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Design a New Mechanism for Finger Rehabilitation

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Abstract: *Rehabilitation Operations Use A Reference Path As A Default To Guide Patients In A Correct Path And Correct Their Motor Errors. This Reference Path Is Often Obtained From Clinical Studies On The Movement Of Healthy People. For This Purpose, The Movement Of Various Hand Portions In The Cartesian Space Is Achieved When Performing Various Tasks As Functions Of Time. These Functions Later Turn Into Functions Of The Angles Of The Joints And Create The Pattern Of Movement Of The Part And Can Be Used For Various Tasks Such As Treatment. In This Paper, A Mechanism For The Rehabilitation Of Fingers Is Presented.*
Keywords - *Robotic, Rehabilitation, Finger, Mechanism, Hand*

I. Introduction

Different Exercises Are Used To Treat Injuries To The Body. One Of These Lesions Is The Lesion Associated With Peripheral Nervous System Lesions, Which Are Used To Treat Permanent And Continuous Exercises. These Exercises Can Be Regular Movements With A Specific Pattern. So In This Section, You Can Use Robots To Perform The Relevant Moves. In This Mechanism, A Method Can Be Used That A Person Performs His Own Rehabilitation On His Own And The Physician Only Supervise It. In This Scheme, The Mechanism Can Rehabilitate The Fingers.

II. Literature Review

Various Works Has Been Done On Rehabilitation In Various Fields From Robot Mechanics To Haptic. For Example, Gassart Et Al. [1] Used A Haptic Device With A Parallel Mechanism For Rehabilitating Hands That Only Handled In Fist Mode. Boyan Examines The Effects Of Virtual Reality On Patient Recovery [2]. He Used A Glove That Only Traced The End Phalange Gestures. Nahavandi Et Al. [3] Developed A Device That Was Designed To Help Writing. They Used A Phantom-Omni Device For This Purpose. But They Reported That It's Settling Time Was Big, And The Used A Derivative Controller To Compensate It. Ito Et Al. [4] Provided A Device For The Simultaneous Rehabilitation Of Wrist And Finger. But The Treated Part Handled The Movements In The Corresponding Part And Could Not Move Alone. In 2013, Lumbercy Et Al. [5] Developed A Device That Was Used Only For Thumb Rehabilitation. A Cable Rehabilitation System For Fingers Was Invented By Jones Et Al. [6] In 2014, Which Made The Control Difficult Due To The Mechanism Complexity. The Basis Of Control Is Impedance Control. The Global Innovation Osaka Company [7] Has Provided A Rehabilitation Device That Covers All Of The Fingers And Cannot Rehabilitate Different Phalanges Individually. Thus, By Controlling The Motor Located At The First Phalange Of The Finger, The Movements Of The System Could Be Controlled. REHA-DIGIT Company [8] Offers A System With Cam Frames That Takes Fingers Inside It And Moves Them In One Direction. This Device Does Not Have The Ability To Move Fingers In The Opposite Direction. In 2016, Gezgin Et Al. [9], Using The Wat II Mechanism, Designed A System That Was Used To Rehabilitate Fingers, But This System Moved All Four Fingers Together, And Was Used Only For Exercises That Were For Fist. Robotic Assistance Should Not Interfere With The Right Moves. Researches Have Been Done Which State That Feedback Of The Movements Can Be Coordinated With The Robot Outputs [10]. This Sync Can Be Created In A Variety Of Ways. One Way Is To Have Injured Hand Gestures Controlled With The Healthy Hand Gestures [11]. The Robot Should Be Set According To The Main Subject Of The Exercise [12]. If The Injured Person Performs His Tasks With The Help Of The Robot Properly, In Subsequent Exercises, The Robot's Help Will Be Reduced And The Robot Will Provide Minimum Assistance And The Least Error.

III. System Design

All Of The Rehabilitation Devices Reviewed Here Has Two Parts Of The Rehabilitation Mechanism And The Control Algorithm. The Most Important Point Is How To Implement And Design A System That Provide The Best Performance From A Simple System. Also, In The Future, This Tool Can Be Used To Train

Medical Students And Physiotherapists.Due To The Huge Variety Of Physiotherapy Practices And Changes In Approach From One Person To

Another And From Hospital To Hospital, People Are Trying To Use New Methods In This Field. Using A Robotic Rehab Means, The Therapist Can Use Automatic And Repetitive Exercises To Train A Part Of The Skeletal Muscle System. Due To The Purpose Of This Paper, There Is A Need To Design A Mechanism That Moves Fingers And Wrist And Can Rehabilitate Each Of Them Individually. There Are Various Ideas That Following Various Studies It Is Concluded That Using The 4 Bar Linkage Or Cable Mechanism Are The Best Choices.One Of The Designs Was Using Two Sheets At The Top And Bottom Of Each Finger And This Two Pages Were Closed Together. A Cable Passed From The Hooks That Are Connected To The Plates, And Therefore Opening Or Closing The Fingers Could Be Provided By Force And Depending On The Direction Of The Motor Rotation. Its Simplicity Is One Of Its Advantages, But Its Precise Control Is Hard And The Number Of Motors Is High. Fig 1 Shows This Mechanism.

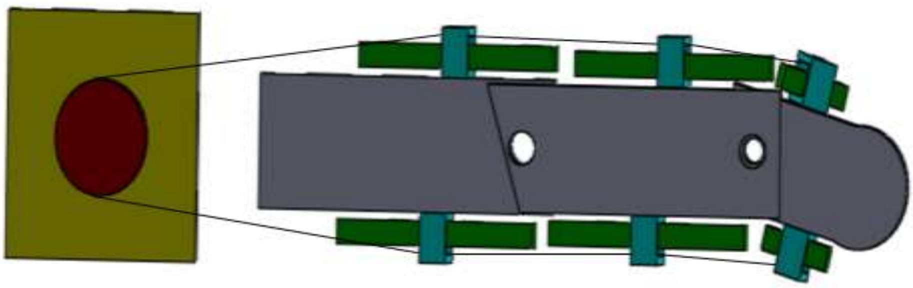

Figure 1 Proposed Cabling Mechanism

In The Next Mechanism, Transferring Of Power From The Motor To The Joints Is Carried Out By A Four-Bar Mechanism, And Its Control Is Done Through The Movement Of The First Link, And The Next Four-Bar Mechanisms Move The Other Blocks. The Design Was Also A Good Plan, But The Engines Which Were Series Made The Mechanism Heavy And Too Massive. In Fig 2, An Initial Design And In Fig 3, A Secondary Design For This Mechanism Is Observed.

Figure 2 Mechanism With Four-Bar Linkege (Initial Design)

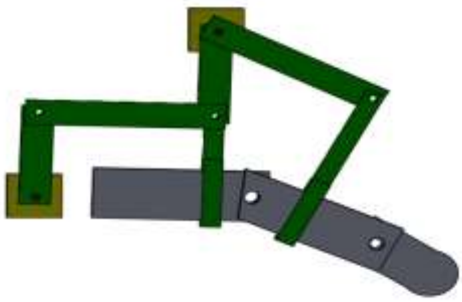

Figure 3 Mechanism With Four-Bar Linkege (Final Design)

The Third Mechanism Could Be Of A Gear Type, But The Stiffness And The Required Precision Are Of Its Disadvantages. Its Simplicity And Precise Control Are Of The Advantages Of This Mechanism. An Example Of The Proposed Design For Using The Gears Is Given In Fig 4.

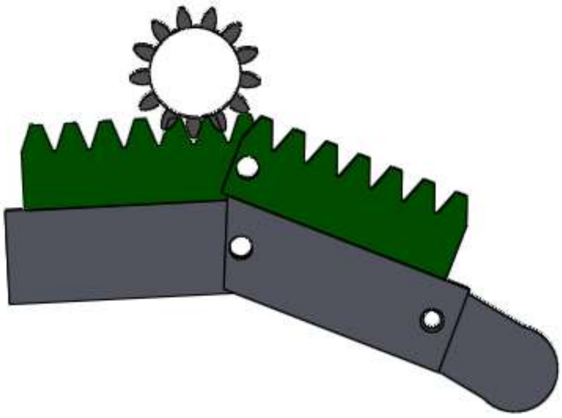

Figure 4 A Sample For Gear Mechanism

With The Help Of Hinged Joints And Moving The Rods In Each Other, A Mechanism Was Designed That Could Be Useful In This Area, But For Each Rod And The Connection, There Was A Need For The Installation Of A Motor, And The Design Was Rejected For This Reason (Fig. 5).

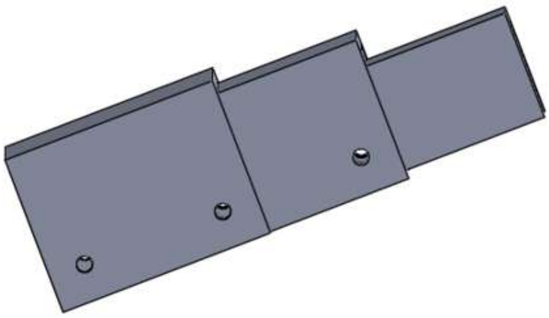

Figure 5 Designed Mechanism With Rod And Hinged Joints

One Of The Important Advantages Of Exoskeleton Mechanisms Is Locating Motors On The Fingers. In Other Words, The Engine Is Not A Separate Part Of The Mechanism And Its Movements Are Transmitted To The Fingers By A Mechanism. These Mechanisms Are A Good Choice, But Their High Weight Makes A Little Difficulty For The Patients. According To The Above Points, A Combination Of These Mechanisms Was Considered As The Current Proposal (Fig. 6)

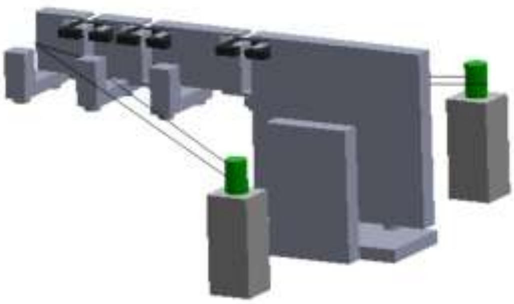

Figure 6 Current Proposed Design

This Design Consists Of Four Parts, In Which The Hand Is Placed In The First Part. The Phalanges Are Located In The L-Shaped Parts And The Black Clips Shown In The Figure Will Lock Each Phalange To Its Previous Phalange. By Removing Each Clamp, The Related Phalange Can Move In The Desired Direction. For Example, In Figure 7, The First Phalange Is Bent And The Other Joints Are In Their Place.

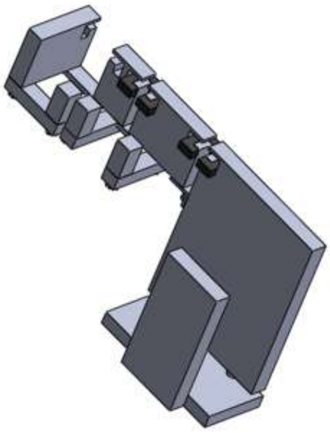

Figure 7 The Proposed Design With Bended First Phalange

IV. Results

In This System, The Tensile Strength Of The Cables Were Measured To Determine How Much It Is Needed To Use Cables For Rehabilitation. Also, The Upper Limit Of The Cable Strength Is Also Important That If The System Is In Error And Force Is Too Much, The Cable Is Torn And This Force Is Not Entered Into The Person. Typically, The Force Inside The Cable Is 3 Times The Force Applied To The Tip Of The Finger During Hand-Fist. This System Was Implemented And The Force Inside The Cable Was Obtained For Each Joint And It Is Reported In Table 1.

Table No 1 Required Forces For Rehabilitation Of Each Phalange

Finger	Force In First Phalange (N)	Force In Second Phalange (N)	Force In Third Phalange (N)
Index	25.2	23.7	21.5
Middle	32.4	30.1	28.2
Ring	31.7	29.8	27.6
Little	24.5	22.9	20.3

V. Conclusion

In This Paper, A New Finger Rehabilitation System Was Provided And The Force Needed To Rehabilitate Each Finger Was Measured And All Of These Forces Were Within The Acceptable Range For The Device And The Movements Of The Device Were Performed Correctly. The Forces Are In A Range That An Engine Can Easily Meet Them And Does Not Require A Specific Power Transmission System. The Forces Used To Rehabilitate The Middle And The Index Finger Are A Little More Than The Forces Required For The Other Two Fingers, Due To Manual Shifting Of Hand For Each Of Them.

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