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DESIGN OF AN ADJUSTABLE LOWER LIMB (ALL) TRACTION DEVICE.

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Abstract

In orthopedic medicine, traction is a device for straightening broken bones or relieving pressure on the spine and the skeletal system to regain normal length and alignment by application of a pulling force. In Ghana the traction device are imported and some are locally manufactured. Some problems were identified to be associated with these traction devices. These problems were addressed in the work presented in this paper by designing an adjustable traction device for the lower limbs. The device consists of two parts, the thigh and lower leg supports. The fractured or the affected leg is made to rest on the device with the thigh and the lower leg resting on their supports. The leg is then adjusted correctly and comfortably, the thigh support would then be pulled upward towards the lower leg support through an angle of about 30^{o}. The lockers are tightened to maintain the current adjustments. Once the device is set up, the orthopedic nurse would tie the weight attached to the end of the rope to the pin inserted in the affected bone according to the instructions given by the physician. The patient would then be monitored until the fracture heals or the dislocation aligns. This device can be used with a chair or a hospital bed compared to existing locally made ones that can only be used with a hospital bed. Though limited only to the lower limbs it is simple and easy to move compared to the cumbersome, bulky imported types.

Key words: Traction, Orthopedic, muscle, limbs, musculoskeletal

1.0 INTRODUCTION

Orthopedic medicine is a branch of *surgery* devoted to the diagnosis and treatment of illnesses, injuries, deformities and malformations of the musculoskeletal system, including bones, joints, ligaments, muscles, and tendons [3].Traction is the application of pulling force on any part of the body to treat a fracture, maintain bone alignment, relieve pressure on the spine and the skeletal system or prevent spinal injury [8]. It is the commonest method used in orthopedic medicine. There are two types, skin traction and skeletal traction. Skin traction includes weight traction, which uses lighter weights to apply force to fractures or dislocated joints. In this method weights, typically of 2-4kgs are attached to the skin using adhesive tape or straps. Skeletal traction requires an invasive procedure in which pins, screws, or wires are surgically installed for use in longer term traction requiring heavier weights [1]. This is the case when the force needed is more than the force skin traction can bear, or when skin traction is not appropriate for the body part needing treatment. Weights used in skeletal traction generally range from 11–18 kg. In traction treatment plan, the physician's order will contain the type of traction, amount of weight to be applied, frequency of neurovascular checks and site care of inserted pins, wires, or tongs [1]. Research conducted in two out of the three biggest hospitals in Ghana (Korle-Bu Teaching Hospital and 37 Military Hospital) by the authors showed that skeletal traction devices used in Ghana are two types; the imported one which is adjustable and the locally made one which is not adjustable. There are some problems associated with these traction devices. These problems are identified as;

i. Non-adjustability of the locally manufactured ones, making its use difficult for patients whose thighs cannot fit in it.

ii. Bulky nature of imported ones. When assembled, it is a whole hospital bed therefore it becomes cumbersome when it has to be moved and also it is expensive.

iii. Insecurity of existing locally made ones.

In this paper, the problems listed above are addressed by designing, fabricating and testing an adjustable lower limb traction (ALL) device. Lower limb traction is done on the lower limb, (from the thigh to the toe). In the design, a typical iterative engineering design process comprising problem identification and problem statements, design objectives, methods, concept generation, fabrication, evaluation and testing of the product was employed.

The device consists of two parts namely thigh and lower leg supports. When it is in use, the affected leg is made to rest on the device with the thigh and the lower leg resting on their supports. The device is then adjusted correctly by pulling the thigh support upward towards the lower leg support through an angle of about 30^{o}. The lockers are tightened to maintain the current adjustments. Once the device is set up, the orthopedic nurse would tie the weight attached to the end of the rope to the pin inserted in the affected bone as instructed by the physician. The patient would then be monitored until fracture heals or dislocation aligns. This device can be used with a chair or a bed compared to existing locally made ones that can only be used with a hospital bed. Though limited only to the lower limbs it is simple, cheaper and easy to move than the cumbersome bulky imported types.

2.0 METHOD

To carry out the design of ALL device, a typical iterative engineering design process comprising problem identification and statement, concepts generation and selection, evaluation and testing of product was employed.

2.1 PROBLEM IDENTIFICATION AND STATEMENTS.

It was identified through investigations by the authors at Korle-Bu Teaching Hospital and 37 Military Hospital (two out of the three biggest hospital in Ghana) that there are four main problems associated with the existing skeletal traction devices used in Ghana. These problems create a lot of inconveniences and difficulties during traction treatment.

The problems identified are enumerated as follows;

i. The non adjustable nature of locally made traction device [Figure 2.1].

ii. Bulkiness of imported adjustable traction devices.

   Most of the adjustable traction devices are bulky [Figure 2.2], as a result carrying from ward to ward becomes a problem. The cumbersome nature also makes packing of these devices difficult for users.

iii. Insecurity of locally made traction device.

   The bar on which the rope holding the about 15 kg weight, normally slips off from the edge of the bar of the locally manufactured traction device as shown in Figure 2.3a and b. This failure can lead to destruction of thigh muscle and in severe case, leads to paralysis of patients.

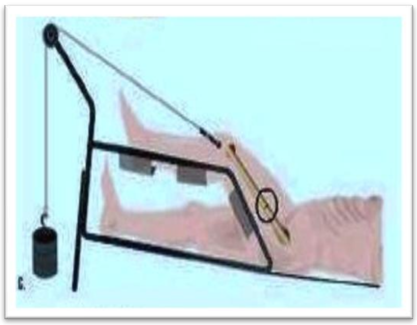

Figure 2.1 Non-adjustable locally made traction device.

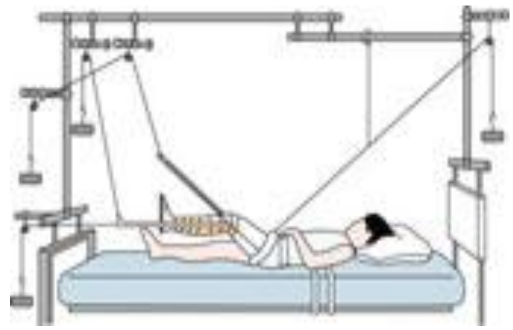

Figure 2.2 Bulky adjustable traction device.

Fig. 2.3a Unsecured traction rope

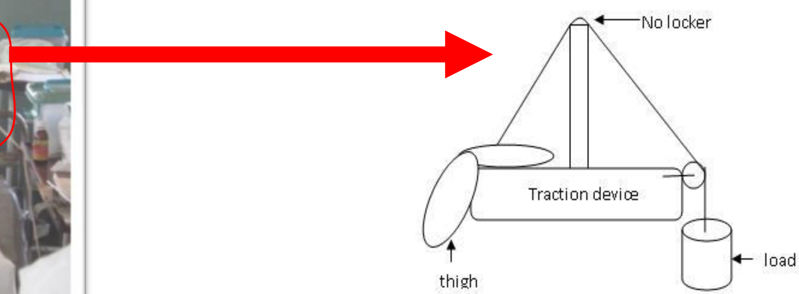

Fig 2.3b Magnification of unsecured rope.

2.2 Design Objectives

The objectives of this work are to design and fabricate a product that can be adjusted to fit and provide comfort for thighs of different lengths and to design a product that is adjustable, portable and cheaper.

2.3 CONCEPT GENERATION AND SELECTION

The whole system was broken into two sub systems:

i. Adjustability and the locking system and

ii. The base support system

In order to arrive at a suitable design, various possible alternatives or concepts from the two subsystems were considered and analyzed. Based on the customers' requirements, the final concept was chosen. Concepts from the system are as follows.

a. The Adjustability and the Locking System

The main purpose of this idea is to choose the appropriate method of adjusting the parts of the device that are movable. Once these parts have been adjusted there is the need to lock the parts in place (press fit). Two main methods came up from this idea. Piston like adjuster with an attached bolt and nut (wing head) and sliding rod system [5]. The bolt and nut adjust continuously whiles the sliding rod system is a discrete adjustor. The piston adjuster with bolt and nut system was selected based on customer needs.

b. The Base Supporter System

This aspect of the design is to provide stability for the device. This is very important in a situation where the device would be subjected to a lot of weights such as, the thigh weight, lower leg weight and a load. Three possible base areas were calculated and the maximum base area selected because that has the maximum stability. A benchmarking was done to compare the existing devices in the market to the proposed design [2], [4], [6], [7].

3.0 FINAL DESIGN

The details of the design which consisted of adjustable slanted and horizontal edges (thigh and leg supporters and a pulley system shown in Figure 4.1 are drawn using mechanical desktop. The various parts of the device were subjected to stress analyses using anthropometric data [8] on adults of which an average person has a mass of 70 kg, with an average thigh length of 39.32 cm and 41.82 cm as average calf/ lower leg length.

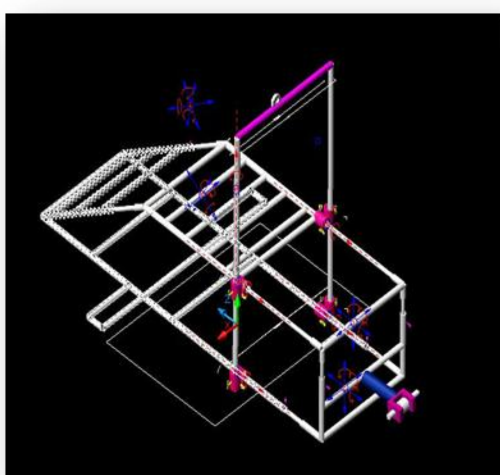

Figure 4.1 Mechanical Desktop Drawing of Design

3.1 Fabricated Design:

The two sub systems that were built separately are joined by bolts and knots to form a complete system (device) [Figure 4.2].

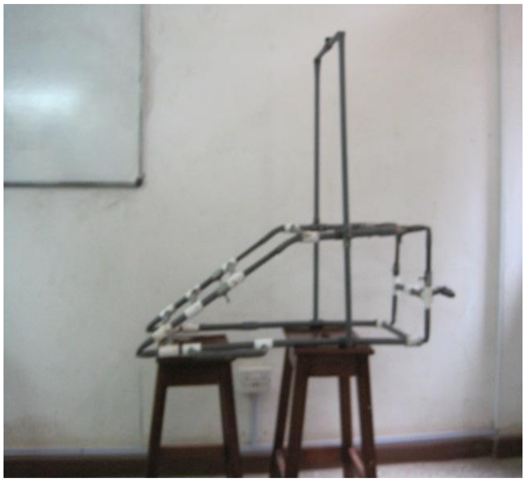

Figure 4.2 Prototype of Design

3.2 How the device works

The thigh support touches the ground at an angle of $30^0$and to the lower leg support at150^0. The lower limb is made to rest on the device with the thigh on the thigh support and the lower leg on the lower leg support. The patient sitting in a chair or lying on a bed depending upon physician instruction then positions his or her lower limb correctly and comfortably by pulling the thigh support upward towards the lower leg support.The lockers are then fixed to maintain the positions.

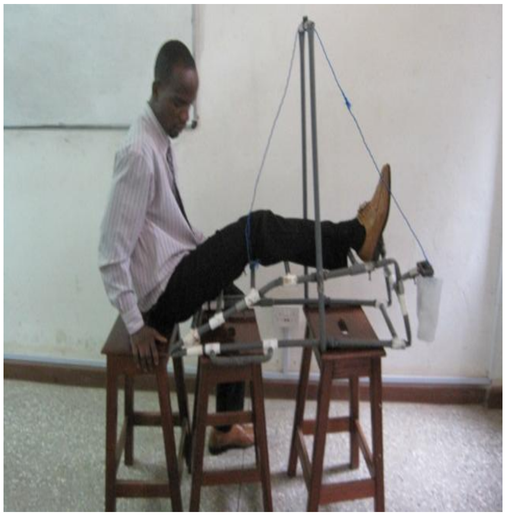

Figure 4.3a Normal thigh placed on support

Figure 4.3b System adjusted to comfortably support longer thigh

3.3 Testing of device

The testing of the device was done automatically with a mechanical desktop. Stress analyses were done and the appropriate allowable stresses were determined based on the theories of elastic failure [5]. The parts that experience significant stresses were identified as the thigh support, calf support and the bar on which the rope hangs.

3.4 Strength and Weakness of Design

The problems associated with the existing designs have been addressed in this work to a large extent, in the sense that the product can be adjusted to suit different patient thigh lengths. There is a pulley system that addresses the insecurity of the existing locally made device. In addition it can either be used with or without a bed. The device can be dismantled and assembled conveniently which makes it portable. It is also aesthetically pleasing.

However, the device has long operating time as a result of locking and unlocking of the adjusters. It is only limited to the lower limb.

4.0 CONCLUSION

The design of this adjustable lower limb (ALL) traction device clearly shows the required scientific and engineering processes, concepts and assumptions and how to employ them to produce the best design. Since the device is composed of much complex architecture, it made some calculations difficult and assumptions had to be made in certain calculation. The device had the unique feature of continuous adjustment in addition to its portability.

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