Robotic Prosthetic Hand with Multi-Articulating Capabilities

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Key points

- **Requirements of soft prosthetic hand**
- **Use of EMG Technology in prosthetic hands**

Hand amputations are suffered by more than 3 million people due to health disorders caused by infections, congenital absence, cancer or others. If we look at a person's functional aspect, hand loss has an important impact.[1] With the advancement in technology, prosthetic hands have been made to facilitate amputated people. Moreover, sophistication has arisen in current commercial prosthetics. The sensors and actuators fitted in them are quite reliable and sophisticated therefore allowing the motorized fingers to perform grasping movements. However, these prosthetic limbs are expensive.

Material and Methods

Real human hand measurements were used as a reference on which the prosthetic hand was based on, this included the dimensions, proportions and functionality of the human hand. The 3D drawing technology scanned the human hand phalanges and designed the prosthetics based on it. Carpal bones, Metacarpal bones, Proximal, Middle and Distal Phalanges are parts of human hand. The bones of the fingers include: Metacarpal bone, Proximal, Middle and

Distal Phalanges. The thumb has one phalange less than the other fingers.

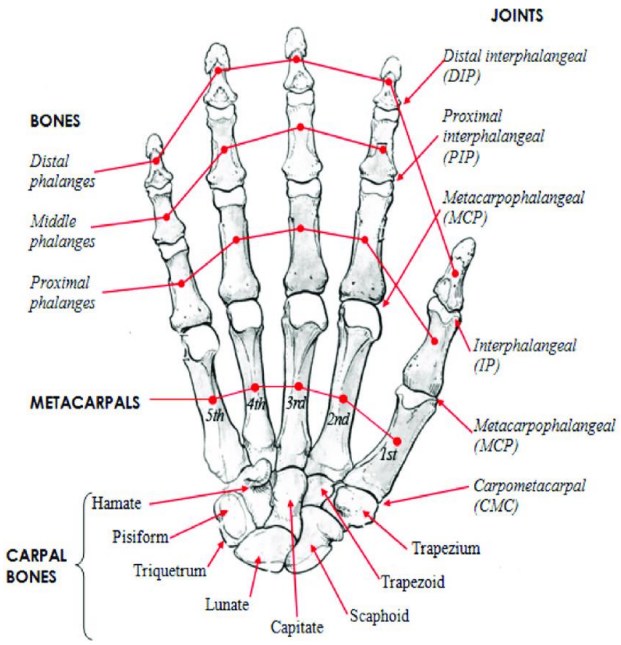

Figure 1: *Human hand skeletal structure depicting finger bones, joints, metacarpals, and carpal bones*
***(Source:** researchgate.net)*

In the designing of practical soft prosthetic hands, the following requirements need to be addressed;

1. Reliable and light weight (less than the average weight of a human hand).
2. Natural actuation system (embedded in the hand structure).
3. Strong finger kinematic design and compliance in the mechanical design.
4. Powered thumb for multiple grasping types.
5. Ease of manufacture and personalization.
6. Sufficient functionalities and the balance between the functionalities and complexity.[2]

There are various types of bionic prosthetic hands distinguished by their characteristics and properties.

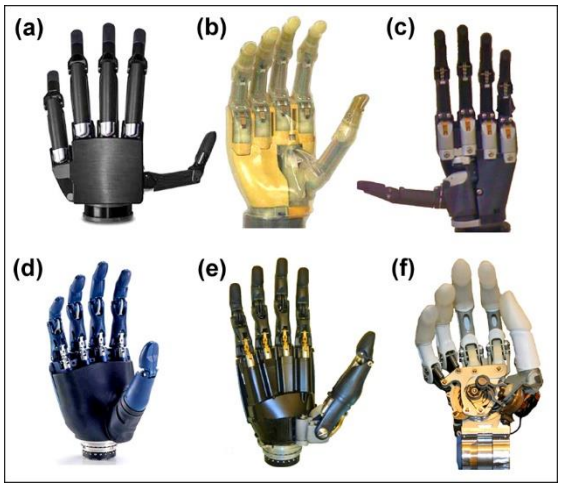

Figure 2: (a) Vincent hand by Vincent Systems, (b) Limb hand by Touch Bionics, (c) Limb Pulse by Touch Bionics, (d) Bebionic hand by RSL Steeper, (e) Bebionic hand v2 by RSL Steeper, and (f) Michelangelo hand by Otto Bock. All hands shown without cosmetic glove.
Source: *rehab.research.va.gov*

Working of the Prosthetics

Some of the prosthetics are controlled via Electromyograms (EMG). Surface EMGs are used in most common EMG controlled prosthetic hand, while others use intramuscular EMG. EMG based prosthetic hands are more esthetical as they do not have external cables. More conditions are introduced such as triggering or artificial intelligence (pattern recognition and classification) in order to obtain more than two movements of the prosthetic hand. Prosthetic hands also include hybrid prostheses that are body powered as well as externally powered.

Results of the Experiments

To identify the correct functionality of the device, experiments were performed. Along with this, the evaluation of the structure was also performed to determine the strength and integrity of the prosthetics. Three different objects were used for grasping (a) grasp of a tennis ball (b) pencil grasp (c) notebook grasping. It was witnessed that the hand could grab all the three things. Further experiments were also carried out to ensure the reliability of the prosthetic hand.

Conclusions

The proposed mechanical architecture of the prosthetic hand offers a broad range of movements and is based on the human hand anatomy. The articulation joints increase the degrees of freedom of the fingers and improve the hand flexibility and functionality. The proposed prosthetic can grasp different sized objects. Also, the use of EMG technology in the prosthetics enables an increase muscle actuation. In conclusion, the proposed solution shows interesting advantages versus available alternatives, enhancing the functionality and ergonomic nature of the device and not only relying on aesthetic aspects.

References

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2. Mohammadi A, Lavranos J, Zhou H, Mutlu R, Alici G, Tan Y, Choong P, Oetomo D. A practical 3Dprinted soft robotic prosthetic hand with multi-articulating capabilities. PloS one. 2020 May 14; 15 (5):e0232766