

Three-dimensional modeling and simulation of biceps femoris based on Matlab

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Abstract. In order to study the properties of human muscle, it's necessary to construct a three-dimensional model. Biceps femoris has been taken as an example in this paper. Firstly, point cloud data of biceps femoris at different angles were extracted by IMAGEWARE software. Then we can get different polynomial functions correspond to different contraction states of biceps femoris in the Matlab environment. Finally, we calculate the pairwise polynomial parameters and get the correlation of the muscle shapes in different joint angle. The morphological changes of biceps femoris in different joint angle can give us more information about the properties of human muscle.

Keywords: biceps femoris; three-dimensional model; matlab; correlation analysis.

1 Introduction

Nowadays, musculoskeletal injuries are a common phenomenon. In addition to muscle damages in heavy manual labor, sports injuries also occupy a large proportion. Muscle injury, which is caused by a sharp contraction under the action of external force or excessive tensile force, is the most common form of sports injuries. According to the statistics of Beijing research institute of sports medicine, this kind of damage accounts for more than 25% in the incidence of various muscle damage.

The major parts of muscle injuries are triceps surae, muscles of leg anterolateral and hamstring muscles [1]. Therefore, the biomechanics analysis of muscle in the state of movement is significant to predict state of lower limb muscle strength, learn the distribution of the sports injuries and make sports reasonably and scientifically.

2 Three-dimensional modeling based on Matlab

This study based on five adult healthy male volunteers. MRI measurement experiment was done to collect the data of biceps femoris when lower limbs were under knee flexion condition. Form the test, we get the point cloud data of biceps femoris in different flexion angle.

Using IMAGEWARE software [2], Muscle parallel section of biceps femoris muscle in three different angles can be acquired by using parallel section method. Then the point cloud data were

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imported to Matlab for three-dimensional modeling by using plot3 function and writing assignment statements. In order to improve the quality of graphic display, grid statements were used to draw grid[3]. Three-dimensional curves in different angles of biceps femoris are shown in Fig. 1.

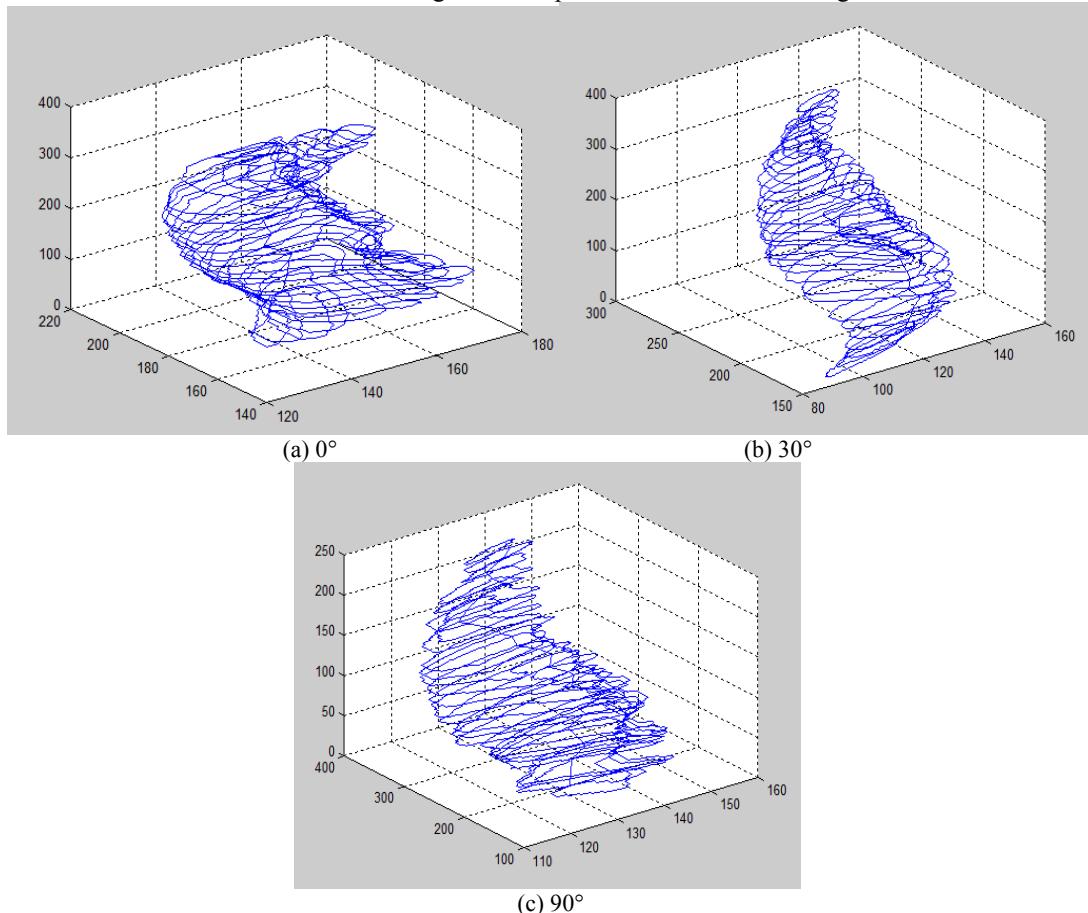


Figure 1. Three-dimensional curves under different angles of the biceps femoris

Through analyzing the cross section of the parallel point cloud section, a similar cross graphic section always can be found in the same Z plane. For example, the similar curves of biceps femoris are shown in Fig. 2.

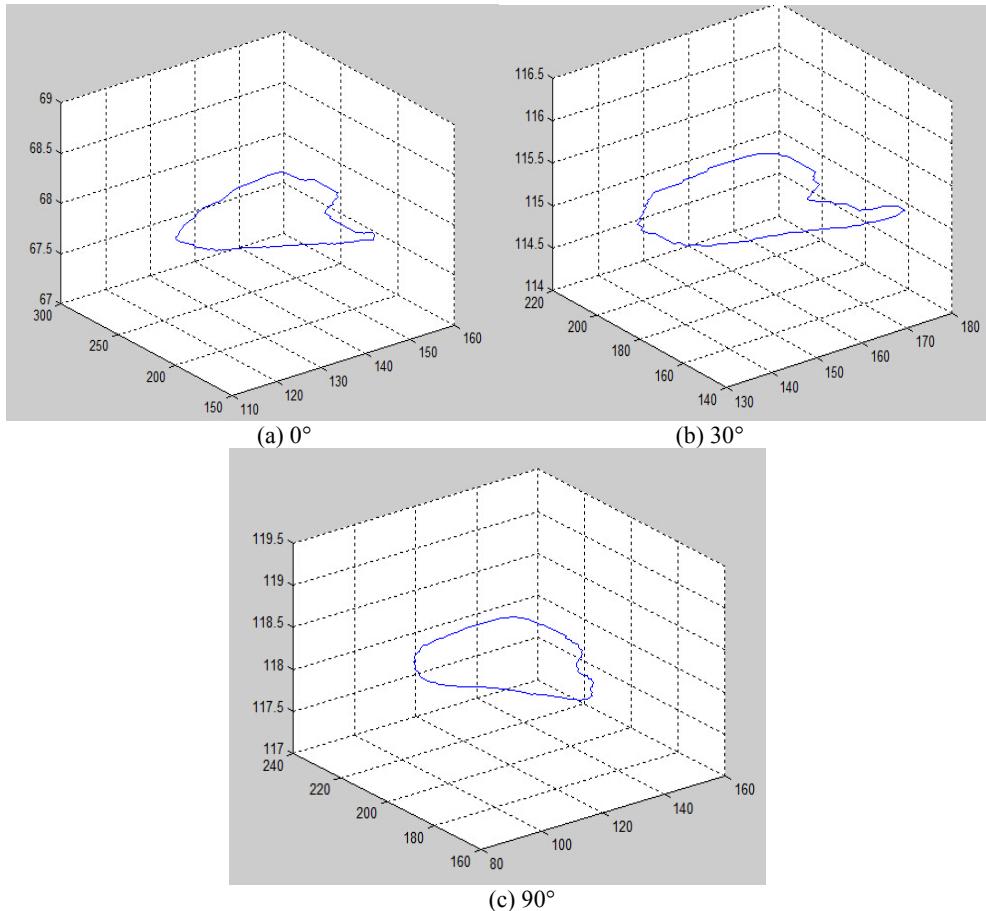


Figure 2. Three-dimensional curves under different angles of the biceps femoris's single cross section

3 Piecewise fitting of three-dimensional curves

Because muscle curve shape is complicated, so it is difficult to use a function express. The purpose of the study is to find a general transformation matrix, which can get contraction state of different muscles. Because there is an error among transformation matrixes, so researchers usually use curve segments to reduce the error and enhance the correlation[4]. In this research, we transfer the three-dimensional curves of biceps femoris into two-dimensional curves in XOY plane. The curve segments are shown in Fig. 3.

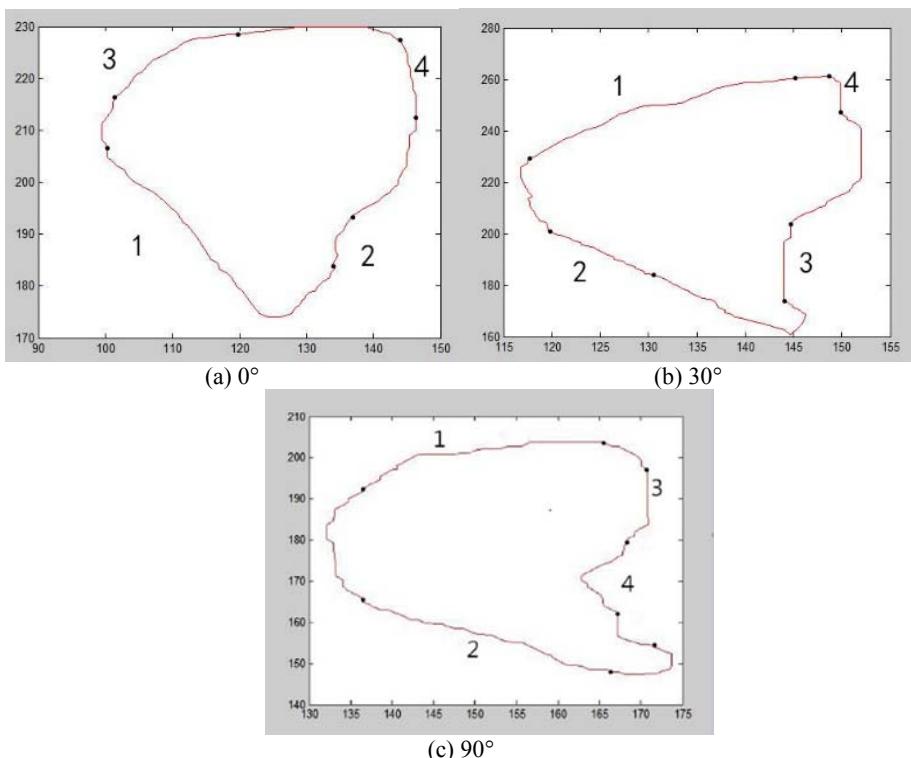


Figure 3. Biceps femoris segmented curve under different angles of the biceps femoris

4 The simulation results of the curves

Through the simulation processes above, we get the segmented curves of biceps femoris in the angle of 0° , 30° and 90° , and each segmented curve has four parts. So we can get 24 thirteen-dimensional matrixes. Then choosing the second part of segmented curves in 0° , the first part of segmented curves in 30° and 90° as the example to make matrix transform. The matrix data are shown in Fig. 4.

P_1	P_2	P_3
3.51913617902650e-16	8.86286912934963e-16	2.18168241787696e-15
4.46500787545383e-13	-1.34924976661418e-12	-3.10251794377111e-12
2.30340757353886e-10	9.37769764435102e-10	1.94973581900785e-09
-5.55777847186180e-08	-3.93783690078043e-07	-6.98351706186778e-07
2.46419169800099e-06	0.000111360292400346	0.000149621909542974
0.00217185568839754	-0.0223657800978418	-0.0163782485987878
-0.599462829964678	3.27554222877678	-0.484827346393379
57.7090590731439	-353.140417839094	507.493111960178
3163.07907531300	27903.6671298073	-94040.4256086646
-1539581.63777394	-1584992.30003838	10099750.7558451
195358729.768081	62184366.5168785	-701935177.070357
-13210727805.4943	-1561826271.01845	31323666192.7373
484027151076.678	21475527111.4819	-821888686927.463
(a) 0°	-106101833601.928	9688926136096.90
(b) 30°		
(c) 90°		

Figure 4. Biceps femoris curve matrix

5 The correlation analysis of simulation data

A is the transformation matrix between 0 degree and 30 degree of biceps femoris, and B is the transformation matrix between 30 degree and 90 degree of biceps femoris. Then we use SPSS software to analyze the two groups of data, the output is shown in Table 1[5].

Table 1 . Correlation analysis results of A

Correlation		VAR00001	VAR00002
VAR00001	Pearson correlation	1	.423
	Significance (bilateral)		.0356
	Sum of cross product and square	1127.614	28.793
	covariance	178.845	5.166
	N	7	7
VAR00002	Pearson correlation	.473	1
	Significance (bilateral)	.364	
	Sum of cross product and square	31.424	4.421
	covariance	5.237	.814
	N	7	7

From table 1, we can get the correlation coefficient $r = 0.423$, which is between 0.3 to 0.5, is low correlation. This kind of error appears because muscle cross section was uneven and the shape of each muscle is different. The two transform matrix were correlation, so the relationship of two pieces of muscle can be gotten in one transformation matrix.

6 Conclusion

In this paper, the three-dimensional model of biceps femoris were established and simulated by using the Matlab software. Through correlation analysis, the relative relationship of biceps femoris in different contraction angles were gotten. In the further research, we can get more experiment data, and analyse the relationship of the geometrical morphology between different muscles in different contraction state through combining the existing theories. This will give a hand to understand the rule of muscle movement deeply and treat muscle injuries effectively.

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