

# Simulation of Elbow Movement with MSMS and MATLAB

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**Abstract**— This paper describes Biomechanical model of arm which is totally computational approach for modeling the complex mechanical properties of muscles of Hand. This can be embodied as a simulation model for use with Matlab and Simulink. The model allows the creation of realistic Muscle structure and movement of arm. Here we have considered elbow movement and the muscle which are activated during the elbow movement. Flexion and extension of elbow and associated muscles are studied. This paper also gives relation between force and given stimulation to particular muscle. The model presented here can be employed to design FES controller for subject who suffered from quadriplegia due to spinal cord injury (SCI) or multiple sclerosis (MS)

**Key Words:** Flexion, Extension, Muscle study of Elbow, MSMS

## I. INTRODUCTION

To restore normal movement in subject with spinal cord injured which caused quadriplegia in the subject FES (Functional Electrical Stimulation) can be used to restore the motor functions[3]. Human being is more precise in nature also more sensitive so before applying stimulation directly to human body first we need to check it on virtual muscle model (Computational model of Human body with muscle) and then after observing all parameter in computational model according to requirement we can apply stimulation on subject. For this purpose development and evaluation of real time Computational model for such type of devices is primary concept of this paper. Operating a FES require accurate control. This computational model can be helpful in designing control system for FES. Neuromusculoskeletal modeling provides insights into the muscular system which are not always obtained through experiment or observation alone. One of the major challenges in Neuromusculoskeletal modeling is to accurately estimate the musculotendon parameters on a subject-specific basis. Biomechanical models of the musculoskeletal system are frequently used to study neuromuscular control and simulate surgical procedures. Here we report on the development of a computational model that can simulate the behavior of elbow muscle in partially paralyzed patient considering muscles geometric parameters such as PCSA, number of sarcomeres in series, Optimal fascicle length etc. that has effect on force generating capacity of muscles.[16]

## II. METHOD

This model is particularly developed for Elbow movement. In this model we considered five rigid body segments

including Scapula, humerus, radius ulna and Hand; three joints—Shoulder joint, Elbow joint and Wrist joint. Model gives two movements of elbow flexion and extension. Here we want to develop only model for elbow movement, we fix the Movement of Shoulder and Wrist joint in this model. The model is built using MSMS (Musculoskeletal modelling software) and MATLAB.

To achieve real movement and measure the force generated in elbow we use weld type of joint in shoulder so humerus is fixed with no motion at the Shoulder. Six electrically stimulated muscles which generate Elbow movement are considered and force generated by that muscles are plotted. Brachialis, Brachioradialis, Biceps, ECRL, Brachialis, pronator teres, Triceps, Flexor Carpi ulnaris, Ancones are taken and put into the model for elbow movement. MSMS has a ADD JOINT command in model menu so we can add required joint and its Appropriate property of the Joint shown in fig.2. Also software provide us options for the types of Joint which we want to use for example weld type, pin-revolute type, bearing type etc. Here we kept the Shoulder joint as a weld type joint to fix it and other two joints are pin-revolute type joint. Elbow angle is from 10 to 160 degree.

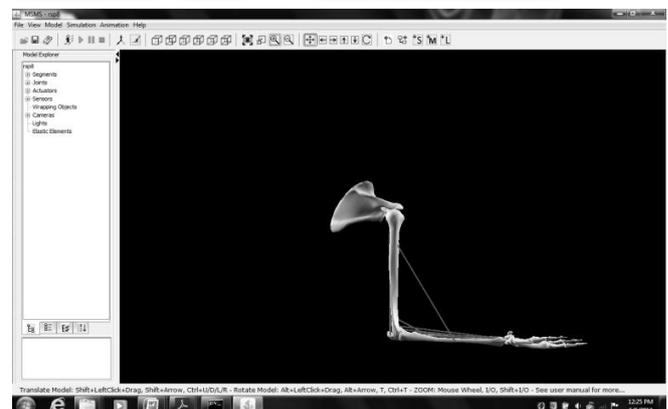


Fig. 1: Musculoskeletal model of arm in MSMS

Default angle is 90 degree for elbow joint. Following figure shows the musculoskeletal model for Elbow movement in MSMS. All the muscles which are listed above are added by using ADD MUSCLE Command from Model menu of menu bar. Muscle attachments are shown in following model by red line shown in fig 1. After Clicking on ADD MUSCLE command cursor of window in MSMS will turn into red colour then decide the origin of muscle and draw the straight path between the origin and the insertion point. After that panel of model software shows individual window

for setting the default and Morphometry parameter of individual muscles (fig 3)

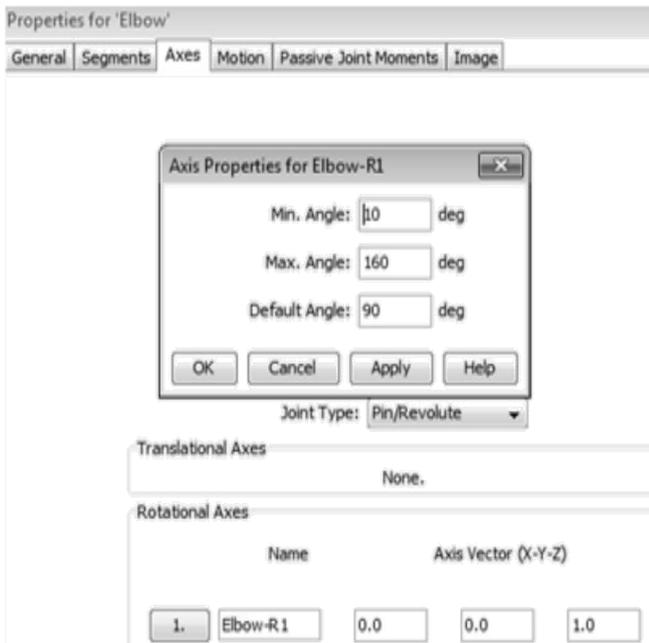


Fig. 2 Property of Elbow Joint Window in MSMS

This Morphometry parameter for the all muscle is shown in following Table I. To complete the model related architectural parameters are taken from paper reported by Murray [1]. Following table shows the name of muscle and related architectural parameter given by Murray [6].

Sr. No	Name of the Muscle	Tendon Length	Optimal muscle length	Optimal Fascicle length	PCSA
1	Brachioradialis	16.9	26.0	17.7	1.2
2	Biceps-long	22.9	21.6	12.8	2.5
3	Biceps-short	18.3	23.4	14.5	2.1
4	ECRL	24.8	13.9	9.2	1.5
5	Brachialis	11.6	21.2	9.9	5.4
6	Pronator teres	12.0	17.6	5.5	2.8
7	Triceps long	21.7	35.6	12.7	4.3
8	Triceps short	18.7	29.1	9.3	10.5

Table 1: Summary for architectural parameter

After making model in MSMS and setting up all the parameter we create Simulation Model is in MATLAB. Pulse generator from Simulink library of MATLAB is given for the excitation to each muscle .Pulse generator parameter like pulse width, amplitude, phase delay and period is given according to the requirement of movement.

For run the model and see the movement we have to run the Simulink model generated in MATLAB. We can also see the live movement of arm while the Simulink model is running by setting the Animation path from Animation Menu of MSMS menu bar Shown as following fig.4

### III. RESULTS

After completing the model, MSMS has one option in Model menu bar PLOT ANATOMICAL DATA which can

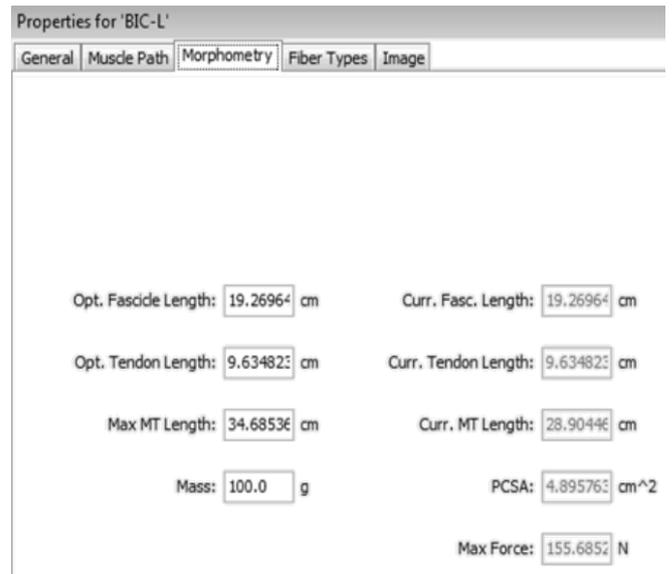


Fig. 3: Muscle property Window in MSMS

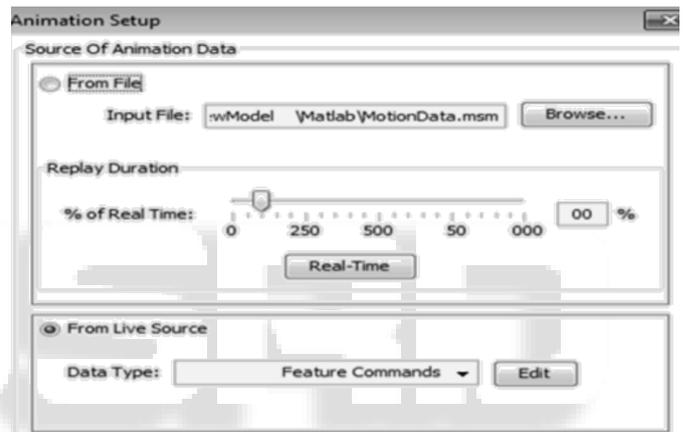


Fig. 4: Animation Setup Window of MSMS

Plot the anatomical data of muscle when we set the muscle attribute, Name of joint and Name of muscles. Muscle fibre generates tension during the action of actin and myosin cross-bridge cycling. While under tension, the muscle may lengthen, shorten, or remain the same. From the Graph we can say that the principle muscle acts for the flexion of the Elbow are Biceps, Brachialis, Brachioradialis and pronator teres. Extension caused by mainly due to the contribution of Triceps muscle. Also according to the load, role of Triceps long and triceps short may be varied. Anconeus muscle also provides little bit contribution in extension of elbow. The generation of Forces in Elbow is very large when elbow extends from a flexed posture. Generated force is calculated from this equation from following formula as [4].

$$\text{Force} = \text{PCSA} * \text{Maximum isometric Stress} \quad [4]$$

Following figures shows the graph of various attributes of muscle varuses Elbow joint. Fig.5 shows the curve which represent ALL ELBOW MUSCLE Fascicle length and Elbow joint curve. Here Brachioradialis (Yellow line in curve fig. 5) has longest fascicle length whereas pronator teres (Light pink line in curve fig. 5) has shorter fascicle length. Brachioradialis (Yellow line in fig. 5) have a larger moment generating capacity. ECRL (Pink line in fig. 5) has

a similar muscle path as Brachioradialis but shortest fascicle length than Brachioradialis.

The colour representation for all the curves shown below is as follow,

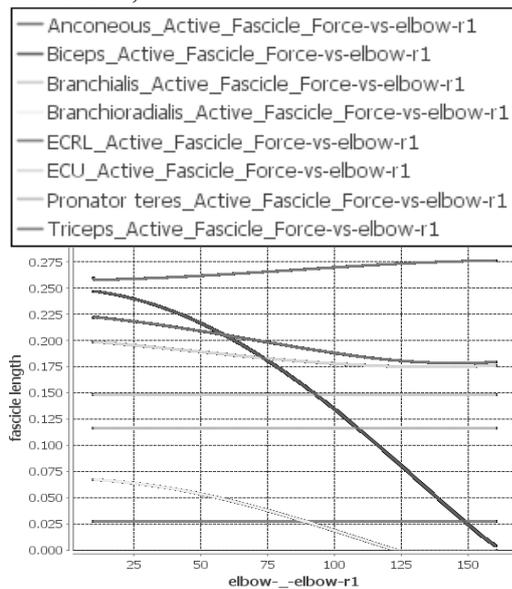


Fig.5: Anatomical Graph of various Muscles' Fascicle Length versus Elbow joint in MSMS

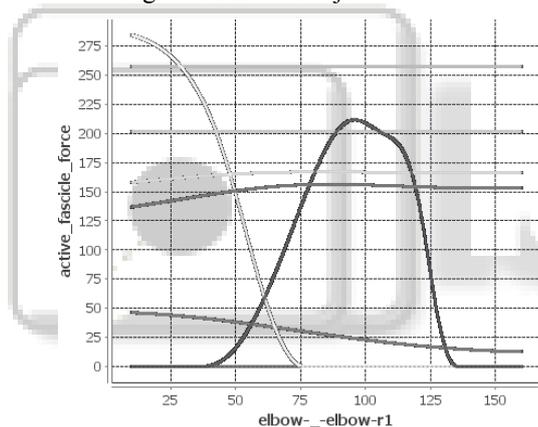


Fig. 6: Anatomical Graph of various Muscles' Active Fascicle Force versus 4Elbow joint in MSMS

Fig 6 shows the active force generated during Muscle action. Branchioradialis (Yellow line in fig. 6) and Biceps (Blue line in fig. 6) have broad range of force generating area .Fig. 7 Shows the Total fascicle force length and elbow joint.

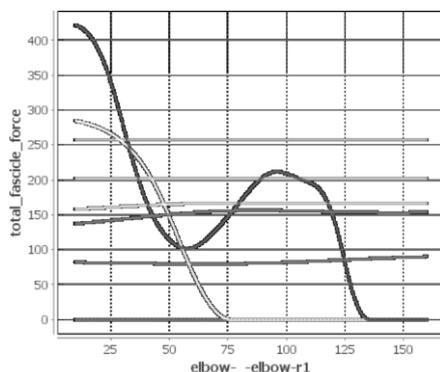


Fig.7 Anatomical Graph of various Muscles' Total Fascicle Force versus Elbow joint in MSMS

#### IV. CONCLUSION

We have tried to model correctly all the Elbow muscle and Elbow joint. From all these Graphs we can study and analyse the muscle attribute by changing the value of Morphometry parameter of muscle and also by changing the control parameter through sim model of MATLAB. We observe that Biceps has larger area for force curve than Triceps due to it's Architectural difference. These results also give the fundamental difference in muscle force generating capacity and movement produce by that particular muscle. Brachioradialis give more contribution in Elbow Flexion. all these due to Muscle Architecture and stimulation given to the particular muscle by pulse generator. Also we can see the effect on virtual muscle and joint movement. This study provides best way to design a FES system which is used for subject who suffered from paralysis. Also this model try to cope the study of all type of muscles and it's vital role in movement. Neuroprosthesis developer can use this model for virtual testing and then accordingly develop the FES system .We can change the Morphometry data according to subject so no specific data is require to run the model .Also selection of MATLAB base simulation environment enables model to share with everyone. The Study improves upon previous anatomical investigation of Elbow muscle by considering more number of muscles. We are also developing the same model for the Wrist movement in real time environment and also try to validate these data with real time available data. Finally we can conclude that Architectural property of muscle is a good predictor of the Muscle Function.

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