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OBJECTIVE ASSESSMENT OF SOFT TISSUE INJURY

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DEFINITION OF SOFT TISSUE INJURY

Soft tissue injury is defined as pathology or dysfunction involving the connective tissues.[1] This chapter will deal exclusively with the injuries that affect skeletal muscles and connecting fascia. The myofascial train or mantle is complex.[3] It involves the fascial attachments around bones, ligaments, muscles, tendons, and capsules. The fascia covers individual muscular fasciculi and fibers.[4]

Clinically, myofascial injuries act as one functional component.[4,5] Trauma usually involves an accelerated type stretch. Often, there are myofascial pain and dysfunction consequences related to acute hyperextension or flexion types of trauma.[4,6] Most if not all myofascial injuries result in the classic signs of "rubor, calor, dolor, and functio laesa" (erythema, heat, pain, and loss of function.)[7–12] This may occur locally, at the location of the injury, and result in a degree of splinting of the lesioned muscles and myofascia of the traumatized area. It is of relevance to note that, after the initial "splinting" period, there may be a subsequent radiation of the myofascial dysfunction such that the contralateral anatomic and functional area starts acting as a "protective guardian" and becomes dysfunctional in time, itself.[4,6] The rehabilitation specialist needs to address an injured muscle within the context of the primary myotatic unit, vector of homologous proximal and distal units, as well as the contralateral homologous muscles.[3,5]

Ongoing attention must be paid to the differential diagnosis of the protective guarding pattern in terms of classical affected muscles versus "maverick" radiation. The rehabilitation specialist has a difficult but challenging task to evaluate and treat soft tissue injury. An old English proverb reminds us that "*bones forget, muscles remember.*"

THE OBJECTIVE EVALUATION OF SOFT TISSUE INJURY

There has been a change in the mentality of rehabilitation specialists and specialists in related fields. This change in mentality and clinical practice has been brought about by the recent "Daubert Rule of Evidence."[2,13] Thus, the specialist who acted in court in terms of giving personal opinions needs to act at present by giving evidence based on objective investigation and objective documentation. Time has passed since one could render rather non-specific acute or chronic diagnoses such as "sprains," "strains," "spasm," "rigidity," etc. The modern requirements are such that the rehabilitation specialist needs to consider any and all parameters involved in the symptoms and signs of soft tissue trauma/injury.[2,14–16]

The most common symptomatic parameters of soft tissue trauma/injury are as follows:

1. Pain, initially related to splinting and later related to protective guarding in the subacute or chronic stage
2. Functional loss of strength of the affected muscle and myotatic unit, to be followed in time by loss of strength of the myotatic vector
3. Possible loss of ROM, despite negative x-rays of the joints concerned
4. Loss of adequate function of the myotatic unit and increased dependence on the "protective" function of the contralateral myotatic unit
5. Symptoms radiation to the contralateral myotatic unit
6. Development of myofascial pain syndrome (MPS) with tender and/or trigger points
7. Eventual development of muscular hypotrophy/atrophy and relative muscle shortening and dysfunction

Radiologic testing such as x-rays, CT scans, or MRI do not demonstrate one way or another the presence of soft tissue injury and its symptoms most of the time.[1] It is most relevant to understand that appropriate clinical learning and experience are paramount in the investigation of soft tissue injury. The rehabilitation specialist may decide the type of objective testing that needs to be done in a case of soft tissue injury and relevant symptoms after the comprehensive physical examination.[2,17] Within forensic and to a lesser extent clinical parameters, the rehabilitation specialist needs to learn to utilize the objective testing for soft tissue injury. Such learning needs to be specific and render valid results.

In statistical terms, validity is defined within a number of criteria. The most common criteria of validity are the following:

1. Internal consistency. That depends on repeating a given objective test an adequate number of times in similar environmental and physical conditions.
2. Test/re-test repeatability of any methodology needs to be proven not only within the individual clinical context but also by the utilization of methodologies proven to demonstrate repeatability in the peer reviewed literature.
3. The reliability of the results obtained from objective testing depends on the accuracy of the testing and also on the available comparison with known databases or norms.
4. Epidemiologic considerations require that testing be conducted within a framework of specificity, sensitivity, and predictive values. As such, the clinical measurements of an individual patient/evaluee's soft tissue injury presentation can be described within the statistical framework of the appropriate tests.
5. Accuracy of the clinical evaluation and concordance with the results of the objective testing are paramount to the clinical decisions regarding rehabilitation and evaluation of results thereof.
6. Epidemiologic, forensic, and insurance requirements point toward the utilization of the results obtained from different methodologies in conjunction with the ongoing or point evaluation of improvement of the clinical case under consideration.

The topic of objective assessment of soft tissue injury will be presented in detail with regard to each objective methodology, including major strengths and limitations thereof.[5] The rehabilitation specialist is well advised to become familiar with the set of objective investigative methodologies described in this chapter in order to decide which methodology to use at a particular time or which methodologies to use concurrently, when the limitation of one is countered by the strength of another or several objective methodologies.

The objectives of identification of specific diagnoses of soft tissue injury and treatment thereof are as follows: (1) objective evaluation of each major symptom/sign; (2) objective evaluation of all the presenting symptoms as a whole; (3) diagnostic decision; (4) treatment plan divided within the short term, medium term and long term aspects; and (5) evaluation of the results of the treatment plan at given points in time.

A number of objective methodologies will be described below, including strengths and limitations of each. The description is followed by a table that summarizes the need for combined utilization of different methodologies for different soft tissue injury symptoms.

METHODOLOGIES FOR ASSESSMENT OF SOFT TISSUE INJURY

Soft Tissue Injury Questionnaires

Most available questionnaires refer to the subject of soft tissue injury pain and other dysfunction.[2,17] Since the patient/evaluee answers to any questionnaire are subjective by nature, the utilization of such questionnaires needs to be structured such that the rehabilitation specialist/evaluator may be enabled to assess the internal consistency of the responses over time. Wherever numerical data are utilized, validation may become possible in statistical terms. In order for the establishment of validation, the following parameters of the soft tissue injury questionnaires need to be presented and utilized:

1. The soft tissue injury questionnaire needs to be repeated at least five times within the diagnostic framework and, if necessary, within the rehabilitation treatment time framework. Wherever possible, numerical responses need to be elicited. As such, the responses may be validated in terms of internal consistency. Most commonly, that can be done by calculating coefficients of variation CV < 10% derived from the average response of several repetitions for each question and response as well as standard deviations thereof.
2. Repeatability can be assessed through the diagnostic and framework time period by repeating the questionnaire testing at appropriate intervals. As such, the clinician/evaluator may assess the consistency of the response over time. An acceptable variation is within 10%.

3. The establishment of databases of various kinds, corresponding to the most common or relevant parameters of soft tissue evaluation symptoms/signs, is paramount to the establishment of the reliability factor of given questionnaires.

4. The development of databases will allow for the statistical interpretation and validation in terms of specificity, sensitivity, and predictive values for any soft tissue injury assessment questionnaires.

5. Soft tissue injury assessment questionnaires may be utilized at key points during the rehabilitation period, as indicated clinically or within a medical-legal context.

In terms of clinical effectiveness and efficiency, it is advisable to utilize such assessment questionnaires at least once during the diagnostic period, at the beginning of the treatment period, and at the end of the rehabilitation period.

The Soft Tissue Injury Assessment Visual Analogue

There are several types of visual analogues. Whereas the responses are subjective, a repetition of the visual analogue testing may render the results objective in terms of the internal consistency of the response over time.[2] The issues of validation of the visual analogue are quite like those of the soft tissue injury questionnaire described above. More often than not, the patient or evaluee is asked to describe the frequency or intensity of a soft tissue injury symptom in terms of a ratio ranging between 0 and 10/10. Most frequently, a self-declared 0/10 reflects the presence of no symptom whatsoever, e.g., no pain at all. The statement of 10/10 represents a maximal and intolerable level of the symptom, e.g., excruciating and unbearable pain. Any intensity or frequency in between 0 and 10 may reflect the perceived symptom in a more objective way than possible if the patient/evaluee would have to describe such intensity/frequency in less numerical or objective values.

Visual analogue formats allow the patient/evaluee to express oneself in terms that can be assessed in a longitudinal fashion. Thus, visual analogues could be utilized during the diagnostic period in terms of describing symptoms such as, e.g., pain on the day of injury and at the time of the evaluation. As such, the clinician or medical-legal examiner may utilize the data in a more objective and numerical manner in order to make more sense and write a more objective report. Repeating the visual analogue testing through the rehabilitation period may result in a better and more precise understanding of the individual's self-perception of the frequency and intensity of a symptom over time.

In terms of maximal effectiveness and efficiency, the clinician may utilize the visual analogue testing at least three times during the clinical encounter. It should be utilized at least once during the diagnostic period. It needs to be utilized at least twice during the rehabilitative period, at the beginning and at the end. If further evaluation is done in time, the visual analogue may be utilized again and the results compared in terms of test/re-test repeatability, testing reliability, and internal consistency.

The Pain Perception Threshold (PPT)

Several types of soft tissue injury have an expression of edema, tissue softness, or increased rigidity. The pain perception of an individual may be different in terms of intensity and early appearance as compared with a contralateral asymptomatic region. Therefore, the fact that an individual may perceive the appearance of pain and the intensity of pain differently and usually stronger in a traumatized soft tissue region allowed for the creation of an instrument: the pain perception threshold meter. This instrument, placed in the epicenter of the soft tissue pain trauma region,

allows the clinician to measure in actual kilograms the number of kilograms of pressure necessary to elicit pain first and the numbers of kilograms of pressure necessary to produce pain of maximal tolerable intensity in that region. This methodology is particularly applicable in fibromyalgia or myofascial pain syndrome (MPS) where the pressure gauge is pressed on a trigger point.[18,19] The objectivity of PPT testing is found in the fact that it can identify differentially a trigger point area in terms of the number of millimeters of pressure that differentiates the pressure perception from that of pain and/or that of pain recognition versus that of maximal pain tolerance. Furthermore, it can differentiate between the symptomatic area and its asymptomatic contralateral.

The PPT method has also medical-legal or forensic utilization. It allows for the identification of symptom magnification of pain perception/tolerance. This is done by utilizing the PPT gauge on several chosen areas, homolateral and contralateral to the traumatized area. Symptom magnifying individuals will show inconsistency in the expression of the perception of soft tissue pain, including locations that have no reason to be symptomatic.[2]

In forensic utilization, it is relevant to utilize PPT testing in a manner similar to that of other soft tissue objective tests. The clinician needs to repeat the test at least five times on the traumatized area and on the contralateral area. This may need to be repeated at least once during the diagnostic period and at least twice during the rehabilitation period. The validation of the responses is done via the internal consistency principle. As such, coefficients of variation CV < 10% among the five or more repetitions for each test are expected in terms of good internal consistency of performance. This may relate to the perception of the initial pain and that of maximal tolerated pain.

In terms of test/re-test repeatability as well as repeatability for reasons of validation, it will be necessary to establish firm databases of soft tissue injury performance in terms of the PPT for different regions of the body. Such documentation will allow for statistical comparison of the PPT responses of one patient or evaluee to those found in the database.

The Tissue Compliance Measurement (TCM)

Soft tissue injury may result in localized edema. Traumatized muscles may show a "rubbery" texture to palpation, they may be softer than adjacent muscles, or they may feel more rigid. A pressure applied with a standardized instrument may allow for earlier and deeper penetration than in the contralateral muscle. The TC meter allows for the measurement of millimeters of depth of penetration differential between traumatized soft tissue in comparison with contralateral or other normal tissue. The methodology is particularly applicable to fibromyalgia or myofascial pain syndrome (MPS) where the pressure gauge is pressed on a tender or trigger point area.[20-26]

The objectivity of TCM testing is found in the fact that it can identify differentially the depth of tissue compliance to the penetrating gauge. In theory, it can differentiate between the symptomatic and traumatized area and its asymptomatic contralateral. The TCM method has also medical-legal or forensic utilization. It allows for the identification of symptom magnification of pain perception/tolerance. This is found simply by the fact that non-traumatized soft tissue has quite established penetration and the same values could be found in the alleged symptomatic areas as in the non-symptomatic areas. In this case, the clinician or forensic examiner can demonstrate that there is no difference in the tissue compliance, thus obviating the allegation.

In forensic utilization, it is relevant to utilize TCM testing in a manner similar to that of other soft tissue objective tests. The clinician needs to repeat the test at least five times on the traumatized area, on close-by areas as well as on the contralateral area and similar close-by areas. This may need to be repeated at least once during the diagnostic period and at least twice during the rehabilitation period. The validation of the responses is done via the internal consistency principle. As such, coefficients of variation CV < 10% among the five or more repetitions for each test are expected in terms of good internal consistency of performance. This may relate to the perception of the initial pain and that of maximal tolerated pain.

In terms of test/re-test repeatability as well as repeatability for reasons of validation, it will be necessary to establish firm databases of soft tissue injury performance in terms of the TCM for different regions of the body. Such documentation will allow for statistical comparison of the TCM responses of one patient or evaluee to those found in the database.

Dynamometry

Loss of strength related to splinting, protective guarding, or de-conditioning is a frequent result of soft tissue injury.[2,4,5] The skeletal muscles involved suffer usually from pain or edema. Trigger points are a frequent occurrence that limit functionally motion and allow the affected area to progress to de-conditioning.[4] Dynamometry is the modality most often utilized to assess the intensity or of loss of strength.[2,14] Whereas only one muscle from a myotatic unit may be injured, the whole myotatic unit may suffer in consequence. Dynamometry cannot assess the loss of strength of individual muscle but the sum total of the whole myotatic unit strength.[27]

Because of the advent of protective guarding as a natural phenomenon after splinting, soft tissue injury symptoms such as trigger points may be found eventually in the myotatic unit(s) that provide protective guarding to the injured muscle. Therefore, dynamometry may be necessary also in the area of the protecting myotatic unit. Dynamometry can be done with a variety of gauges, of mechanical or electronic type. Usually, the testing requires the performance of the evaluee at maximal voluntary contraction.

Medical-legal or forensic testing requires ruling out of symptom magnification, since it is found especially frequently in terms of allegations of loss of strength (LOS). Therefore, dynamometry should be tested in a specific way that allows for validation of the allegation or rules it out. This involves repeating the strength testing in the following areas: (1) the involved myotatic unit; (2) the contralateral myotatic unit; (3) two unrelated contralateral units (e.g., the right biceps may be the involved traumatized muscle: the right and left arm muscles are tested for strength: the right and left thigh muscles undergo dynamometry as well); (4) if the evaluee gives an honest history and allegation of weakness in the right arm, dynamometry should show loss of strength only in that location; (5) the testing is repeated five times, and the results are averaged; (6) SD and CV are calculated after the five repetitions are averaged, and the test could be considered to show good internal consistency if CV < 10% is found in the four locations.[2]

The total responses may be validated also in terms of test/re-test repeatability and reliability in terms of databases where such databases of dynamometry may be available. Further validation may be done in terms of specificity, sensitivity, and predictive values, where such databases are available.

Dynamometry should be done at least three times during the course of evaluation or treatment in order to assess the stability of the condition or improvement with the rehabilitation procedures for the particular case.

Goniometry (Inclinometry)

A muscle or myotatic unit functions best around a joint when the maximal degree of motion is functionally and structurally possible.[28] Muscle or tendon injury may be followed by relative shortening of the tissue, spasm, rigidity, or edema. Any of these could affect the total ROM by reducing it. The reduction is at least partly due to pain. Trigger points may also contribute to the pain and functional reduction in the maximal ROM.

Goniometry is the methodology necessary for measuring joint motion.[28] Like dynamometry, it measures the overall reduction of the myotatic unit ability for joint motion, not that of the individually traumatized muscle. Goniometric testing may be necessary in diagnostic terms in order to assess the joint dysfunction. It may also be necessary at the beginning and the end of the musculoskeletal rehabilitation treatment period in order to assess the degree of improvement.

Medical-legal or forensic requirements are like those described above for dynamometry.[2] They include accurate goniometric or inclinometric measurements, five repetitions of each joint motion measurement through the entire ROM for that joint. Determination of the average degree of motion for each segment is followed by the calculation of the SD and CV. Determination of the internal consistency of the ROM is done via consideration of the number of CV < 10% found for the overall ROM. The evaluator may need to consider the presence of symptom magnification if either the target joint of the contralateral (or other unrelated joints) shows ROM with CV < 10% without clinical reasons.

The test/re-test repeatability and reliability of the goniometry testing may be compared in terms of known databases.

S-EMG

Muscular trauma results in a number of symptoms such as pain, loss of strength, length reduction, resulting myotatic restriction of ROM around the pertinent joints, and muscular dysfunction.

Surface electromyography is a respected electrophysiological methodology for the investigation and treatment of skeletal muscles affected by injury.[17] It demonstrates the different pattern of electromuscular potential activity (μV RMS) shown by traumatized muscles in comparison with the asymptomatic contralaterals. S-EMG may also demonstrate by spectral analysis the different pattern of utilization of myofibrils, thus reflecting objectively the subjective perception of early and prolonged muscular fatigue.[15,27,29,30,36,37]

Within the amplitude domain, a number of parameters of S-EMG amplitude potentials (μV RMS) apply. Muscular dysfunction parameters have been described. They include abnormal electrical activity defined as spasm, hypertonus, hypotonus, co-contraction, myokymia, fasciculations, elevated resting potential values, and abnormal laterality values differences between the affected sites and the non-affected contralateral sites.[15]

The S-EMG method is applicable in the differential diagnosis and muscular rehabilitation of all skeletal muscles testable with the technology. Publications on this methodology have shown excellent results in terms of specificity, sensitivity, predictive values, laterality, internal consistency, repeatability, and reliability.[16,27,32,33]

The S-EMG protocols can be utilized in the diagnosis of muscular injury or dysfunction.[15,29] They involve dynamic protocols of bilateral myotatic units, at least one of which is affected by a soft tissue injury site.[37] S-EMG with static protocols may be valuable in the diagnosis of postural back dysfunction.

The parameters of S-EMG dynamic protocols is that of identifying changes related to muscular dysfunction in terms of loss of ROM, of strength, or of balance. Therefore, the parameters of testing involving segmental motions comprising the full ROM around a joint. They may involve testing against a given resistance and testing for the accomplishment of a given function. Whatever the testing, there is need for five repetitions of activity and rest for each motion in order to enable the statistical package to render valid results in terms of internal consistency. Testing involves the affected myotatic unit and its contralateral. The validation of the responses is in terms of the coefficient of variation, CV < 10% for each test.

The S-EMG dynamic protocols for muscular testing for soft tissue injury evaluation have been demonstrated to show good test/re-test repeatability as well as reliability.[32] This was established with testing done repeatedly on 180 muscles and compared with a database of 6400 muscles. The methodology has also been assessed in terms of specificity, sensitivity, and predictive value.[27,32,33]

S-EMG is a rather singular methodology in terms of applicability. The same principles applicable to soft tissue injury (muscle) diagnosis could be used for the neuromuscular rehabilitation program of S-EMG biofeedback. Therefore, the clinician may utilize S-EMG dynamic protocols for the actual diagnostic process and for the biofeedback-related treatment.[27]

SOFT TISSUE INJURY SYMPTOMS/SIGNS ASSESSABLE WITH OBJECTIVE METHODOLOGIES

The methodologies above serve to assess, most usually in combination, a number of soft tissue injury symptoms and signs. Several pertinent examples are described below.

The Soft Tissue Injury Questionnaire

It is highly advisable for the clinician or evaluator of soft tissue injury to ask the patient/evaluee to complete a comprehensive questionnaire related to the history, symptoms, signs, and related parameters.[34,35]

The evaluee responses provide first hand documentation of the actual event and longitudinal changes over time in the symptomatology as well as ADL and vocational-related factors.

The questionnaire should contain subsections related to at least the following factors: (1) pain, (2) ADL, (3) muscular dysfunction, (4) loss of ROM, (5) loss of strength, (6) concomitant pathology, (7) psychosocial factors and consequences of the soft tissue injury.[2]

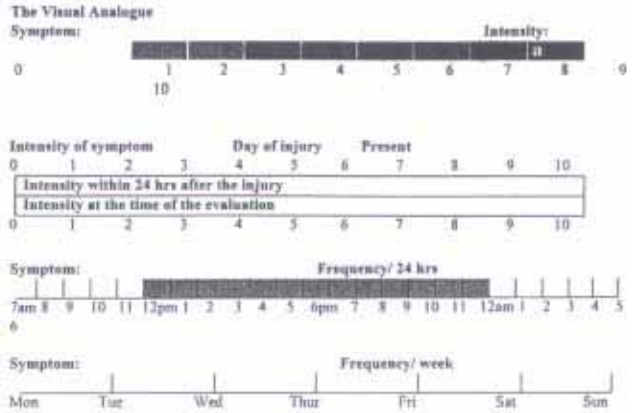
The main strength of the questionnaire is the prima facie testimony of the individual's perception of the event cluster. This can be extended longitudinally by repeating the questionnaire at appropriate intervals.

The main limitation is that the responses are ultimately subjective and the interpretation depends on the trust of the valuator in the veracity of the evaluee. Any such questionnaire value could be limited by secondary agenda intent, such as in forensic events.

The Visual Analogue

The visual analogue test is amenable to utilization in the course of investigation of any soft tissue injury symptom. The visual analogue could be presented for updating

or as a method of confounding at any time pertinent to the investigation or treatment on a longitudinal time scale.



The visual analogue may serve to understand better the perception of the patient/evaluee of the intensity and frequency of a diversity of symptoms and signs.[2,34] The visual analogue could be depicted as a straight line or equivalent encompassing at one end the "zero" (0) value and at the other, the "ten" (10) value. The former reflects complete freedom from any named given symptoms/signs, while the latter reflects the most intense and intolerable level. The intervening values reflect, in a crescendo order, the intensity and/or frequency of the symptom/sign under discussion.

As depicted in the visual analogue designs above, there are frequency (time) and intensity domains with regard to the soft tissue symptoms and signs.

SYMPTOMS OF SOFT TISSUE INJURY ASSESSABLE WITH THE VISUAL ANALOGUE METHOD

1. Pain: the presence of acute, subacute, or chronic pain of continuous or intermittent type can be expressed on the visual analogue in a semi-quantitative way.
2. Loss of strength: functional or structural self-perception of loss of strength compared with the period pre-injury can be verified in a longitudinal manner with the visual analogue through the diagnostic and treatment periods.
3. Loss of affected joints ROM, functional or structural, could be evaluated in terms of self-perception with the visual analogue in a longitudinal manner.
4. Myofascial symptoms that may involve the above symptoms in various combinations, including overall muscular dysfunction, may be evaluated with the visual analogue in a longitudinal perspective.
5. The ability/inability to perform a number of activities of daily living (ADL) as related to the presence of any of the symptoms above or combinations thereof can be evaluated with the visual analogue in a longitudinal fashion.
6. The ability/inability to perform one's main vocational tasks or secondary occupational tasks as related to the soft tissue injury could be assessed in the form of self-perception with the visual analogue during the diagnostic period and at the end of the rehabilitation period.

The Pain Threshold Meter

This semi-quantitative methodology serves to evaluate the self-perception of the depth of gauge pressure on a tender or trigger point that is necessary to produce pain (of self-described intensity) and the subsequent depth of pressure needed to produce maximal tolerable pain.[18] A summary procedural table for the PTM is as follows:

Pain Threshold Meter Testing (kg pressure)

PTM	Target area	Contra-lateral area	3 cm above or below target area	3 cm above or below contra-lateral area
Initial pain Perception				
Maximal tolerable pain				

Each location value represents the average of five repeated measurements done in rotation following a random pattern of measurement of the above locations. Each location is marked (water marker) such that the PTM is applied over the same spot through the five repetitions.

It is expected that the perception of pain, initial or maximal tolerable intensity, should be at a lesser gauge pressure than that needed on the asymptomatic sites. The averaging allows for the statistical analysis, including the internal consistency considerations.

The PTM test is applicable during the diagnostic period and at least twice during the treatment period.

Symptoms of Soft Tissue Injury Assessable with the PTM Method

1. Pain: the presence of acute, subacute, or chronic pain of continuous or intermittent type can be expressed via the pain threshold meter method in a semi-quantitative way.
2. Myofascial symptoms involving pain and dysfunction may be evaluated with the PTM in a longitudinal perspective during the diagnostic period and at the end of the rehabilitation period.

Strengths of the PTM Method

1. Ease of completion once the method is well learned and followed in a standardized manner.
2. Elimination of linguistic limitations in terms of verbal expression related to the pain (the evaluee has to state the pain perception intensity as a number from 1 to 10).
3. Ease of comparison of the symptomatic perception of pain in a time frame of at least three repetitions of the test during the evaluative and rehabilitative period.
4. Statistical analysis of the pain symptom trend and consistency expressed in the quantitative way.

Limitations of the PTM Method

1. Evaluator/clinician dependence on evaluee/patient pain perception and expression thereof at any given point in time, especially related to the concept of "maximal tolerable pain."
2. Cultural diversity factors in the amplitude of the pain-perception.

3. Factors of functional overlay, symptom magnification, or malingering connected to medical-legal or forensic secondary agendas in the realm of post-traumatic soft tissue pain.
4. Need for extensive database of pain threshold in individuals in symptomatic and asymptomatic states.

The Tissue Compliance Meter (TCM)

This quantitative methodology serves to evaluate the depth of gauge pressure on a tender or trigger point as compared with the tissue compliance on the point contralateral to the tender/trigger point under evaluation. The methodology is based on the concept that injured soft tissue may show edema, muscle softness, or rigidity, any or all in contradistinction from non-symptomatic myofascial or other soft tissue component.[20–22] A summary procedural table for the TCM is as follows:

Tissue Compliance Meter Testing (mm pressure)

TCM	Target area	Contra-lateral area	3 cm above or below target area	3 cm above or below contra-lateral area
Tissue compliance				

Each location value represents the average of five repeated measurements done in rotation following a random pattern of measurement of the above locations. Each location is marked (water marker) such that the TCM is applied over the same spot through the five repetitions.

It is expected that the tissue compliance to the TCM gauge should be different during the diagnostic period and should become more similar or similar at the end of successful rehabilitation. The averaging allows for the statistical analysis, including the internal consistency considerations. The TCM test is applicable during the diagnostic period and at least twice during the treatment period.

Symptoms of Soft Tissue Injury Assessable with the TCM Method

1. Edema: the presence of acute, subacute, or chronic edema of continuous or intermittent type can be expressed via the TCM method in a quantitative way.
2. Myofascial symptoms involving spasm, rigidity, pain, and dysfunction may be evaluated with the TCM in a longitudinal perspective during the diagnostic period and at the end of the rehabilitation period.

Strengths of the TCM Method

1. Ease of completion once the method is well learned and followed in a standardized manner.
2. Elimination of linguistic limitations in terms of verbal expression related to the edema, muscle spasm, rigidity, or pain.
3. Ease of comparison of the tissue compliance in a time frame of at least three repetitions of the test during the evaluative and rehabilitative period.
4. Statistical analysis of the tissue signs (i.e., edema, etc., trend, and consistency) expressed in the quantitative way.

Limitations of the TCM Method

1. Tissue compliance is not a completely understood phenomenon. It may be different from normal in a variety of conditions unrelated to soft tissue injury (e.g.,

myxedema). However in such conditions, it would not be expected to be different on the area involved in a soft tissue injury from another area.

2. Conditions of self-inflicted blunt injury (e.g., boxing blows), possible in well-orchestrated secondary agendas such as functional overlay, symptom magnification, or malingering connected to medical-legal or forensic situations.

3. Need for extensive database of tissue compliance in healthy and symptomatic individuals.

Dynamometry

This quantitative methodology serves to evaluate the strength of the myotatic unit of the injured muscle, in comparison with the contralateral unit under evaluation. The methodology is based on the concept that injured soft tissue, especially muscle, may show loss of strength associated with splinting, protective guarding, deconditioning, or learned dysfunction. There is a methodological need for comparison with the contralateral, asymptomatic area.[2]

A summary procedural table for dynamometry is as follows:

Dynamometry testing (kg pressure)

Dynamometry	I. Target myotatic unit	II. Contra-lateral myotatic unit	III. Unrelated myotatic unit homo-lateral to the target area	IV. Unrelated myotatic unit contra-lateral to III
Grip strength*				

Legend: * or strength measurement of any myotatic unit around a joint.

Each location value represents the average of five repeated measurements done in rotation following a random pattern of measurement of the above locations. It is expected that the strength of the affected myotatic unit should be inferior to that of its unaffected contralateral during the diagnostic period and should become more similar or similar at the end of successful rehabilitation. The averaging allows for the statistical analysis, including the internal consistency considerations. The dynamometry test is applicable during the diagnostic period and at least twice during the treatment period to assess improvement or normalization of strength.

Symptoms of Soft Tissue Injury Assessable with Dynamometry

1. Loss of strength in a myotatic unit secondary to that of an injured muscle: the presence of acute, sub-acute, or chronic weakness.

2. Myofascial symptoms involving spasm, rigidity, pain, and dysfunction, all involved with relative loss of strength, may be evaluated with dynamometry in a longitudinal perspective during the diagnostic period and at the end of the rehabilitation period.

Strengths of Dynamometry

1. Ease of completion once the method is well learned and followed in a standardized manner.

2. Elimination of linguistic limitations in terms of verbal expression related to loss of strength.

3. Ease of comparison of the loss of strength in a time frame of at least three repetitions of the test during the evaluative and rehabilitative period.

4. Statistical analysis of the myofascial group strength trend and consistency expressed in the quantitative way.

Limitations of Dynamometry

1. Loss of strength related to soft tissue injury may be structural, functional, or a combination of both possibilities. There are no longitudinal studies to show if the loss is constant over the course of one day, several days, or weeks. The maximal myotatic group contraction is at least partly related to motivation or other emotional factors.

2. The quantitative measurement with dynamometry, although quantitative and quite precise, may be limited in validity because of extraneous factors. However, in such conditions, it would not be expected to be limited only to the area involved with the soft tissue injury.

3. Conditions of secondary agendas such as functional overlay, symptom magnification, or malingering connected to medical-legal or forensic situations.

4. Need for extensive database of myotatic units dynamometry, including factors such as gender, age, and symptomatic versus asymptomatic conditions.

Goniometry

This quantitative methodology serves to evaluate the ability of the myotatic unit of the injured muscle or tendon to move fully through the ROM of the involved joint.[14,28] Normal ROM requires that the arc of motion be similar to that of the contralateral joint under evaluation. The methodology is based on the concept that injured soft tissue, muscle tendon, ligament, bursa, or capsule may be edematous or show other signs of injury that limit the ability to perform a full ROM on the primary joint. There is a methodological need for comparison with the contralateral, asymptomatic area, especially because it is assumed that the contralateral, or asymptomatic, joint is able to perform a full ROM.[2] A summary procedural table for goniometry is as follows:

Goniometry testing (° of motion)

Goniometry	I. Target joint	II. Contra-lateral joint	III. Unrelated joint homo-lateral to the target area	IV. Unrelated joint contra-lateral to III
ROM segment*				

Legend: * refers to the measurement of the arc of motion unit around a joint.

The table should be enlarged to contain all the classic segments of ROM. It may include also ergonomic segments, when the measurements are pertinent.[38] Each location value represents the average of five repeated measurements of degrees of motion done in rotation following a random pattern of measurement of the above locations. It is expected that the arc of motion of the affected myotatic unit or joint should be inferior to that of its unaffected contralateral during the diagnostic period and should become more similar or similar at the end of successful rehabilitation. The averaging allows for the statistical analysis, including the internal consistency considerations. The goniometry test is applicable during the diagnostic period and at least twice during the treatment period to assess improvement or normalization of joint ROM.

Symptoms of Soft Tissue Injury Assessable with Goniometry

1. Loss of joint motion secondary to that of an injured muscle or soft tissue structure: the presence of acute, subacute or chronic inflammation.

2. Myofascial symptoms involving spasm, rigidity, pain, and dysfunction, all involved with relative loss of joint motion, may be evaluated with goniometry in a longitudinal perspective during the diagnostic period and at the end of the rehabilitation period.

Strengths of Goniometry

1. Ease of completion once the method is well learned and followed in a standardized manner.
2. Elimination of linguistic limitations in terms of verbal expression related to loss of joint motion.
3. Ease of comparison of the loss of joint motion in a time frame of at least three repetitions of the test during the evaluative and rehabilitative period.
4. Statistical analysis of the joint motion functional trend and consistency expressed in a quantitative way.

Limitations of Goniometry

1. Loss of joint motion related to soft tissue injury may be structural, functional, or a combination of both possibilities. There are no longitudinal studies to show if the loss if constant over the course of one day, several days, or weeks. The maximal joint motion performance may be at least partly related to motivation or other emotional factors.
2. The quantitative measurement with goniometry, although quantitative and quite precise, may be limited in validity because of extraneous factors. However, in such conditions, it would not be expected to be limited only to the area involved with the affected joint.
3. Conditions of secondary agendas such as functional overlay, symptom magnification, or malingering connected to medical-legal or forensic situations.
4. The databases on joint ROM are multiple and show differences from one to another. They are based mainly on clinical consensus rather than on a large study of the "human joint ROM." Therefore, it is difficult to be sure that an asymptomatic joint can be the right frame of reference in terms of performance of an optimal joint ROM.
5. Need for extensive database of human range of motion, including age and symptomatic factors.

S-EMG

This quantitative methodology serves to evaluate the electrical activity of the myotatic unit of the injured muscle through the ROM and rest.[27,36,37] The intactness of the electrical activity can be evaluated in the amplitude domain via the evaluation of the characteristics of the activity and resting action potentials. It can also be evaluated in the frequency domain, i.e., the spectral analysis.[36] Whereas the former is partially dependent on autonomic or emotional factors, the latter is not known to be dependent on anything related to the ANS. The spectral analysis serves to assess the muscular expression of "fatigue factor," which may be quite different in a traumatized muscle than in an asymptomatic one.[36] The amplitude domain is paramount to the assessment of dynamic muscular behavior.[27,28,36] The action potentials reflect the muscular energy utilization for any segment of motion, with or without resistance, at any level of effort. The resting potentials reflect the electrical utilization at rest, with or against gravity, with the muscle knowingly relaxed or tense as related to emotional factors. A muscle affected by injury or dysfunction may display a variety of

amplitude potentials phenomena. These may include hypertonus, spasm, hypotonus, myokimia, co-contractions, fasciculations, loss of mirror image with the contralateral muscle in motions such as rotation or bending, and definite amplitude imbalance in comparison to the contralateral.[15,16,31] The resting tonus may be abnormally elevated in muscles affected by soft tissue injury.[27,37] Normal S-EMG activity of a muscle through motion and rest requires that the activity be similar through the arc of motion to that of the contralateral muscle under evaluation. The methodology is based on the concept and analytic determination that injured muscle shows a different electrical pattern of behavior than asymptomatic muscle.

There is a methodological need for comparison with the contralateral, asymptomatic muscle and myotatic unit, especially because it is assumed that the contralateral, or asymptomatic, structures perform normally from the amplitude potential perspective.

A summary procedural table for S-EMG is as follows:

S-EMG testing (μV RMS)

S-EMG	I. Target muscle	II. Contra-lateral muscle	III. Unrelated muscle from myotatic unit homo-lateral to the target unit & muscle	IV. Unrelated muscle & unit contra-lateral to III
Activity potentials of S-EMG through given ROM segment*				
Resting potentials of S-EMG through given ROM segment*				

Legend: * refers to the measurement of the amplitude potential during rest or segmental activity around a joint.

The table should be enlarged to contain all the classic segments of ROM. It may include also ergonomic segments, when the measurements are pertinent. Each location value represents the average of five repeated measurements of S-EMG potentials done sequentially, activity being interspersed with rest.

It is expected that the S-EMG activity and/or resting potentials pattern of the affected muscle and myotatic unit should be abnormal or dysfunctional in comparison with those of the unaffected contralateral during the diagnostic period and should become more similar or similar at the end of successful rehabilitation. The averaging allows for the statistical analysis, including the internal consistency considerations.

The S-EMG test is applicable during the diagnostic period and at least twice during the treatment period to assess improvement or normalization of joint ROM.

Symptoms of Soft Tissue Injury Assessable with S-EMG

1. Loss of joint motion secondary to that of an injured muscle or soft tissue structure: the presence of acute, subacute, or chronic inflammation.
2. Myofascial symptoms involving spasm, rigidity, pain, and dysfunction, all involved with relative loss of joint motion, may be evaluated with S-EMG in a longitudinal perspective during the diagnostic period and at the end of the rehabilitation period.

STRENGTHS OF S-EMG

1. Ease of completion once the method is well learned and followed in a standardized manner. This methodology has a database comprised of 6400 muscles tested through the classic ROM. The database and published (peer-reviewed) articles comprise analytical parameters such as muscular imbalance in symptomatic versus asymptomatic muscles, reliability, test/re-test repeatability, specificity, sensitivity, and predictive values.
2. Elimination of linguistic limitations in terms of verbal expression related to perception of symptomatic muscle behavior.
3. Ease of comparison of the muscular electrical behavior in a time frame of at least three repetitions of the test during the evaluative and rehabilitative period.
4. Statistical analysis of the muscular activity functional trend and consistency expressed in a quantitative way.
5. Conditions of secondary agendas such as functional overlay, symptom magnification, or malingering connected to medical-legal or forensic situations. These conditions can be identified and ruled out with the S-EMG technique via the statistical analysis that demonstrates lack of internal consistency of action potentials of the affected and unaffected muscles.

LIMITATIONS OF S-EMG

1. The muscles of expression may exhibit a different pattern of resting potentials behavior, dependent on the emotional state of the person at the moment of testing. However, that emotional state would have similar expression on the affected and unaffected muscle at one point of time.
2. Need for expanded database of the electrical activity of symptomatic muscles through activity and rest.
3. Need for expanded database of the spectral analysis of human skeletal muscles in health and disease.

The Combined Utilization of Pertinent Soft Tissue Injury Assessment Methods

It should be clear from the previous section that each methodology discussed has strengths and limitations. No method can assess by itself all the common soft tissue injury symptoms or signs.[2] The most common pattern of multi-modality investigation is described in a tabular form, as follows.

Soft Tissue Injury Symptoms and Assessment Methods

Symptoms	Questionnaire	Visual Analogue	PTM	TCM	Dynamometry	Goniometry	S-EMG
Pain	x*	x	x	x	x	x	x
Loss of strength	x	x	x	x	x		x
Loss of ROM	x	x				x	x
Loss of ADL	x	x			x	x	x
Muscular dysfunction	x	x	x	x	x	x	x
Inflammation	x	x	x	x	x	x	x
Tender/Trigger points	x	x	x	x	x	x	x

Legend: x* the methodology could be useful for the assessment of the symptom.

Each method may assess a different component of the symptomatic parameter. Whereas the diagnosis is subject to the presence of each methodological limitation, the strengths of any assessment method allow for a greater and more certain diagnostic poser, in the search for the optimal rehabilitation.

DISCUSSION

Soft tissue injury is a complex subject. It is probably the source of more pain than the injuries of other body structures.[1] Its investigation is complex by comparison with other types of injury, e.g., bony fracture.

Radiologic methods of investigation reflect poorly the intensity or even the presence of soft tissue symptoms.

The soft tissue symptoms/signs discussed in this chapter are the most common in terms of clinical presentation. The methods of objective assessment presented in this chapter are likewise quite common but not unique.

It is relevant to better understand the complementarity of the strengths and limitations of the various methods. For instance, dynamometry assesses the strength of a given myotatic unit as a whole. However, it cannot give much information about the strength and intactness of function of the individual muscles comprising the myotatic or functional unit. In contradistinction, S-EMG assesses the (electrical) activity potentials of each individual muscle of a myotatic unit and describes the behavior of individual symptomatic muscles. It cannot describe the strength, but the effort of each muscle. The simultaneous utilization of dynamometry and S-EMG allows the investigator to assess the overall myotatic unit strength and the contribution, in a pathologic sense, of the injured muscle(s).

A more comprehensive presentation of the combination of different methods of soft tissue investigation, including forensic dimensions, is beyond the requirements of the present topic.[2] The reader is advised to become familiar and experienced in the utilization of the methodologies described in the sections above. It is very relevant to learn and proceed with standardized protocols in order to render results more repeatable within the clinical, forensic, and research frameworks.

SUMMARY

Soft tissue injury is a complex subject in terms of investigation and treatment. The diagnostic precision of one type of investigation such as radiologic diagnosis of bone fracture is not possible most of the time in the realm of soft tissue injury. The skillful combination of a number of objective methodologies aimed at a variety of factors and parameters of soft tissue injury allows for a rather specific and focused diagnosis. The methodologies described above may be utilized within the diagnostic framework. They may also be used in a longitudinal fashion during the course of the rehabilitation of the soft tissue injury.

REFERENCES

1. Cailliet, R., *Soft Tissue Pain and Disability*. Rene Cailliet Pain Series, Edition 2, FA Davis Co, Philadelphia, 1988.
2. Sella, G.E., and Donaldson, C.C.S., *Soft Tissue Injury Evaluation: Forensic Criteria: A Practical Manual*. GENMED Publishing, Martins Ferry, OH, 1998.
3. Busquet., L., *Les Chaines Musculaires*. Tome I, II, III, IV, Frison roche, Paris, 1998.
4. Travell, J., Simons, D., *Myofascial Pain and Dysfunction: A Trigger Point Manual*, Vol. I & II, Baltimore: Williams & Wilkins, 1983.
5. Cailliet, R., *Pain: Mechanism and Management*. Rene Cailliet Pain Series, FA Davis Co, Philadelphia, 1993.

6. Pope, M., Anderson, G., Frymoyer, J., and Chaffin, D. (Eds.), *Occupational Low Back Pain. Assessment, Treatment and Prevention*. Mosby Year Book, St. Louis, 1991.
7. Cailliet, R., *Head and Face Pain Syndromes*. Rene Cailliet Pain Series, Edition 1, FA Davis Co, Philadelphia, 1992.
8. Cailliet, R., *Neck and Arm Pain*. Rene Cailliet Pain Series, Edition 3, FA Davis Co, Philadelphia, 1991.
9. Cailliet, R., *Knee Pain and Disability*. Rene Cailliet Pain Series, Edition 3, FA Davis Co, Philadelphia, 1992.
10. Cailliet, R., *Shoulder Pain Syndrome*. Rene Cailliet Pain Series, Edition 3, FA Davis Co, Philadelphia, 1991.
11. Cailliet, R., *Low Back Pain Syndrome*. Rene Cailliet Pain Series, Edition 4, FA Davis Co, Philadelphia, 1988.
12. Cailliet, R., *Hand Pain and Impairment*. Rene Cailliet Pain Series, Edition 4, FA Davis Co, Philadelphia, 1994.
13. Sella, G.E., Daubert and New Technologies: An Independent Medical Examiner's View, Parts 1 & 2, *Forensic Examiner, The Official Journal of the American College of Forensic Examiners*, Vol. 6 & 8, Nos. 5, 6, 7 & 8, May/June & July/August 1997
14. AMA Guides to Evaluation of Permanent Impairment. 4th Edition, 1993.
15. Sella, G.E., *Neuromuscular Testing with S-EMG*, GENMED Publishing, Martins Ferry, OH, 1995.
16. Sella, G.E., The Utilization of S-EMG in Neuromuscular Rehabilitation, Proceedings: 9th European Congress of Clinical Neurophysiology, Ljubljana, Slovenia, June 4–7, 1998, pg. 375–359, Monduzzi Editor, International Proceedings Division.
17. Sella, G.E., *Guidelines for Neuro-muscular Reeducation: The Electromyographic Approach*, GENMED Publishing, Martins Ferry, OH, 2000.
18. Fischer A.A., New developments in diagnosis of myofascial pain and fibromyalgia. *Phys Med Rehabil Clin North America* 1977;8:1–21.
19. Fischer, A.A., Application of pressure algometry in manual medicine. *J Manual Medicine*, 1990;5:145–150.
20. Fischer, A.A., Clinical use of tissue compliance meter for documentation of soft tissue pathology. *Clin J Pain* 1997;3:23–30.
21. Fischer, A.A., Quantitative and objective documentation of soft tissue abnormalities: Pressure algometry and tissue compliance recording. *Spinal Manipulation*, Summer 1994;1–4.
22. Fischer, A.A., Pressure algometry over normal muscles. Standard values, validity and reproducibility of pressure threshold. *Pain* 1987;30:115–126.
23. Fischer, A.A., Pressure threshold measurement for diagnosis of myofascial pain and evaluation of treatment results. *Clin J Pain* 1987;2:207–214.
24. Fischer A.A., Diagnosis and management of chronic pain in physical medicine and rehabilitation. In *Current Therapy in Physiatry*, edited by Ruskin AP, Philadelphia. 1984, WB Saunders, 123–145.
25. Fischer, A.A., New approaches in treatment of myofascial pain. *Phys Med Rehabil Clin North America* 1977;8:153–169.
26. Fischer, A.A., Muscle tone in normal persons measured by tissue compliance. *J of Neurological & Orthopaedic Medicine & Surgery* 1987;8:227–233.
27. Sella, G.E., *Muscular Dynamics: Electromyographic Assessment of Energy and Motion*, GENMED Publishing, Martins Ferry, OH, 2000.
28. Gerhardt, J.J., Documentation of Joint Motion, Revised 3rd edition, Portland, OR, Oregon Medical Association, 1992.
29. Sella, G.E., *Muscles in Motion: The S-EMG of the Range of Motion of the Human Body*, GENMED Publishing, Martins Ferry, OH, 1993.
30. Hagberg, M., Electromyographic signs of shoulder muscle fatigue in two elevated arm positions. *Am J Phys Med*, 1981,60:111–121.
31. Sella, G.E., S-EMG Utilization in Low Back Pain Investigation and Rehabilitation. *Kinesitherapie Scientifique*, p. 35, No. 383, Paris, France, November 1998.
32. Sella, G.E., Internal Consistency, Reproducibility and Reliability of S-EMG Testing. *Europa Medicophysica*, March 2000, Vol. 36, No. 1, pp. 31–38.
33. Sella, G.E., Surface Electromyography Testing: Sensitivity, Specificity, Positive and Negative Predictive Values. Europa Medico-physica, December 2000.
34. Anchor, K., Felicetti, T.C., eds. Disability Analysis In Practice. Kendall/Hunt Publishing Co. Dubuque, Iowa, 1999, Chapter 15, pp 279–314.
35. Sella, G.E., S-EMG assessment. In Yan-Ping Zheng and Shu-Qiao Yao, *The Practice of Biofeedback*, Chapter IV, High Education Press in P.R. China, July 2001.
36. Basmajian, J.V., and DeLuca, C.J., Muscles Alive, Their Functions Revealed by Electromyography. 5th Edition, Baltimore, Williams & Wilkins, 1985.
37. Sella, G.E., Graphics of Motion: *The Electromyography of Muscular Dynamics*, GENMED Publishing, Martins Ferry, OH, 2000.
38. Kumar, S., Mital, A. Electromyography in Ergonomics, Taylor & Francis, 1996.

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They only are deceived who willingly deceive themselves.
—James of Scotland

Diagnosticians are challenged by patients whose reported problems are difficult to verify objectively. These patients present with disorders that lack definitive research and objective medical tests. The diagnosis of the disorder relies heavily upon accurate patient symptom reporting. Examples of these types of disorders are headaches, chronic pain syndromes, concussions, chronic fatigue syndrome, and fibromyalgia. Medical-legal and compensation issues are often involved.

Confronted by these types of cases, the medical diagnostician typically obtains a history and reports of symptoms from the patient and significant others. This is followed by appropriate medical tests that are usually negative. After exhausting the available avenues of objective medical exploration, there is consideration of psychological conditions such as somatoform disorders (unconscious psychological causes). When medical-legal compensation issues are involved, there may be suspicions of secondary gain. In some cases, malingering (conscious deliberate feigning of illness for monetary rewards) is considered.

Following the negative medical findings, the patient is usually referred to a psychiatrist or psychologist for evaluation. The psychiatric evaluation involves medical records review and an interview of the patient. Significant others may be interviewed. A diagnostic conclusion is formed and a report issued.