Modelling and Analysis of Shoulder Traction Surgery Kit

K Aruna prabha 1*, S Swetha 1, Priyadarsini Morampudi1, CH Naveen Reddy1

1Department of Mechanical Engineering, VNR Vignana Jyothi Institute of Engineering and Technology, Telangana, India

E-mail: arunaprabhakolluri@gmail.com

Abstract- The shoulder traction surgery kit supports and improves efficiency in performingarthroscopic shoulder surgeries. Shoulder Traction Kit provides a convenient method to apply traction and position the patient’s arm for shoulder procedures. It provides a proper vision within the shoulder joint and provides easy access for sub-acromial space. This paper presents a traction based shoulder kit aiding surgeries where the design and outlay requirements are reviewed and collected from research papers and suggestions taken from medics. This project initially deals with a simple design and model of the shoulder traction kit which is reliable and cost effective. A design which is simple to handle and easy to maintain has been the main moto of this project. Initial equipment outlay is modelled using software CATIA V5, SOLID WORKS and analysis is done on ANSYS. The model is simple, with few mechanisms involved and flexible which is easy to use. Based on analysis results and observations it is found that the designed shoulder traction kit can withstand 8 Kg loads with lesser deformations, stress within limits without any failure.

Keywords: Traction, Shoulder kit, Modelled, CATIA V5, ANSYS.

1. INTRODUCTION

In ortho medics traction force is applied to attain a convenient and accessible position for a shoulder arthroscopy. Traction is a pull force applied to the two objects to keep an interface to perform actions. In ortho field this phenomenon is applied to construct devices using pulleys and loads to aid a fractured or injured bone/joint in order to cure or restore or aid for surgery. The tension created by traction suspends and stretches muscles and bones for certain amount of time [1]. A tapered/ dislocated joint is fixed by incessantly and steadily pulling the bone by using gravitational force when 7-8Kg weights are suspended onto pulley device [2]. An economical and reliable traction kit is built which stretches and suspends the shoulder by using supports cables, pulleys and loads. Point tractions with required inclination are obtained by assigning loads onto three point traction chain [3]. Generally, shoulder arthroscopy is carried by appropriately positioning the subject in lateral decubitus or beach chair depending on the conditions and the effectiveness. This gives an idea for design and developing a
traction kit useful for surgeons [4]. Shoulder positioning such as lateral decubitus is desirable as it avoids difficulties and improves efficiency of surgical procedures. This benefit surgical group taking into account of patient’s safety [5]. Grace Benson [6] developed a traction based unit containing a hook belt, a sleeve strap 25° inclination maintained suspended by the pulleys a scale with load suspended. This gave an idea for many orthopedic doctors for setup and making use of traction in performing complex shoulder surgeries. The shoulder to be operated is subjected to traction to gain joint recess by using arrangement which includes A frame hooks holders etc where one end of rope is in tension and pulls the shoulder the other end is pulled by traction making a lateral decubitus position [7] as shown in figure 1. The importance of LD position is emphasized as it gives much room for set up of surgical equipments with better image and operative environment [8]. Neurological and cardio complications and damages cannot be ruled out in LD position caused by traction hence it is advisable that the weights should be restricted below 8kg to prevent tearing and injuries [9][10][11]. Ravi Kumar Ray et al [12] developed a traction kit which is useful for 2 positions in shoulder surgeries which is much economical and reliable. This paper intends to present a solid model of shoulder traction kit which is easy to handle and use. The basic design provides us with an excellent mechanism for the sake of arthroscopic shoulder surgery but it fails at several aspects which include durability, easy handling, safety etc. Improved version of this design presented in the paper provides the user to use the equipment with greater balance, improved accuracy while holding the patients hand firmly against the equipment at required angle. The user can comfortably use as it has height and level adjustments, simple nut and bolt mechanisms with greater life span. Traction device for arthroscopy of shoulder and wrist possesses simple structure and easy to operate characteristics. The system of traction device for arthroscopy of shoulder and wrist can attain maximum traction (pull force) when simply rotate the tension wheel. The pull force of this traction can be able to adjust, which can achieve change the size of the traction force effect through adjust the weight of Farmar. The traction can adjust traction force, angles and height, etc. Thus, it is very convenient to operate. The figure 2 shows the fully designed shoulder traction surgery kit.

Figure 1: Lateral Decubitus Position for Shoulder Arthroscopy [7]
2. MODELING
Initially a basic model of the shoulder traction kit has been made to get a realistic view of the design. The images below are the replica of the idea behind the project which has been done using CATIA V5 software. The design shows few unique parts and mechanical motions which delivers most important mechanism. This design has got the following parts namely angle plug, adjustable rod, gears, top cap, sliding cap, handle, guide rod, pulley, base jig etc. The base components or parts which have been designed to be assembled are below.

2.1. Base Jig & Central Threaded Rod

The above figure 3 represents the main base of the whole mechanism. It supports the 2 guide rods and the central threaded rod. The 2 holes of 25.5 mm diameter are to hold the 2 guide rods and the 100 mm diameter slot is to hold the central threaded rod. The above figure 4 represents the central threaded rod of diameter 99.50 mm – M12, which is 1800 mm long as per the requirements of the customer. Its position is fixed and any kinds of movements are restricted.
2.2. Guide Rod & Sliding Cap

As represented in the above figure 5 the guide rod is 1800 mm long and 25.40 mm diameter, this allows and also restricts the movement of the sliding cap, vertically. The above figure 6 shows the dimension of the sliding cap which has a 100 mm diameter hole which has internal threading to allow its movement along the vertical axis of the central threaded rod. The front view shows there is also another slot of 40 mm diameter which is to facilitate the placement of the angle plug. The two similar holes of diameter 17.50 mm are to allow the passage of the guide rods and hence the sliding cap attains stability. Also, it has a 5 mm diameter hole which aligns with the angle plug slots to fix upon a required angular position.

2.3. Top Cap & Horizontal Hand

The top cap shown in figure 7 is very similar to the sliding cap and also has a central hole of 100.5 mm diameter and the side view has a square slot unlike the sliding cap, the square slot has been chosen just to restrict the movement of the plug which mates the caps and the horizontal hands. The figure 8 shown above is the horizontal hand which is in a U-shape when seen from the side view. There are 2 holes of diameter 8 mm present at either ends to facilitate the entrance of the pin that locks the pulley and the horizontal hand. There is also a square slot in the centre of the rod to facilitate the entrance of the plugs depending on its position.
2.4. Pulley and Angle Plug

The pulley in figure 9 is of 80 mm diameter with a central slot of 8mm diameter to allow the passage of a pin and hold it together with the horizontal hand for 4 pulleys. The angle plug as shown in the figure 10 has been designed to mate/hold together, both the handle and the sliding cap. The one end of the plug has holes of 5mm diameter, these are present to facilitate the locking at require angle, based on the requirements of the horizontal hand. There is slot in the sliding cap which aligns with these slots and a pin is to be placed when they align to lock in the angle required. The whole 60mm length of the plug fits into the sliding cap leaving the 30mm part visible which has a central hole for the screw to fit in and tighten the locking further.

2.5. Static Plug & Handle

The static plug in figure 11 is used to mate the 2nd horizontal hand with the top cap which is in static position. The bigger square end sits inside the slot allotted in the top cap and the other end is set in the horizontal rod. A mating hole of 10mm is put down and the plug is tightened in the horizontal rod with the help of screw. The handle in figure 12 goes in the slot of one of the guide rods and is freely movable and rotatable, the key slot on the handle of 10 mm mates with the smaller gear.

2.6. Small Gear & Big Gear

The smaller gear in figure 13 mates with the handle using a key and slot of 10x10 mm. The gear was designed according to the distance between the 2 centre points of the locations. The pressure angle taken = 14.5°, Module taken = 1, Pitch circle diameter = 84 mm, Bore = 30 mm.
The bigger gear in figure 14 is to be welded to the end of the central threaded rod. This meshes with the smaller gear which can give rotary motion to central threaded rod.

![Figure 13 Small Gear](image13.png) ![Figure 14 Big Gear](image14.png)

3. Assembled Model

The overall assembly of the above mentioned parts adds up to the shoulder traction kit as shown in figure 15. The working principle is that the handle is rotated to move the threaded rod which provides motion to the sliding cap so that the height can be adjusted. The sliding cap holds the horizontal hand using the angle jig, the angle of the horizontal hand can be adjusted and the cord is placed on the pulley. The second horizontal rod is used based on the requirement of the operation. A total of up to 8 kg loads can be placed on either of the hands through the pulleys.

![Figure 15 Shoulder Traction Kit](image15.png)

4. ANALYSIS

The analysis is done on ANSYS software. The model is subjected to maximum load conditions of 8 kg on the pulleys keeping base fixed subjected to boundary conditions as shown in figure 16. The resultant output analyzed are equivalent stress, factor of safety, total deformation etc are within permissible limits which validate the model. Figure 17 and 18 are stresses and total deformations obtained in ANSYS.
5. DISCUSSION & CONCLUSIONS:

The developed design and model of shoulder traction kit aids arthroscopic shoulder surgeries with simple mechanisms involved. It also assures that the equipment has greater balance, improved accuracy, providing greater comfort to user as height can be adjusted by rotating the handle. The visualization of the equipment model is done by CATIA V5, SOLIDWORKS software and the reliability of the product is checked using ANSYS software. The design shows unique parts which involves few mechanical motions and mechanisms making it easier to use. The model when analyzed in ANSYS and subjected to max load conditions of 8 kg, the equivalent stress, strain, factor of safety, total deformation are found to be within limits. The product designed covers all the demerits and is specially made to cut down the price of the equipment to a great level and which works equally well. Scope for the project is very high since the product if produced is very much affordable and reliable for the customer.
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