AUTOMATIC MOTOR-DRIVEN MACHINE FOR LEG EXTENSION AND FLEXION MOVEMENT

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***Abstract*--- Every person who had a severe fracture in leg will have his/her leg tied tightly either folded are stretched for a long time nearly 4 to 6 months. After the healing process, the patient as to undergo a training period of folding and stretching exercise to strengthen the bones and muscles. The physician must treat every patient individually which makes it time consuming and tiresome work. The proposed paper is about Automatic Fold and Stretch machine which is an innovative idea that can automatically moves the affected leg according to the patients need, that provide flexibility, balance and strengthening exercises that leads to a gradually increase of activity. It has a fold and stretch mechanism which is done by threaded screw and nut where the motion is driven by the DC motor and controlled by a microcontroller. This machine works on varying counts and speed. This machine can be used for children and elders. The machine will reduce the work of the physician and reduces the time. It is automatic and can be accessed by the patient itself. It may not require a physician in the whole time process.**

Keywords*--- *Fracture, Fold and Stretch, Microcontroller, DC Motor.

I. INTRODUCTION

Fractures generally healed around four to six weeks, but some fractures may take several months depending on the level and the depth of the injury and the treatment procedure and rehab instructions given by a therapist on a rehab practice is important to avoid further injury and complications in future.

Once the bone is healed and made strong, it is safe to start muscle building. During the disuse, the muscles will have emaciated and be extremely frail. Tendons and ligaments will also become stiff from a lack of use. Rehabilitation procedure involves flexibility, balance and strengthening exercises and a gradually increase of activity. Physical therapy is the chosen method of securely getting back into regular form.

Rehabilitation will involve stretching and strengthening exercises after the acute stage. Physical therapy may be considered to help and ensure return to most favorable function as quickly as possible. A physiotherapist is required at many times after the suffering of a fracture. Depending on the sternness of the injury and the effect may be temporary or permanent. Physical training will help to return to the optimum efficient mobility as soon as possible.

Following an injury or a fracture healing, an exercise conditioning program will help to return to daily activities and have a more active, healthy lifestyle. A well-structured conditioning program will also be helpful to return back to sports and other recreational activities.

- Strengthening the muscles that can sustain the lower leg, foot, and ankle will help keep the ankle joint stable. Keeping these muscles strong may ease foot and ankle pain and avoid further injury.
- Flexibility may be increased by stretching the muscles that can be strengthened is vital for restoring range of motion and avoiding an injury. Gently stretching after strengthening exercises can help to reduce muscle tenderness and keep the muscle strong and flexible.
- The muscle groups of the lower leg are targeted in the conditioning program along with tendons and ligaments that is used to control movement in lower leg and feet.[10][11]

II. METHODOLOGY

The conventional methods to reduce the stiffness and to provide conditional exercising for the damaged legs are:

A. Manual Training

Fig.1: Physical Exercise

Figure 1 show the manual training given by the physiotherapist. A physiotherapist has to assist the patient to train the damage leg. The physical treatment is given to patient either in hospital or in home. The treatment may be comprises of more than one exercises that helps the patient to improve their waking ability. It is a time consuming method. The therapist can treat only one patient at a time thereby it is a tiresome work.

B. Continuous Passive Motion

It is most commonly used after the joint are knee replacement surgery. It is preferred within few days after surgery to train the replaced joints. Requires a therapist to control and monitor the whole treatment process. The efficiency is still controversy. [2][4][5]

The work of Ritter et al makes it clear that CPM (Continuous Passion Motion) and physiotherapy training does not improve the range of movement at one year after TKA (Total Knee Anthroplasty) when compare with physiotherapy alone, thus they found no differences in function of the affected leg. [3]

The most common complication may be increased bleeding. While many studies and surveys found no major difference in wound drainage or transfusion requirements with CPM usage following total knee replacement, but some of the studies found increased wound drainage with CPM that may be a issue. Some patients may require a surgery again for mass departure of hematoma under such circumstances due to CPM emphasized by Shawn W. O'Driscoll et al. [1]

Jennifer Morris points out the disadvantages of CPM that may include cost and the development of additional lag are also considered, as it is the issue of most advantageous duration of application of CPM. The results of the studies are inconclusive, but quite a few trends are identified under conditions and their implications for rehabilitation are still discussed. [8]

C. Proposed Automated Method

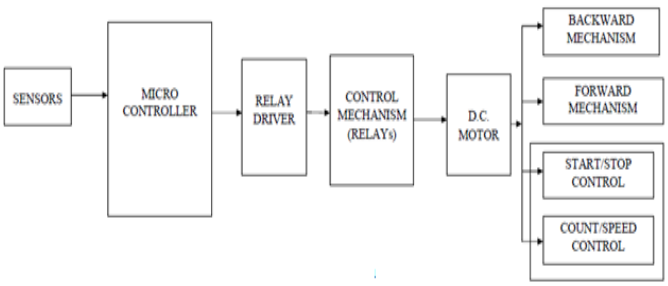

Fig.2: Block Diagram of the Proposed Method

Figure 2 is the Block Diagram of the automated method which is proposed. This automated motor driven machine for leg extension and flexion movement for leg after a leg fracture is based on a simple technique that and enhance the folding and stretching of the damaged leg.

A long threaded screw and nut is used as the base of the machine where the screw is rotated clockwise and counterclockwise direction that in turn moves the nut forward and backward therefore the fold and stretch motion of the machine is achieved. The DC motor is used to rotate the screw. The process is controlled and monitored by the microcontroller.

Two optocouplers are used as sensors which senses the distance of fold and stretch for the damaged leg. Optocouplers are highly sensitive and cheap and used to prevent ripples and isolate circuit. It consists of an infrared emitting LED chip, silicon semiconductor chip**.** The infrared LED to the silicon chip provides a maximum transfer of the desired electrical signal. The continuous flow of light for LED is detected by the detector, when an obstruction is found the voltage changes in the detector that is sent to the MC. The optocoupler output is often connected to an amplifier (or series of amplifiers) to change a low-level input voltage into an appropriate higher signal level.

Microcontroller is used for its memory storage and processing ability. The program is given as mnemonic codes. MC controls the motion of the motor and the machine. The counts of the fold and stretches are set prior and the speed can also be set and controlled. The Microcontroller is the heart of the whole machine. The start, stop, reset control are administered by microcontroller. The output of the microcontroller is given to relay driver.

The output from the microcontroller is given to the Relay Driver. The Relay Driver is a high-voltage, high-current Darlington transistor array. The Relay Driver for each Darlington pair is directly coupled with TTL devices. The relay can be connected to the Microcontroller through any of the selected port via a relay driver. The output of the Relay Driver is used to switch on and OFF the relays that on the other hand drives the motor. Four relays are used to control the DC motor.

The bidirectional DC motor provides the clockwise and counterclockwise rotation of the screw that is connected through a shaft.

III. IMPLEMENTATION AND RESULTS

The leg placed on a V-arm which is comfortable for the injured leg. The machine moves forward and backward slowly that loosen the muscle and ligament. Therefore the folding and stretching of the muscle is obtained. The leg exercise is done regularly for certain number of counts advised by the physician. A sudden power off switch is given to the stop the machine in cause of pain or emergency in the hand of the patient. The machine can be restarted later.

A. Significance

1. To Enhance Hip and Knee Control

Figure 3 shows the Hip exercise which is to enhance the hip and knee movement. The exercising steps are as follows.

- Initially start to bent the knee, while feet resting on the floor.

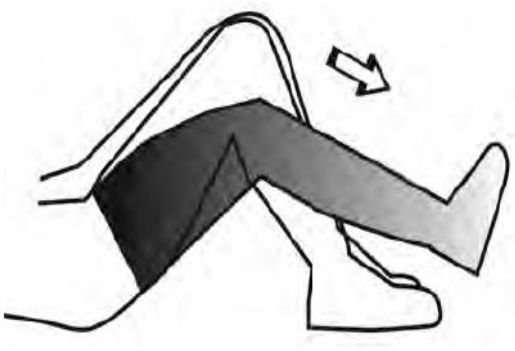

Fig.3: Hip Exercise

- Then slowly slide the heel of your affected leg down so that the leg is straightened.
- Again slowly bring the heel of your affected leg along the floor, returning to the starting position.
- Keep your heel in contact with the floor throughout the exercise.

2. *Thigh Squeezes*

Figure 4 shows the Thigh Squeezes exercise which is helps the lower muscle to regain flexibility. The exercising steps are as follows.

- Lie flat on your back and tighten the muscles in front of your thigh by pushing the back of your knee down toward the floor. Hold for five seconds and relax.
- This exercise helps reduce swelling in the knee and builds distal quadriceps strength. This is crucial for standing with your knee locked and for walking.[9]

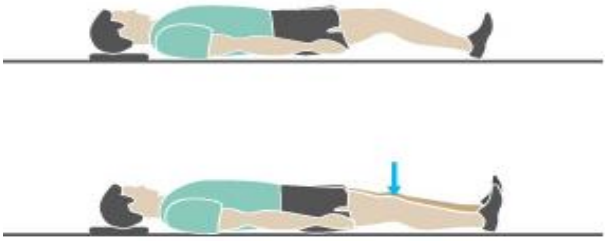

Fig.4: Thigh Squeezes Exercise

3. *Heel Slides - to regain the bend (flexion) of the knee*.

Figure 5 shows the Heel Slides Exercise that helps to improve and strengthen the ankle and foot. The exercising steps are as follows.

- While lying on your back, actively slide your heel backward to bend the knee.
- Keep bending the knee until you feel a stretch in the front of the knee.
- Hold this bent position for five seconds and then slowly relieve the stretch and straighten the knee.
- While the knee is straight, you may repeat the quadriceps setting exercise. Continue this exercise until you can fully bend your knee equal to the unoperated side.
- Also, as you start to gain flexion, you can assist your efforts to gain flexion by assisting the heel slide with a towel.
- Repeat 20 times, three times a day.

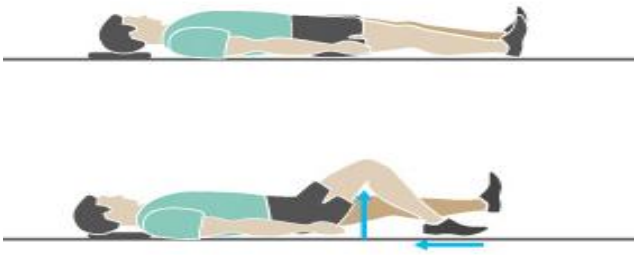

Fig.5: Heel Slides Exercise

- This exercise focuses on building hamstring strength as well as improving active knee flexion range of motion. Both are important for all activities of daily living.[9]

This automated system will be a helpful in rehabilitation after fracture or serious injury in the leg region. The dc motor used has high torque and minimum speed that causes no harmful effects to the fractured leg. It is used to reduce the stiffness in the fractured leg after the healing process. This automated motor-driven machine will help the patients to improve their mobilization after the injury. The machine would not cause any injury or problem in the future. It does not affect the walking style of behavior of the patient at any circumstance.

IV. IMPROVISATION

This automated machine is a basic idea that is implemented which can be improvised in all aspects. It can be modified for the hand also. The hand joint problem can also be solved. The speed factor is always slow but improvising the speed in every trial can also be done. Children who are prone to injury can also use the machine. Future development may lead to a more helpful machine that satisfy the needs of the patient and makes ease work for the physiotherapist.

V. CONCLUSION

Therefore the proposed method is an automated motor machine which helps the patient to fold and stretch the leg after a fracture healing process or an injury. This would help the physiotherapist to train the patient in a short duration with being with the patient in all times. Thus the patient may return to the normal lifestyle for the injury in short time duration. The patient need not visit the clinic or hospital. Thus the proposed method will be helpful in rehabilitation on developments.

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