3D-Personalised Muscles Reconstruction

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Introduction

Little is known about muscle geometry. Muscular models, when they are geometrically personalised require those data. Most authors [1] extract geometry using MRI and maximum physiological area is set to the highest area value found for the muscle on the MRIs, but this approach does not lead to a muscle reconstruction. We present here a new method to reconstruct 3D-personalised muscle geometry.

Material & methods

Exams for the subjects are composed of a stereo-radiography (Frontal and sagittal X-rays in a calibrated environment) and a fast MRI axial slicing of the thoraco-lumbar region (30 to 40 slices), from which 9 where localised at the centre of the inter-vertebral joints from T10/T11 to L5/S1 and the femoral heads.
The reconstruction method is divided in two steps. From the stereo-radiography, 3D-personalised bones geometry is obtained (vertebrae, pelvis and rib cage). On the other hand, using a specially designed program, perimeter of each muscle is localised on the 9 MRIs.
Muscle insertions are defined using the 3D-reconstruction of the bones and based on anatomical data. Muscle "shape" is set using the MRI. Combining those two sets of data, a set of control points is created and a 3D-generic muscle geometry (reconstruction from Visible Human) is deformed [2] to fit the control points (Figure 1).

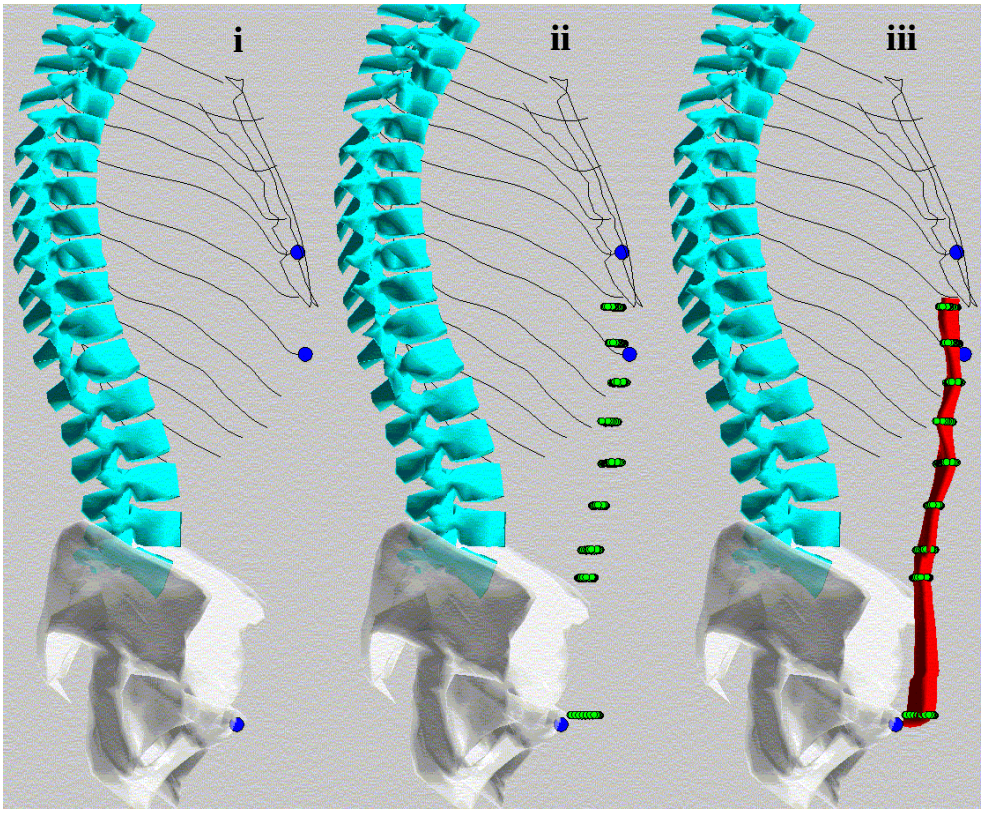

Figure 1 : The 3-steps for muscle reconstruction. i. Bones 3D-reconstruction determine muscle insertions locations. ii. Muscle body shape measured on the MRIs are placed at the different intervertebral levels. iii. Generic 3D-muscle is deformed to fit the control points

As a validation, we used the intermediate MRI slices that were not used to generate the muscle geometry. We compared the intersections of the reconstructed volume of the muscle with the plane of those slices. Three subjects (one healthy and two post-operated kyphotic patients) and two measurements (from reconstruction and directly measured on the MRI) were realised: Position of the centroïd and physiological area of *psoas* and *rectus abdominis* muscles.

Results & Discussion

A view of the 3D reconstruction is shown in figure 2.
Table 1 presents the results of two muscles reconstruction for 3 subjects.
Reconstruction shows a good agreement with direct MRI measurements.
Most of the largest errors are localised between L5/S1 and the femoral heads. Indeed, it may be difficult to identify muscles perimeters on MRI, because of their low resolution. Moreover, the generic muscle shape resulting from Visible human is quite specific. Accuracy should be improved by using a standard geometry closer to a 50th percentile one.

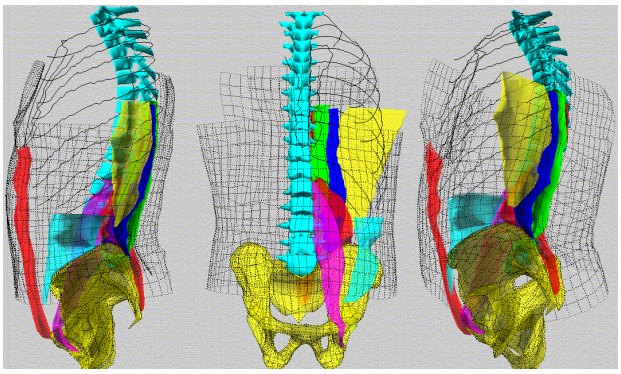

Figure 2. 3D-personnalised reconstruction of some muscles.

		Left Rectus Abdominis				Left Psoas			
		Surface error		Lever arm error		Surface error		Lever arm error	
		cm²	%	cm	%	cm²	%	cm	%
All subjects	*Mean*	**0.59**	*2.9*	**0.23**	*0.3*	**1.12**	*15.6*	**0.22**	*5.8*
	Std. Dev.	**0.61**	*14.4*	**0.25**	*3.1*	**1.12**	*26.5*	**0.17**	*4.8*
Healthy	*Mean*	**0.54**	*6.7*	**0.3**	*0.9*	**0.49**	*0.5*	**0.16**	*4.6*
	Std. Dev.	**0.63**	*10.7*	**0.26**	*3.2*	**0.59**	*14.8*	**0.1**	*3.6*
Patient 1	*Mean*	**0.62**	*9.6*	**0.23**	*1*	**1.67**	*39.4*	**0.38**	*9.7*
	Std. Dev.	**0.59**	*9.7*	**0.32**	*3.2*	**0.94**	*36.7*	**0.21**	*6.7*
Patient 2	*Mean*	**0.62**	*8.1*	**0.16**	*1.1*	**1.41**	*17.8*	**0.19**	*5*
	Std. Dev.	**0.62**	15.2	**0.18**	2.7	**1.32**	18.3	**0.14**	3.6

Table 1. . Surface and lever arm stated as differences between direct MRI measurements and 3D reconstruction for 2 muscles and 3 subjects.

Conclusion

Feasibility of this personalised reconstruction was assessed, which was a challenge regarding the complexity of the system to be modelled.
Work is in progress to model all muscles of the lumbar region, and also to control and improve accuracy.

References

[1] D. Guzik & Al., A biomechanical model of the lumbar spine during upright isometric flexion, extension, and lateral bending., Spine, 1996, 4, 427-433.
[2] D. Mitton,& Al., 3D reconstruction method from biplanar radiography using non-elastic deformable meshes., Med. Bio. Eng. Comput., 2000, 38, 133-139.