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Research Article

The Sciatic Nerve Elastography in the Clinical Pathway

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Abstract

Last few years there are more papers related to the usefulness of sciatic nerve elastography in clinical practice. Sonoelastographic evaluation was performed predominantly in patients with deep gluteal syndrome (DGS). In this review in the final processing, 14 studies were identified, three with strain ratio. 11 with shear wave elastography. The final processing was done by ROC analysis of patients results. The scientific data were from 2013th to 2019th. Looking at the reviewed studies, there were applied different techniques (quasi-static, ARFI and shear wave elastography), with various joint movements ("knee movement", "limb movement", "ankle motion", "plantar or dorsal flexion"), the several position of the transducer at the "region of interest", non-standardized measurement units and in patients were dissimiliar pathology. The ultrasound equipment upgraded with shear wave elastography option gave a new opportunity to this review technique. It is based on direct measurement of muscle stiffness. In the musculoskeletal field, the quasi-static method was not often applied, looking at a relative strain ration, and that the region of interest (ROI) was not clearly defined. However, some authors have presented the referent values of relative stiffness in knee extension, and in knee flexion. Some authors have noted the neurodynamic sciatic nerve changings in exercises of plantar flexion to dorsiflexion. The shear wave features were presented in different conditions and diseases, respectively in healthy patients and in patients with chronic low back leg pain. The shear wave sciatic nerve stiffness was also tested during human ankle motion in conclusion the follow of EFSUMB Guidelines and Recommendations for the Clinical Practice of Elastography in Non-Hepatic Applications: Updated by 2018 was required. In this review the resume of all obtained results lead us to conclude that sciatic nerve ultrasound elastography test is not well established and clinically standardized. However, in everyday practice this method can be applied. The nerve and surrounding muscles have to be assessed by color scale and B mode. Determining strain index may be useful, on particular equipment and within the same institution. The shear wave technique provides much more secure, direct results, comparable to those of other institutions and researchers. Most proven this method can use deep gluteal syndrome with a wide range of manifestations, unilateral lumbar disc hernia, in the assessment of sports injuries, to study musculoskeletal activity, in monitoring the course of rehabilitation and in monitoring postoperative recovery.

Keywords: *Sciatic Nerve Elastography; Shear Wave; ARFI; Strain Elastography; Deep Gluteal Syndrome*

Abbreviations

DGS: Deep Gluteal Syndrome; MRI: Magnetic Resonance Imaging; ARFI: Acoustic Radio Force Impulse

Introduction

It is time to tear the knot around the usefulness of sciatic nerve elastography in clinical practice. Last few years there are more and more papers on this issue, most of which through various studies have provided controversial messages, some hope and many dilemmas. "It`s interesting, but not very useful" is very often the clinician`s statement. Infect the sciatic nerve pathology is still controversial, closely connected with its position. The sciatic nerve stretch and slide during normal joint movement. In case of entrapped or compressed conditions it causes pain with a change in its elasticity [1]. The sciatic nerve roots descend from the lumbar plexus, passes through the pelvis with an exit on the sciatic notch inferior to the piriformis muscle [2-4]. Some authors believe that it`s connected with deep gluteal syndrome (DGS) [5-7]. The clinical decision making depends on neurological examination, electromyography (EMG), and very often on pelvic and lumbar MRI [2,6]. Last few years authors involve ultrasound elastography techniques in clinical decision making. The first announcement was based on strain elastography features [8,9], later acoustic force impulse (ARFI) data were involved [10,11] and last few years the experience was incompletely surrounded with shear wave elastography [12-17]. The potential pain generator caused by a sciatic nerve lesion can be connected with ischiofemoral impingement and hamstring dysfunction, by a combination of hip extension, adduction and external rotation, by abnormal contact between the lesser trochanter of the femur and the ischium, and in those with the DGS [1-4]. DGS may manifest as a specific entrapments within the subgluteal space include fibrous and fibrovascular bands, piriformis syndrome, obturator internus syndrome, quadratus femoris and ischiofemoral pathology, hamstring conditions, gluteal disorders or other orthopaedic causes [1-4,18]. Sonoelastographic evaluation of the sciatic nerve was also performed in patients with unilateral lumbar disc herniation [19,20]. A subject with a known recent ipsilateral hip or pelvic fracture, femoral head avascular necrosis or metastatic disease have to be excluded from the matter.

Materials and Methods

In this review at the beginning 26 studies were identified. Those were citations in reviewed manuscripts. The case reports and small series (five or fewer cases), as well as the theoretical studies, non-representative population studies, or studies without clear data were excluded. In the final processing, 14 studies were identified, three with strain ratio. 11 with shear wave elastography. The final processing was done on the basis of patient data, ROC analysis results, with processing and by conclusions. The scientific data were from 2013th to 2019th. The applied equipment was up to date. The Meta-analysis was not quite appropriate for processing obtained studies data. Looking at the reviewed studies, there were applied different techniques (quasi-static, ARFI and shear wave elastography), with various joint movements (“knee movement”, “limb movement”, “ankle motion”, “plantar or dorsal flexion”), the several position of the transducer at the “region of interest”, non-standardized measurement units and in patients were dissimiliar pathology [8,10,12,14-17,19,21]. In early 2013th, Santos and Armada have tested sciatic nerve hardness measurement by using ultrasound elastography [8]. Elastography results demonstrated that healthy sciatic nerve has a higher percentage of blue color (hard properties). In conclusion the sciatic nerve hardness can be measured by elastography [10]. With this study the sciatic nerve was identified as a hard structure. The statement is that sciatic nerve alterations can be identified. Also, one of the first announcement was Brandenburg and collaborators (2014) [9] information about different ultrasound elastography techniques for studying muscle stiffness, including strain elastography, acoustic radiation force impulse imaging, and shear-wave elastography. They discussed about the basic principles of these techniques, including the strengths and limitations of their measurement capabilities. Looking at the influence of elastography on rehabilitation, author François Hug (2016) [15] notes that there is growing evidence that elastography may be a useful tool in detecting subtle changes in muscle, tendon or nerve mechanical properties that occur early in the course of an injury or disorder. This is particularly important as earlier detection could improve sports training and rehabilitation strategies. The quantification of muscle, tendon or nerve stiffness also provides insight into the mechanisms which may underlie treatment and rehabilitation programs and could ultimately assess their efficacy. Neto Tiago Goncalves in his doctoral thesis (2017) [17] processed the effects of neural tension by the sciatic nerve stiffness, in healthy people and people with low back related leg pain. This thesis aimed to determine the immediate effects of neural tension in the sciatic nerve stiffness. Andrade with his team announced during 2016th in *Journal of Biomechanics* [12] and in 2018th in *Scientific Reports* [21] the potential role of sciatic nerve stiffness in the limitation of maximal ankle range of motion, using shear wave elastography in estimation of sciatic nerve stiffness. Sciatic nerve stretching induced both a decrease in the nerve stiffness and an increase in the maximal joint dorsiflexion. Greening and Dilley in Muscle and Nerve (2017) [13] have practiced with shear wave elastography changes in peripheral nerve stiffness of upper (median nerve) and lower (tibial nerve) limb position. Dikici and his team (2017) [16] evaluate the tibial nerve with shear-wave elastography, as a potential sonographic method for the diagnosis of diabetic peripheral neuropathy. They conclude that the tibial nerve stiffness measurements appear to be highly specific in the diagnosis of established diabetic peripheral neuropathy. In 2018 Demirel and collaborators [22] also have showed that the muscle elasticity and tissue hardening increased on the problematic side both on piriformis muscle and gluteus maximus. According to them ultrasound elastography may provide early diagnosis of piriformis muscle syndrome. The study of Ellis., *et al*. (2018) [23] showed that ultrasound elastography was seen to be a reliable method for calculating sciatic nerve hamstring muscle interface by shear strain and sciatic nerve displacement. Using ultrasound elastography to quantify sciatic nerve displacement as the body moves, peripheral nerves are constantly being exposed to mechanical forces and stress from the surrounding tissues. Stajic., *et al*. (2018) [10,11,24] concluded that the variation of the sciatic nerve is challenging for diagnostic and therapeutic procedure in many clinical and surgical cases. Quick ultrasound detection of the sciatic nerve makes surgical approaches more precise and effective, with a better outcome. This procedure could provide crucial information about the degree of nerve stiffness very useful in the process of the surgical decision making and during the follow up (2019) [25]. In 2019th Celebi and collaborators [19] had shown results of sonoelastographic sciatic nerve evaluation in patients with unilateral lumbar disc herniation. They also used shear wave technique to evaluate sciatic nerve stiffness. Their experience was that patients with unilateral lumbar disc hernia have increased stiffness of the sciatic nerve compared to healthy control subjects. Wang., *et al*. (2019) [20] established the relationship of the shear wave elastography findings of patients with unilateral lumbar disc herniation and clinical characteristics. According to their findings ultrasound imaging can be considered as a useful tool to detect changes in the sciatic nerve due to disc herniation.

Results and Discussion

There is no significant evidence of sciatic nerve color elastograms, except Santos and Armada observation from 2013th [8]. The ultrasound equipment upgraded with shear wave elastography option gave a new opportunity to this review technique [16]. It is based on direct measurement of muscle stiffness [22]. In the musculoskeletal field, the quasi-static method was not often applied, looking at a relative strain ration, and that the region of interest (ROI) was not clearly defined [15]. However, Stajic., *et al*. in 2018 [10,11,24] presented the referent values of relative stiffness in asymptomatic patients, with cut off 2.78 SR in knee extension, and 5.75 SR in knee flexion. The diameters of sciatic nerve were 8.21 mm in extension, 4.7 mm in the flexion. The specificity was 93.5%, sensitivity 88.9%, with the accuracy 90.6%. They continued with follow up sciatic nerve stiffness in patients with the deep gluteal syndrome, underwent surgery [25]. Their results suggest the significance of sciatic nerve stiffness differences (by ARFI), in the knee extension and flexion movements, in patients before and after surgery. The stiffness decrease was evident, from 7.32 to 1.32 SR (knee extension) and from 11.97 to 4.07 SR (knee flexion), as a sign of recovery, but the accrual of nerve fibrous strips with mild stiffness increase was noted one year later as 3.25 and 6.76 SR (extension/flexion). The follow up was updated by shear wave technique after a slump neurodynamics technique [26] without significant stiffness changing (0.35 - 1.15 m/s). Also, neurodynamic sciatic nerve changings were noted by Francois Hug [15], in exercises of plantar flexion to dorsiflexion (from 1 to 7 m/sec, by color scale). The shear wave features were presented in different conditions and diseases, respectively in healthy patients. Neto., *et al*. [26] presented in patients with chronic low back leg pain, higher sciatic nerve stiffness compared to the unaffected limb (8.2 - 16.2 m/sec in affected limb, contrary to 9 - 13.6 m/sec, with up 11.3%, $P = .05$), without differences of the unaffected limb (low back syndrome) and the healthy controls ($P = .34$). Shear strain during active and passive knee extension were observed by Ellis [17]. The shear strain in flexion, during active knee movements were 73.06%, while in passive knee movements 80.92%. The shear strain in extension, during active knee movements was 59.84%, while in passive knee movements 63.26%. The shear wave sciatic nerve stiffness was also tested during human ankle motion [12]. The shear wave velocity of the sciatic nerve significantly increased ($p < 0.0001$) during dorsiflexion when the knee was extended (knee 180°), but without changes when the knee was flexed (90°). Posture-induced changes in peripheral nerve stiffness (shear-waves), by Greening and Dilley [13], were for tibial nerve in different positions, from 3.47 to 8.10 m/sec (man), 3.08 to 7.15 m/sec (woman). By Çelebi and his team [19] the sciatic nerve stiffness in patients with unilateral lumbar disc herniation assessed on both the axial (12.3 kPA) and longitudinal (14.3 kPA) planes of the involved side and was significantly higher than non-involved side (6.8 and 8.3 kPA) in the patient group ($p < 0.001$). On the other side, Wang., *et al*. [20] established sciatic nerve stiffness on affected side 20.4/27.5 kPa ($P < 0.05$), contrary to unaffected side 12.9/17.3 kPa. Demirel and his team [22] have tested piriformis muscle syndrome by shear waves. The stiffness of piriformis muscle was on painful side 1.59 m/sec (mean value), according to 0.5 m/sec (normal side). The sciatic (tibial) nerve was evaluated by Dikici [16]. Patients with diabetic peripheral neuropathy had much higher stiffness values on both sides. A cutoff value proximal to the medial malleolus was 51.0 kPa, with the sensitivity of 90%.

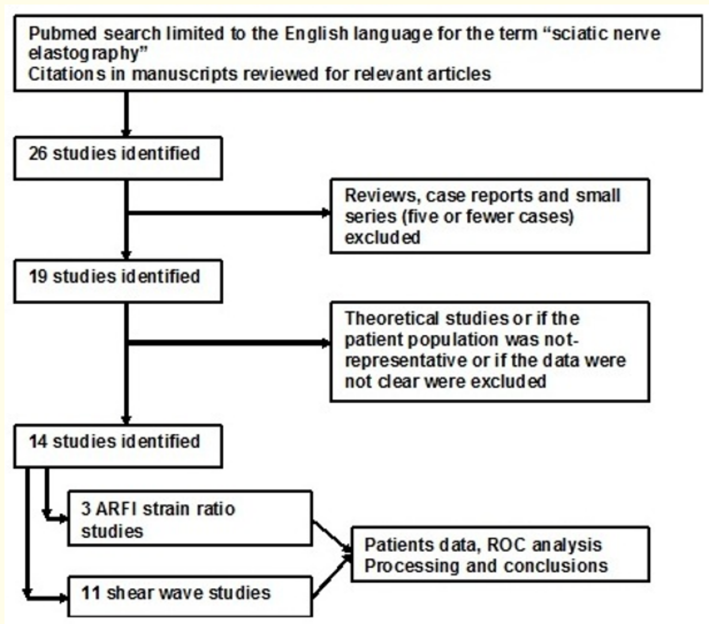

Figure 1: *Flow chart of the search for included studies.*

Conclusion

The EFSUMB Guidelines and Recommendations for the Clinical Practice of Elastography in Non-Hepatic Applications: Update 2018 [27] suggests: The operator has to be experienced and well educated. Applied ALARA principle (as low as reasonably achievable) when using ultrasound elastography. In patients with diabetic peripheral neuropathy tibial nerve elastography has to be recommended. Pay attention that strain elastography is an operator-dependent technique. B-mode ultrasound appearance influences the quality of the strain elastogram.

In this review the resume of all obtained results lead us to conclude that sciatic nerve ultrasound elastography test is not well established and clinically standardized. The review data showed that the use of this method is widely spread, mostly within projects, different studies, but clinical backup is not established. It is not a part of clinically and diagnostically pathway. However, in everyday practice this method can be applied. The nerve and surrounding muscles have to be assessed by color scale and B mode. Determining strain index may be useful, on particular equipment and within the same institution. The shear wave technique provides much more secure, direct results, comparable to those of other institutions and researchers. The shear wave technique has to be standardized (m/sec or kPa). Most proven this method can use deep gluteal syndrome with a wide range of manifestations, unilateral lumbar disc hernia, in the assessment of sports injuries, to study musculoskeletal activity, in monitoring the course of rehabilitation and in monitoring postoperative recovery. The further investigations have to be continued. The orthopedic and the ultrasound community have to make agreement about basic principles in sciatic nerve ultrasound elastography examination. The shear wave elastography have to be basic method. The color scale elastograms to be established (how many subgroups), regardless shear wave or quasi static method. The region of interest (ROI) have to be determined (intra or extra-neural or surrounding tissue). The agreement looking at the validate cut off (the collected data of well-founded studies). It`s certain that in everyday practice, B mod with color scale elastograms will be sufficient in quick clinical decision making.

Conflict of Interest

None.

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