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Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

OVERCOMING BRACHIAL PLEXUS INJURIES USING A PASSIVE ORTHOSIS

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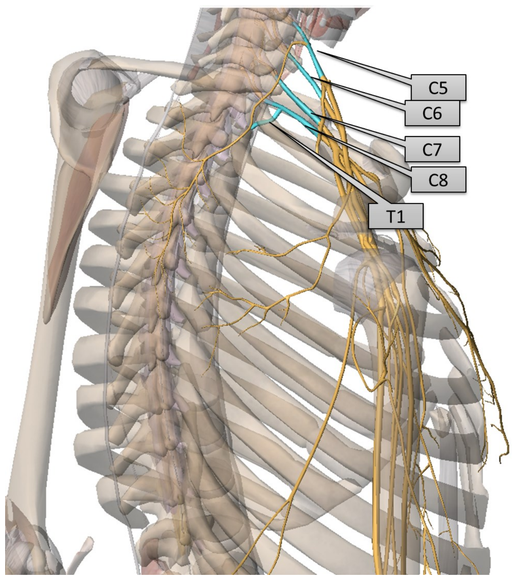
BRACHIAL PLEXUS INJURY

Brachial plexus injuries (BPI) typically caused by trauma, birth complications, inflammation processes and even tumours result in total or partial paralysis of upper limbs due to the lesion of some neural pathways such as the cervical C5-C8 and thoracic T1 nerve roots [1]. Among adult traumatic BPI, motorcycle accidents represent the overwhelming majority cause, mainly involving male subjects below the age of 30 [2]. As with some neuromuscular diseases, these injuries reflect residual or absence of muscular activity.



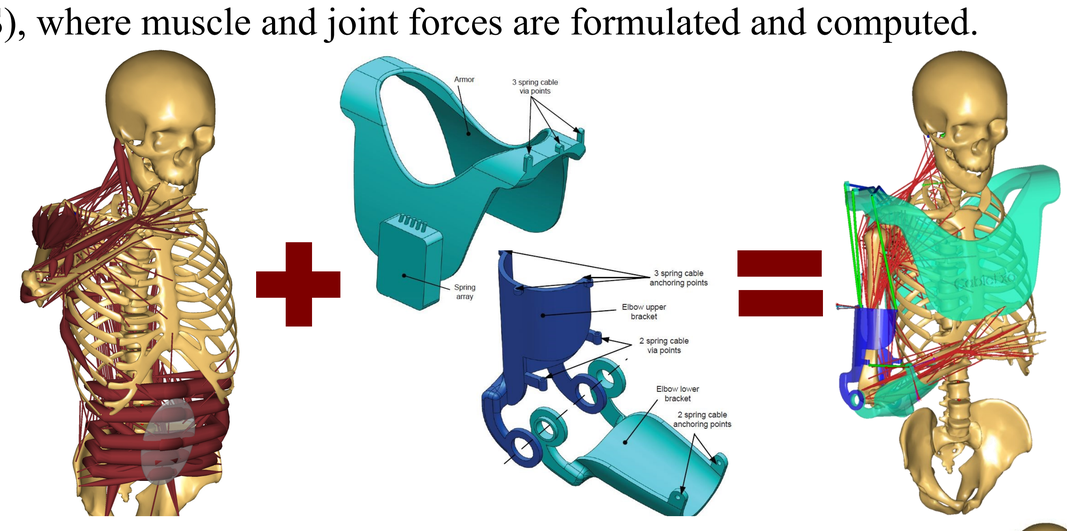
GRAVITY BALANCING MECHANISMS

The gravity balancing principle [3] states that it is possible to counteract the gravitational force (i.e. to compensate weight) using only passive linear elastic elements such as springs. Thus, a mechanism designed this way is able to maintain its position in any possible configuration.

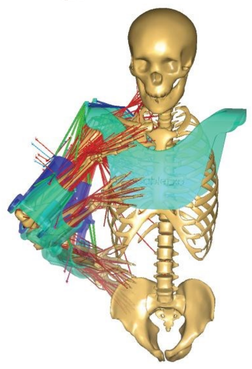
ORTHOSIS DESIGN: AIM AND METHODS

Passive arm assistive devices do not require actuators nor complex control algorithms, contrarily to the active ones found in literature [4].The design of a spring-loaded, cable-driven, wearable passive orthosis (four degree-of-freedom) is explained here on the basis of simulation [5]. Five cables (three for the shoulder and two for the elbow joints) linked to springs provide support.

➢ The co-simulation between a patient-specific biomechanical model and a passive orthosis model is performed using the AnyBody Modeling System (AMS), where muscle and joint forces are formulated and computed.



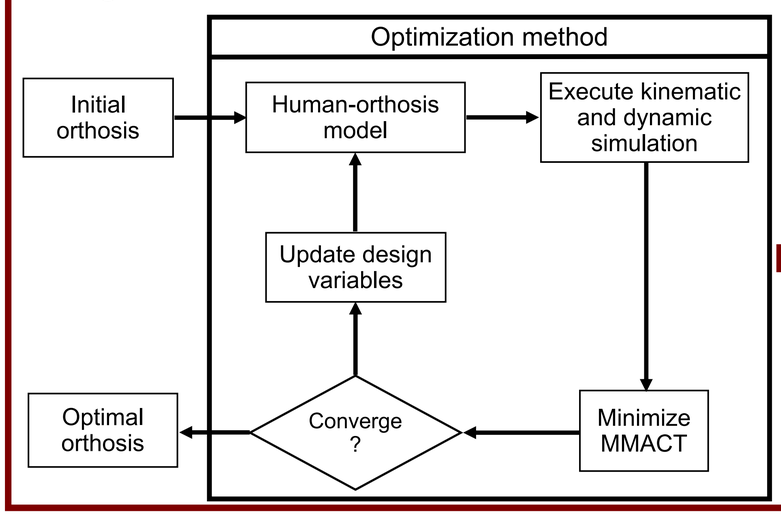
➢ Motion data of picking up a cup and drinking was captured during 3s using two Kinect™ sensors [6], while a 0.5 kg payload was carried by the hand and used as the design case.

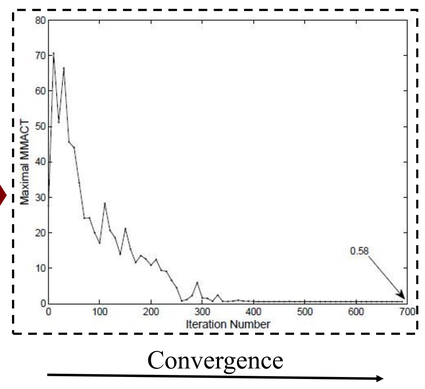


↳ Different nerve conditions can be simulated with the musculoskeletal model by disabling paralyzed muscles.

↳ Both springs' stiffness and pre-loaded lengths are design parameters.

↳ The residual muscle activity is exploited in an optimization process through the minimization of the maximal muscle activation (MMACT) [7].



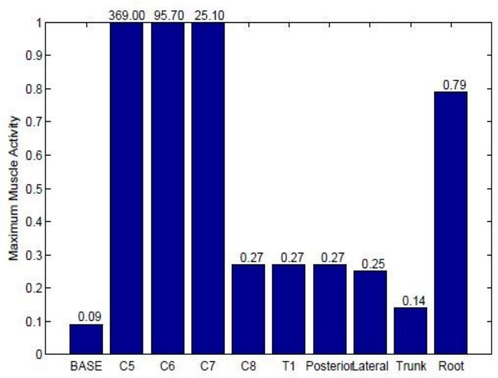


Convergence

RESULTS AND DISCUSSION

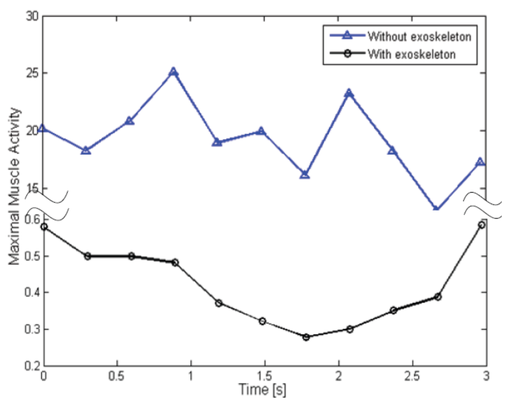
The motion of picking up a cup aimed to study the MMACT for different nerve lesion conditions:

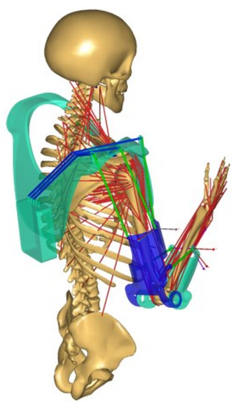
- ➢ C5/C6 nerve root lesion ⇒ MMACT ↑;
- ➢ C7 nerve root lesion (MMACT of 25.1) may be assisted by the orthosis.



Selection of C7 nerve root lesion as study case:

- ➢ all pre-load lengths of five springs are set to l_{pre}=0.06 m;
- ➢ optimal spring stiffness $k_{gh1\text{-}5}$ = [1473.4,0.3,0.03,102.0,1979.0] N/m;
- ➢ glenohumeral joint is only supported by cable 1;
- ➢ motion is restored when wearing the orthosis.





FUTURE DEVELOPMENTS

In addiction to this proof-of-concept, experimental validation is required. A patient-specific musculoskeletal model can be used to optimise a patient -specific orthosis for essential activities of the daily living. Both wearability and aesthetics of the current design must be improved using light-weight materials and 3d-printing.

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