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Design; Prosthetics of Artificial Fingers by Incremental Production with Silicone Coating and Controller

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Abstract

Definition: According to modern man's daily life as well as irreparable damage that may occur to a human finger, there is an alternative, one of the most important issues in today's society that thought stuck. In this research, tried to design an electromechanical finger prosthesis to stop the damage caused to human fingers or maternal defects that can be replaced by a finger. After the construction, it will respond to the individual's needs. It is light and comfortable and can be flexed like a finger.
Methods: The stitch material is used to create a solid state with respect to the movement of each of the fingers from the steel bars and to protect them from light steel. The manufacture of this prosthesis was done using a 3D printer using PLA[1] soft materials. The design of this prosthesis has been used by CATIA and Inventor software and ABAQUS software has been used for analysis.
Goals: In this project, tried to build artificial finger that's where the convenience of using your finger or can dentures, if desired, use of electromechanical prosthesis.
Result: Due to the increasing need for artificial finger, due to increased production can be replied to this need and to prevent the production of heavy prosthetics.

Key Words: Electro-mechanical synthetic finger prosthesis, 3D printer, Controller, ABAQUS software, CATIA & Inventor software.

1- Introduction

Today, due to increased work and daytime development, due to the lack of concentration and mental transmissions that may occur to an individual, it can engage the person and cause serious damage to the person, especially for the fingers, or because of the fingers' smoothness the hand is the possibility of cutting fingers. In the industrial sectors in different countries there is a

[1] POLYCARBIXYLIC Acid.

possibility of this disconnection. There is this member[1]. The causes of amputation in the world vary greatly from country to country. Trauma, congenital disease and congenital defects, war, accidents and etc. are among the most important causes of the world's most common disadvantages[2,3,4,5]. These days, from 350,000 amputations in the United States, between 25% and 30% of the cases include upper limb amputation; about 10% of all upper limb amputations, including wrists and arms[6]. However, according to other studies, only half of the upper limb organs have received prosthesis[7]. Arterial limb amputation is a defect in rehabilitation, the result and outcome of which is an individual's disability, which decreases or increases under the influence of social factors and the type of rehabilitation activity[8]. The problem is that people who receive prosthesis after a while complain about their orthoses[9]. At present, the lack of a proper prosthesis instead of fingers and hands is one of the medical problems[10]. The overall trend of congenital anomalies is different in different countries[11]. The mechanical shock caused by accidents is a major cause of prosthesis release due to upper limb abnormalities in individuals[12]. One of these is the design of virtual systems that the patient can interact with in a virtual environment, and in this way, according to predicted design, improves the performance of hand movements, including the range, speed, and strength[13]. The finger should be made with a flexible fuzzy structure such as the finger of the human so that it can handle various tasks and can do the fingertips, as well as the finger of a person[14]. In the development of assistive devices therapist, various parameters such as weight, dimensions, appearance, security and human interaction with machines to run different modes, such as the hands of a mature man needed to be considered[15]. In the therapist, the placement of tools and devices to drive the prosthesis and all kinds of them, such as electrical, mechanical, etc. has always been one of the major issues in design[16,17]. One of the most effective mechanisms used in prosthetic therapist, power transmission and power through a system that can act like tendons of the hand and the fingers open to do for us[18,19,20&21].

1-1- Anatomy of the finger

Other than the thumb, which has two pairs, the rest of the fingers have three legs, each finger has one proximal end, one distal end and one trunk. The first[2] part of the second[3] clause is called third [4]clause. Fig 1,[22].

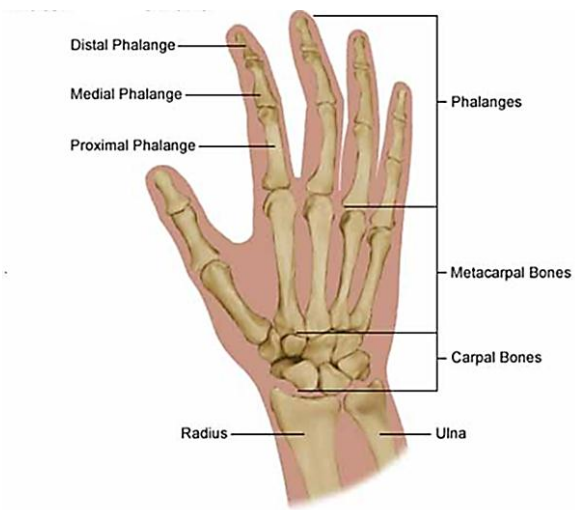

Fig1- Anatomy of the fingers

[2] proximal
[3] middle
[4] distal

The DIP[5], PIP[6] and MCP[7] joint is respectively assigned the task of connecting these claws and metacarpal bone from the tip of the finger. The fingertip system has 4 degrees of freedom, so that all three knuckles can rotate around the corresponding axis. In addition, it is designed in such a way that the possibility of this MCP deviation allows the finger joint to move from the axis to the lateral movement. Although the maximum index fingerprint range varies from one person to the next, the average value for DIP, PIP, and MCP joints is given in the following table1[23].

Table1-Joints size

Degrees of freedom (°)	Joint
110	MCP
90	PIP
80	DIP

The cause of the difference in the range of motion in the fingers is issues such as bone geometry, the structure of the muscles and tendons, and how it is used by one's own hands, which is very important . [24,25]Fig2.

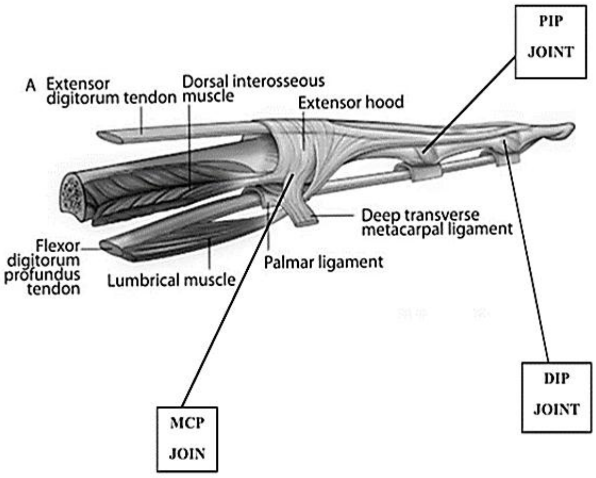

Fig 2- Finger Anatomy[26]

1-2- Examining PIP Angles and Joints

Considering the fact that we made a series of assessments to make the finger, which, according to the artificial finger made for it in the PIP joint, made a series of tests on the finger prosthesis, Fig3.

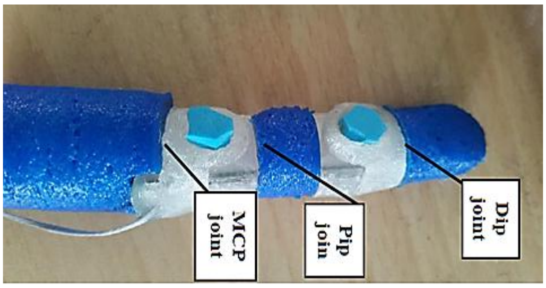

Fig 3- Synthetic finger produced by incremental method

[5] Proximal interphalangeal joint.
[6] Distal interphalangeal joint.
[7] Metatarsophalangeal joint.

Considering the measurements done on the artificial finger, the above measurements are obtained for bending and reaching the above dimensions, which are obtained in tables 2 and 3 relative to the angles and the amount of finger displacement in the PIP joint.

Table 2 - The angles and displacement of the artificial finger joint

Extension)

Displacement angle(°)	Load (g)
2	150
10	200
12	240
20	400
28	550
30	600
33	900

Table 3- The angles and displacement of the artificial finger joint

Flexion)

Displacement angle(°)	Load (g)
15	160
25	200
40	289
45	400
52	689
56	728
60	1100

1-3- Description and Construction

The human finger has a complex anatomy that includes bones, muscles, tendons, ligaments, arteries, nerves and skin protective layer[27]. The bones form the most internal structure of the finger. On the skin, the skin forms a protective layer and initially acts against other external agents[28]. It contains several internal layers that are widely classified as carenum stratum, epidermis, dermis and hypodermic apart from papillary veins, sweat glands, and blood vessels, left-handed with increasingly receptors, Touch to facilitate sensitivity[29]. Control of muscle activity is a necessary and common method for performing voluntary movements in healthy and clinical populations during daytime work[30,31]. Understanding musculoskeletal pain, the use of prosthetics to design and implement new prosthetic designs is essential in addition to the use of clinical injuries to promote motor development in children[32,33]. Adequate care should also be taken for adults, and it is necessary to use prosthesis to increase the efficiency and comfort[34].For sophisticated mechanics, the use of a cache (such as a human hand tension) for each finger, which has been subject to mechanical and control overload, is given for each part with a degree of freedom given to each elastic joint, and this Work makes the more complex mechanics and more sophisticated controllers used to prevent inappropriate structures, such as hall effect, barometer, piezo resistor, light sensor, and so on[35].In Sharma's project, the number of tendons can be considered as an advantage over other plans designed by(Lutty and his colleagues), including limitation movements[36].(Mr. Alpes and their colleagues)pointed out in 1999 that curvature was a constraint[37]. In the manufacture of our prosthesis, we pursue a goal that, if one wants to use artificial fingers, simultaneously uses a flexible silicone veneer that has its own beautiful beauty fig4.

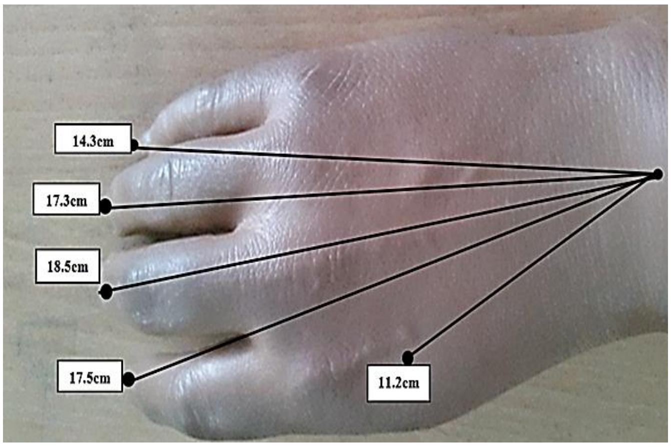

Fig 4- Silicone gloves

Depending on the model of the amputation, one can use silicone gloves for his finger. We use the Arduino Wound to launch the prosthesis[38]. Arduino Uno is a microcontroller based on ATmega328. Fig 5.

Fig 5- Arduino electronic board

It is specifications are given in Table 4.

Table 4- Arduino electronic board specifications

Microcontroller	328ATmega
Operating voltage	5 volt
Input voltage (suggested)	7-12Volt
Input voltage (range)	6-20Volt
Input / Output Digital Pins	14
Analog input pins	6
Streaming every DC input and output pin	40mA
Pin DC Current Pin - Power Pin V3.3	50mA
Flash memory	32Kilo bite , We use 0.5 KB.
SRAM	2Kilo bite
EEPROM	1Kilo bite
Clock speed	16M Hz

We use this board to control the fingers. Depending on the finger, we can also use it to fit our needs. We use the Bluetooth module to communicate with the handset or computer. The module in the HC05 for communicating via Bluetooth via Bluetooth module is a standard HC-05 module with serial output. This module is a good choice for connecting microcontroller and

Bluetooth mobile and tablet as well as two micro-high-speed devices together. You can also create a PC-based serial communication serial communication link between microcontroller-made projects and Bluetooth -enabled Bluetooth laptops[39,40,41,42&43]Fig 6.

Fig 6 - Bluetooth Modul

The servo motor is a robust and precise electric motor that reverses a single axis at a specific angle. Servo motors consist of direct DC motor, selective gearbox, electronic board, microcontroller. The main function of the electronic board is to control the servo motor's rotation angle. The potentiometer, by receiving a signal, controls the output of the gear according to the desired angle. Fig7[44].

Fig 7- Servo motor

We use this motor to flex and retrieve the finger. According to the above, the finger diagram can be plotted as follows, Fig 8.

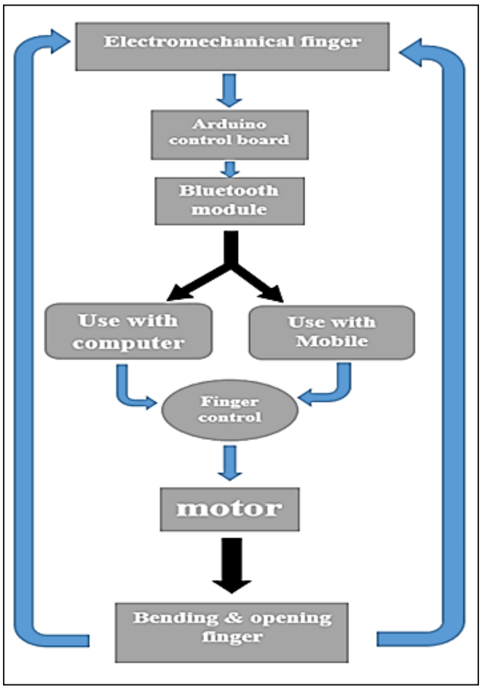

Fig 8 - Electromechanical fingerprint diagram

Regarding the shape of the diagram, the prosthesis is initially controlled by an interface. Then, with the attention of motors, we design an app on the lips or in the mobile, then we can control that prosthesis. Or, to the mechanical form of the prosthesis should be used. According to our prosthesis, the simple form of the diagram is as follows, Fig 9.

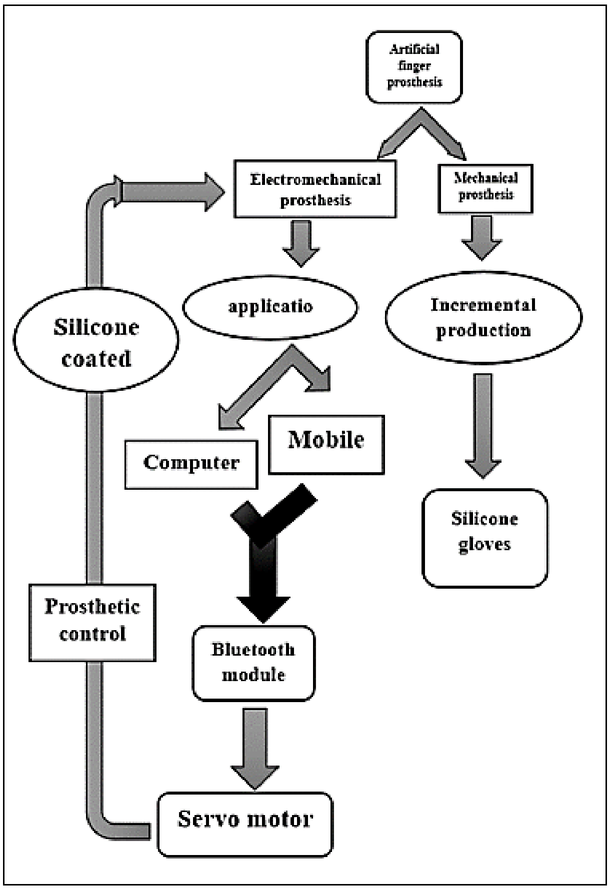

Fig 9- Diagram and final map of mechanical and electromechanical finger prosthesis

1-4- Design and Analysis

After the above steps, we designed the CATIA software, and we added the following features that are designed in CATIA software, Pic A, fig10. We got the dimensions using Catia 's software and Inventor software. Pic B, Fig10.

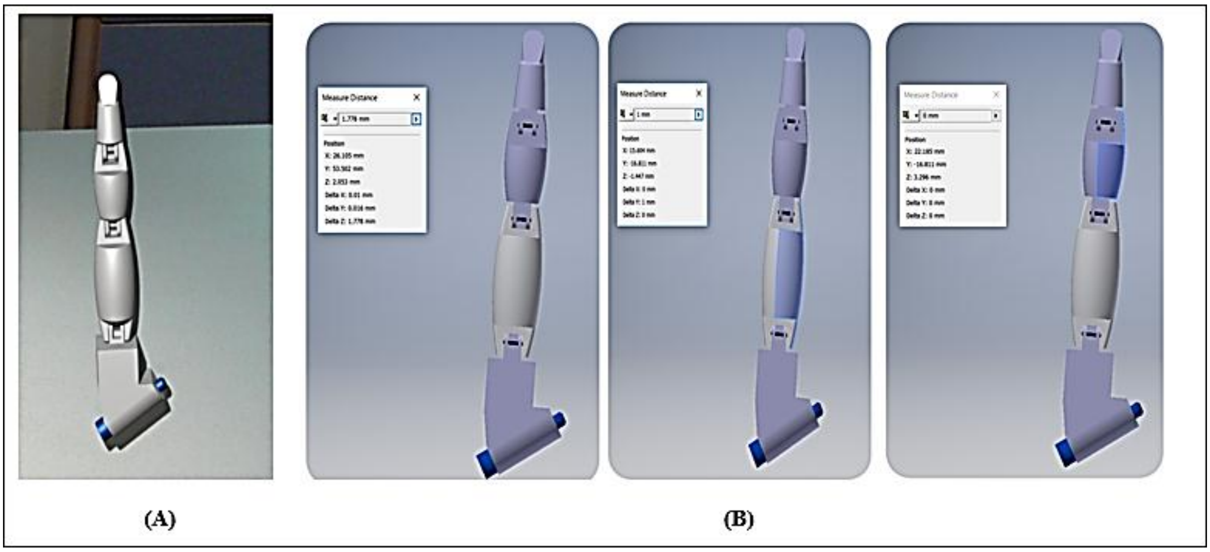

Fig 10 - A) Final fingernail rendering. B) Dimensions and design sizes for fingertip.

The forces needed to move the finger dynamically and statically after insertion are as follows, Pic A, fig11. A force measurement on the finger that is in the direction of the Y axis is a shape, Pic B, fig11. In the next image, we will examine how the force is applied to the joints by cutting in different axes with a longitudinal cut, Pic C, fig11. Considering the force involved, we will examine the burden on joints such as MCP, Pic D, Fig11.

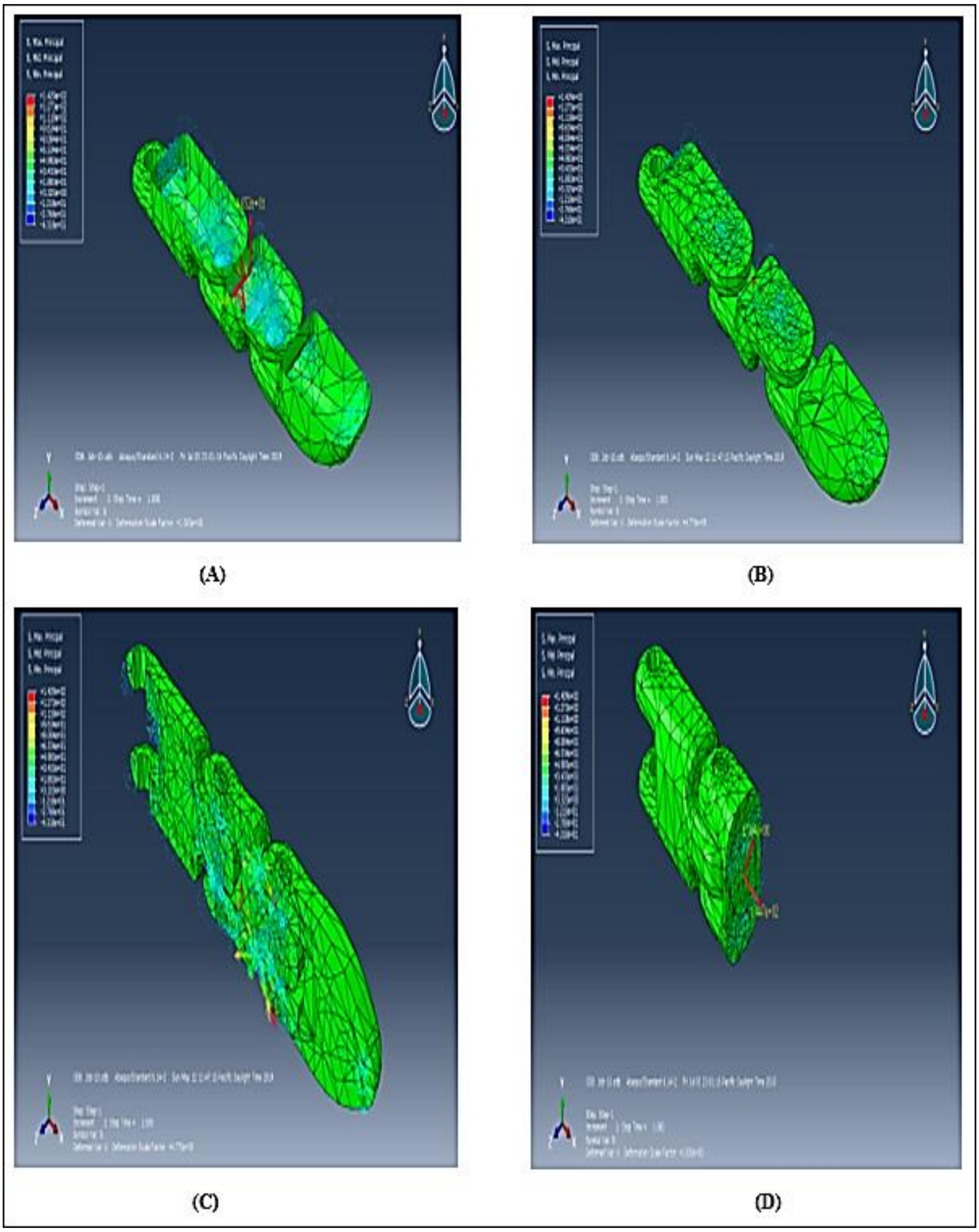

Fig 11- A) Importing force. B) Transverse cutting after the force tensor enters. C) Force influences on the various fingers of the fingers with respect to the input of 200 N force. D) The force applied to the MCP joint

Using the Inventor software, we gain horizontal and vertical forces on the finger and we obtain the dynamic force on the fingers. We get the vertical position of your fingers as follows, Pic a, fig12. Considering the material in question, we will change the location at a later stage, Pic b, fig12.

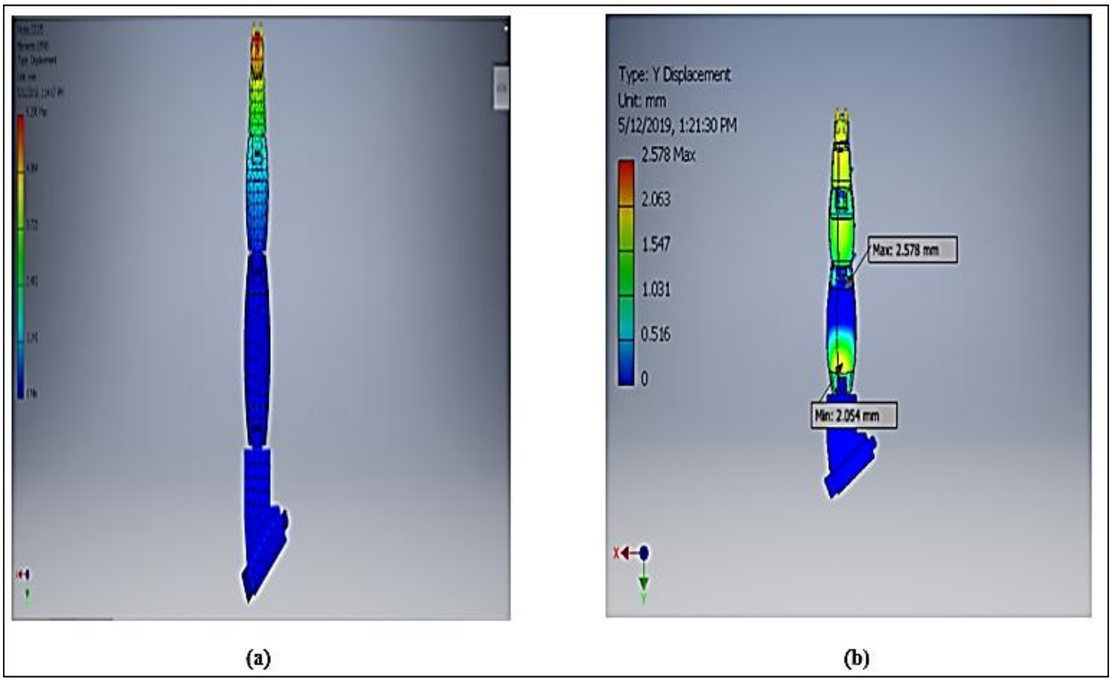

Fig 12- a) Force on the fingers and the DIP joint .b) Displacement and resizing of the artificial finger in the PIP &MCP joint

The maximum and minimum displacement after pulling on an artificial finger is obtained as follows, Pic a, fig13. The displacement carried out after applying a force of 50 N is as follows, Pic b, fig13.

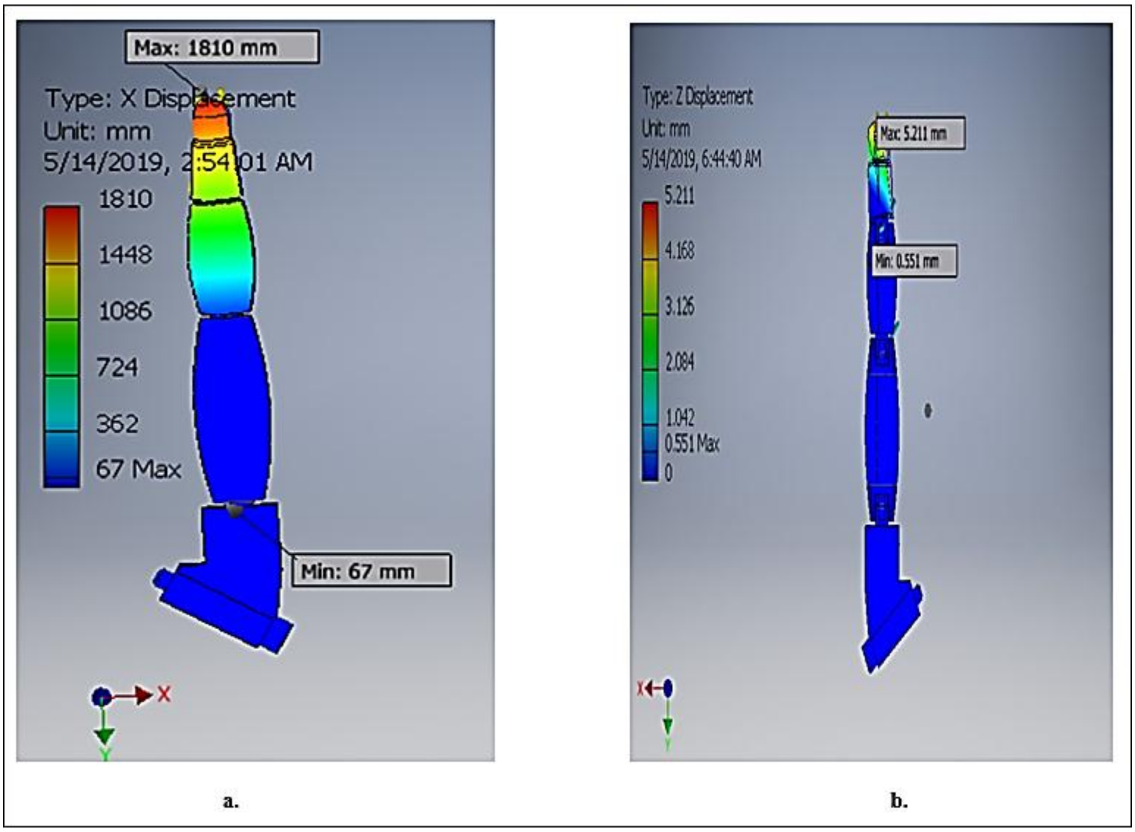

Fig 13- a) Move on the DIP joint. b) Moving after applying a force of 50 N in the Z axis

Given the force applied to the dynamic as follows ,Pic a, fig14. The force applied to the joints after applying the load is as follows, Pic b, fig14.

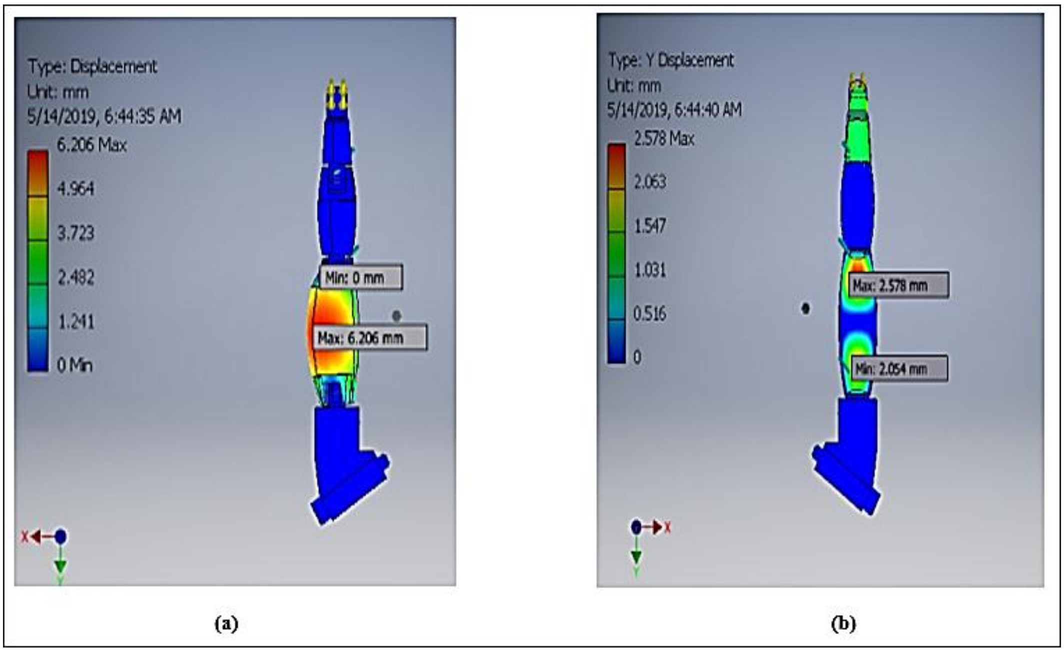

Fig 14- a) Dynamic load applied after applying to the MCP, PIP joint. b) Vertical and horizontal force after applying to the joints and see displacement

1-5- Construction of orthosis with silicone coating

Using materials used to make a finger, we use materials such as PLA. These materials have their own properties. And because of the limited resources of the petroleum, plastic industries are encouraging the use of biodegradable plasticizers (biodegradable). Biodegradation plastics, due to being decomposed and decoupled over a period of time, will open the environment cycle. It is considered to be a good alternative to conventional plastics. As one of the most widely known, the PLA is widely accepted as a 100% renewable material. PLA is readily soluble in water, in appropriate conditions, it is completely degraded and degraded and then converted into fertilizer[45,46,47&48]. We have used materials such as PLA materials to produce fingerprints. We use silicone material for coating. Prosthodontics is a prosthetic prosthesis that, in addition to its beautiful appearance, has a high safety and good appearance[49&50]. Possibility of making a sufficiently thick silicon denture can be a good option for covering[51]. Eventually the inheritance will be as follows, fig15.

Fig 15 - Finger grip and overcoat after preparation

According to the analyzes obtained from the results of the analyzes in ABAQUS and inventor software, we see the difference between the tensions and power and energy according to the following graphs, fig16.

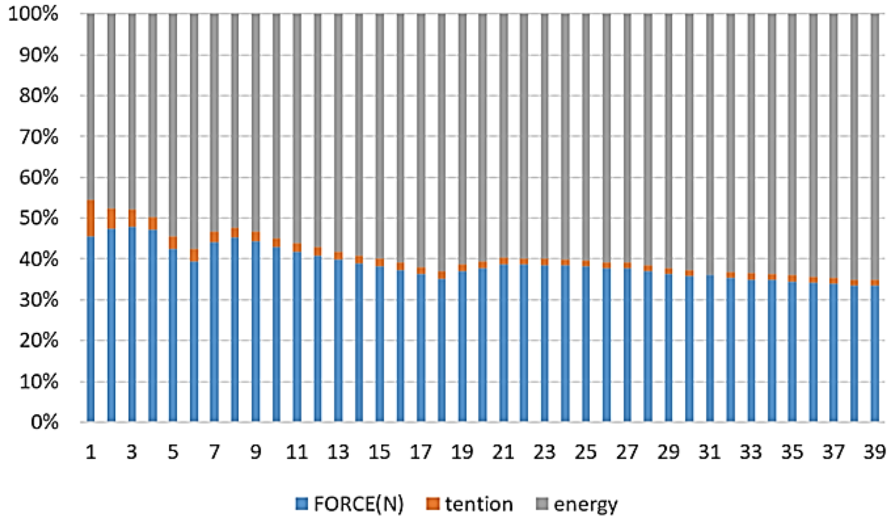

Fig 16. The difference between force and energy and stretch in the bar graph

The difference between force and intensity in the information obtained from the analysis of ABAQUS software is as follows. Considering the fact that we can decide to make prostheses better in using material, Fig17.

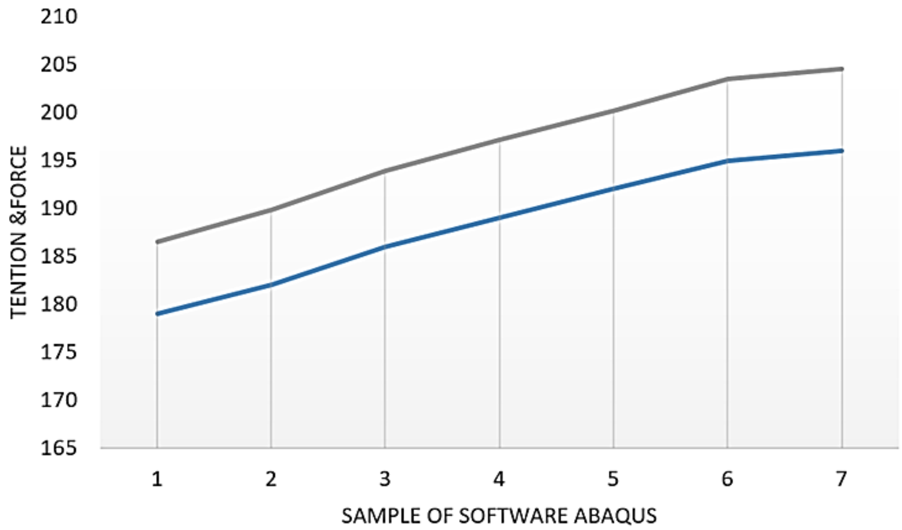

Fig 17- Difference between force and stretching

2- Conclusion

Given the need today, prosthetics can be used in an incremental way. In this method, in addition to lightweight materials, according to today's need, it is necessary to construct a prosthesis that can meet the needs of today and defect due to any kind of injuries by means of Heal the injuries, and he can compensate for the incapacity of an individual. Also, due to the cheap and modern needs and the availability and availability of both mechanical and electromechanical systems, it can be an alternative to other prosthetics.

3- Suggestion

With regard to the existing sensors, their use can be used in the artificial finger prosthesis, such as the Hall sensor and other sensors in this case, as well as according to the individual's need for other interfaces needed for it.

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