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Research Article

NERVE STIFFNESS - A CHALLENGE FOR ULTRASOUND ELASTOGRAPHY

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A B S T R A C T

Nerve stiffness associated with limb movements was a challenge for sonoelastography in the diagnosis of sciatic nerve entrapment in deep gluteal syndrome. The sciatic nerve was scanned by ultrasound strain elastography, during limb movements, in healthy persons (62) and in patients with deep gluteal syndrome (108). The results were presented by "B" mod, color maps and strain ratio. In flexion movements sciatic nerve diameters were statistically significantly lower, than in extension movement in both groups ($p<0.001$). Patients with deep gluteal syndrome, had significantly lower diameters of sciatic nerves ($p<0.001$), than the healthy group of persons. The group of healthy persons had significant increase of strain value ($p<0.001$) from extension to flexion movement of leg. The group of patients with deep gluteal syndrome had significant increase of strain value ($p<0.001$) in extension and in flexion movement of leg, than the healthy persons. In deep gluteal syndrome the specificity of method was 93.5%. sensitivity was 88.9%, with accuracy of 90.6%. Strain elastography imaging is currently the only diagnostic procedure based on the assessment of nerve stiffness with crucial information about the degree of nerve entrapment.

INTRODUCTION

Changes in periferal nerve stiffness, associated with tightening and relaxing, during limb movements, may be important in understanding various nerve diseases, as deep gluteal syndrome. Miller and Cass believed that deep gluteal syndrome is a result of sciatic nerve compression caused by piriformis muscle (14,2). Symptoms vary and can include pain and numbness down the leg (Cass and Liebert) and are worsened with sitting or running (2,11). The radiographs and the MRI image of the lumbar spine and pelvis showed no pertinent findings, by Martin and Michel (12,13).

Authors Andrade, Greening (2016,2017), Santos, Ellis (2015,2018), Neto and Dikici reffered that elastography was applied (1,3,4,5,6,7,15 and 17) to develop diagnostic possibilities and improve therapeutic modalities. The full testing of sciatic nerve during limb movements have not been examined in detail, but Andrade and Ellis noticed sciatic nerve tightening with ankle and knee movements (1,5).

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The morphological changes of sciatic nerve during extension and flexion movements were observed, but elastography test of mechanical properties with sciatic nerve stiffness was the challenge. The aim of the study was to demonstrate relevance of strain elastography test in the diagnosis of sciatic nerve disease.

MATERIAL AND METHODS

The sciatic nerve was scanned during limb movements in two groups of people, in asymptomatic healthy persons (62) and in symptomatic patiens with deep gluteal syndrome (108). The imaging was performed at the posterior thigh in both groups. The region of interest (ROI) was on sciatic nerve and up to pyriformis muscle. The nerve was typically visualized at a depth of 6 to 8 cm depending of field of view. By ultrasonography, sciatic nerve was visualized as a hyperechoic, slightly flat oval and striped structure. The strain elastography results were presented by color maps and relative strain ratio. Nerve excursions were measured in transverse and longitudinal planes during extension and flexion movement.

The sciatic nerve was scanned using ultrasound elastography equipments (Toshiba Aplio 300 and GE Logiq S8). The strain elastography diagnostic imagings were performed by two types of probes, linerar (5 to 10 MHz), and curved one (3 to 5MHz) for visuelization of deep parts. That method requires the probe force application by compression-decompression repeated test. The tissue displacement resulted in color map, and the calcualtion of the strain ratio (SR) was between different ROI`s (region of interest). In strain elastography of sciatic nerve special attention was focused at pre compression force.Obtained data were analyzed using SPSS software (version 22.0 for Windows). The measures of central tendency (arithmetic mean, median), measurements of variability (standard deviation) and relative numbers (structural indicators) were used. The Pearson linear correlation coefficient was used for the analysis of dependence. Statistical hypotheses were tested at the level of statistical significance (alpha level) of 0.05. Finally ROC analysis was performed.

RESULTS

In the healthy group, as in the group with deep gluteal syndrome, during limb movements, diameters of sciatic nerve changed. In flexion movement diameters were statistically significantly lower, than in extension movement ($p<0.001$). In the course of the extension movement, patients with deep gluteal syndrome, had significantly lower diameters of sciatic nerves than the healthy group of persons.

Table 1 Diameters of sciatic nerve (mm)

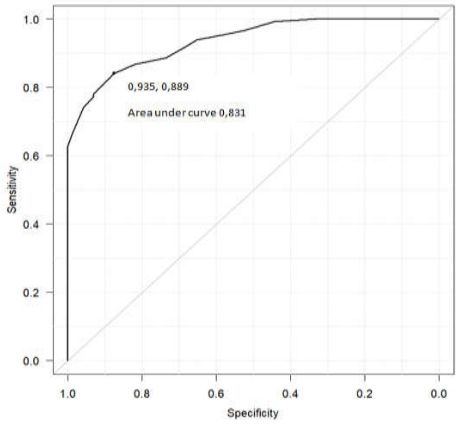
Patients	$\bar{x}$	sd	Cut off	min	max	p-value
Sciatic nerve extension in healthy persons (62)	8.21	0.54	9.29	7.3	9.2	
Sciatic nerve flexion in healthy persons (62)	4.7	0.29	5.28	4.3	5.8	<0,001
Sciatic nerve extension in deep gluteal syndrome (108)	5.86	0.74		4.1	7.1	
Sciatic nerve flexion in deep gluteal syndrome (108)	4.3	0.68		1.7	6.1	<0,001

The group of healthy persons had strain ratio of 1.32SR in extension movement of the leg, with significant increase ($p<0.001$) in flexion movement of leg (4.27SR). The group of patients with deep gluteal syndrome had strain value of 6.38SR in extrension movement of leg, with significant increase ($p<0.001$) in flexion movement of leg, 10.54SR. The cut off strain ratio in extension movement was 2.78 SR, and in flexion movement was 5.75 SR.

Table 2 The strain ratio (SR) of sciatic nerve

Patients	$\bar{x}$	sd	Cut off	min	max	p-value
Sciatic nerve extension in healthy persons (62)	1.32	0.73	2.78	0.7	4.1	
Sciatic nerve flexion in healthy persons (62)	4.27	0.74	5.75	2.8	5.7	<0,001
Sciatic nerve extension in deep gluteal syndrome (108)	6.38	2.83		1.9	15.9	
Sciatic nerve flexion in deep gluteal syndrome (108)	10.54	2.98		3.7	13.4	<0,001

By ROC analysis the specificity of ultrasound elastography in patients with deep gluteal syndrome was 93.5%, the sensitivity was overall 88.9%, with the accuracy 90.6%. The positive predictive value was 82.6%, while the negative predictive value was 96%.



By color map in healthy persons during extension movements sciatic nerve colored in green and yellow, while during flexion movement sciatic nerve was predominantly with blue color coded areas. In the group with deep gluteal syndrome during extension movement sciatic nerve was more blue than green colored, and in flexion movements the sciatic nerve was predominantly blue and grey colored.

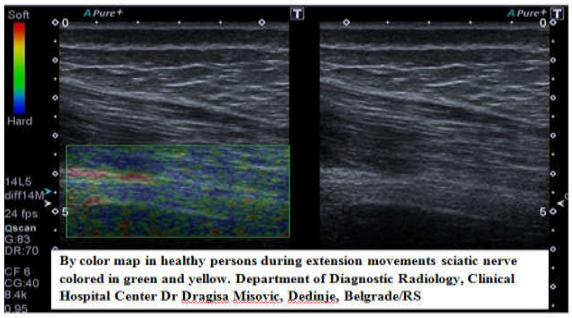


Fig. 2

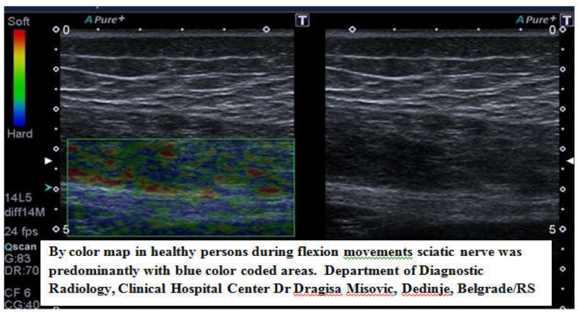


Fig. 3

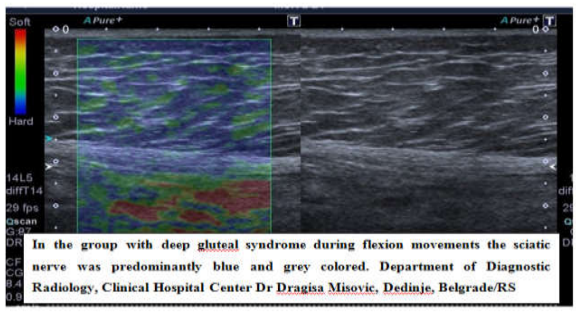


Fig. 4

The Pearson linear correlation coefficient was used for the analysis of dependence. The correlation coefficient between sciatic nerve diameters and between sciatic nerve strain ratio was significant in both groups during extension and flexion movements (r=0.510 and r=0.754). The correlation coefficient between sciatic nerve diameter and strain ration during extension movements was also most significant with r=0.784.

The strain elastography of sciatic nerve in patients with deep gluteal syndrome was performed as preoperative test.

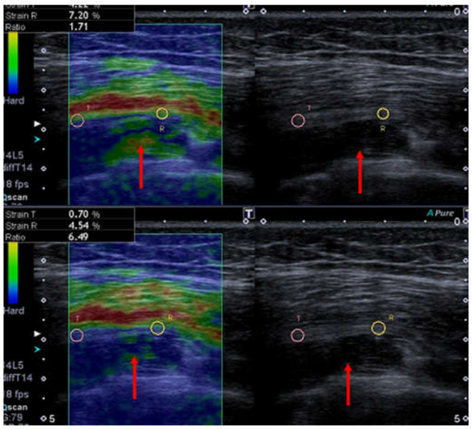


Fig. 5 **The strain elastography of sciatic nerve in symptomatic leg pain patients with tags near m.piriformis (red arrow), during the leg extension (1,7 SR) and flexion (6,49 SR) (preoperative test). Department of Diagnostic Radiology, Clinical Hospital Center Dr Dragisa Misovic, Dedinje, Belgrade/RS**

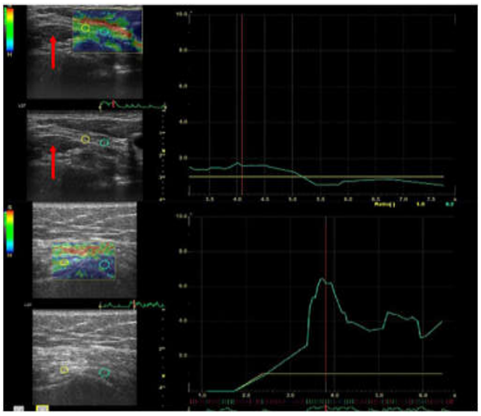
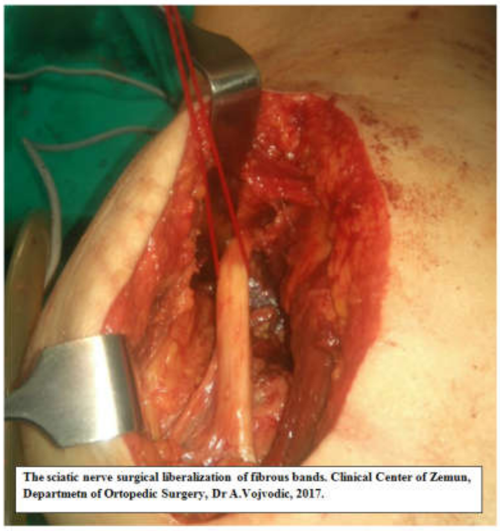


Fig. 6 **The strain elastography of sciatic nerve in symptomatic leg pain patients with tags near m.piriformis (red arrow), during the leg extension (1,8 SR) and flexion (6,3 SR)(preoperative test). Department of Diagnostic Radiology, Clinical Hospital Center Dr Dragisa Misovic, Dedinje, Belgrade/RS**

The surgical treatment with liberalization of piriformis muscle and n.peroneus beneath it was applied. The applied surgical treatment considered open surgery by posterior (Moore) approach to accesses the joint with tenothomy of m.piriformis. Clinical Center of Zemun, Departmetn of Ortopedic Surgery, Dr A.Vojvodic, 2016.

Fig. 7

Upon surgical exploration of the sciatic nerve, a fibrotic tendinous scar beneath the piriformis muscle was found and released.



The sciatic nerve surgical liberalization of fibrous bands. Clinical Center of Zemun, Departmetn of Ortopedic Surgery, Dr A.Vojvodic, 2017.

Fig. 8

DISCUSSION

In our investigation strain elastrography have shown high and very usefull operating characteristics by ROC analysis (1,7). This can be explained by shortening of sciatic nerve diameter during the flexion. During such a movement, the nerve was tense, and the strain ratio raised up.

In healthy persons sciatic nerves was freely stressed and relaxed in repeted test. The shortening of the nerve diameter with the increased strain ratio in sciatic nerve flexion movement was observed. The specificity was representative.
The fibrous bands with nerve entrapment in patients with deep gluteal syndrome significantly decreased the diameter of sciatic nerve in extension, and sciatic nerve flexion movement, as the result of nerve tightening (1,4,5). It was observerd that movement resulted in the increased nerve stiffness (with increased strain ratio).

The color coded maps were not particularly helpful, due to the fact that there was a precompression, and sciatic nerve was typically visualized at a depth of 6 to 8 cm. This limitation is a challenge and suggests a need for further research. In four patients with deep gluteal syndrome there were marked increased sciatic nerve strain ratio during extension, followed by slight decrease of values in flexion. This can be explained with massive fibrous bands (found by operative findings), with paradoxal relax in flexion.

The prevalence of female population was represented by clinically confirmed cases. Looking at the age there were no differences in sciatic nerve diameter. In effort to stadardize the elastography test, it was shown that the differencies beetwen surrounding muscle`s structure and sciatic nerve are more compresed dependent, than the differences of intraneural stiffness, especially seen in the morfological changes of nerves and surronding fibrous processes in symptomatic patients. Therefore the position of ROI was marked up to priformis muscle structure. The resection was done from trochanter's attachment, by separation of joint tendon of m.piriformis and m.obturator internus, and by release of n.peroneus and n.tibialis from fibrous bands and surrounding muscles (Hopayian, Hernando and Perez Carro, 14-17). The study was limited by the technology used and depended on external probe force, ultrasound equipment, the position of ROI and by colour maps. We are going to systematize the approach by depth of field, in order to identify the exact area of referent tissue, and to obtain the referent colour map. The application of new technological advances allowed more accurate reproducible strain elastography results in preoperative processing.

CONCLUSIONS

The variation of sciatic nerve is challenging for diagnostic and therapeutic procedure in many clinical and surgical cases. Quick recognition of sciatic nerve makes surgical approaches more precise and effective, with better outcome. Ultrasound strain elastography images tend to be good and are currently the only diagnostic procedure that is based on the assessment of nerve stiffness, and this procedure can give us crucial information about the degree of nerve entrapment.

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