Morphological characteristics of the median and sciatic nerves assessed via Magnetic Resonance Imaging and Freehand 3D Ultrasound

Dorina Lungu[1], David McDonald[2], Ricardo J. Andrade[2,3], Michel W. Coppieters[2,4], Raúl Oliveira[1,5], Sandro R. Freitas[1]

[1] Neuromuscular Research Lab, Faculty of Human Kinetics, University of Lisbon, Lisbon, Portugal; [2] School of Health Sciences and Social Work, Griffith University, Brisbane and Gold Coast, Queensland, Australia; [3] Nantes Université, Movement - Interactions - Performance, MIP, UR 4334, F-44000 Nantes, France; [4] Amsterdam Movement Sciences, Faculty of Behavioural and Movement Sciences, Vrije Universiteit Amsterdam, Amsterdam, The Netherlands; [5] CIPER, Faculty of Human Kinetics, University of Lisbon, Lisbon, Portugal

1 Introduction

Magnetic resonance imaging (MRI) and ultrasound have been used to assess the morphological characteristics of peripheral nerves. However, previous studies focused on specific anatomical regions rather than considering potential anatomical variations along the entire nerve course [1]. Furthermore, morphological outcomes such as peripheral nerve volume have never been quantified before.

2 Objective

Evaluate the **median** and **sciatic nerves** shape and three-dimensional (3D) geometry (i.e., **cross sectional area** (CSA), **volume** and **length**) between **MRI** and **freehand 3D ultrasound** (F3DUS) imaging methods.

3 Methods

3.1 Participants

✓ **N=10 healthy subjects**

(4 females; 27 ± 7 yrs; 1.74 ± 0.088 m; 73.6 ± 11.14 kg; 24.34 ± 3.79 kg/m^2)

Exclusion criteria

x History of systemic neurological disorders

x Posttraumatic changes to the nerve

x Neuropathies and nerve entrapment syndromes

x Systemic metabolic and neurodegenerative diseases

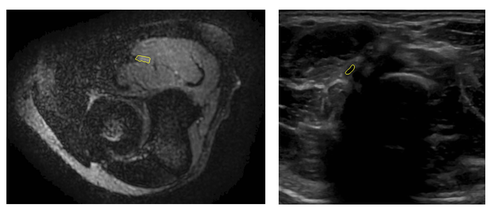
x Spine, upper or lower limb surgery

3.2 Data collection and processing

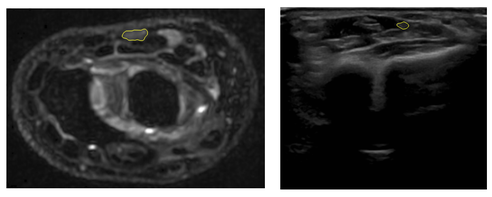
	Median nerve	Sciatic nerve
Session 1 - MRI	Subjects in a **supine** position: - Right forearm placed supine - Extension of the elbow - Wrist in neutral position	Subjects in **prone** position: - Hip neutral - Knee fully extended - Ankle in a resting position
Session 2 - F3DUS		

3D reconstruction of the nerves from both imaging methods was performed using Stradview software (v.7.2). Anatomical landmarks were defined for the beginning and the end of segmentation:

Proximal reference: Antecubital fossa



Distal reference: the wrist crease



Median nerve

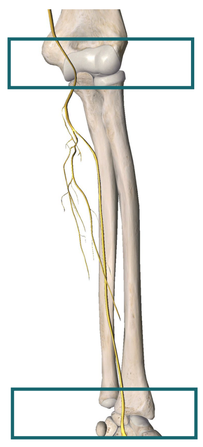
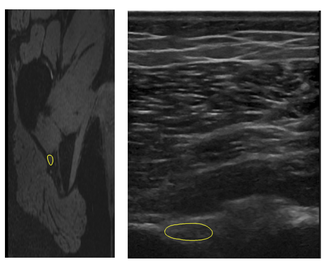
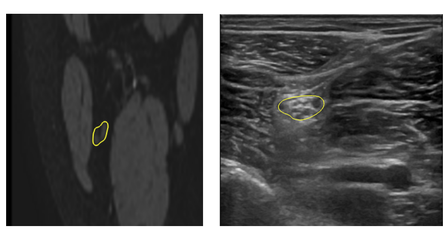


Figure 1. Median nerve anatomical landmarks for manual segmentation

Proximal reference: Ischial tuberosity



Distal reference: Before bifurcation into tibial and common peroneal nerves



Sciatic nerve

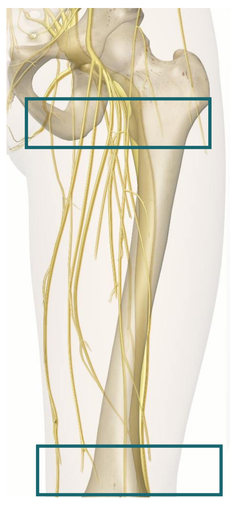


Figure 2. Sciatic nerve anatomical landmarks for manual segmentation

All MRI and F3DUS images were **manually segmented**. **Sparse contour interpolation** method was used to reconstruct the nerves 3D surface, which was saved as point clouds.

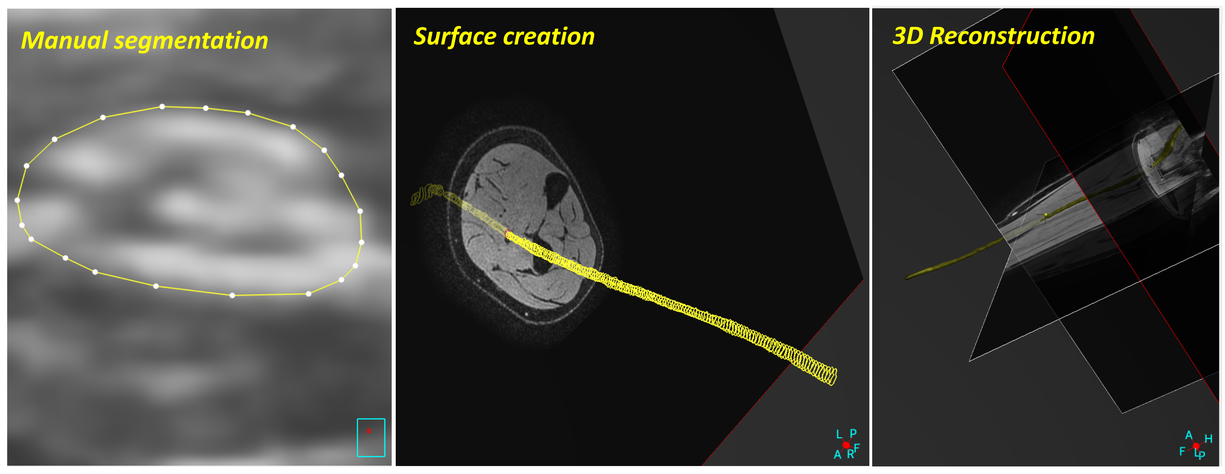


Figure 3. Median nerve manual segmentation and interpolation.

3.3 Data analysis

The CSA and volume of the nerves were derived by outlining the CSA in a series of transverse sections and were processed directly from the 3D reconstructed images through the Stradview software.

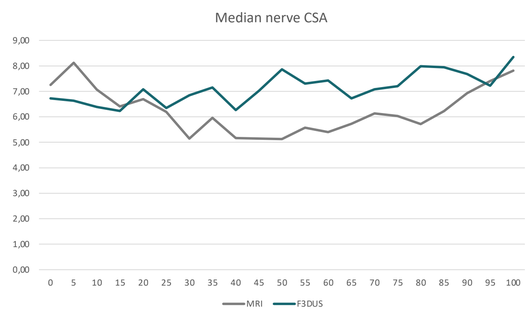
Nerves length was calculated as the cumulative sum of the distances between consecutive 3D centroid points, whereas the starting and ending references were set as 0% and 100% [2].

4 Results

Median nerve:

	MRI	F3DUS	
Volume (cm^3)	1.51 ± 0.22	1.57 ± 0.23	≠ 0.06
Length (cm)	23.56 ± 1.29	24.4 ± 2.69	≠ 0.84

Table 1. Median nerve mean volume and length assessed via MRI and F3DUS.

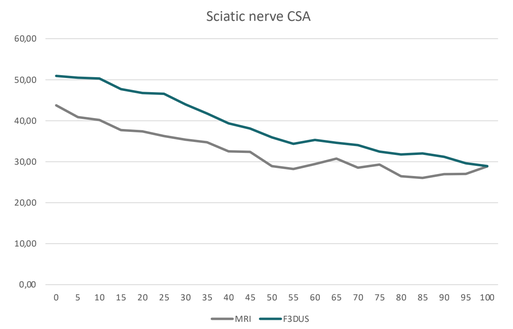


Graph 1. Median nerve CSA along the length assessed via MRI and F3DUS.

Sciatic nerve:

	MRI	F3DUS	
Volume (cm^3)	10.6 ± 1.75	13.18 ± 2.16	≠ 2.58
Length (cm)	31.61 ± 2.63	33.08 ± 2.7	≠ 1.47

Table 2. Sciatic nerve mean volume and length assessed via MRI and F3DUS.



Graph 2. Sciatic nerve CSA along the length assessed via MRI and F3DUS.

5 Conclusion

The median nerve CSA tended to be ↑ close to articular regions and ↓ at mid-forearm level. The sciatic nerve CSA was larger at the ischial tuberosity and decreased along the thigh to the popliteal region. Overall, there was a tendency for the F3DUS to overestimate the nerve's CSA, volume and length compared to MRI.

References: [1] Andrade, R. J., Freitas, S. R., Hug, F., Coppieters, M. W., Sierra-Silvestre, E., & Nordez, A. (2022). Spatial variation in mechanical properties along the sciatic and tibial nerves: An ultrasound shear wave elastography study. *Journal of biomechanics*, *136*, 111075.; Devaprakash, D., Lloyd, D. G., Barrett, R. S., Obst, S. J., Kennedy, B., Adams, K. L., Hunter, A., Vlahovich, N., Pease, D. L., & Pizzolato, C. (2019). [2] Magnetic Resonance Imaging and Freehand 3-D Ultrasound Provide Similar Estimates of Free Achilles Tendon Shape and 3-D Geometry. *Ultrasound in medicine & biology*, *45*(11), 2898–2905.