

Analysis of 3-Dimensional Structure of upper limb Muscles in Transradial Amputee : A MRI Case study

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Objective

The purpose of this study is to quantify the muscle volume and Surface area of the Unamputated limb and amputated limb of upper extremity.

Subject & Methods

In this study, subject is 55-years-old male who weared myoelectric hand prosthesis with below elbow amputation due to a industrial accident in March 2015. The subject visited the hospital once to take an Magnetic Resonance Imaging(MRI) and the data was reconstructed in three dimensions using 3D Modeling Software(Mimics[®], Belgium). Unamputated limb was analyzed according to the length of amputated limb. And we measured volume and surface area of muscles of the unamputated and the amputated were compared.

Results

We measured the volume and Surface area reduction ratio of the amputated side compared to the unamputated side for each muscle group (Figure 1). Among all the muscles, the highest volume reduction ratio was finger extensor digitorum 76.7% and the lowest reduction ratio was anconeus -0.7% (Table 1). The highest surface area reduction ratio was extensor digitorum 59.4% and the lowest reduction ratio was supinator -1.43% (Table 2).

Conclusion

The purpose of this study is to identify the anatomical structure of the upper limb amputee and the attachment point of the dynamic electromyographic(EMG) sensor. This study can be used as a database for the study on amputees and the development of artificial arm.

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Muscle group	Muscle	Unamputation (mm ³)	Amputation (mm ³)	Reduction ratio (%)	
Elbow	Flexor	Biceps	88095.49	43.67	
		Brachialis	111197.73	101338.52	8.87
		Brachioradialis	60624.68	36908.06	39.12
	AVERAGE			30.55	
	Extensor	Triceps	149628.79	102815.6	31.29
Anconeus		8304.06	8360.8	-0.68	
AVERAGE			15.30		
Forearm	Supinator	Supinator	21681.97	20664.8	4.69
		AVERAGE			4.69
	Pronator	Pronator teres	32583.97	29548.13	9.32
		AVERAGE			9.32
	Wrist	Flexor	Flexor carpi radialis	18550.76	10573.99
Flexor carpi ulnaris			14499.22	5574.59	61.55
AVERAGE			52.28		
Extensor		Extensor carpi Radialis longus	55783.07	25394.26	54.48
		Extensor carpi Ulnaris	11107.75	5574.59	49.81
AVERAGE			52.15		
Phalanx	Flexor	Flexor digitorum Superficialis	34475.74	18651.65	45.90
		Flexor digitorum Profundus	43348.06	25016.61	42.29
		AVERAGE			44.09
	Extensor	Extensor digitorum	29397.84	6853.89	76.69
		AVERAGE			76.69

Table 1. Volum reduction ratio of each muscle group on the amputated side compared to the unamputated side

Muscle group	Muscle	Unamputation (mm ²)	Amputation (mm ²)	Reduction ratio (%)		
Elbow	Flexor	Biceps	14033.51	27.56		
		Brachialis	21433.48	12.57		
		Brachioradialis	17476.72	28.30		
	AVERAGE				22.81	
	Extensor	Triceps	22912.75	18898.91	17.52	
Anconeus		3300.03	3229.42	2.14		
AVERAGE				9.83		
Forearm	Supinator	Supinator	7372.46	-1.43		
		AVERAGE				-1.43
	Pronator	Pronator teres	8024.20	8123.86	-1.24	
		AVERAGE				-1.24
		Flexor	Flexor carpi radialis	5319.92	4367.86	17.90
Flexor carpi ulnaris	5054.82		2957.53	41.49		
AVERAGE				29.69		
Wrist	Extensor	Extensor carpi Radialis longus	12956.46	8775.74	32.27	
		Extensor carpi Ulnaris	3800.67	2957.53	22.18	
		AVERAGE				27.23
	Flexor	Flexor digitorum Superficialis	8172.68	5318.59	34.92	
		Flexor digitorum Profundus	9088.28	7578.27	16.61	
AVERAGE				25.77		
Phalanx	Extensor	Extensor digitorum	7445.93	3021.72	59.42	
		AVERAGE				59.42

Table 2. Surface reduction ratio of each muscle group on the amputated side compared to the unamputated side.











Muscle	Reduction Ratio	Unamputation (Lt.)	Amputation (Rt.)
Extensor digitorum	Volume. 76.7% Surface. 59.4%		
Flexor carpi ulnaris	Volume. 61.6% Surface. 41.5%		
Extensor carpi radialis longus	Volume. 54.5% Surface. 32.3%		
Flexor digitorum superficialis	Volume. 46.0% Surface. 32.3%		
Flexor digitorum profundus	Volume. 35.0% Surface. 16.7%		

Figure 3. Muscle of upper limb – 3D reconstruction