanied with stationary cycling. Following the warm-up, the participant received a Graston Technique® treatment and ART. Specifics of the treatments were not detailed in the study; however, the treatments were noted to be performed how the respective protocols suggest.[1,12] The Graston Technique® and ART were applied to the muscles of the posterior leg before eccentric calf lowering exercises were performed. The treatment session was completed with static gastrocnemius and soleus stretching followed by an ice pack application.

The participant was also given at-home instructions for the time following in-office treatments. This protocol included ice pack application, gentle stretching, and eccentric exercises. An ice pack was applied using the 10-10-10 protocol; consisting of ten minutes on, ten minutes off, ten minutes on for a total treatment time of no more than an hour. After the ice application, the participant was instructed to complete gastrocnemius and soleus stretching. After two days of the at-home protocol, a series of eccentric exercises were performed within the participant's pain tolerance. The stretching routine was completed again once the exercises were fulfilled and the participant was instructed to apply an ice pack in the same manner for at least two times per day.

During a re-evaluation of the patient in-office, he was questioned on his pain levels and perception of function. No specific patient outcomes were recorded, but the researchers simply questioned the patient after each visit. After the sixth visit, the participant reported a decrease in pain by 50% (3-4 vs 7-8 on a 10-point scale). Upon completion of the study, the participant reported little to no symptoms during rest or activity and reported a pain level of 0-1 out of 10. The participant subjectively determined the condition had been resolved due to the decrease in symptoms. Although positive patient outcomes resulted, multiple treatment techniques were utilized and cannot be attributed to one specific technique. The resolution of the condition suggests a clinically significant effect, but more research is indicated to determine the true recommendations for use of the Graston Technique® on chronic Achilles tendinopathy.

The Graston Technique®, as a treatment option, has been incorporated into more research examining conservative management of chronic Achilles tendinopathy through case study.[25] In addition to the case study performed by Miners[12], Papa[25] reported a case study about a 77-year-old female with gradual symptoms of Achilles tendinopathy. The patient was treated with medical acupuncture and electrical stimulation, the Graston Technique®, and rehabilitative stretching and strengthening. The participant was asked to rate her pain on the Verbal Pain Rating Scale (VPRS) of 0-10 prior to any intervention. At rest, the participant rated her pain at 2-

3/10 and 6-7/10 with activity. The Lower Extremity Functional Scale (LEFS), a self-report measure used to determine the perceived disability in performing activities of daily living, was given to the participant before and after the completion of the study. Scores of the LEFS range from 0 (high degree of disability) to 80 (low degree of disability).

The nine-week study incorporated medical acupuncture with electrical stimulation and the Graston Technique® in conjunction with therapeutic stretching and strengthening during all sessions. The medical acupuncture was performed in points on the Achilles tendon and gastrocnemius-soleus complex that were tender as reported by the patient. The Graston Technique® was performed in the same spots, as well as on areas of dysfunctional tissue as determined by the clinician during the physical examination. However, the Graston Technique® instruments and strokes used were not specified in the methodology. For the first four weeks, the participant was treated twice per week, while every week after included one treatment per week. The exercises were performed every time the participant was being treated in the office and 3-4 times per week at home. Upon completion of the study, the patient reported a VPRS score of 0/10 and an improvement in her LEFS score (48 vs. 80). The researcher of this case report concluded the conservative treatment measures were successful in treating Achilles tendinopathy. The Graston Technique® may be indicated for the treatment of Achilles tendinopathy, but more extensive research is still needed to quantify the significance the treatment technique may offer since multiple treatments were used at once.

As with other conditions, a limited amount of research exists indicating the use of the Graston Technique® on chronic tendinopathies. A case study on the post-surgical treatment of a patellar tendon rupture was performed.[26] The subject was a 37-year-old male who sustained a non-contact patellar tendon rupture. No evidence of tendinopathy or chronic dysfunction existed at the time of the participant's surgery, but the participant showed a decrease in ROM following surgery. This dysfunction was treated with the Graston Technique®, joint mobilizations, strengthening exercises, as well as techniques for edema and pain control. Prior to receiving a Graston Technique ® treatment, the patient applied a hot pack to the area for 5-7 minutes. Then, the patient received the Graston Technique® to the quadriceps and anterior tibialis muscles. Scanning strokes with the GT5 instrument were used to identify any adhesions in the tissue.[1,26] After areas of dysfunction were identified, deeper strokes were applied to these localized areas for 30-60 seconds. The localized treatment was applied on the suprapatellar notch, the medial and lateral patellar borders, the infrapatellar fat pad, the rectus femoris, and tibialis anterior muscles. After each session, fewer superficial adhesions were identified by the clinician.

In addition to the Graston Technique®, joint mobilizations were performed on the patella and the tibiofemoral joint. As the patient progressed through treatment, range of motion and strengthening exercises were incorporated. These additions included biking, active-assisted ROM, quadriceps activation exercises, mini-squats, along with a focus on terminal knee extension. The patient experienced increases in active and passive ROM (93° to 110° for active, 95° to 123° for passive) after attending five sessions. There was also a decrease in the patient's quadriceps lag after five treatments (22° to 3°). Overall, Black[26] analyzed the use of the Graston Technique® as a supplement to common physical therapy treatments. Since the Graston Technique® was not used alone, identifying the effects of the technique is difficult. The patient in this case study showed success with the methods used. The results suggest a potential clinical use of the Graston Technique® for patellar tendinopathy. Further research is indicated with larger sample sizes and a focus on the Graston Technique®. Ailments such as patellar tendinopathy may benefit from a non-invasive technique like the Graston Technique®.

Lateral epicondylitis is a musculoskeletal disorder that causes forearm extensor pain and dysfunction that may be resolved with the Graston Technique®. A case report completed by Papa[27] examined two females with cases of lateral epicondylitis. The first patient was a 48-year-old female with a gradual onset of symptoms caused by repetitive flexion and extension movements of the wrist and fingers. Prior to any interventions, the patient reported her pain on the Verbal Pain Rating Scale (VPRS) as a 7/10. Her Quick-DASH Work Module Score (QDWMS) was a 95 out of 100. A higher score of this measure indicates increased disability. The second patient was a 47-year-old female with a similar onset of symptoms. This patient reported her pain on the VPRS as a 5/10 and a QDWMS of 62.5. Both patients reported pain over the forearm extensor mass, as well as pain during forearm supination, wrist extension, and middle finger extension.

Treatment for the condition included acupuncture with electrical stimulation, the Graston Technique®, and rehabilitative exercises. The exercises included a combination of forearm extensor stretches along with eccentric and concentric strengthening exercises. The patients received all interventions a total of 12 times over a nine-week period. Specific application of the Graston Technique® was not mentioned, but the researcher noted concordance with the Graston Technique® protocol by a certified provider.[1,27]

After completion of the treatments, both patients reported a decrease in the VPRS to 0/10. The first patient's QDWMS decreased to 0/100 while the second patient's score decreased to 1/100. Decreases in these scores indicated a great pain reduction and increase in function. Like previous studies incorporating the Graston Technique® into traditional rehabilitation protocols, deciphering the effects of the Graston Technique® alone is difficult. This case report showed success in the resolution of symptoms related to lateral epicondylitis; therefore, further research is needed to explore the true effects of the Graston Technique® alone on the condition.

Most recently, the effect of the Graston Technique® on patellar tendinosis was examined in a thesis by Labodi et al.[28] Fifteen participants with either patellar tendinopathy (n=13) or Achilles tendinopathy (n=2) participated in the study. The diagnosis of their tendinopathy was made by an athletic trainer or physician and confirmed with diagnostic ultrasound by the researcher. Diagnostic ultrasound was used to take measurements including the trace of tendinosis and tendon thickness in longitudinal and short axes. All measurements were taken before and after treatment was performed. For patient outcomes, the Numeric Pain Rating Scale (NPRS) and Lower Extremity Functional Scale (LEFS) were used and were completed before every treatment session.

Over the course of two weeks, participants received four treatments with three days between as suggested by the Graston Technique®.[1,28] Prior to receiving the Graston Technique® treatment, participants completed a 10-minute cycling warm-up. Diagnostic ultrasound was then used to identify the area of pathology and was marked on the skin to note the location during the treatment. Emolient was then applied to the skin and sweeping and fanning strokes were performed over the quadriceps femoris muscle group with a GT4 instrument. These strokes were performed lateral to medial, as well as proximal to distal on the muscle group for up to one minute. Then, framing strokes were performed with the GT3 instrument around the patella and tibial tuberosity with a clockwise and counter-clockwise strumming stroke. Next, brush strokes were applied for up to 20 seconds over the patellar tendon to desensitize the tissue. After the tissue was prepared for deeper treatment, the GT3 instrument was used for 10 strokes per width of the instrument over the patellar tendon. Additionally, passive stretching of the quadriceps and hamstrings was then performed and the participants were instructed to complete exercises. The quadriceps and gluteus medius muscles were the focus for the exercises. Participants were also given an at home care sheet identifying any adverse effects that could occur.

Over the duration of the treatment, the trace of tendinosis in the short axis view decreased significantly between the first and last treatment session (P = 0.001).[28] In the long axis view, a significant decrease also existed in the trace of tendinosis (P = 0.001).[28] The LEFS scores showed a significant decrease between the first and last treatment (P = 0.02), while the NPRS did not show a significant decrease (P = 0.60).[28] The decrease in the trace of tendinosis reveals some resolution in the tendinosis occurred and improvements in patient outcomes were reported. This study provides evidence indicating the use of the Graston Technique® as a treatment option for tendinosis. This is the only study that used the Graston Technique® as the sole treatment for patellar tendinopathies and substantial results were found in 4 treatment sessions. More higher-level research is indicated to determine whether the Graston Technique® can resolve patellar tendinopathies with more treatment sessions as recommended by the Graston Technique® manual.[1] The strokes used in this study were replicated for each trial and although effective, this is not the approach that is taken clinically. Performing customized treatments to patients should be considered in future research. In this study, the use of diagnostic ultrasound provided an objective measure to monitor the repairing of tendinosis after treatment with the Graston Technique® and should be replicated in future studies.

Conclusion

The Graston Technique® is used to identify tissue dysfunction in soft tissue and is indicated in the management of various soft tissue ailments.[1] An extensive literature review was performed with little success in identifying research with high levels of evidence for the efficacy of the Graston Technique®. Much of the research performed involving the Graston Technique® incorporated the method with other treatments and on a single patient. Although positive results were reported in case studies on participants with tendinopathies, the evidence is low level and cannot indicate the Graston Technique® for such dysfunction. With the absence of Graston Technique® research on large participant groups and as a sole treatment, further research is indicated. This research should be completed examining the Graston Technique® alone on soft tissue dysfunction and tendon thickening. More objective measures, such as diagnostic ultrasound, should be used to objectively determine the benefits of the Graston Technique®.

Diagnostic Ultrasound

When compared to basic radiography (X-ray), computed tomography (CT), and magnetic resonance imaging (MRI); diagnostic ultrasound provides several benefits to musculoskeletal imaging. Diagnostic ultrasound allows for real-time examination of tissues during active, passive, and resisted motions.[29-33] The practitioner may also perform sonographic palpation to detect abnormalities in the most painful areas for the patient.[2,29] When concerns arise, various joints and regions of the body can be examined in a single session and the area in question can be compared bilaterally with ease.[29,30,32,33] Disease progression of such pathologies can be monitored and the efficacy of therapeutic treatments can be examined over time.[29,33] The use of diagnostic ultrasound also removes the risk of harmful effects of radiation for practitioners and patients.[2,29-32] Diagnostic ultrasound provides a non-invasive imaging technique that allows for interactive examination of musculoskeletal injuries.

Although an effective and non-invasive method of detection, the accuracy of diagnostic ultrasound is dependent on the user's experience and education of the tool.[29,30,32,33] Proper utilization of diagnostic ultrasound also requires substantial knowledge on the anatomy of the area being scanned.[31] Pattern recognition, the ability to recognize and learn the images and techniques necessary to successfully identify structures with diagnostic ultrasound is developed when clinicians gain substantial experience.[31] Although training is required to become proficient with diagnostic ultrasound, the experience is practical and can greatly benefit a musculoskeletal examination.

How Diagnostic Ultrasound Works

Diagnostic ultrasound is performed with a transducer that is attached to the ultrasound machine where the images are produced. The transducer is responsible for generating the ultrasonography beam and transporting the returning echoes to the computer.[29] Piezoelectric crystals inside the transducer expand and contract to allow electrical signals from the ultrasound machine to be changed into ultrasonic energy and transmitted into the tissues.[25,2] An acoustic transmission gel is used as a medium to allow the sound waves to enter the tissues.[2] After the waves are transmitted into the tissue, a period of time where no waves are emitted occurs, called pulse-echo, so the waves can return to the transducer and an image is produced When transmitted, wave frequencies typically range from 3-25 MHz and are transmitted through structures depending on composition and impedance of the tissue.[2] Higher frequency transducers (10 MHz or greater) are used to examine superficial structures, while lower frequencies are used for deep structures.[2,32] In addition, the frequency of the transducer affects the image generated; higher frequencies produce higher resolution images, while lower frequencies produce a lower resolution image.[2]

The images on musculoskeletal ultrasound are on a grey-scale with tissues ranging from black to white. Echogenicity refers to the ability to reflect or transmit waves in the tissues.[31] Images are classified by categories depending on the intensity of the echo. These categories are:

anechoic (high water content that does not produce internal echoes), hypoechoic (decreased brightness of its echoes relative to adjacent tissues), hyperechoic (low water content that produces increased brightness of its echoes relative to adjacent tissues), and isoechoic (equal echogenicity to adjacent tissues).[29,2,31] Anechoic and hypoechoic structures are dark, while hyperechoic structures appear lighter and are brighter in the image generated. The denser the material, the more reflective it appears.[2,29] Dense tissues, such as bone, appear white and tissues containing high water content, such as fat, appear darker as the sound waves travel right through it.[29] Reflectivity of the waves is dependent upon two factors: acoustic impedance of the tissues and the angle of incidence of the sound beam.[29] Acoustic impedance is dependent on the density of the material and the speed of sound within the tissue.[29] The angle of incidence of the sound beam is dependent on the angle of the transducer over the target tissues. Many factors play into the image that is displayed on the diagnostic ultrasound machine and proper knowledge on image generation results in a successful exam.

Tissue Appearance

Different tissues have varying echogenicities in their normal states due to the way sound waves reflect to the transducer. Bones and sources of calcification appear hyperechoic due to the dense structure (Appendix B).[2] The cortex of bone is what appears bright and hyperechoic on the screen as the bone itself cannot be viewed .[31] Bony landmarks are often used to orient the clinician in the area they are scanning to identify other soft tissue structures.[2] Similarly, fibrocartilage, such as that of the labrum of the hip and shoulder and the menisci of the knee, appear hyperechoic since the material is denser (Appendix B).[2] However, articular cartilage that lies on the articular surfaces of bones appear hypoechoic and are uniform across the surface if no damage is present (Appendix B).[2,31] Articular cartilage is more penetrable by diagnostic ultrasound when compared to bone and is why it appears more hypoechoic.[31]

Uniquely, normal muscle tissue appears hypoechoic and the fibers are grouped into fascicles (Appendix B).[2,30,31,33] The hypoechoic appearance is separated by the hyperechoic appearance of the perimysium that separates the muscle bundles.[2] Comparatively, normal tendons appear with parallel and fine fibers and are hyperechoic (Appendix B).[2] The fibers that are viewed typically represent the endotendineum septa containing connective tissue, elastic fibers, nerve endings, blood, and lymph vessels.[2] The interfasicular substance between fibers appears as anechoic lines.[30] Although similar in appearance to tendons, ligaments appear hyperechoic and, but are more compactly striated (Appendix B).[2,31] Recognizing a ligament connects two osseous structures is helpful in identifying ligaments and distinguishing them from tendons.[2,31] When surrounded by hypoechoic subcutaneous fat, normal ligaments may appear more hyperechoic due to the sound wave reflection.[2] The recognition of normal tissue is important when scanning an area so abnormal areas can be addressed and examined further.

Artifacts

Proper education and experience using diagnostic ultrasound is essential in generating an accurate image of the underlying tissues. Artifacts may be produced and may hinder or help in examining an image. An artifact is an image attribute that is not present in the original imaged object.[29] Artifacts may produce false and misleading information by the imaging system or by interaction with adjacent tissue.[29] The angle of the transducer and ultrasound contacting the tissue is important for the display of accurate images.[31] If the angle of the transducer is perpendicular to the target tissue, more sound waves are reflected back to the transducer and fewer are reflected elsewhere.[31]

Anisotropy is an artifact that may appear when examining tendons and ligaments. This artifact occurs when the ultrasound beam is not perpendicular to the tendon or when the angle of incidence is not correct (Appendix C). [29,30,2,31,33] The normal hyperechoic appearance of the tendon or ligament is then lost and appears hypoechoic as an injured tendon would appear.[2] Anisotropy can also be used to the practitioner's advantage when distinguishing hyperechoic tendons and ligaments that are surrounded by other hyperechoic tissue.[2] When scanning tendons or ligaments in an area of hyperechoic structures, the transducer may be intentionally moved to produce anisotropy to identify the tendon or ligament. To exclude anisotropy, the clinician may move the transducer to scan the length of the tissue being examined or may make small movements with the transducer to exclude anisotropy when not intentionally producing it. In both the short axis view and long axis view, the clinician may toggle the transducer using heel-toe maneuver to exclude the artifiact.[2]

Shadowing is another artifact that exists when the ultrasound beam is reflected, absorbed, or refracted by the tissues.[2] Shadowing occurs with bone and areas of calcification, foreign bodies, and gas (Appendix C).[2] The shadow appears as an anechoic, or completely black area, under the structure producing the artifact.[2] Another artifact type is posterior acoustic enhancement or increased through-transmission. This artifact occurs during examination of fluid and solid soft tissue tumors.[2] When posterior acoustic enhancement occurs, deeper soft tissues appear more hyperechoic than the surrounding soft tissues (Appendix C). This occurs because the ultrasound beam penetrates the fluid and accumulates below showing a brighter, hyperechoic area.[2] Unlike other artifacts, posterior reverberation is an artifact that occurs when the surface of the object is smooth and flat, such as bone or metal objects that may be implanted.[2] The ultrasound beam is continuously reflected between the transducer and the smooth surface to produce linear echoes and appears as hyperechoic lines in the image (Appendix C).[2] Proper technique and knowledge is essential to identify and distinguish artifacts from abnormal tissue.

Injuries

Although diagnostic ultrasound may be used for the identification of a variety of injuries, research on patellar tendon pathologies will be presented here. Injuries to tendons can appear differently depending on the severity and location, but diagnostic ultrasound can be used to uncover these pathologies as they are predominantly superficial structures.[29,34] It is important to use diagnostic ultrasound in conjunction with a full examination and not as a sole resource.[4] The symptoms in conjunction with the morphological findings from imaging can successfully identify a pathology.[4]

The proper positioning of the patient and the transducer is important in examining the patellar tendon. The patient should be positioned supine with the knee flexed around 20-30 degrees.[34] This tendon is easily evaluated in both axes to reveal tendinopathy, swelling, partial or full thickness tears, neovascularity, and any other irregularities.[34] Proper identification of the patellar tendon requires application of correct orthogonal direction of the ultrasonography beam to avoid anisotropic artifacts. Placing the knee in a flexed position with an object under the knee stretches the tendon and helps to minimize anisotropy.[30]

Tendon pathologies that may be identified with diagnostic ultrasound are tendinosis or degeneration of the tendon, partial-thickness tears, and full-thickness tears.[29] Early tendinopathy appears as tendon thickening and results in changes in the normal contour.[34] The terms tendinosis and tendinopathy are more commonly used rather than tendinitis, as research has shown there is not always active inflammation in painful tendon pathologies.[4] Tendinosis describes the degeneration of the tendon.[30] When examining macroscopically, the patellar tendons of those with patellar tendinopathy does not appear organized or continuous as a normal tendon would look.[4] As increased damage occurs, tendinosis appears as an ill-defined, hypoechoic appearance without tissue volume loss on diagnostic ultrasound.[4,29,30,32,33] Increased tendon thickness is also present when tendinosis occurs.[30,32,33] Alternatively, partial thickness tears show a more defined defect in the tendon.[29,30] Partial tears may be difficult to differentiate from tendinosis because the pathologies coexist and their imaging features may be similar.[33] However, full thickness tears are easier for clinicians to detect. A focal, hypoechoic gap through a tendon may reveal a full-thickness tear.[29,33] Active and passive movement can be used to evaluate a tear.[2,30,33,34]

Proper identification of the severity of tendinopathy is important in the proper treatment of the pathology. To determine proper treatment and prognosis, Gemignani et al[35] used diagnostic ultrasound to grade patellar tendinopathies. Two hundred ninety-eight professional and semi-professional athletes reporting overuse patellar tendinopathies were included in the study. The tendinopathies were classified into four categories: grade one (less than 20% of the whole tendon section examined was injured), two (between 20% and 50% of the whole tendon section was injured), three (greater than 50% of the whole tendon section was injured), or four (subtotal or total tears with partial and total tendon retraction).[35] Using diagnostic ultrasound, participants were divided based on the grade, type of injury, and injury severity of their tendinopathy. The researchers also distinguished single or multiple focal injuries from widespread micro tendinosis where tendon thickening was superior to two centimeters.[35] Insertional fibrosis and calcifications were also noted during the examination.[35]

Tendinopathies that were graded either one, two, or three were treated with physical therapy and medications. The specifics of this treatment were not specified in the study, but participants received the intervention for one to three months. Tendinopathies classified as a grade four or those not responding to conservative treatment were referred for surgical intervention. At the conclusion of the study, the results revealed 21.8% of injuries were classified as grade one (100% responded to treatment, average prognosis 20 days), 61.2% were classified as grade two (94.5% responded to treatment, average prognosis of 40 days), 16.4% were classified as grade three (85.7% responded to treatment, average prognosis of 90 days), and 0.6% were classified as grade four.[35] The results of the study show thorough diagnosis of the severity of patellar injury can provide adequate evidence for how to treat the pathology. Further research examining the need for personalized treatment based on the severity of patellar tendinopathy is indicated.

Conclusion and Future Research

Diagnostic ultrasound is a non-invasive tool beneficial for identifying multiple musculoskeletal pathologies, including tendinopathies and allowing for bilateral comparison for a more accurate examination. Proper knowledge and experience with the tool will ensure accurate imaging and the elimination of artifacts. The appearance of normal and abnormal tissue is dependent on the clinician's experience and the areas being scanned. Since diagnostic ultrasound is effective in identifying several musculoskeletal conditions, further research should focus on both identification and progression of the pathologies after receiving treatments.

A gap in the literature exists on the effects of the Graston Technique® on patellar tendinosis. The use of diagnostic ultrasound as an objective measure to monitor the progression or improvement of tendinosis is also fairly absent in the literature. Future research should be performed with diagnostic ultrasound to examine the effects of the Graston Technique® on patellar tendinosis.

CHAPTER 3. METHODOLOGY AND PROCEDURES

The purpose of this study was to determine how clinical athletic trainers use the Graston Technique® and how clinical use compares to the recommended Graston Technique® protocol. The following research questions were examined over the course of this study: 1) What training do certified athletic trainers have in the Graston Technique®? 2) What pathologies do clinical ATs treat with the Graston Technique®? 3) What elements of the recommended Graston Technique® protocol do clinical ATs perform? The current chapter describes the nature of the study/experimental design, the population of the study, procedures and instruments for data collection, and data analysis procedures.

Nature of the Study/Experimental Design

This study was a cross-sectional survey design. An electronic survey was used to collect information on the use of the Graston Technique® in clinical practice by certified athletic trainers.

Population of the Study

Participants were clinical certified athletic trainers recruited through the National Athletic Trainers' Association (NATA) database. A potential 1,000 members out of 45,000 were recruited. Participants were members of the NATA and certified athletic trainers, so this included males and females over the age of 21. According to Katie Scott, MS, ATC (written communication, May 2020), the NATA average response rate for 1,000 surveys was 8-10%, so the goal of this study was to obtain a minimum of 80 completed surveys.

Participants were excluded if they were not a certified athletic trainer or a member of the NATA. Only certified athletic trainers currently practicing were included. This study was presented and approved by the University's Institutional Review Board before data collection began. Consent was implied upon voluntary submission of the survey.

Instruments for Data Collection

The survey instrument to determine how the Graston Technique® is performed by practicing athletic trainers was developed by using information and recommendations from the Graston Technique® manual[1]. All questions in the instrument were developed with neutral and non-leading language to maintain validity and reliability.[36,37]

The survey instrument began with questions regarding demographic information. Understanding age, gender, job setting, as well as years of experience as a certified athletic trainer provided an opportunity to draw connections and give information on how the Graston Technique® is used in clinical practice.

Next, the survey instrument included questions on experience with the Graston Technique® and other instrument assisted soft tissue mobilization techniques to gain an understanding of the training participants have with IASTM. This section contained "yes" or "no" questions, open-ended questions, and multi-select questions. Following the questions on experience, questions regarding the four elements of the Graston Technique® were included. Participants were asked if they incorporate each element (warm-up, IASTM, stretching, exercise/strengthening) and answered using a Likert scale of "never", "sometimes", "always". Those who reported "never" or "sometimes" for any of the four elements were prompted to explain why they do not always incorporate all elements when performing a Graston Technique® treatment.

Since the Graston Technique® can be used on a variety of pathologies, all participants were then prompted to select the pathologies they treat with the Graston Technique® using a multi-select question. The pathologies listed were taken from the Graston Technique® manual[1] in addition to an "other" option that allowed participants to add in pathologies that may not be listed. The next series of questions consulted participants on the length of the IASTM portion of their Graston Technique® treatments. A recommended Graston Technique® treatment is 8-10 minutes[1], so if participants indicated less than eight minutes or greater than ten minutes they were prompted to explain their treatment length. Participants were also asked the total number of Graston Technique® treatments they perform to compare the recommendation of eight total treatments for one pathology.[1]

Perceived efficacy of the Graston Technique® was analyzed through open-ended questions requesting examples of improvement participants observe after performing the Graston Technique®, in addition to improvements their patients have reported. The responses were coded into objective and subjective reports of improvement. Examples of objective improvement included those on range of motion or edema reduction. An example of subjective improvement included a reduction of pain.

Procedures

After the survey was developed, the instrument was sent to three experts to ensure construct and content validity prior to submission to the NATA. The survey was analyzed to guarantee it encompassed all elements of clinical practice and the Graston Technique®. After confirmation that the survey was representative of the information warranted, the request to distribute the survey to certified athletic trainers was submitted to the NATA. When approved, the request to distribute the survey to certified athletic trainers was submitted to the NATA. When accepted, the survey was sent via email to 1,000 members of the NATA. Athletic training students were excluded to maintain the instrument's validity.[36,37] The first page of the instrument described the study to participants. When choosing to proceed to the survey, it was assumed subjects were consenting to participation. The survey was made with the Qualtrics online system, so participants were able to take the survey at their convenience during the four-week collection period.

Data Analysis Procedures

Descriptive statistics were used to determine frequencies and percentages. For qualitative responses or those recorded from open-ended questions, the data was coded for themes to determine common constructs among answers.

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CHAPTER 4. MANUSCRIPT

Abstract

The Graston Technique® is a commonly used treatment that combines a warm-up, Instrument Assisted Soft Tissue Mobilization (IASTM), stretching, and strengthening protocols. The treatment is commonly chosen by clinicians to treat musculoskeletal injuries. The purpose of this study was to determine how the Graston Technique® is used in clinical practice by certified athletic trainers to compare to recommendations made by the Graston Technique®. Factors such as time, expense, lack of training in the Graston Technique®, availability of resources, and an overall lack of evidence-based recommendations may have influenced inconsistencies in clinical practice. Although the technique is not always performed according to recommendations, these findings suggest both clinicians and patients report objective and subjective improvements when treating musculoskeletal pathologies regardless of the techniques used.

Introduction

The Graston Technique® is a form of Instrument Assisted Soft Tissue Mobilization (IASTM) that combines soft tissue mobilization with stretching and strengthening protocols. The purpose of the Graston Technique® is to reduce adhesions and restrictions that result from musculoskeletal injury.[1] The Graston Technique® is indicated for pathologies such as epicondylitis, tendinopathies, sprains, strains, localized pain, or restricted range of motion.[1] Treating these dysfunctions may also reduce pain and increase range of motion which may improve comfort and functionality for patients.[1] To begin the treatment, a warm-up is performed to prepare the tissues prior to using the Graston Technique® instruments. The warm-up also assures optimal nutrient and blood flow to the target tissues.[1] Next, a variety of stainless steel instruments are used with varying strokes and pressures to reach both deep and superficial structures.[1] Sweeping, fanning, brushing, strumming and the J-stroke encompass the strokes performed with the six Graston Technique® instruments. The Graston Technique® instruments were developed with the contours and joint shapes of the body in mind and fall into two categories: convex or concave.[1] The use of a convex surface on a concave body part allows for equal dispersal of pressure as the instrument glides over the area. The dispersal of pressure allows for greater patient comfort since the instrument is gliding over a larger treatment surface. In addition, a convex instrument allows for greater precision in the treatment area. When using a convex instrument over a convex body part, maximum pressure is localized in one area. Although this allows for greater precision, it is often less comfortable for the patient. A recommended Graston Technique® treatment time with the instruments is 8-10 minutes.[1] Stretching is used immediately following to enhance mobilization in the tissue. Then, establishing proper electrical signaling with strengthening exercises is attempted to trigger biological responses stimulating repair.[1] Strengthening is ideally performed with low load and high repetition exercises to the target tissue. This model reinforces the SAID principle and may help stimulate repair.[1] The Graston Technique® incorporates as much active treatment as possible to ensure the body positively adapts to the stresses and changes applied. It is recommended the Graston Technique® be performed with at least 72 hours between treatments.[1] Resolution of pathologies should take approximately eight treatments.[1]

Although the Graston Technique® and the unique instruments were engineered to identify and treat soft tissue dysfunctions, little research exists on the treatment. The technique has been researched in conjunction with other treatment modalities, but the effects of the treatment alone have not been examined extensively. Studies performed on pathologies such as limited shoulder range of motion, a ruptured quadriceps tendon, lateral epicondylitis, and Achilles tendinopathy show efficacy of the Graston Technique®, but the methodology (instruments used, strokes, pressures, time) were not specified.[2-5] With these studies using multiple modalities and the inability to ensure the technique is being performed according to recommendations, it is difficult to generalize the results and conclude the Graston Technique® is a useful modality for pathologies.

Although having many recommendations on the use of the instruments, strokes, and pressures, research on how the Graston Technique® is used clinically by medical professionals has not been studied. The Graston Technique® is meant to be taught the same way to all clinicians, but the methodology of previous research shows inconsistencies. Without studies on how the Graston Technique® is applied to clinical practice, it is difficult to ensure the treatment is performed according to recommendations, therefore the purpose of this study was to determine how the Graston Technique® is used in clinical practice by certified athletic trainers to compare to recommendations made by the Graston Technique®.

Methods

Design

This study was a cross-sectional survey design. An electronic survey was used to collect information on the use of the Graston Technique® in clinical practice by certified athletic trainers.

Participants

In order to generalize the results to as large of a population as possible, a professional memberships association for certified athletic trainers was utilized. Participants were clinical certified athletic trainers recruited through the National Athletic Trainers' Association (NATA) database. A potential 1,000 members out of 45,000 were recruited. Participants were members of the NATA and certified athletic trainers, so this included males and females over the age of 21. Recruitment was performed directly through the NATA and the sampling technique was explained by Katie Scott, MS, ATC as “a full list of all availability and eligible participants was pulled based on the criteria for the project. From that master list, 1,000 participants were randomly chosen” (written communication, July 2020). The NATA average response rate for 1,000 surveys was reported as 8-10% by Katie Scott, MS, ATC (written communication, May 2020), so the goal of this study was to obtain a minimum of 80 completed surveys.

Participants were excluded if they were not a certified athletic trainer or a member of the NATA. Only certified athletic trainers currently practicing were included; therefore, no subjects were excluded. This study was presented and approved by the University’s Institutional Review Board before data collection began. Consent was implied upon voluntary submission of the survey.

Procedures

The survey instrument to determine how the Graston Technique® is performed by practicing athletic trainers was developed by using information and recommendations from the Graston Technique® manual[1] (Appendix E). All questions in the instrument were developed with neutral and non-leading language to maintain validity and reliability.[6,7]

The survey instrument began with questions regarding demographic information. Understanding age, gender, job setting, as well as years of experience as a certified athletic trainer provided an opportunity to draw connections and give information on how the Graston Technique® is used in clinical practice.

Next, the survey instrument included questions on experience with the Graston Technique® and other instrument assisted soft tissue mobilization techniques to gain an understanding of the training participants had with IASTM. This section contained “yes” or “no” questions, open-ended questions, and multi-select questions. Following the questions on experience, questions regarding the four elements of the Graston Technique® were included. Participants were asked if they incorporate each element (warm-up, IASTM, stretching, exercise/strengthening) and answered using a Likert scale of “never”, “sometimes”, “always”. Those who reported “never” or “sometimes” for any of the four elements were prompted to explain why they do not always incorporate all elements when performing a Graston Technique® treatment.

Since the Graston Technique® can be used on a variety of pathologies, all participants were then prompted to select the pathologies they treat with the Graston Technique® using a multi-select question. The pathologies listed were taken from the Graston Technique® manual,[1] in addition to an “other” option that allowed participants to add in pathologies that were not listed. The next series of questions consulted participants on the length of the IASTM portion of their Graston Technique® treatments. If participants indicated less than eight minutes or greater than ten minutes, they were prompted to explain their treatment length. Furthermore, participants were asked the total number of Graston Technique® treatments they perform on a specific condition to compare to the recommendation of eight total treatments for one pathology.[1]

In addition to the types of pathologies treated, we analyzed the participants’ perceived efficacy of the Graston Technique® through open-ended questions requesting examples of improvement they observed after performing the Graston Technique®, as well as improvements their patients reported. The responses were coded into objective and subjective constructs of improvement. Examples of objective improvements included range of motion or edema reduction. An example of a subjective improvement included a reduction of pain.

After the survey was developed, the instrument was sent to three experts to ensure construct and content validity prior to submission to the NATA. The survey was analyzed to guarantee it encompassed all elements of clinical practice and the Graston Technique®. After confirmation that the survey was representative of the information warranted, the request to distribute the survey to certified athletic trainers was submitted to the NATA. When accepted, the survey was sent via email to 1,000 members of the NATA. Athletic training students were excluded to maintain the instrument's validity.[6,7] The first page of the instrument described the study to participants. When choosing to proceed to the survey, it was assumed subjects consented to participation. The survey was made with the Qualtrics online system, so participants were able to take the survey at their convenience during the four-week collection period.

Statistical Analysis

Quantitative data was transferred from Qualtrics to IBM SPSS. Descriptive statistics was used to determine frequencies and percentages on age, gender, job setting, years of experience (Table 4.1); training in the Graston Technique® (Table 4.2); and training in other IASTM methods (Table 4.5). To assess internal consistency, Cronbach's Alpha was used. For the Likert questions including a scale of 'never', 'sometimes', 'always' and others surveying on the Graston Technique® recommendations, a Mann-Whitney U test was performed to compare differences between clinicians trained and untrained in the Graston Technique® (Table 4.12).

The qualitative responses or those recorded from open-ended questions was coded for themes to determine common constructs among answers using constant comparative analysis developed by Lincoln and Guba.[10] This method begins by sorting data into unnamed categories and as the data is further analyzed, categories become clearer and inclusion becomes apparent through common themes. The raw data set was obtained from Qualtrics and quantitative information was removed. The qualitative responses were analyzed using a primarily inductive process. The following steps were taken to code the data and find themes: 1) familiarizing with the data by reviewing the entire dataset; 2) line-by-line coding was performed for each question; 3) themes were defined based on common constructs in responses; 4) the finalized analysis and report was produced. The themes were shared with a qualitative research expert to ensure validity.

Results

Since the survey was sent out to 1,000 certified athletic trainers, the demographic information contained information for all respondents (n=60). As participants continued through the survey, only 31 participants reported using the Graston Technique® in their clinical practice. These 31 participants were prompted to complete the rest of the survey while those who reported not using the Graston Technique® (n=29) were directed to the end of the survey. One participant using the Graston Technique® in clinical practice did not complete all questions of the survey. Cronbach's Alpha was found for the survey instrument and was reported as 0.265.

Table 4.1. Demographic information (n=60)

Demographic	N	%
Age (years)		
20-30	29	48.33
31-40	29	48.33
41-50	0	0.00
51-60	2	3.33
61-65	0	0.00
66+	0	0.00
Prefer not to answer	0	0.00
Gender		
Male	17	28.33
Female	42	70.00
Prefer not to answer	1	1.67
Years of experience as a certified athletic trainer		
0-5	16	27.12
6-10	24	40.68
11-15	18	28.81
16+	2	3.39
Job setting		
College/university	30	51.72
High school	14	24.14
Hospital/clinic	8	13.79
Military	2	3.45
Professional Athletics	3	5.17
Industrial	1	1.72
Performing Arts	0	0.00

The experience level with the Graston Technique® was asked of the remaining 31 participants (Table 4.2). The Graston Technique® requires clinicians to complete both the M1 and M2 trainings to be considered certified in the technique.[1] Most clinicians completed the M1 course; therefore, they were not certified in the Graston Technique®.

Table 4.2. Graston Technique® experience (n=31)

Graston Technique® experience	**N**	**%**
Years		
0-5	18	60.00
6-10	11	36.67
11+	1	3.33
Training		
Graston M1	19	50.00
Graston M2/Certified	5	13.16
Graston Instructor	0	0.00
None	9	23.68

To perform the Graston Technique® per recommendations, the instruments provided by the Graston Technique®, LLC need to be utilized. Participants were asked about the instruments they used and were able to select multiple answers with this question (Table 4.3). The certified athletic trainers that reported using other instruments were prompted to explain why they did not use the Graston Technique® instruments. Factors hindering the use of the instruments were described as cost (n=7), availability of the instruments in the workplace (n=4), in addition to the make of the instruments "being too slippery" (n=1).

Table 4.3. Types of instruments used by clinicians (n=31, multi-select question)

Instrument Type	N	%
Graston Technique®	20	62.5
Hawk Grips	7	21.88
Myofascial Tools	1	3.13
Rock Tape®	1	3.13
Tecnica Gavilan	1	3.13
Smooth edge of scissors	1	3.13
The Edge	1	3.13

In addition to challenges identified with the Graston Technique® instruments, participants (n=31) were prompted to describe any overall challenges with the technique (Table 4.4). The majority of participants (N=9) described no challenges, while some reported patient discomfort (N=6). Some examples from those reporting patient discomfort as a challenge were: "patients attributing the tools to pain", "pain level, bruising", and "some patients experience more pain than others". Examples of the 'other' responses (N=6) were: "is a trendy therapy so many athletes that don't need it request it", "limited effectiveness in certain body regions", "patient population", "traveling with tools can be challenging when flying without checking luggage", and "other training gave me many more skills in just one course".

Table 4.4. Challenges identified by certified athletic trainers (n=30)

Challenge	N	%
None	9	30.00
Other	6	20.00
Time	4	13.33
Clinician fatigue	2	6.67
Design of instruments	2	6.67
Inconsistency	2	6.67

Participants reported other IASTM methods they use in their clinical practice (Table 4.5). Those selecting 'other' did not have training in the types of IASTM listed and no data was reported about the 'other' training because they were not prompted to provide this information.

Table 4.5. IASTM training (n=30, multi-select question)

Type of IASTM training	N	%
Gua Sha	2	9.52
Astym	6	28.57
FAKTR	0	0
Fascial Abrasion Technique	1	4.76
Other	12	57.14
None	0	0

To complete a full Graston Technique® treatment, all elements (warm-up, IASTM, stretching, strengthening) must be included.[1] If participants chose 'never' or 'sometimes' for any of the elements, they were prompted to describe in an open-ended question (Table 4.6). Answers were then coded for similarities and from those responses (n=38), time (N=12), clinical intent (N=11), unfamiliarity (N=7), phase of healing (N=3), and other factors (N=5) were identified. For the one participant reporting 'never' using the IASTM portion, they reported "not familiar with technique". Examples of 'other' factors were: "utilize other forms of IASTM to "warm-up patients depending on previous response to Graston®", "only need strengthening for intense knots and trigger points", "patient population, high school athletes aren't good at stretching, so IASTM is used to loosen the tissues", and "time constraints and treatment protocols we developed at our institution". Responses such as "used at the end of the day so already warmed up", "depends on what I am looking for in outcomes", and "depends on tissue type", were classified as clinical intent.

Table 4.6. Incorporation of each element of the Graston Technique® (n=32)

Element of the GT	**N**	**%**
Warm-up		
Never	3	9.38
Sometimes	13	40.63
Always	16	50.00
IASTM		
Never	1	3.13
Sometimes	10	31.25
Always	21	65.63
Stretching		
Never	2	6.45
Sometimes	16	51.61
Always	13	41.94
Strengthening		
Never	2	6.45
Sometimes	11	35.48
Always	18	58.06

Participants were surveyed on the common pathologies identified in the Graston Technique® manual[1] and which they address in their clinical practice (Table 4.7). The question allowed participants to select multiple pathologies. The most common pathologies identified were plantar fasciitis (N=29), neck/back pain (N=28), tendinitis/osis (N=28), strains (N=28), reduced range of motion (N=23), scars (N=23), epicondylitis/osis (N=21), and sprains (N=20).

Table 4.7. Pathologies treated with the Graston Technique® (n=30, multi-select question)

Pathology	N	%
Plantar fasciitis	29	12.39
Neck and/or back pain	28	11.97
Tendinitis/osis	28	11.97
Strains	28	11.97
Reduced range of motion	23	9.83
Post-surgical/traumatic scars	22	9.40
Epicondylitis/osis	21	8.97
Sprains	20	8.55
Edema	10	4.27
Carpal Tunnel Syndrome	9	3.85
Pre-competition warm-up	9	3.85
Post-competition recovery	7	2.99
Other	0	0.00

The Graston Technique® manual[1] recommends a treatment time of eight to ten minutes. Out of the 31 participants surveyed, 19 reported their treatments lasting less than eight minutes, 11 reported a recommended treatment time of eight to ten minutes, and 1 reported treatment lasting longer than ten minutes. Those reporting a treatment time less than or greater than recommended (n=20) were prompted to give a reason (Table 4.8). Some answers contained multiple reasons that were coded in different categories. Examples of reasons why treatments were performed for less than eight minutes included: “I don’t want to overly disrupt soft tissue as my patients are athletes and may be going out to practice”, “specific attention to each small area lasts around 30 seconds, with sweeping and focus on adhesion during the treatment usually lasts from 5-10 minutes”, “I was trained that each area needs to be under 60 seconds. I don’t treat large areas”, and “because that is all the time I have”.

Table 4.8. Common reasoning for treatment times (n=20)

Treatment Time Themes	N	%
Less than 8 minutes		
Treatment on small areas	7	33.33
Time	5	23.81
Learned in course	5	23.81
Prevent damage to tissues	3	14.29
Clinical intent	1	4.76
Greater than 10 minutes		
Incorporate other methods	1	100.00

The Graston Technique® suggests resolution in pathologies over approximately eight treatments performed with 72 hours in between treatments. This translates to two to three treatments per week. Certified athletic trainers (n=30) were also surveyed on the amount of time given between treatments (Table 4.9). Most commonly, participants reported giving two off days in between treatments (N=19). Those who reported giving less than two off days (N=7) or greater than two off days (N=4) were prompted to explain why (Table 4.10). Common explanations were: “time off depends on patient reporting and tissue inspection”, “I use it for injured and healthy athletes, so it depends on why I am using it”, and “one day off was taught when I took the course”.

Table 4.9. Number and frequency of treatments performed on one pathology (n=30)

# of Treatments	N	%
Per pathology		
1-2	6	20.00
3-4	14	46.67
5-6	9	30.00
7-8	0	0.00
>8	1	3.33
Per week		
1-2	11	36.67
3-4	13	43.33
5-6	3	10.00
7	3	10.00

Table 4.10. Common themes for not performing treatment with 72 hours between

Reason	N	%
Prevent damage/irritation to tissues	4	44.44
Taught in Graston course	3	33.33
Dependent on patient/injury	2	22.22

All participants (n=30) were surveyed on whether they see improvements when using the Graston Technique® in addition to their patients reporting improvements. All 30 participants reported improvements after using the Graston Technique®. In addition, all 30 participants reported their patients observing improvements. Fifty percent of participants reported seeing improvements by clinicians and patients after one to two treatments (Table 4.11). The most common improvements reported by clinicians and patients were decreased pain and increased ROM (Table 4.11).

Table 4.11. Clinician and patient-reported improvements after Graston Technique® treatments

Improvement after treatment	**N**	**%**
Number of treatments		
1-2	15	50.00
3-4	13	43.33
5-6	2	6.67
7-8	0	0.00
>8	0	0.00
Improvements reported		
Decreased pain	48	38.71
Increased ROM	30	24.19
Improved function	18	24.19
Decrease in “tightness”	14	11.29
Better tissue elasticity	5	4.03
Decrease in scar tissue	4	3.23
Decrease in edema	3	2.42
Increased blood flow	1	0.81
Decreased muscle spasm	1	0.81

Table 4.12 Mann-Whitney U Test: clinicians trained and untrained in the Graston Technique® ($p < 0.05$)

Variable group	**U-statistic**	**p-value (p)**
Treatment time	65.5	0.355
Warm-up	48.0	0.059
Stretching	78.5	0.886
IASTM	74.0	0.670
Strengthening	66.5	0.398
Treatments per pathology	68.5	0.403
Off days between treatments	74.0	0.653

Discussion

To consider a modality efficacious for treating pathologies, it is important to establish evidence that the pathology improves, but also to ensure the modality is performed according to recommendations. Although containing a very small sample size of 31 participants, this survey study has shown that certain factors prevent clinicians from performing the Graston Technique® according to recommendations from the Graston Technique® manual.[1]

The sample of athletic trainers that responded to the survey included a majority of female athletic trainers aged 20-30 years old practicing in a collegiate or university setting (Table 4.1). This information includes all respondents prior to eliminating those who do not use the Graston Technique® in their clinical practice (N=29), so the demographics of those who completed the survey in its entirety was unknown. This sample makes it difficult to generalize the results to other work environments and clinicians.

Elements specific to the Graston Technique® and recommendations from the manual were questioned throughout the survey instrument and areas for improvement were identified. Almost 25% of clinicians surveyed were not trained in the Graston Technique® (Table 4.2). Also, just under half of clinicians were not utilizing the instruments provided by the Graston Technique® (Table 4.3). According to Graston Technique®, LLC, clinicians must be using the instruments provided by the company and have completed at least the M1 course to advertise they are performing the Graston Technique® as a treatment modality.[1] The results revealed some clinicians were classifying training in other IASTM methods as the Graston Technique®. In addition, reports of high cost and unavailability of the Graston Technique® instruments in the job setting prevented clinicians from utilizing the technique as recommended.

In addition to not using the instruments recommended by Graston®, the recommendations on strokes, pressures, and treatment times were not always followed. Some clinicians reported not incorporating all aspects of the treatment (warm-up, Graston® strokes, stretching, and strengthening) (Table 4.6). The least commonly used elements were the warm-up, stretching, and strengthening elements (Table 4.6). Common reasons for not completing these elements were time, unfamiliarity, and clinical intent. Clinicians simply reported some pathologies treated "do not require stretching". Others worked in an environment where they were responsible for a multitude of patients during a short time period.

The warm-up is important to prepare the tissues for the Graston Technique® strokes which causes microtrauma to the tissues. One of the concerns of not following the Graston Technique® recommendations is potentially harming patients. For example, one limitation reported by patients was pain (Table 4.10). According to the Graston Technique®, the patient should not report any pain when receiving a treatment. The clinician should be actively engaging with their patient to ensure no more than slight discomfort is felt. The Graston Technique® instruments are developed with convex and concave surfaces to treat superficial and deep tissues that can be used as needed by the clinician while not causing pain to the patient. Clinicians using other instruments such as the "beveled edge of sports medicine scissors" may cause harm as these tools are not engineered to contour the body like Graston Technique® instruments. In addition, stretching is important to enhance mobilization of the tissues.[1] Strengthening reinforces the SAID principle and helps to stimulate repair.[1] If clinicians are not having their patients perform stretching following the Graston Technique® strokes, the tissues may not be properly loaded during the strengthening exercises. Skipping the active portions of the protocol may not allow the body to positively adapt to external stresses as quickly as challenging the tissues immediately following the Graston Technique® strokes. Performing and classifying the Graston Technique® without training may lead to adverse effects and patient hesitance in the modality.

The Graston Technique® recommends giving two days in between treatments and suggests pathologies will resolve in eight treatments.[1] It is also recommended that the treatment time with the Graston Technique® instruments should be eight to ten minutes.[1] Our results indicated the clinicians surveyed were not following these recommendations and are either performing treatments too little or too often (Table 4.8, 4.9). The clinicians performing the Graston Technique® for less than eight to ten minutes reported time in their busy environment as the most common factor (Table 4.10). The clinicians performing the Graston Technique® longer than eight to ten minutes reported utilizing other methods (active release and active movements) while performing the Graston Technique® strokes. There was no difference between how closely recommendations were followed by clinicians trained in the Graston Technique® versus those that were untrained (Table 4.12). The Graston Technique® strokes are the element most used by most clinicians and what is commonly classified as the Graston Technique®, but according to Graston®, the technique is the entire process of a warm-up, IASTM, stretching, and strengthening.

Many inconsistencies were identified when comparing the Graston Technique® recommendations to clinical practice, but the pathologies used by clinicians coincide with what is recommended in the manual (Table 4.7).[1] Common pathologies treated by the clinicians surveyed in this study were plantar fasciitis, tendinitis, and muscle strains. A study examining ten patients with plantar heel pain treated with the Graston Technique® strokes and stretching exclusively showed clinically significant improvement over the course of a maximum of eight weeks.[8] In addition, an unpublished thesis examined the effects of the Graston Technique® on patellar tendinosis confirmed with diagnostic ultrasound over the course of two weeks.[5] This study followed the full protocol of the Graston Technique® and showed clinically and statistically significant changes in patellar tendinosis as well as improved patient outcomes. Likewise, other studies have shown subjective improvements when treating Achilles and patellar tendinopathy with the Graston Technique, but the researchers incorporated other treatment methods.[2,3,9] Due to the methodology, the results could not be fully attributed to the Graston Technique®. Although limited, there is low-level research available to support treatment of such pathologies with the Graston Technique®.

Although examining an area of research that is limited, the validity and reliability of this study was restricted. Cronbach's Alpha was reported as 0.265 showing the survey instrument is not statistically reliable for testing the use of the Graston Technique® in clinical practice. This may be due to the absence of a pilot study to eliminate bias, to ensure questions were understood by participants, and to ensure the survey instrument included focused questions encompassing all aspects of the Graston Technique® in clinical practice. In addition, this study included many open-ended questions, so it should be noted that themes may contain bias due to one researcher coding the answers although a qualitative researcher reviewed the sample after codes were formed. The results of this study provided insight on how the Graston Technique® is used in clinical practice by athletic trainers. Despite performing the treatment against recommendations, all clinicians surveyed reported improvements in pathologies in addition to perceived improvements by their patients (Table 4.11). This raises questions about which Graston Technique® elements are stimulating healing, but also the elements of other IASTM methods that are stimulating healing. Further research should address how each element of the Graston Technique® affects pathologies. In addition, studies should compare the use of the Graston

Technique® as recommended versus inconsistencies in its use in clinical practice. Studies examining this may provide insight on whether the improvements of the pathology are truly attributed to the strict recommendations given by the Graston Technique®. There is little evidence supporting how the technique is performed; therefore, the reasoning behind treatments times, times between treatments, and the importance of each element should be examined more extensively.

Further surveying on how the Graston Technique® is used in clinical practice may be useful as well. Newly developed survey instruments should include the information surveyed in this study, but potentially focus on each element of the Graston Technique® in greater depth. The IASTM element (strokes, pressures, instruments) should be researched more extensively as this is the step that has the potential to cause the most harm to the patient if done incorrectly. Larger sample sizes with not only certified athletic trainers, but other clinicians practicing the Graston Technique® should be surveyed. The information gained from studies like this may help to adjust and support the recommendations made by the Graston Technique®, but also improve how clinicians are taught and how further methodology is performed.

Conclusion

Overall, the purpose of this study examined the clinical use of the Graston Technique® and compared it to the recommendations presented in the Graston Technique® manual. Factors such as time, cost, availability of resources (training and instruments), and a lack of evidence for the technique's efficacy, were identified as common themes behind inconsistencies in applying recommendations. Although the small sample of certified athletic trainers had training in other IASTM methods and did not follow the strict recommendations in clinical practice, clinicians reported objective and subjective improvements in a variety of musculoskeletal pathologies. This research is important to determine best methods of treatment so those who are practicing clinically are being educated and performing treatments while preventing any harm to patients. The results of this study and future research are important for clinicians to enhance their treatment plans by ensuring they are using the best practice in the Graston Technique® supported by not only clinical knowledge, but a high-level of evidence-based recommendations.

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APPENDIX A. GRASTON TECHNIQUE® INSTRUMENTS

Top GT1, left top GT6, right middle GT5, left middle GT2, left bottom GT3, right bottom GT4[1]

APPENDIX B. NORMAL TISSUE APPEARANCE ON DIAGNOSTIC ULTRASOUND

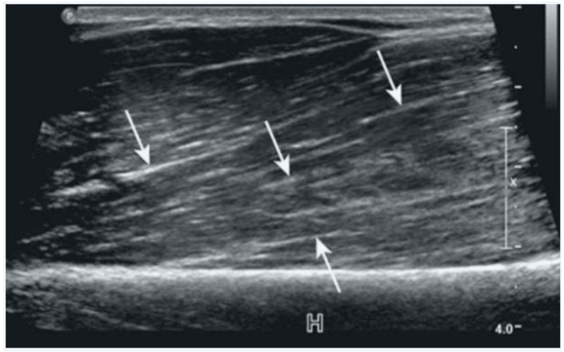

Figure B1. Biceps brachii muscle and cortex of humerus[2]

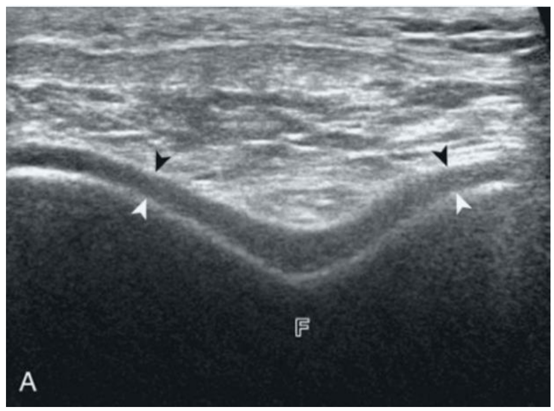

Figure B2. Articular cartilage on trochlea of femur[2]

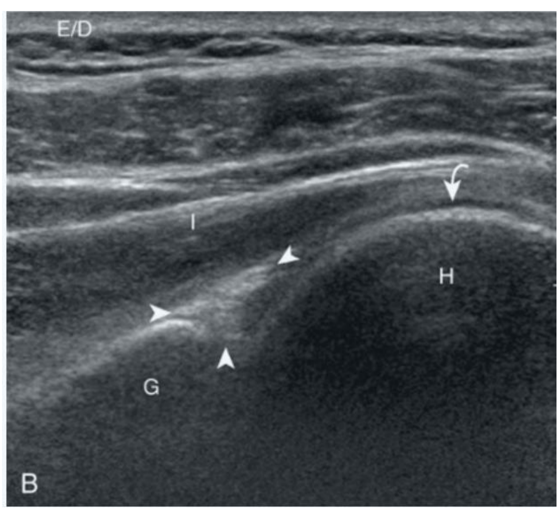

Figure B3. Fibrocartilage of posterior labrum[2]

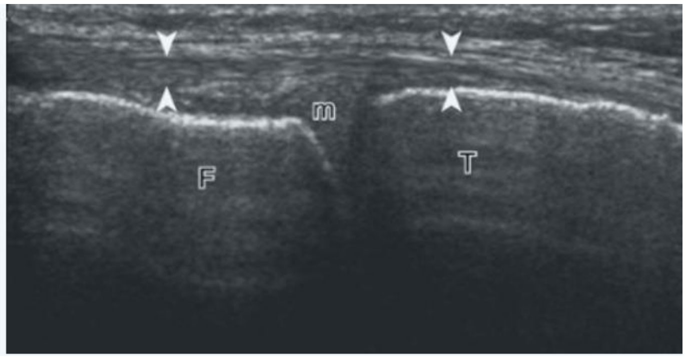

Figure B4. Medial collateral ligament[2]

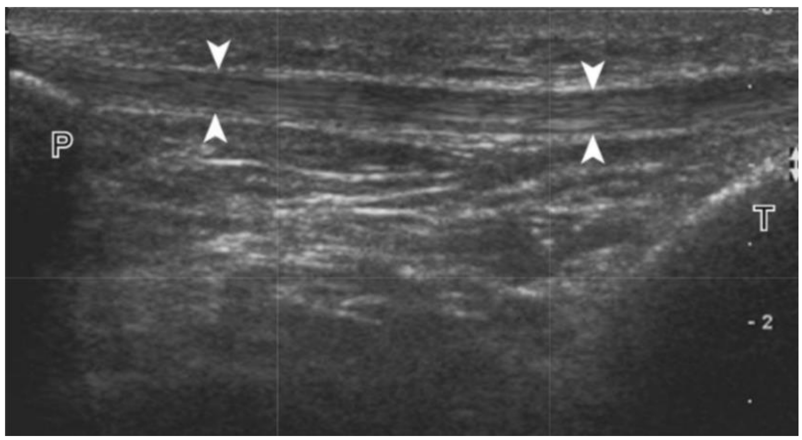

Figure B5. Patellar tendon[2]

APPENDIX C. DIAGNOSTIC ULTRASOUND ARTIFACTS

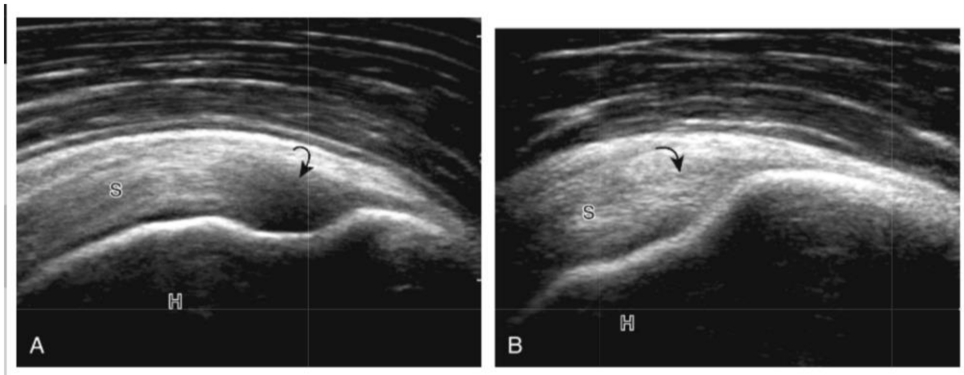

Figure C1. Anisotropy[2]

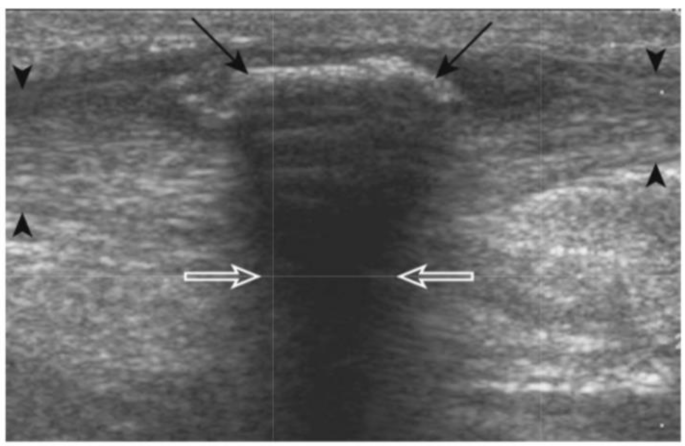

Figure C2. Shadowing[2]

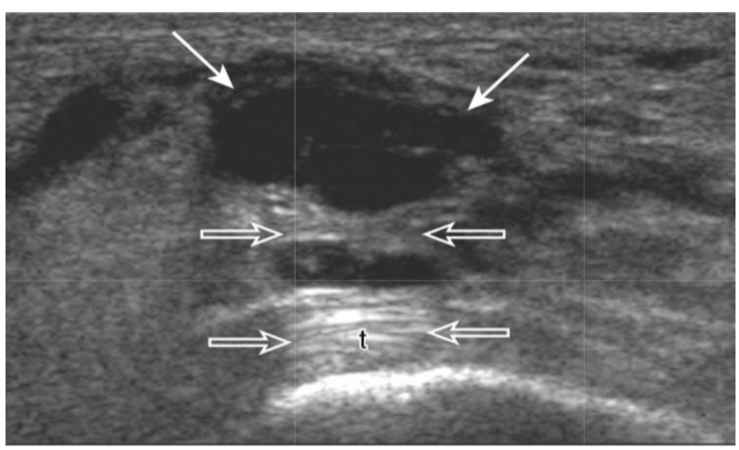

Figure C3. Posterior acoustic enhancement/increased through-transmission[2]

Figure C4. Posterior reverberation[2]

APPENDIX D. GRASTON TECHNIQUE® CONTRAINDICATIONS[1]

Absolute Contraindications:

- Open Wound
- Unhealed or unstable fractures
- Thrombophlebitis
- Uncontrolled hypertension
- Patient intolerance/non-compliance/hypersensitivity
- Hematoma
- Osteomyelitis
- Myositis ossificans
- Hemophilia

Relative Contraindications:

- Medications: anti-coagulants, steroids, hormone replacement therapy, NSAIDS
- Cancer
- Varicose veins
- Burn scars (mature scars 9 months post-healing)
- Acute inflammatory conditions
- Kidney dysfunction
- Lymphedema
- Inflammatory condition secondary to infection
- Rheumatoid arthritis
- Pregnancy
- Osteoporosis
- Hemophilia
- Polyneuropathies
- Unhealed, closed, uncomplicated stable fractures

APPENDIX E: SURVEY INSTRUMENT

What is your gender?

- Male
- Female
- Prefer not to answer

What is your age?

- 20-30 years old
- 31-40 years old
- 41-50 years old
- 51-60 years old
- 61-65 years old
- 66+ years old
- Prefer not to answer

What is your job setting?

How many years have you been a certified athletic trainer?

Do you use the Graston Technique® in your clinical practice?

- Yes
- No

How long have you used the Graston Technique® in your clinical practice?

What training do you have in the Graston Technique®?

- ☐ Graston MI
- ☐ Graston M2
- ☐ Graston Certified
- ☐ Graston Instructor
- ☐ None

Do you use Graston Technique® instruments?

- ○ Yes
- ○ No

What instruments do you use?

Why don't use the Graston Technique instruments?

What challenges have you identified with the Graston Technique®?

Do you have training in any other instrument assisted soft tissue mobilization (IASTM) method?

- ○ Yes
- ○ No

What other IASTM training do you have?

- ☐ Gua Sha
- ☐ Astym
- ☐ FAKTR
- ☐ Fascial Abrasion Technique (FAT)
- ☐ Other
- ☐ None

I incorporate the 'warm-up' element of the Graston Technique® into my clinical practice (passive or active warm-up)

- ○ Never
- ○ Sometimes
- ○ Always

Explain why you do not incorporate the 'warm-up' element

Explain why you only sometimes incorporate the 'warm-up' element

I incorporate the 'IASTM' element of the Graston Technique® into my clinical practice

- ○ Never
- ○ Sometimes
- ○ Always

Explain why you do not incorporate the 'IASTM' element

Explain why you sometimes incorporate the 'warm-up' element

I incorporate the 'stretching' element of the Graston Technique® into my clinical practice

- ○ Never
- ○ Sometimes
- ○ Always

Explain why you do not incorporate the 'stretching' element

Explain why you sometimes incorporate the 'stretching' element

I incorporate the 'exercise/strengthening' element of the Graston Technique® into my clinical practice

- ○ Never
- ○ Sometimes
- ○ Always

Explain why you do not incorporate the 'exercise/strengthening' element

Explain why sometimes incorporate the 'exercise/strengthening' element

What pathologies do you use the Graston Technique® for?

- ☐ Epicondylitis/osis
- ☐ Carpal tunnel syndrome
- ☐ Neck and/or back pain
- ☐ Plantar fasciitis
- ☐ Tendinitis/osis
- ☐ Post-surgial/traumatic scars
- ☐ Sprains
- ☐ Strains
- ☐ Reduced range of motion
- ☐ Edema
- ☐ Pre-competition warm-up
- ☐ Post-competition recovery
- ☐ Other

Describe other pathologies you treat using the Graston Technique®.

During a typical Graston Technique® treatment, how long does the IASTM portion take you to complete?

- Less than 8 minutes
- 8-10 minutes
- Greater than 10 minutes

Explain why your treatments are under 8 minutes.

Explain why your treatments exceed 10 minutes.

When treating one pathology on one patient, how many TOTAL Graston Technique treatments do you perform?

- 1-2
- 3-4
- 5-6
- 7-8
- Greater than 8

In a typical week, how many treatments do you perform?

- 1-2
- 3-4
- 5-6
- 7

How many "off" days do you have in-between treatments? (Days when you do not complete the treatment)

- Less than 2 days
- 2 days
- More than 2 days

Why do you have less than 2 "off" days between treatments?

Why do you have more than 2 "off days" between treatments?

Do YOU see improvements in pathologies when using the Graston Technique?

- ○ Yes
- ○ No

How many treatments do you perform before seeing improvement in pathologies?

- ○ 1-2
- ○ 3-4
- ○ 5-6
- ○ 7-8
- ○ Greater than 8

Describe what improvements you see.

Do YOUR PATIENTS report improvements in pathologies when using the Graston Technique?

- ○ Yes
- ○ No

Describe what improvements they report.

NDSU

We thank you for your time spent taking this survey.
Your response has been recorded.