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CONTINUOUS PASSIVE MOBILISATION IN THE HAND - AN INEXPENSIVE SMALL UNIT

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SUMMARY : An inexpensive device for continuous passive mobilisation of the hand has been fabricated for usage in hand physiotherapy units. It is simple to use, effective and can be fabricated easily. 25 digits in 22 patients who suffered from a variety of hand injuries and consequent restricted joint motion were treated with this device. A high patient compliance, decreased pain and significant improvement in the range of motion were observed. The device is suitable for use in a hospital department. The concept and evolution of continuous pasive motion is also discussed.

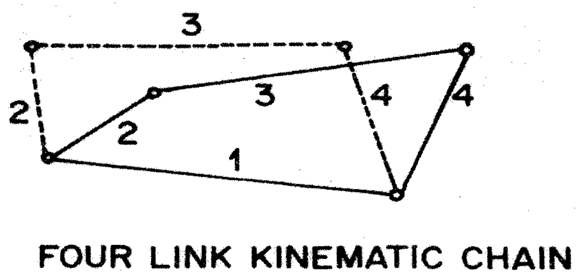
INTRODUCTION

The successful management of an injured hand depends on an accurate preoperative assessment, skilled surgery and meticulous aftercare. This is the trinity on the bedrock of which hand surgery is built. Passive motion has been shown, in both experimental and clinical studies, to enhance healing and facilitate early rehabilitation of the hand by a number of authors.[1-3] Mechanical devices for passive mobilisation have made a significant contribution ever since Salter first asked Saringer to design a device for mobilising the knee joint.[4] These devices utilizing the principles of passive motion were initially applied to the large joints viz. knee, hip, elbow and ankle and later extended to the hand. However, they seem to be in limited use in mobilising the small joints of the hand especially in developing countries probably due to its non-availability, cost-factor and the need for skilled engineers to fabricate and maintain the device. Faced with these problems, the authors designed a device that is simple to fabricate in an engineering department of any hospital and calls for minimal maintenance. An analysis of the device is followed by a detailed discussion on passive motion and continuous passive mobilisation.

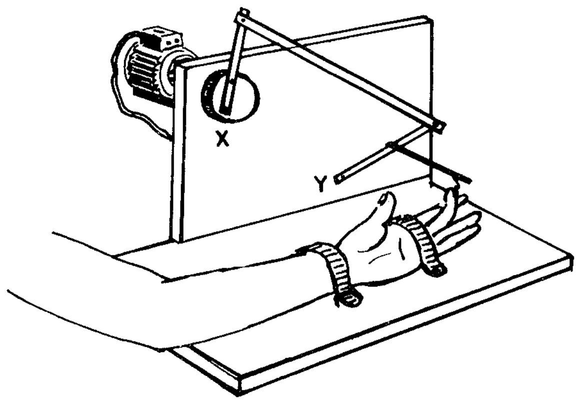
MATERIAL AND METHODS

Analysis of the device

The principle of kinematic chains forms the basis of the mechanism of this device. It consists of 4 links, 1,2,3 and 4 (Fig.1) all of which have turning pairs forming quadric cycle chain. Link 1 and its two ends, the pivot points X and Y are fixed while links 2,3 and 4 and the turning pairs are freely mobile (Fig.2).



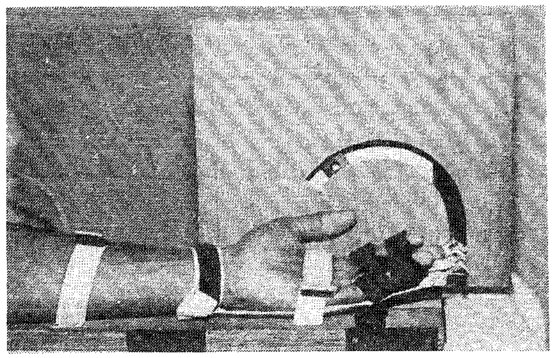
(Fig-1)



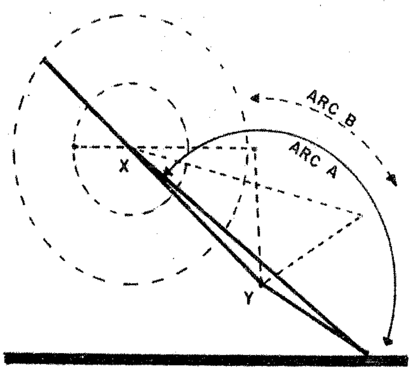
(Fig-2)

The length of links 2,3 and 4 are chosen such that while link 2 moves in a complete circle about the fixed point X, the link 4 will only be able to move in an arc (Fig. 3). Thus a circular form of motion is successfully converted to an oscillating arc motion by using the "crank and lever" mechanism.

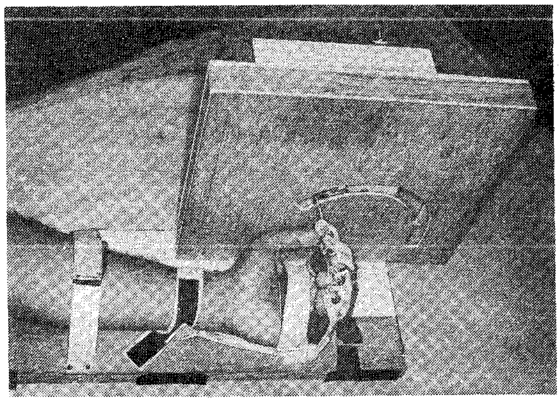
At the point X, there is a 230 volt AC motor which provides the circular motion with a torque of 40 kg.cm at source and a speed of 2.5 RPM. This arc motion is transferred to the finger using a horizontal bar (Fig.2). In order to do this, the hand is strapped to a brace by velcro bands, and then fixed at the wrist and forearm by velcro straps. The brace is connected to the horizontal rod by elastic bands. This is the position from which the hand is now mobilised.



(Fig-4a)



(Fig-3)



(Fig-4b)

The to and fro arc motion brings about flexion and extension of the fingers (Figs. 4A and 4B). One can selectively mobilise the interphalangeal joints by using velcro straps just proximal to the selected joint. The advantage of using elastic bands is that it prevents the fingers from getting unduly stretched as any extra stress is taken up by the elastic bands. In order to achieve a greater range of movement elastic bands of lesser elasticity are utilised.

PATIENT SELECTION

This is the preliminary report of the use of this machine in 25 digits in 22 patients. The patients were evaluated by a hand clinic team consisting of a plastic surgeon, resident doctors, a physiotherapist and an occupational therapist. Screening involved disqualification of alcoholics, amnestics, drug addicts, psychiatric cases and patients with other physical disabilities that would preclude them from taking part in this study. Selected patients were photographically documented and measurements were taken using a goniometer. The joints included being the metacarpophalangeal joint, the proximal interphalangeal joint and the distal interphalangeal joint. Patients were subjected to both routine physiotherapy and mobilisation on the CPM device for a period of 1 hour. This routine was carried out daily and weekly measurements were taken in the hand clinic on an OPD basis. Assessments were carried out for a minimum of 4 weeks and continued for as long as 8 weeks, depending upon the improvement shown by the patient. The diagnosis of the patient who used the device and the number in each category is listed in Table 1.

TABLE 1

DIAGNOSIS	NUMBER
Fractures and joint injury	8
Flexor tendon injury	6
Post-burn contracture release	3
Skin and soft tissue loss	3
Post infective stiffness	2

RESULTS

It was found that all the patients were comfortable during the course of the therapy and experienced less pain as therapy progressed. In order to compare results, a matching group of patients and evaluation with and without Continuous Passive Motion will be necessary. As such a cohort was not available, no statistical analysis was carried out. The average improvement in range of movement was about 25° in four weeks.

DISCUSSION

It has been recognised for many years that the lack of motion of joints leads to stiffness. Formation of adhesions and the resultant poor gliding function following immobilisation in repaired tendons have been convincingly shown in the past.[1-3] Gap formation between repaired tendons, disoriented fibroblastic proliferation, delayed collagen maturation, decreased gliding function due to adhesion formation and poor vascular filling at the repair site have all been observed with uncontrolled early mobilisation.[1,5,6]

However, when passive motion is performed in a controlled fashion it has been shown to be useful. Micro angiographic and biochemical studies in dogs showed that passive motion resulted in the reorientation of blood vessels to a more normal pattern and an increase in the total DNA content of the healing tendon and sheath signifying better remodelling and accelerated tendon maturation.[7] The strength properties represented by the ultimate load and linear slope values and the gliding function reflected by the angular rotation and linear excursion values are significantly improved by early passive motion.[1]

The concept of Continuous Passive Motion (CPM) originated by Salter[8] has since been studied in experimental as well as clinical situations. Mooney[9] performed soft tissue incisions and arthrotomies in rabbit knees and observed that wound subjected to CPM were significantly stronger, stiffer and tougher with respect to the breaking force, tensile strength, strain at failure, stiffness and toughness as compard to the immobilisation group. CPM causes a rapid metaplasia from undifferentiated mesenchymal tissue to hyaline articular cartilage thereby providing an important stimulus to the joint reparative processes and has also been shown to prevent joint stiffness.[8]

Although initially used for large joints viz. knee, hip, elbow and ankle, its use has been extended to various conditions in the hand such as following tendon injuries, tenolysis, joint reconstruction, treatment of intra-articular fractures, reflex sympathetic dystrophy and burns.[10-12]

Since 1978, a lot of mechanical devices have been designed to provide CPM in affected joints with positive results. Bentham used a CPM device in patients who had flexion contractures following burns, trauma and Dupuytren's disease and found them to be well tolerated and effective.[13] Bunker using the Toronto Mobilimb continuous passive motion machine for the first four and a half weeks showed excellent results in 85% of cases following repair of flexor tendon injuries.[14] It has even been shown that hand oedema of varied aetiology decreased when subjected to CPM with limb elevation.[15] However, some authors have had unsatisfactory experiences with using CPM devices in rehabilitation of Dupuytren's disease[16] and following tenolysis.[17]

The device used in our study was built in the engineering department of our hospital. The total cost of fabricating this device works out to about Rs.3,000/= (about 100 US$) and therefore, should be economically viable in any setup. The device being impersonal, human behavior and apprehensions did not play a significant role. The gradual increase in force and the slow speed (2.5 r.p.m) provided definite, slow and non-jerky mechanical motion, both of which helped to reduce pain considerably. The availability of the device throughout the day was convenient to the patients. Patients compliance was thus high with an overall attendance rate of 97%. The 3 burn patients who were subjected to CPM experienced little pain and no graft loss occurred during the therapy. A decrease in hand oedema was observed subjectively towards the end of therapy but this could also be attributed to limb elevation and the resolution of inflammation.

Our device is not without its limitations. The thumb and wrist movements will have to be incorporated. Minor mechanical breakdowns are imminent and frequent checks by technical personnel are necessary to see that the device functions well. The provisions to vary the frequency will be advantageous when incorporated, but we are continuing our studies on this. It is ideal to use the machine for a longer time each day. Expensive machines are more compact and portable whereas our device needs to be kept in the department. This is a significant limitation. A skilled therapist is essential at all times to see that the force, duration and direction is correctly adjusted depending on the digit being subjected to CPM.

In conclusion we believe that this device serves as an additional arm to the therapist's mode of management and that the role of the therapist is pivotal to the ultimate outcome in hand rehabilitation.

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