

The rotated foot as a new leg: TMS brain mapping of lower limb muscles after Van Nes rotationplasty

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Introduction

Van Nes rotationplasty is a rare limb-salvage procedure for knee sarcomas (Badhwar et al. 1998). The distal thigh and the proximal leg are amputated and the femoral and tibial stumps are grafted, with the leg being axially rotated by 180° and then prosthetized. On the rotated side the Soleus (SOL) becomes a (pseudo) knee extensor. We investigated if changes occur in the cortical representation of the unaffected Vastus medialis (VM) and both SOL muscles.



Methods



One adult patient was studied (man, 31 years, left leg rotationplasty at age 10, right-footed). Six controls volunteered for the study (men, 23-31 yrs, right-footed). Motor evoked potentials (MEPs) were elicited through a Magstim 70 mm figure-of-eight coil, model 200² stimulator. Then, subjects wore a swimming cap with 176 scalp spots spaced-out 1.5 cm. A neuro-navigation apparatus (Softaxi Optic E.M.S. srl, Bologna, Italy) allowed to digitize these spots. The VM muscles were tested one week after the SOL muscles. The active motor threshold (AMT) was defined as the minimum TMS intensity able to evoke, from the most sensitive spot ("hot spot"), 3 out of 5 MEPs larger than 100 μV, in a slightly contracted muscle (5% of maximal isometric force; visual EMG-feedback provided on line; belly-tendon arrangement of skin electrodes). Then, stimuli were given at 110% AMT in adjacent spots. For each spot, 4 MEPs were recorded and their peak-to-peak amplitude measured and averaged. For each muscle, maximal M waves (Mmax, peak-to-peak) were also recorded. MEPs amplitude was then given as Mmax percentage; gradients were then outlined.



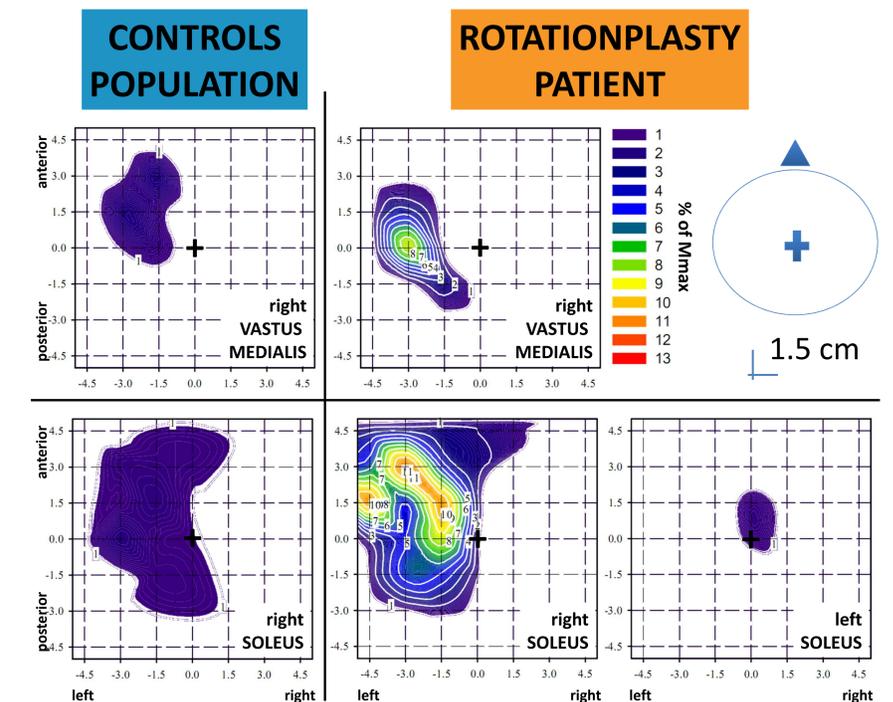
References

Badhwar R, Agarwal M (1998) Rotationplasty as a limb salvage procedure for malignant bone tumours. *Int Orthop*, 22:122-125
Schwenkreis P, et al. (2003) Reorganization in the ipsilateral motor cortex of patients with lower limb amputation. *Neurosci Lett*, 349(3):187-190

Results

In 3 control subjects no MEPs could be evoked from SOL bilaterally. In the remaining 3 subjects, VM and SOL maps covered on average 6 and 7 spots, respectively, and widely overlapped. These maps were centered about 1.5 cm lateral and 0.5 cm in front of Cz on the hemisphere contralateral to the muscles, on either sides. They showed MEP/Mmax amplitudes ranging 0.6÷2.7%. In the patient the maps of the right unaffected muscles spanned 3 and 11 spots for the VM and SOL, respectively, and were normally centred. MEP/Mmax ratios were increased, i.e. 4.9 and 7.0%, respectively. The map of the left rotated SOL spanned 5 spots and was normally centred. The MEP/Mmax amplitude was 0.9%.

TMS cortical maps of Vastus Medialis (VM) and Soleus (Sol) muscles. Stimulation spots are located at the intersections between horizontal (X) and vertical (Y) axes with 1.5 cm spacing. The vertex (Cz,+ symbol) is located at 0,0 (see the sketched head on the right). For the patient (right) the average location of 4 peak-to-peak MEP/Mmax ratios is computed. For the 3 controls (left), the grand-average is given. MEPs/Mmax % levels are represented through a colour-coded palette ranging from 0 to 12+ (purple to red) in 2% steps; contour plots are obtained through linear interpolation of spot values



Muscle	CONTROLS, N=3		ROTATIONPLASTY PATIENT	
	Area (#spots)	Mean MEP amplitudes, N=3	Area (#spots)	Mean MEP amplitude
right SOL	4 ÷ 15	0.6 ÷ 2.5	11	7.0
left SOL	2 ÷ 12	0.7 ÷ 2.1	5	0.9
right VM	3 ÷ 8	1.2 ÷ 2.6	3	4.9
left VM	1 ÷ 9	1.3 ÷ 2.1		

Area: number of supra-threshold spots

MEP amplitude: expressed as MEP/Mmax ratio

Conclusions

i) in some healthy controls focal TMS can be used to map the cortical representation of VM and SOL; ii) maps of homolateral VM and SOL seem superimposable; iii) in this patient, on the sound side rotationplasty entailed shrinking of the VM map and enlargement of the SOL map, with increased excitability of both muscles. No changes could be detected in the representation of the rotated SOL. Changes in maps of the unaffected muscles are consistent with reports on changes in lower limbs in amputees, perhaps reflecting a decreased inter-hemispheric inhibition and/or overuse of the sound lower limb (Tegenthoff et al. 2003).